XMAS-IV ORAL ABSTRACTS

KS1 Tara Oceans: Eco-Systems Biology at Planetary Scale

Chris Bowler, Ecology and Evolutionary Biology Section, Institut de Biologie de l'Ecole Normale Supérieure (IBENS), Paris, FRANCE
Tara Oceans Consortium,
Presenter Email: cbowler@biologie.ens.fr

The ocean is the largest ecosystem on Earth and yet we know very little about it. This is particularly true for the plankton that drift within, even though they form the base of marine food webs and are key players in Earth's biogeochemical cycles. Ocean plankton are at least as important for the Earth system as the forests on land, but most of them are invisible to the naked eye and thus are largely uncharacterized. To increase our understanding of this underexplored world, a multidisciplinary consortium, Tara Oceans, was formed around the 110-ft research schooner Tara, which sampled plankton at more than 210 sites and multiple depth layers in all the major oceanic regions during expeditions from 2009-2013 (Karsenti et al. Plos Biol., 2011). This talk will summarize the first foundational resources from the project (see Science special issue May 22, 2015 and Nature 28 April, 2016) and their initial analyses, illustrating several aspects of the Tara Oceans' eco-systems biology approach to address microbial contributions to macro-ecological processes. The project provides unique resources for several scientific disciplines that are foundational for mapping ocean biodiversity of a wide range of organisms that are rarely studied together, exploring their interactions, and integrating biology into our physico-chemical understanding of the ocean. These resources, and the scientific innovations emerging to understand them, are critical towards developing baseline ecological context and predictive power needed to track the impact of climate change on the oceans.

KS2 Modeling Continental Shelf Nutrient and Carbon Budgets: Approaches and Challenges

Eileen E. Hofmann, Center for Coastal Physical Oceanography Old Dominion University
The USECoS Team,
Presenter Email: hofmann@ccpo.odu.edu

Understanding and projecting the fate and transport of carbon and nutrients for continental shelf systems requires integrated modeling frameworks that encompass the land-estuary-shelf continuum, resolve seasonal and annual variability in fluxes, and include complex biogeochemical interactions that modify nutrient and carbon cycling. Such a modeling framework has been implemented for the Middle Atlantic Bight region of the U.S. east coast. Watershed inputs of nutrients and carbon are provided by the Dynamic Land Ecosystem Model and estuarine transformations (Chesapeake Bay) are simulated by a

high-resolution circulation-biogeochemical model. Fluxes from the estuary provide inputs to a coupled circulation-biogeochemical model implemented for the MAB shelf. Nutrient budgets generated from multi-year simulations provide estimates of the relative importance of internal transformation processes in the estuary and export to the coastal ocean. Similar budgets for the MAB continental shelf provide estimates of net community production and fluxes of inorganic and organic nitrogen due to coastal currents, rivers, and estuaries. Passive tracer simulations provide insights into transport pathways that connect the estuary, inner shelf, and outer shelf and identify export pathways from the MAB to the open ocean and other shelf regions. The MAB simulations improve understanding of the coupling at the land-water interface and shelf-wide transport patterns that advance the ability to predict the effects of localized human impacts and broader-scale climate-related impacts on the U.S. east coast continental shelf system. The integrated modeling framework implemented for the MAB also provides a basis for comparing with other continental shelf systems, highlighting approaches for projecting the effects of climate change on nutrient and carbon cycling, and identifying the challenges associated with including socio-economic effects of changes in nutrient and carbon cycling in continental shelf systems.

KS3 Implications of anthropogenic sea-level rise for mitigation and adaptation decisions

John A. Church, Climate Change Research Centre, University of New South Wales
Presenter Email: john.church@unsw.edu.au

Climate change has become one of the most important economic, environmental and social challenges of the 21st century, with sea-level rise a key aspect. Today, the order of 100 million of people live within a metre of high tide level, and more people are moving towards the coast in both the developed and developing world. Historical and paleo observations, the advent of modern satellite and in situ ocean and climate observing systems and the development of improved ocean and climate models has greatly improved our understanding of contemporary sea-level change. There is now a reasonable understanding of the reasons for sea-level change over recent decades and since 1900, including the attribution of the observed change to the climatic drivers. There are important implication for the 21st century and beyond. Critically important for sea level around the globe is the changing structure of the oceans and the role of the oceans and atmosphere in the future of the ice sheets of Antarctica and Greenland. Projections for the 21st century, sea levels could rise by a metre or more for unmitigated emissions. Sea levels will not stop rising in 2100, even for the strongest mitigation scenario. Indeed, failure to mitigate our greenhouse gas emissions will lead to a world of catastrophic changes. Avoiding these changes will require significant, urgent and sustained mitigation of greenhouse gas emissions. But even with successful mitigation, society will have to

adapt to that component of climate change we cannot avoid. As a result, sea-level rise has the potential to have major impacts.

KS4 On the use of stable isotopes as deliberate tracers to elucidate ecosystem functioning

Jack Middleburg, Utrecht University
Presenter Email: J.B.M.Middelburg@uu.nl

Biogeochemistry and ecosystem ecology aim to advance our understanding of material flows within, and the functioning of, ecosystem. The (bio)geochemists provide quantitative rigor and tools for tracing flows, while ecologist emphasize the need to embrace biodiversity. The link between organism identity/activity and biogeochemical processes is still poorly known. I will discuss how organic geochemical tools, biogeochemical process studies and whole ecosystem isotope labelling studies can be combined to elucidate the flow of carbon and nitrogen through ecosystems and present examples from marine sediments, cold-water corals, sponges and phytoplankton.

KS5 Biogeochemical-Argo: Status and Implementation Plan

Kenneth Johnson, Monterey Bay Aquarium Research Institute
Herve Claustre, Monterey Bay Aquarium Research Institute
Presenter Email: johnson@mbari.org

Biogeochemical-Argo is the extension of the Argo array of profiling floats to include floats that are equipped with biogeochemical sensors for pH, oxygen, nitrate, chlorophyll, suspended particles, and downwelling irradiance. Robust sensors now allow profiling floats to observe biogeochemical properties with sufficient accuracy for climate studies throughout the global ocean, including seasonally ice-covered waters. The floats have enough power to operate for as much as 7 years, enabling seasonal and interannual changes in biogeochemical processes to be resolved. This talk will provide a summary of sensor performance and the significant scientific results that have been obtained with biogeochemical sensors on profiling floats. It will also provide an update on plans to implement a global array of floats. Computer and statistical models indicate an array of 1000 biogeochemical floats will provide a transformative impact on our knowledge of oceanic biogeochemical and carbon cycles. With a mean float lifetime near 4 years, a sustained array requires approximately 250 replacements each year. A detailed Biogeochemical-Argo Science and Implementation Plan is available at http://biogeochemical-argo.org/.

O-T-01 Statistical analysis of time series and its applications to the global sea level rise and to tide predictions in the shallow waters of the gulf of mexico

Alexey Sadovski, Department of Mathematics & Statistics, Texas A&M University -Corpus Christi
Presenter Email: alexey.sadovski@tamucc.edu

This presentation is based on the research done at the Texas A&M University-Corpus Christi. We applied different tools of statistical analysis and neural networks to analyze time series data collected by the Texas Coastal Ocean Observation Network (TCOON) along the coast of the Gulf of Mexico. The results of this approach is a good predictions of primary water levels for 12-48 hours period as well as a reliable shorter term predictions of fast changing water levels in the cases of tropical storms. Another investigation is used factor analysis to deal with the global and local time series data to explain and predict sea level rise. Discoveries include, but not limited to, the Geoid impact, sea level rise due to global ice melting, and local factors such as a land subsidence.

O-T-02 Neogene burial of organic carbon in the global ocean

Yige Zhang, Department of Oceanography, Texas A&M University, College Station, TX 77843, USA
Ziye Li, Department of Oceanography, Texas A&M University, College Station, TX 77843, USA; College of Marine Geosciences, Ocean University of China, Qingdao, 266100;
Presenter Email: yige.zhang@tamu.edu

The burial of organic carbon (OC) in marine sediments is a process that controls the organic sub-cycle of the global carbon cycle. Buried OC is effectively isolated from the Earth's surficial system therefore serve as a net sink for atmospheric CO_2, and a source for O_2, and contributes to the formation of organic-rich sources rocks essential for petroleum or natural gas. The global rate of OC burial is conventionally calculated using the mass balance between inorganic carbon and OC, each with distinct isotopic values ($\delta^{13}C$). However, the uncertainty associated with some key parameters complicates this approach. The history and imperative controls of OC burial are being debated. Here we used a "bottom-up" approach independent from model calculations, to utilize the total organic carbon (TOC%) reported from numerous sites drilled by the International Ocean Discovery Program (IODP). Although TOC% measurement is an IODP standard practice, these data are rarely explored in-depth or synthesized. We targeted > 80 sites covering all major ocean basins and sedimentary environments, to quality-control the data, update their age models, and establish regional and global pictures of TOC mass accumulation rates over the Neogene (23.0-2.6 Ma). This study helps shed light on some fundamental questions such as the spatio- temporal variability of OC burial. We show that over the Neogene, regional and global changes of OC burial rates were substantial which largely impacted the carbon and oxygen cycle as well as the occurrence of organic-rich sediments/rocks. For the special tutorial session of XMAS IV, I will explicitly demonstrate the acquiring and processing of the physical and chemical property data of IODP sediments, as well as the chronology controls.

O-T-03 The Adaptive Metropolis algorithm as a tool for model selection given irregular and imperfect time-series data

Sherwood. Lan Smith, Marine Ecosystem Dynamics Research Group,Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Yokohama JAMSTEC,
Presenter Email: lanimal@jamstec.go.jp

Oceanographic and other ecological observations often yield irregular time-series of data, including substantial uncertainties. Models, which express quantitatively our hypotheses about the underlying processes, are useful and in many cases essential tools for interpreting such observations. However, given the uncertainties in both the data and models, rigorous model-data comparison is a daunting task. Here I will present details from a previously published example (Smith et al. J. Plankton Res. 38, doi: 10.1093/plankt/fbv038, 2016) using the Adaptive Metropolis (AM) algorithm (Haario et al. Bernoulli 7, p. 223-242, 2001) to combine oceanic time-series observations with plankton ecosystem modelling. Time-series observations consisted of nutrients, chlorophyll, and primary production, from the K2S1 project (https://ebcrpa.jamstec.go.jp/k2s1/en/). The Bayesian statistical foundation of the AM algorithm allows for systematically combining: 1) prior knowledge of parameter values, 2) irregular time-series data of different types, each with its own uncertainties, and 3) different model formulations. The algorithm generates an ensemble of model simulations tuned to match the range of observations. It thus provides: 1) quantitative metrics for determining which model formulation is best supported by the available data (i.e., model selection), 2) posterior distributions of model parameter values and corresponding model outputs, and 3) uncertainty estimates (from Gibbs sampling) of the model-data mismatch for each observation type, respectively. Such Bayesian approaches provide a systematic means of quantifying uncertainties and evaluating competing hypotheses given irregular time-series data. This is important for interpreting large, modern data sets consisting of multiple data types, each having different units and associated uncertainties. It also works well with complex models having non-linear dynamics. However, even these computationally efficient statistical methods require thousands to many millions of model simulations, depending on data quality and the number of parameters being optimized. Until recently this has limited their use to 0-D models, but fast modern computers have recently made it possible to apply them with 1-D ocean models as well (Chen and Smith. Geosci. Model Dev., doi: 10.5194/gmd-11-467-2018, 2018), expanding their potential for studying the combined effects of physical,

ecological, and biogeochemical processes.

O-T-04 Long-term variation of subsurface oxygen and nutrient in North Pacific: Do they reflect each other?

Tsuneo Ono, National Research Institute for Far Seas Fisheries, Japan Fisheries Research and Education Agency
Presenter Email: onotsu@biglobe.jp

It is well known that the oxygen content of subsurface waters has been decreased in the wide area of North Pacific, but its mechanism is not completely resolved. Nutrients are useful side variable to investigate this mechanism, as oxygen and nutrients are connected by Redfield relationship through the most of biogeochemical processes in subsurface waters. We have examined 20-years concentration change of oxygen and nutrients (phosphate, nitrate and silicate) in 100m-1000m depth range of entire North Pacific, and confirmed that increasing rate of both phosphate and nitrate in this depth range were consistent with decreasing rate of oxygen with normal Redfield stoichiometry. Estimated increase of nitrate inventory in 100m-1000m of North pacific was 200 Gmol/y, whereas no decrease of nitrate inventory in top 100m of North Pacific was observed [Yasunaka et al., 2016]. This discrepancy indicates that either southward transport of subsurface nitrate or decrease of nitrate in the waters below 1000m must be required, if we assume constant nitrate inventory in the whole north Pacific. This conclusion further indicates that either southward transport of low-oxygen signal or oxygen increase in the waters below 1000m must have been occurred in the recent North Pacific, both of which are not predicted from the present studies based only on the oxygen data. We also found that ilicate concentration in subsurface waters of western subarctic North Pacific had increased at 6~10 times higher rate than that expected from oxygen decrease with normal Redfield stoichiometry. In this presentation, I would like to discuss about these findings and cause of non-Redfield behavior among oxygen and nutrients.

O-P1-01 Nearshore Circulation, Transport, and Implication on Population Connectivity in a Macro Tidal Coastal Environment

Huijie Xue, University of Maine
LeAnn Conlon, University pf Maine
Phil Yund, Downeast Institute
Ron Etter, University of Massachusetts Boston
Presenter Email: huijiexue@scsio.ac.cn

Population connectivity of many marine organisms is dependent on the extent of along- and across-shelf larval transport. We use a high resolution (100 m to 4 km) unstructured grid coastal circulation model based on FVCOM coupled with the offline particle tracking code FISCM to simulate movement and development of larval blue mussels (Mytilus edulis) along the coast of eastern Maine, which is an area of interest by itself due to its high tide, complex coastline, many bays and small rivers, strong coastal current, and numerous mussel populations spread across the bays. The circulation model resolves individual bays along the coast, and the combination of temporal and spatial validation improved confidence in the model's ability to recreate realistic flow patterns that determine particle movements. The model also demonstrates how temporally and spatially variable along- and across-shelf transports interact with biological traits to create dispersal patterns of blue mussel larvae. In agreement with the recruitment data, the model predicted settlement shows primarily two clusters: the Frenchman Bay cluster that appears to be self-seeding and the Pleasant Bay cluster that contributes both locally and downstream. The two clusters appear to be preconditioned by the reproductive output, while the longer distance connectivity relies on the coastal current, which requires the cross-shelf transport to bring larvae out to the coastal current and later on from the coastal current back to the neashore. The connectivity is less sensitive to timing within the bed specific two-week spawning windows. Lastly, the model suggests an increase in settlement in a warming scenario.

O-P1-02 Recent development in coastal oceanography

Xiao Hua Wang, Sino-Australian Research Centre for Coastal Management (SARCCM), UNSW Australia

Presenter Email: x.h.wang@unsw.edu.au

Many world estuaries and coast environments are under tremendous stress in response to the increased anthropogenic forcing and climate change. A good understanding of the current state of these marine environment and lessons learnt from these human influences would be extremely valuable to restore and protect these habitats and ecosystems from further environmental degradation and catastrophe. This talk will provide a synthesis in which the latest research addressing the physics, sedimentary processes, biology, chemistry and ecological processes associated with these rapidly changing estuarine and coastal environments. It will explore the challenges and opportunities for future research in Chinese estuaries and coastal waters around the world.

O-P1-03 The possible effect of stratification on the vertical structure of the semidiurnal tidal ellipse in the Changjiang River estuary, China

John Z. Shi, School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University

Xiang Pu, School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University,

Guo-Dong Hu, Survey Bureau of Hydrology and Water Resources of the Changjiang River Estuary, Changjiang Water Resources Commission, Shanghai

Presenter Email: zshi@sjtu.edu.cn

The possible effect of stratification on the vertical structure of the semidiurnal tidal ellipse in the Changjiang River estuary is analyzed based on obervational data. A pycnocline occurs at each station along the North Passage on a neap tide only. Calculated potential energy anomalies within the North Passage are 100 - 200 Jm-3 larger on a neap tide than on a spring tide. The tidal ellipses degenerate to rectilinear motion at each layer of the water column at each station along the North Passage, while they rotate clockwise at each station over the Hengsha Shoal. The surface-to-bottom inclination angle difference of the tidal ellipse at a seaward station is 40 degree on a neap tide but a few degrees on a spring tide. Rapid changes in the inclination angles and phrase shifts of the tidal ellipses occur at the pycnocline. An abrupt reduction in the vertical eddy viscosity at the pycnocline seems to be the major cause for the vertical variability of ellipticity, inclination angle and phase of the tidal ellipses on a strongly stratified neap tide. The surface-to-bottom ellipticy difference appears to have a positive linear relation with the overall Richardson number mainly along the North Passage on a neap tide.

O-P1-04 The nonlinear effects of the eddy viscosity and the bottom friction on the Lagrangian residual velocity in a narrow model bay

Fangjing Deng, Ocean University of China
Wensheng Jiang, Ocean University of China
Shizuo Feng, Ocean University of China
Presenter Email: wsjang@ouc.edu.cn

The nonlinear effects of the eddy viscosity and the bottom friction on the Lagrangian residual velocity (LRV) are studied numerically in a narrow model bay. Three groups of the experiments with different eddy viscosity and different forms of the bottom friction are designed and are carried out in the three kinds of the topography. When the eddy viscosity is obtained from a two-equation turbulence closure model, the pattern of the LRV is more complex than that of the time invariant eddy viscosity case and the intensity is from more than 1.3 times to one order smaller than that of the linear eddy viscosity condition. The LRV are also acquired when the eddy viscosity varies from the flood-averaged one to the ebb-averaged one. It is found that when the flood-averaged eddy viscosity is bigger than the ebb- averaged eddy viscosity (flood-dominated asymmetry), the direction of the breadth-averaged LRV and the 3D LRV is nearly opposite to that when the eddy viscosity asymmetry is reverse (ebb-dominated asymmetry). However, the intensity of the LRV for the ebb-dominated case decreases toward the flood- dominated case as the ratio of the maximum depth in the deep channel and the minimum depth on the shoal increases. The different forms of the bottom friction also play a role in the LRV. The structures of the 3D LRV and the depth-integrated LRV are simpler, and the intensity of the LRV is two times smaller when the linear bottom friction is used than those when the quadratic bottom

friction is used.

O-P1-05 Frictional interactions between tidal constituents in tide-dominated estuaries

Huayang Cai, Institute of Estuarine and Coastal Research, School of Marine Sciences, Sun Yat-sen University
Erwan Garel, Centre for Marine and Environmental Research (CIMA), University of Algarve, Faro, Portugal
Presenter Email: caihy7@mail.sysu.edu.cn

When different tidal constituents propagate along an estuary, they interact because of the presence of nonlinear terms in the hydrodynamic equations. In particular, due to the quadratic velocity in the friction term, the effective friction experienced by both the predominant and the minor tidal constituents is enhanced. We explore the underlying mechanism with a simple conceptual model by utilizing Chebyshev polynomials, enabling the effect of the velocities of the tidal constituents to be summed in the friction term and, hence, the linearized hydrodynamic equations to be solved analytically in a closed form. An analytical model is adopted for each single tidal constituent with a correction factor to adjust the linearized friction term, accounting for the mutual interactions between the different tidal constituents by means of an iterative procedure. The proposed method is applied to the Guadiana (southern Portugal-Spain border) and Guadalquivir (Spain) estuaries for different tidal constituents (M2, S2, N2, O1, K1) imposed independently at the estuary mouth. The analytical results appear to agree very well with the observed tidal amplitudes and phases of the different tidal constituents. The proposed method could be applicable to other alluvial estuaries with small tidal amplitude to depth ratio and negligible river discharge.

O-P1-06 Seasonal Alternation of Tidal Asymmetry Induced by Mean Sea Level Variation

Yunwei Wang, Hohai University
Qian Yu, Nanjing University
Shu Gao, East China Normal University
Presenter Email: ms.ywwang@gmail.com

Asymmetries are important characteristics of the coastal tide, which determine the direction and magnitude of tide-induced sediment transport. In a tidal channel of the south Yellow Sea coast, China, hourly sea-level data were observed continuously from January 2013 to December 2016 by a tidal gauge. Throughout the 4 years, seasonal changes of tidal asymmetry were indicated by harmonic analysis, which is flood-dominant in winter while ebb-dominant in summer. The seasonal alternation of tidal asymmetry can be interpreted by the seasonal variation of mean sea level (MSL). In winter, monthly MSL is

below the annual mean value, leading to a smaller tidal range and ratio of intertidal storage (Vf) to channel volume (Vc), and thereby to flood-dominant tide. Instead, in summer, the higher MSL results in a larger tidal range and Vf/ Vc as well, and thus the tide is ebb-dominant. The pattern of flood and ebb dominant tide alternation indicates the equilibrium of tidal basin morphology by balancing the onshore and offshore sediment transport in winter and summer, respectively. It is analogized that the sea level rise (SLR) in the future will result in ebb-dominant tide, and the offshore net sediment transport will consequently further enhance coastal erosion. This study provides a typical example of the coastal response to SLR for similar environments.

O-P1-07 The balance of salinity variance in a partially stratified estuary: implications for exchange flow, mixing and water age

Tao Wang, Hohai University
W. Rockwell Geyer, Woods Hole Oceanographic Institution
Presenter Email: haidawangtao@163.com

The balance equations of salinity variance are used to study the relationship between exchange flow and mixing of salinity, as well as the influence of river flow and spring neap cycle on them in the Hudson estuary. As river flow increases, mixing of salinity inside the estuary becomes stronger due to more variance input from the open boundaries driven by exchange flow and river flow. During one spring-neap cycle, maximum exchange flow occurs during neap tides, but maximum mixing occurs during the transition from neap to spring tides due to the combined influence of turbulence production and stratification. During most of the transition time from spring to neap tides, advective input of salinity variance from the open boundaries is larger than dissipation, resulting in the net increase of variance, which intensifies the stratification.
The intensified stratification in turn increases dissipation. As dissipation becomes larger than the advective input, i.e., during most of the transition time from neap to spring tides, salinity variance decreases and the stratification is destroyed. Another notable result is that the spatial distribution of salinity variance is found to be very similar to the distribution of water age under steady state conditions. Low salinity variance corresponds to old water. The similarity of the distribution of these quantities clearly reveals the pathway of exchange within the estuary and its relationship to mixing.

O-P1-08 On the dynamics of buoyant outflows to the coastal ocean

Pablo Huq, College of Earth, Ocean, and Environment University of Delaware Newark, DE 19716, USA
Presenter Email: huq@udel.edu

A large recirculating gyre or bulge (anticyclonic buoyant lens) can occur in buoyant outflows to the coastal ocean. Laboratory experiments were conducted to examine the

characteristics, evolution, and impact of bulges for coastal buoyant outflow. It was determined that the freshwater storage within the bulge was approximately 60–70% of the buoyant outflow. A (buoyant) coastal current propagates downshelf of the bulge. The scales of the downshelf propagating coastal currents are larger in the absence of a recirculating bulge. Scaling arguments are presented that show the coastal current dynamics can be classified by a two-variable non-dimensional parameter space: the ambient depth parameter, h/H, and the bottom slope parameter, R/γb. We also examine the influence of the Kelvin number (K) and fractional depth (h/D) on bulge formation. Here K=W/R is the ratio of the width (W) at the mouth of the estuary to the deformation radius (R), and h and D are the buoyant layer and ambient ocean depths, respectively. The buoyant outflow flows across the entire width of the estuary for narrow estuaries (i.e., K≤1). In contrast, for wide estuaries (K>2), dense oceanic water inflows on the left and the buoyant waters outflow on the right (looking seaward). It is shown that these experimental measurements and oceanic observations are in accord.

O-P1-09 Dispersal of the Pearl River plume over continental shelf in summer

Zhaoyun Chen, Institute of Marine Sciences, Shantou University

Presenter Email: chenzy@stu.edu.cn

Satellite images of turbidity were used to study the climatological, monthly, and typical snapshot distributions of the Pearl River plume over the shelf in summer from 2003 to 2016. These images show that the plume spreads offshore over the eastern shelf and is trapped near the coast over the western shelf. Eastward extension of the plume retreats from June to August. Monthly spatial variations of the plume are characterized by eastward spreading, westward spreading, or both. Time series of monthly plume area was quantified by applying the *K*-mean clustering method to identify the turbid plume water. Decomposition of the 14-year monthly turbidity data by the empirical orthogonal function (EOF) analysis isolated the 1st mode in both the eastward and westward spreading pattern as the time series closely related to the Pearl River discharge, and the 2nd mode with out-of-phase turbidity anomalies over the eastern and western shelves that is associated with the prevailing wind direction. Eight typical plume types were detected from the satellite snapshots. They are characterized by coastal jet, eastward offshore spreading, westward spreading, bidirectional spreading, bulge, isolated patch, offshore branch, and offshore filaments, respectively. Their possible mechanisms are discussed.

O-P1-10 The distribution of age in a coastal river plume

Yeping Yuan, Zhejiang University

Alexander R. Horner-Devine, University of Washington

Presenter Email: yyping@zju.edu.cn

In the study of geophysical flows, it is essential to understand the transport of nutrients,

contaminants, and other particles for predicting changes in water quality in aquatic systems. The chemical and biological processes related to these substances are dependent on the residence time of the particular constituent and often proceed exponentially, making them sensitive to small variations in the age of fluid parcel in the system. In environmental flows, such as river plume systems, vortices and short circuits often cause large deviations from the widely used hydraulic residence time, causing this to be an inaccurate representation of actual residence time. We use a novel technique that resolves the spatial and temporal evolution of the age of fluid parcels in laboratory flows to characterize retention processes in coastal buoyant plumes. An anticyclonic eddy sets up near the river mouth and accumulates a fraction of the river discharge. In the first stages of development, fluid is retained in the core of the bulge, resulting in a spatial age distribution that exhibits a maximum in the core of the bulge and decreases radially. After approximately 10 rotation periods, the bulge becomes unstable, and smaller eddies initiate mixing between the core and outer portions of the bulge, transporting older fluid from the center of the bulge into the coastal current. We found that the age distribution is initially characterized by a single peak that over time degenerates into multiple peaks. The number peaks is predicted by an instability wavenumber determined for baroclinic instability. When the rotation rate is low, retention in the bulge increases and the maximum and average ages are also higher.

O-P1-11 Coupled summer circulation and dynamics between a bay and the adjacent shelf around Hong Kong: observational and modeling studies

Zhiqiang LIU, Division of Environment and Sustainability, The Hong Kong University of Science and Technology
Jianping GAN, Department of Ocean Science and Department of Mathematics, The Hong Kong University of Science and Technology
Xiaoyan WU, Division of Environment and Sustainability, The Hong Kong University of Science and Technology
Presenter Email: liuzhq@connect.ust.hk

Observational and numerical modeling studies are conducted to investigate the coupled circulation between Mirs Bay to the east of Hong Kong and the adjacent shelf sea during an upwelling season. Long- and short-term observations are synthesized to characterize the circulations in the bay-shelf region. A three-dimensional coupled bay-shelf-estuary circulation model was developed with realistic topography and forced with time-dependent wind, tides and lateral fluxes to investigate the processes and physics in the circulation of the coupled bay-shelf regime. Based on the validated model, it was found that a strong northeastward coastal upwelling jet persisted over the shelf with highly variable topography outside the bay, and a strong upslope current occurred where the topography was sharply convex. This upslope current intruded into the bay in the lower layer (>10 m)

as a cold-water stream. A horizontal anti-cyclonic circulation formed inside the bay with a seaward outflow in the upper layer (<10 m). Momentum and vorticity analyses showed that a southwestward along-isobath pressure gradient force over the convex isobaths off the bay intensified that bay-ward intrusion. Negative relative vorticity advection from the jet was responsible for this pressure gradient force. The horizontal anti-cyclonic circulation and elevation fluctuation inside the bay were determined by the interaction between the intruding shelf current and the topographic trough inside the bay, and they were also baroclinically modulated by the intrusion of denser shelf waters. Winds over Mirs Bay intensified exchange flow across its entrance, but suppressed the anti-cyclonic circulation inside the bay.

O-P1-12 A Numerical Study of Coastal-Trapped Waves in Jervis Bay, Australia

Fanglou Liao, 1The Sino-Australian Research Centre for Coastal Management, The University of New South Wales, Canberra, Australia 2School of Physical, Environmental and Mathematical Sciences, The University of New South Wales, Canberra, Australia
Xiao Hua Wang, 1The Sino-Australian Research Centre for Coastal Management, The University of New South Wales, Canberra, Australia 2School of Physical, Environmental and Mathematical Sciences, The University of New South Wales, Canberra, Australia
Presenter Email: Fanglou.Liao@student.adfa.edu.au

Coastal-Trapped Waves (CTWs) in Jervis Bay were investigated using a Jervis Bay Ocean Model (JBOM), based on the Princeton Ocean Model. Under the typical temperature stratification in Jervis Bay in summer, the first three modes of external CTWs can scatter into the bay. The wind stress inside Jervis Bay can generate CTWs and the wind stress on the adjacent shelf can also generate CTWs in the bay by oscillations at the bay mouth which are associated with temperature fluctuations there. The actual sub-inertial CTWs in Jervis Bay are a result of the interference of these CTWs. The amplitudes of the first three CTW modes were calculated from the observed sea-level data. Three numerical experiments were designed to identify the major forcing of the observed sub-inertial temperature oscillations in Jervis Bay during an observational program in the summer of 1988/89. It was found that the local wind stress was the major contributor to the observed oscillations.

O-P1-13 The response of North Yellow Sea Cold Water Mass to the wind-generated near-inertial oscillation

Dehai Song, Key Laboratory of Physical Oceanography, Ministry of Education, at Ocean University of China
Guandong Gao, Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology, Chinese Academy of Sciences
Yingying Xia, National Marine Data and Information Service, State Oceanic Administration

of China
Presenter Email: songdh@ouc.edu.cn

The Yellow Sea Cold Water Mass (YSCWM), which seasonally presents and occupies the central bottom trough, is the dominant hydrological phenomenon in YS in summer. YSCWM is considered to originate locally from previous winter water. The seasonal evolution of YSCWM has been revealed as growth in spring, maturity in summer, decline in autumn, and disappearance in winter. Cold water mass (CWM) in the North Yellow Sea (NYS) is of great significance to local hydrodynamics, marine ecosystems, fisheries, and especially aquiculture in the local marine farms. Using seabed-mounted TD/CTD chains and buoys, the temperature and current variation in the NYS Cold Water Mass (NYSCWM) was studied during the summer of 2009. Besides the flood-ebb and spring-neap variation, the near-inertial oscillation (NIO) was also found in this region, which was generated by the sudden change of winds. Long-term observation indicates that the NIO can only happen in summer due to the CWM generated strong stratification in the northern NYS. However, the stratification is too strong in the CWM occupied water that little energy (<10% of the wind work) can be transfer downward to the CWM interior. Most of the energy is dissipated at the base of mixed layer to drop down the mixed layer depth. Different from deep water, shear instability might be the dominate mechanism on decaying of NIO at mixed layer in the northern NYS.

O-P1-14 Thermal and dynamical response of South China Sea to the climate change

Jun Wei, Peking University
Ming-Ting Li, Peking University
Paola Rizzoli, MIT
Guo-qing Jiang, Peking University
Presenter Email: junwei1116@gmail.com

Based on a fully-coupled, high-resolution regional climate model, this study analyzed three-dimensional temperature and momentum changes in the South China Sea (SCS) from 1970 to 2000, during which period the climate shifts from a decadal La Niña-like condition (before 1976/77) to a decadal El Niño-like condition afterward. With a set of partially-coupled experiments, sea surface temperature (SST) and kinetic energy (KE) changes during this period are first decomposed into two components: those induced by lateral boundary forcing and those induced by atmospheric surface fluxes. The results showed that the total SST and KE changes show an increasing trend from 1970 to 2000. The two decomposed components together determined 96% and 89% of the SST and KE changes respectively, implying their dominant roles on the SCS's surface variability. Spatially, a sandwich pattern of air-sea forcing relationship is revealed in the SCS basin.

O-P1-15 Seasonal sediment transport pattern in a funnel-shaped microtidal estuary

Wenping Gong, Sun Yat-sen University
Lianghong Chen, Sun Yat-sen Univeristy
Presenter Email: gongwp@mail.sysu.edu.cn

Sediment transport pattern in the Huangmaohai estuary, a funnel shaped microtidal one in the Pearl River Delta, was examined based on a combination of numerical modelling and data analysis. The COAWST modelling system was utilized to study the sediment transport pattern and to reveal the underlying physics. A total of 5 sediment classes were introduced into the model for well representing the sediment characteristics in the estuary. The wave-current interaction was activated to examine the wave effects on sediment resuspension and transport.The model results show that different sediment transport patterns prevail during different tidal forcing, river discharge and wave conditions. The sediment transport fluxes were calculated and decomposed into several components. It is found that sediment is mostly entrapped inside the estuary in winter while the sediment can escape from the estuary in summer. Waves play important roles in sediment transport during both the winter and summer seasons.

O-P1-16 Comprehensive analyses of the sediment movement process in the vicinity of the deep-water channel of the Yangtze estuary

Qixiong Liu, College of Civil Engineering and Architecture, Zhejiang University
Haijiang Liu, College of Civil Engineering and Architecture, Zhejiang University
Presenter Email: haijiangliu@zju.edu.cn

Sedimentation in the deep-water channel of the Yangtze River estuary has significantly affected the local navigation conditions. It is therefore necessary to clarify the movement of the sediment and reveal its source. We sampled the bottom sediment both in the flood (2017) and dry (2018) seasons, and analyzed the physical characteristics such as grain size, mineral composition and element composition by means of laser granulometer, polarizing microscope(PM), X-ray diffractometer (XRD)and scanning electron microscope (SEM). Probability density distribution of samples' size was obtained, the result shows clear differences between flood and dry seasons' samples. As for the flood season, sample probability density distribution presents various profiles, e.g., a multimodal, plateau, fine or coarse skewed shape. Nevertheless, the probability density curves of the dry season samples only present two types, i.e., coarse skewed and narrow-banded single peak with a large kurtosis. Subsequently, the associated parameters of sediment size such as sorting coefficient, skewness and kurtosis values were calculated by Folk and Ward formula. Results indicate that the flood season samples have larger sorting coefficient, wider range of skewness value and smaller kurtosis value. Regarding the content of magnetic minerals in sand samples, outliers were found both in the flood and dry seasons but different in

locations. At the same time, through PM analysis, the samples were observed clear differences in transparency and color of different samples under the completely polarized state, which shows the difference of mineral composition in different samples. XRD is being used for further analysis of mineral composition. In addition, the SEM analysis recorded the micro-scaled image of each sample and shows the element composition of samples. Besides, several typhoons have influenced the Yangtze estuary this year. Before and after typhoons Maliya, Anbi and Suli, we sampled the bottom sediment in the vicinity of the deep-water channel of the Yangtze estuary to further study the impact of these typhoons on the suspension, transportation and deposition of sediment movement.

O-P1-17 Hysteresis of suspended sediment concentration to spring-neap tidal variations in turbidity maximum zone of a macro-tidal estuary: the role of bed mud pool movement

Qian Yu, MOE Key Laboratory for Coast and Island Development, Nanjing University, Nanjing, China
Yunwei Wang, College of Harbour, Coastal and Offshore Engineering, Hohai University, Nanjing 210098, China
Jian Hua Gao, MOE Key Laboratory for Coast and Island Development, Nanjing University, Nanjing, China
Presenter Email: qianyu.nju@gmail.com

In estuarine environments where tidal forces are dominant and spring-neap tidal variations are pronounced, suspended sediment concentration (SSC) in estuarine turbidity maximum (ETM) zone does not respond instantaneously to the tidal energy (quantified by tidal range). And a phase lag is found of SSC to the tidal range. This phenomenon is confirmed by field observations at the Yalu Estuary (a macro-tidal well-mixed estuary between China and North Korea). The hysteresis in SSC during the falling and rising spring–neap cycle is traditionally interpreted by the erosion lag effects. However, here we propose another explanation with the movement of bed mud pool in estuarine turbidity maximum zone. The schematized two-dimensional depth averaged numerical models show that, during the falling and rising spring–neap cycle, the bed mud pool moves down stream and upper stream, but with pronounced delays. Because the resuspension of the bed mud pool determines the local SSC in ETM, this lag can cause the SSC delayed in response to the tidal forcing variations. The present study highlights the importance of the bed mud pool acting as a restoring force of the ETM location.

O-P1-18 Multiple timescale suspended sediment concentration variations in the East China Seas indicated by satellite observations

Changwei Bian, Ocean University of China
Zhou Zhou, Ocean University of China

Presenter Email: bianchangwei@ouc.edu.cn

Suspended sediment concentration (SSC) in the East China Seas (ECSs) is modulated by a host of physical processes such as wind waves, tides and circulations on different timescales, which in turn leads to SSC variations on corresponding timescales. SSC variations have attracted enormous interest in the ECSs community owing to its profound impact on biogeochemical processes. However, the SSC variations and its modulation mechanisms remains limited understood. The aim of present study is to quantify the SSC variations on multiple timescales (intra-tidal, seasonal and long-term timescales) and their modulation mechanisms using high spatial-temporal resolution satellite remote sensing data from MODIS and GOCI. The results indicate that in the ECSs (area of 13.01×10^5 Km^2), the monsoon winds play the most important role in modulating SSC, causing strong SSC variation (> 30 mg/L) in 8.1% area (1.07×10^5 Km^2), and medium SSC variation (5−30 mg/L) in 29.5% area (3.89×10^5 Km^2). The tidal currents have significant influence on SSC variation, causing strong SSC variation in 0.7% area (0.10×10^5 Km^2), and medium SSC variation in 26.2% area (3.41×10^5 Km^2). The SSC variations on the long-term timescales (10 years) are not significant, as strong SSC variations are only observed in the Bohai Sea with an area of 0.008×10^5 Km^2. The SSC datasets of this study provide the research community of the ECSs an important data source for a better understanding of SSC spatial-temporal variability and its modulation mechanisms in the ECSs.

O-P1-19 Saltmarsh evolution driven by vegetation-sediment dynamic interaction: comparison of native and exotic species

Yining Chen, Second Institute of Oceanography, SOA
Tinglu Cai, Second Institute of Oceanography, SOA
Yan Li, Xiamen University
Silong Huang, Second Institute of Oceanography, SOA
Presenter Email: yiningchen@sio.org.cn

The interaction between vegetation and sediment dynamics and its function in driving saltmarsh evolution receives increased attention from geomorphologists and ecologists. Once the saltmarsh is invaded by exotic species, the bio-physical interaction is expected to be modified and consequently, the competition between native and exotic species co-drives the saltmarsh evolution. The pioneer zone of a saltmarsh is occupied by the presence of dynamic vegetation patches or tussocks. As the saltmarsh extends, the patches merge together to form homogenous covers. The successive invasion of exotic species also appear in an initial form of patches. Therefore, in order to understand the saltmarsh evolution, it is fundamentally important to compare the vegetation-sediment dynamic interactions between native and exotic species at a scale of patches. Saltmarshes developed on the mudflat of the Andong Shoal, Hangzhou Bay, provide a specific example of rapid evolution of saltmarsh, in association with typical native (*Scirpus mariqueter*) and exotic (*Spartina alterniflora*) species in China. The purpose of this study is to investigate the saltmarsh evolution driven by native and exotic species from a perspective of biomorphodynamics. High resolution (~1m) remote sensing images were collected for large scale vegetation distribution analyses. *In situ* observations of sediment dynamics at a relatively smaller scale were conducted in succeeding seasons, comparing the bare mudflat, the vegetation patches and the gap between neighboring patches. In addition, *in situ* biological investigations and geomorphological surveys were undertaken. The preliminary results revealed that: 1) the patches of *Spartina alterniflora* appear on both the pioneer zone and the high marsh and unlike the native species, they do not follow a self-organization pattern; 2) the *Spartina alterniflora* is better at trapping sediments, but *Scirpus mariqueter* is better in attenuating turbulent energy; and 3) the patch-sediment dynamic interaction is found to be size-dependent and this is likely to be the key of driving saltmarsh evolution.

O-P1-20 Controls on the interannual variability of hypoxia in a subtropical embayment and its adjacent waters in the Guangdong coastal upwelling system, northern South China Sea

Heng Zhang, School of Marine Sciences, Sun Yat-sen University
Presenter Email: zhangheng@mail.sysu.edu.cn

Coastal embayments located downwind of large rivers under an upwelling-favorable wind are prone to develop low-oxygen or hypoxic conditions in their bottom water. One such embayment is Mirs Bay, off the Guangdong coast, which is affected by upwelling and the Pearl River Estuary (PRE) plume during summer. The relative importance of physical and biochemical processes on the interannual variability of hypoxia in Mirs Bay and its adjacent waters was investigated using statistical analyses of monthly hydrographic and water quality monitoring data from 2001 to 2015. The results reveal that the southwesterly wind duration and the PRE river discharge together explain 49% of the interannual variability in the size of the hypoxic area, whereas inclusion of the nutrient concentrations inside Mirs Bay and phytoplankton on the shelf explains 75% of the interannual variability in the size of the hypoxic area. This finding suggests that the interannual variability of hypoxia in Mirs Bay is regulated by coupled physical and biochemical processes. Increase of the hypoxic area under a longer-lasting southwesterly wind is caused by increased stratification, extended bottom water residence time, and onshore transport of a low-oxygen water mass induced by stable upwelling. In contrast, a reduction in the size of the hypoxic area may be attributed to a decrease in the surface water residence time of the particulate organic matter outside Mirs Bay due to increased discharge from the PRE. The results also show that the effects of allochthonous particulate organic matter outside Mirs Bay on bottom hypoxia cannot be neglected.

O-P1-21 Instabilities in river plume fronts during downwelling-favorable winds

Peng Cheng, State Key Laboratory of Marine Environment Science, Xiamen University
Runqing Lv, State Key Laboratory of Marine Environment Science, Xiamen University
Presenter Email: pcheng@xmu.edu.cn

Instabilities are seldom observed in river plumes due to the narrow width that cannot fit eddies of baroclinic instabilities. While the existence of external forcing likely alter the potential vorticity dynamics of river plume fronts and make the plume go unstable. A series of idealized numerical experiments based on ROMS were conducted to investigate the adjustment of river plume fronts in response to downwelling-favorable wind events. During a wind event, Ekman flow advected denser water over light and leads the plume to be well-mixed. As the wind continued, the plume front became unstable with a dominant mode of symmetric instability (SI). After the wind event, baroclinic instabilities developed during the relaxation. A geostrophic current is symmetrically unstable when its Ertel potential vorticity (PV) takes opposite sign of the Coriolis parameter. Atmospheric and Ekman buoyancy fluxes were considered the processes that reduce PV. When the plume approached well-mixed, because the enhanced mixing increased Ekman depth in the plume the Ekman flow was restricted on the seaward side of the front such that it cannot further reduce PV. This study showed that downwelling-favorable winds enhanced downstream freshwater transport that act as a trigger of SI. A comparison of buoyancy flux driven by Ekman transport and along-shelf freshwater transport confirmed that the latter was more important than the former when Si occurred. The wind-driven along-shelf freshwater transport also acted as a driver of frontogenesis and provided energy source to vertical buoyancy flux and geostrophic shear production. When the wind stopped, the wind-driven freshwater extended the plume width that allowed the baroclinic instabilities to be developed. The wave length of those instabilities agreed with the linear stability theory of baroclinic instabilities.

O-P2-01 Interaction among three oceans and climate: A review and perspective

Chunzai Wang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Presenter Email: cwang@scsio.ac.cn

All of the Pacific, Atlantic and Indian Oceans play important roles in climate variability and climate change. The ocean-atmosphere coupling over these three oceans forms and produces various climate phenomena. As a result, the Pacific hosts the El Nino-Southern Oscillation (ENSO) and Pacific decadal oscillation (PDO); the Atlantic has the Atlantic Nino, Atlantic multidecadal oscillation (AMO) and Atlantic meridional overturning circulation (AMOC); and the Indian Ocean owns the Indian Ocean basin (IOB) mode and the Indian Ocean dipole (IOD) mode. These climate phenomena can all affect regional climate, extreme weather events and even global warming. Indeed, interaction among these three

oceans together with the ocean-atmosphere coupling can initialize and modulate climate variability and then change our traditional views of climate and climate change. This talk synthesizes and summarizes climate variability and mechanisms induced by inter-ocean interaction during the past. Because this topic is relatively new and promising, it is hoped that further study and focus may greatly advance our understanding and prediction of global climate. This talk also discusses issues and questions that need to be addressed in the future, providing a global perspective of climate.

O-P2-02 A Global View of Large-Scale Atmospheric Circulation Variability over the Last 60 Years

Qinghua Ding, ucsb
Presenter Email: qinghua@ucsb.edu

The Earth has warmed significantly over the past 60 years, under anthropogenic forcing. We are confident about the robustness of the global surface temperature warming pattern, which is primarily controlled by thermodynamics; however, we have much less confidence in our understanding of the atmospheric circulation aspect of climate change, which is mainly determined by these dynamics. Attribution of the cause of global circulation change over the last 60 years is hindered by our ability to separate intrinsic low-frequency variability from the forced response of the climate system to anthropogenic forcing. In this study, we characterize the spatiotemporal characteristics of intrinsic variability by comparing average Coupled Model Intercomparison Project Phase 5 (CMIP5) historical simulations to the observed trend estimated by five reanalysis data (ERA-Interim+ERA40, ERA-20c, NOAA-20th, NCEP1 and JRA55). For upper-level circulation change, both CMIP5 models and reanalysis data show that the human-caused long-term trend predominates in the tropics, and a weaker trend exists in the high latitudes of the northern and southern hemispheres. After removing this long-term trend from the circulation field, the classical El Nino Southern Oscillation (ENSO) appears to be the leading factor driving global circulation variability on an interannual time scale. On longer timescales, the tropical impact on global circulation is greatest over the polar regions and likely responsible for the destabilization of some ice shelves in the West Antarctic in the 1990s as well as for about half of the remarkable warming over Greenland and northeast Canada in the past 15 years and during the 1950-1960s. These findings suggest that circulation changes in the Arctic and Antarctic over the last 60 years have largely been internally driven as a result of the interdecadal-scale sea surface temperature (SST) variability in the tropics. Finally, I will suggest a way forward so that we can better understand the cause of global climate variability in the past 1000 years and improve projections of future global climate change.

O-P2-03 The Orthogonal PDO and ENSO Indices

Xianyao Chen, Key Laboratory of Physical Oceanography, Ocean University of China

J. M. Wallace, Department of Atmospheric Science, University of Washington
Presenter Email: chenxy@ouc.edu.cn

Two leading principal components (PCs) of sea surface temperature (SST) over the entire Pacific basin are derived using pairwise-rotated EOF method. One PC (designated by P) is nearly identical to the PDO, the leading PC of Pacific SST poleward of 20 degree north, and another (designated by T' is highly correlated with conventional ENSO indices, but with more equatorially focused spatial regression pattern. Based on these orthogonal PDO and ENSO indices, the relationship between PDO and ENSO is re-investigated using observational datasets. It is shown that nearly 60% variance of the winter-month PDO variability can be explained as a reddened response to stochastic extratropical atmospheric forcing due to the thermal inertial of ocean mixed layer, and by the reemergence of SST anomalies in successive winters. The tropical ENSO forcing contribution by the way of the atmospheric bridge adds no more than another 10% of the variance, suggesting that PDO can be regarded as a Northern Hemisphere extratropical phenomenon that exists independently of the interannual variability of tropical ENSO phenomenon. This finding based on observational dataset agrees with previous numerical model results.

O-P2-04 Decadal Variability of Sea-surface Temperatures and Ocean Heat Content in the Southern Ocean

Angela Ditri, College of Earth, Ocean, and Environment, University of Delaware, Newark, DE 19716, USA
Enhui Liao, Geosciences Department, Princeton University, Princeton, New Jersey, USA
Young-Heon Jo, Department of Oceanography, Pusan National University, Busan, South Korea
Xiao-Hai Yan, College of Earth, Ocean, and Environment, University of Delaware, Newark, Delaware, and State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: alditri@udel.edu

Though the global mean surface temperature and greenhouse gas concentrations have reached all time record-highs, the effect on the Earth's climate is not clear. Decadal variations in different parameters, along with changes in space are an important aspect when studying global climate change. The Southern Ocean (SO) plays a critical role in the global climate change variability, making it an important area to research. Two major parameters used to study climate fluctuations are sea-surface temperatures (SST) and ocean heat content (OHC), as the oceans high heat capacity results is less natural signals in these variables. In this study, decadal variations in SST and OHC and their relationship in different regions of the Southern Ocean are compared. The relationship between SST and OHC can be used to identify heat-sinking regions. Areas with high correlation coefficients, as seen in the Indian and Atlantic Ocean sector of the SO, may indicate strong

vertical heat transport into the deeper ocean. In contrast, the low correlation coefficient seen in the western Pacific sector may suggest horizontal heat transport. Results provide further insight and explanation to the dynamics behind of the local variations in the Southern Ocean on decadal timescales that could ultimately play a role in the understanding of cross-basin heat transport and global climate change variability.

O-P2-05 Low Sea Ice Concentration in Central Arctic and its Impact Factors

Jie Su, Ocean university of China
Cheng Li, Ocean university of China
Kexin Song, Ocean university of China
Lixin Wei, National Marine Environmental Forecasting Center
Hongjie Liang, Ocean university of China
Jinping Zhao, Ocean university of China
Presenter Email: sujie@ouc.edu.cn

Central Arctic experiences low sea ice concentration (SIC) in recent years. To study on the occurrence of this unusual phenomenon and its impact factors, the Low sea ice Concentration in Central Arctic (LCCA) index is defined by using several SIC data. Although results from each dataset give different index value, the LCCA process is obvious exist after 2010. The analysis results show that the leading factor of low SIC is not the local air temperature. Dynamically, the drifting pattern of sea ice and the location where the low SIC occurred response consistently to the atmospheric circulation. Particularly, cyclones used to be found north of 70N before LCCA index reached peak value. These cyclones moved towards north with warm air from lower latitudes causing sea ice divergence and rapid melting of sea ice. Frequently, cyclones were accompanied with Dipole Anomaly (DA) atmospheric circulation pattern. LCCA index correlates positively with northward heat advection across the circle of 84N as well as the divergence of Central Arctic sea ice.

O-P2-06 Cross-Basin Heat Transport-Linking the "Switch" and "Engine" of the Climate Change

Xiao-Hai Yan, UD/XMU Joint Center for Remote Sensing and Joint Institute of CRM
Weiwei Zhang,
Hua Su,
Enhui Liao,
Wenfang Lu,
Lu Han,
Presenter Email: xiaohai@xmu.edu.cn xiaohai@udel.edu

Our recent works reveal that the cross-basin transport, heat redistribution and corresponding mechanism in the subsurface and deeper ocean (SDO, 300-2000m) of key regions are playing an important role as planetary heat sink varies during the global

surface warming accelerations and "hiatus", i.e., Southern Oceans, Sub Polar North Atlantic, and Western Pacific Warm Pool, the latter two are considered as the "Switch" and "Engine" of the global climate change, respectively. The so-called "hiatus" refers to the temporary slow-down of the global mean surface temperature (GMST) warming during 1998-2013, caused by heat redistribution and storage in the SDO. Identifying the mechanisms, key regions and their role in cross-basin transport and the linkage of the "switch" and "engine" of the climate change has been hotly debating within scientific communities. Our research shed light upon our understanding of the climate change dynamics and cross-basin transport. Linking together by the Indonesia Through Flow, Agulhas Current/Leakage and Indian Ocean, our studies show that the ocean heat variability is highly inhomogeneous during the "hiatus". Due to poor data coverage, it is not conclusive which ocean basin is more or most important yet. Instead of counting how many joules of heat stored in each ocean basin, it is more imperative to study the physical mechanisms for heat uptake in different key regions and cross-ocean transport by deep ocean remote sensing, which is a promising technique capable to fill the data gap of the thermal and dynamic structure in the SDO.

O-P2-07 The Indian Ocean equatorial surface divergence and subsurface convergence and their relation to the dynamic of equatorial zonal currents during positive IOD

Weiqiang Wang, South China Sea Institute of Oceanology, CAS
Huibin Xing, South China Sea Institute of Oceanology, CAS
Presenter Email: weiqiang.wang@scsio.ac.cn

The features of the Indian Ocean equatorial meridional currents and their linkage with zonal currents associated with the Indian Ocean Dipole (IOD) are examined using the European Centre for Medium-Range Weather Forecasts (ECMWF) Ocean Reanalysis System 4 (ORAS4). At the peak of IOD (Oct-Nov), significant anomalous equatorial surface (0-50m) divergence and subsurface (50-150m) convergence are found in the tropical Indian Ocean. The surface divergence region lies in from the central to western Indian Ocean basin (55E-80E), however, the subsurface convergence locates in the eastern basin (70E-90E). The dismatch of surface divergence and subsurface convergence zones is investigated. The subsurface convergence is caused by equatorward mass transport with results from anomalous wind curls in the off-equatorial regions of both the northern and southern Indian Ocean. The surface divergence is caused by both equatorial east wind anomaly and upwelling due to subsurface convergence and appears west off 80E due to pile-up effect of westward current anomaly induced by east wind anomaly. Furthermore, the surface divergence is found to be close related to the Wyrtki Jet (WJ), which is a strong eastward surface flow and appears at 60E-90E during IOD peak seasons. And, the subsurface convergence is close related to the Equatorial Undercurrent in the (EUC), which

is a strong eastward subsurface flow and normally appears in the western ocean basin but extends to the eastern basin during positive IOD events. The results suggest the linkage of meridional and zonal currents in the equatorial Indian Ocean, which is essential for upper ocean circulation systems in the tropical Indian Ocean.

O-P2-08 Increased variability of eastern Pacific El Niño under greenhouse warming

Wenju Cai, Key Laboratory of Physical Oceanography, Institute for Advanced Ocean Studies, Ocean University of China and Qingdao National Laboratory for Marine Science and Technology, Qingdao, China/Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Tasmania, Australia
Guojian Wang, Key Laboratory of Physical Oceanography, Institute for Advanced Ocean Studies, Ocean University of China and Qingdao National Laboratory for Marine Science and Technology, Qingdao, China/Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Tasmania, Australia
Boris Dewitte, Centro de Estudios Avanzados en Zonas áridas, Coquimbo, Chile/Departamento de Biología, Facultad de Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile/Millennium Nucleus for Ecology and Sustainable Management of Oceanic Islands, Coquimbo, Chile/Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, Toulouse, France
Lixin Wu, Key Laboratory of Physical Oceanography, Institute for Advanced Ocean Studies, Ocean University of China and Qingdao National Laboratory for Marine Science and Technology, Qingdao, China
Agus Santoso, Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Tasmania, Australia/Australian Research Council Centre of Excellence for Climate Extremes, The University of New South Wales, Sydney, New South Wales, Australia
Ken Takahashi, Servicio Nacional de Meteorología e Hidrología del Perú—SENAMHI, Lima, Peru
Yun Yang, College of Global Change and Earth System Science, Beijing Normal University and University Corporation for Polar Research, Beijing, China
Aude Carréric, Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, Toulouse, France
Michael J. McPhaden, NOAA/Pacific Marine Environmental Laboratory, Seattle, WA, USA
Presenter Email: wenju.cai@csiro.au

The El Niño–Southern Oscillation (ENSO) is the dominant and most consequential climate variation on Earth, and is characterized by warming of equatorial Pacific sea surface temperatures (SSTs) during the El Niño phase and cooling during the La Niña phase. ENSO events tend to have a centre—corresponding to the location of the maximum SST

anomaly—in either the central equatorial Pacific (5° S–5° N, 160° E–150° W) or the eastern equatorial Pacific (5° S–5° N, 150°–90° W); these two distinct types of ENSO event are referred to as the CP-ENSO and EP-ENSO regimes, respectively. How the ENSO may change under future greenhouse warming is unknown, owing to a lack of inter-model agreement over the response of SSTs in the eastern equatorial Pacific to such warming. Here we find a robust increase in future EP-ENSO SST variability among CMIP5 climate models that simulate the two distinct ENSO regimes. We show that the EP-ENSO SST anomaly pattern and its centre differ greatly from one model to another, and therefore cannot be well represented by a single SST 'index' at the observed centre. However, although the locations of the anomaly centres differ in each model, we find a robust increase in SST variability at each anomaly centre across the majority of models considered. This increase in variability is largely due to greenhouse-warming-induced intensification of upper-ocean stratification in the equatorial Pacific, which enhances ocean–atmosphere coupling. An increase in SST variance implies an increase in the number of 'strong' EP-El Niño events (corresponding to large SST anomalies) and associated extreme weather events.

O-P2-09 A Recent Shift in the Monsoon Centers associated with the Tropospheric Biennial Oscillation

Lei Wang, Guangdong Ocean University
Jin-Yi Yu, University of California, Irvine
Presenter Email: leiwangocean@yahoo.com

The tropospheric biennial oscillation (TBO) is conventionally considered to involve transitions between the Indian and Australian summer monsoons and the interactions between these two monsoons and the underlying Indo-Pacific Oceans. Here we show that, since the early 1990s, the TBO has evolved to mainly involve the transitions between the western North Pacific (WNP) and Australian monsoons. In this framework, the WNP monsoon replaces the Indian monsoon as the active northern hemisphere TBO monsoon center during recent decades. This change is found to be caused by stronger Pacific-Atlantic coupling and an increased influence of the tropical Atlantic Ocean on the Indian and WNP monsoons. The increased Atlantic Ocean influence damps the Pacific Ocean influence on the Indian summer monsoon (leading to a decrease in its variability) but amplifies the Pacific Ocean influence on the WNP summer monsoon (leading to an increase in its variability). The shift from the strong Pacific-Indian Ocean coupling to the strong Pacific-Atlantic coupling may support the shift of biennial monsoon transitions from the Indian-Australian monsoon transitions to the WNP-Australian monsoon transitions. The stronger Pacific-Atlantic coupling during recent decades is considered to be the primary reason why we observe a shift in the monsoon centers in the biennial monsoon transitions associated with the TBO. These results suggest that the Pacific-Atlantic interactions have

become more important to the TBO dynamics during recent decades.

O-P2-10 Orbital modulation of ENSO seasonal phase locking

Zhengyao Lu, Lund University

Zhengyu Liu, Ohio State University

Presenter Email: luzhengyao88@gmail.com

Modern El Nino-Southern Oscillation (ENSO) events are characterized by their phase locking of variability to the seasonal cycle and tend to peak at the end of calendar year. We show that in an idealized NCAR-CCSM3 simulation of the climate of the last 300,000 years, ENSO seasonal phase locking is shifted periodically following the precessional forcing: ENSO tends to peak in boreal winter when perihelion is near vernal equinox, but to peak in boreal summer when perihelion lies in between autumnal equinox and winter solstice. The mechanism for the change of ENSO phase locking is proposed to be caused by the change of seasonality of the growth rate, or the intensity of ocean-atmosphere feedbacks, of ENSO. It is found that the December peak of winter ENSO is caused by the continuous growth of ENSO anomaly from June to November, while the May-June peak of summer ENSO appears to be caused jointly by the seasonal shift of higher growth rate into spring and stronger stochastic noise towards the first half of the year. Furthermore, the change of the seasonal cycle of feedbacks is contributed predominantly by that of the thermodynamic damping. The summer peak of ENSO is proposed to be caused by the following mechanism. A perihelion in the late fall to early winter leads to a cooling of the surface eastern equatorial Pacific (EEP) due to reduced insolation in spring. This cooling, reinforced by an oceanic process, reduces the latent heat flux damping in spring, and therefore favors the growth of the eastern Pacific-like ENSO (as opposed to the central Pacific-like ENSO). This EEP cooling is also likely to generate more effective short wave-cloud-SST feedback and, in turn, increased instability. Ultimately, the weakened thermodynamic damping in spring, combined with relatively intensive stochastic forcing, benefits the subsequent summer peak of ENSO.

O-P2-11 The changing influences of ENSO and the Pacific Meridional Mode on mesoscale eddies in the South China Sea

Peng-Fei Tuo, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China.

Jin-Yi Yu, Department of Earth System Science, University of California, Irvine, CA 92697-3100, USA.

Jianyu Hu, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China.

Presenter Email: decadesoul@gmail.com

This study finds that the correlation between El Niño–Southern Oscillation (ENSO) and the

activity of mesoscale oceanic eddies in the South China Sea (SCS) changed around 2004. The mesoscale eddy number determined from satellite altimetry observations using a geometry of the velocity vector method was significantly and negatively correlated with the Niño-3.4 index before 2004, but the correlation weakened and became insignificant afterward. Further analyses reveal that the ENSO–eddy relation is controlled by two major wind stress forcing mechanisms: one directly related to ENSO and the other indirectly related to ENSO through its subtropical precursor—the Pacific meridional modes (PMMs). Both mechanisms induce wind stress curl variations over the SCS that link ENSO to SCS eddy activities. While the direct ENSO mechanism always induces a negative ENSO–eddy correlation through the Walker circulation, the indirect mechanism is dominated by the northern PMM (nPMM), resulting in a negative ENSO–eddy correlation before 2004, and by the southern PMM (sPMM) after 2004, resulting in a positive ENSO–eddy correlation. As a result, the direct and indirect mechanisms enhance each other to produce a significant ENSO–eddy relation before 2004, but they cancel each other out, resulting in a weak ENSO–eddy relation afterward. The relative strengths of the northern and southern PMMs are the key to determining the ENSO–eddy relation and may be related to a phase change of the interdecadal Pacific oscillation.

O-P2-12 Quantitative Contributions of Cross-shelf and Air-sea Heat Exchange to Future Heat Budget Changes in the Eastern China Seas

Di Tian, Second Institute of Oceanography, State Oceanic Administration
Jian Su, University of Hamburg
Feng Zhou, Second Institute of Oceanography, State Oceanic Administration
Bernhard Mayer, University of Hamburg
Dmitry Sein, Alfred Wegener Institute for Polar and Marine Research
Han Zhang, Second Institute of Oceanography, State Oceanic Administration
Daji Huang, Second Institute of Oceanography, State Oceanic Administration
Thomas Pohlmann, University of Hamburg
Presenter Email: tiandi@sio.org.cn

The world's oceans are warming. Coastal oceans experience more notable warming than open oceans, which is considered to have severe impacts on coastal marine ecosystems. The Eastern China Seas (ECSs) have one of the widest continental shelves in the world and have been subject to climate warming over the last century. The cross-shelf and air-sea heat exchanges are the two major processes that dominate the heat budget changes of the ECSs, but research is still lacking. In this study, the current and future changes in the cross-shelf and air-sea heat exchanges are discussed, and their relative contributions to the heat budget changes of the ECSs are quantified using an atmosphere-ocean coupled model system. Results show that the recent and future ocean warming in the ECSs is linked overall to cross-shelf heat transport. However, the air-sea heat exchange can

significantly reduce the warming of the ECSs. The relative contribution is projected to increase for the Taiwan Strait and decline for the shelf break according to forecasting scenarios. The strengthened evaporation is the key process for the ECSs to get cooler under these future scenarios. This study will aid in understanding the processes related to coastal ocean warming and their relative importance.

O-P2-13 Decadal variation of SST and wind in the Taiwan Strait during winter

Yuwu Jiang, Xiamen University
Yimin Zhang, Xiamen University
Wenfang Lu, Fuzhou University
Presenter Email: ywjiang@xmu.edu.cn

The decadal coupling of sea surface temperature (SST) and wind in the Taiwan Strait (TWS) during winter (JFM-mean) from 1988 to 2017 was analyzed. The Empirical Orthogonal Function (EOF) method is respectively used to analyze the variability of SST and wind fields, while the Singular Value Decomposition (SVD) method is adopted to analyze the covariance between them. The analysis showed the northeasterly wind from the East Asian Winter Monsoon (EAWM) in the TWS had a decadal decreasing from 1988 to 1998 and then increased from 1998 to 2017. Winter SST in the TWS from 1988 to 2017 increased first, with a maximum rate of 1.5 degree per decade in middle TWS, and then decreased with transition near 1999, with the largest decreasing rate of 1.5 degree per decade located at the western coast of the TWS. The EOF, SVD and sensitive test shows the second model of wind, which is most cross-shore, explaining only 18% of the wind variance although, can cause the 35% SST variance in the TWS. While the first model of wind, which is almost alone-shore with 63% wind variance, only contribute 16% SST variance. Both decreasing mode 1 and increasing model 2 of the wind around the TWS explained the high increasing rate of SST from 1988 to 1999, where the model 2 play more important role. Further researches indicated the response of second model wind to ENSO is regulated by Pacific Decadal Oscillation (PDO), i.e., the second mode wind has negative/positive correction with the ENSO index when the PDO is in positive/negative phase. Both two winters,1976 and 2008, when the cold disasters occurred in the TWS, are La-Nina year in negative PDO phase. The mechanism for these cold disasters is the cold water can be transported into the TWS with the strong alongshore northeasterly wind, and separate to the middle TWS with the offshore wind in the special synoptic process.

O-P2-14 Connection of Antarctic Sea Ice with China summer rainfall on the interannual time scale

Na LIU, Nan-sen Zhu International Research Centre,Institute of Atmospheric Physics, Chinese Academy of Sciences
Shuanglin LI, Climate Change Research Center, Institute of Atmospheric Physics, Chinese

Academy of Sciences
Presenter Email: liuna0209@mails.ucas.edu.cn

Southern Hemisphere climate variability plays important roles on East Asian summer climate. Statistical analyses in the present study illustrate that Antarctic sea ice variability is significantly related to China summer (Jun-Jul-Aug, JJA) rainfall anomaly patterns on the interannual timescale. Prior to the first leading rainfall mode by one year, positive SIC anomaly emerges in East Ross Sea (ERS), along with negative anomaly in East Bellingshausen Sea and Weddell Sea (EBWS) during the preceding austral winter and spring. Then, we define a SIC_Dipole index. A high (low) index, which is characterized by an increased (reduced) sea ice in ERS and reduced (increased) sea ice in EBWS, is related to a southwest-northeast oriented rainfall anomaly pattern, more (less) rainfall in southern China and the lower streams of the Yangtze River, along with less (more) rainfall in other regions. While the sea ice in East Ross Sea increased, the Western Pacific Subtropical High (WPSH) and the East Asian summer monsoon (EASM) are weakened. Despite a high correlation of SIC_Dipole index with ENSO, the cross-seasonal SIC-rainfall relationships still exist after the ENSO-related signal removal. Our results further revealed that the cross-seasonal connections can be related to a tripole pattern of South Hemisphere Ocean SST anomalies.

O-P2-15 The role of tropical basin-interactions in climate predictability

Noel Keenlyside, University of Bergen, Bjerknes Centre for Climate Research
Dietmar Dommenget,
Eleftheria Exarchou,
Yu Kosaka,
Jing-Jia Luo,
Daniela Matei,
Elsa Mohino,
Andrew Robertson,
Belen Rodriguez-Fonseca,
Nicolas Vigaud,
Presenter Email: noel.keenlyside@uib.no

The existence of basin-scale interactions is presenting exciting new possibilities for enhancing climate prediction globally. This talk focuses on interactions among tropical ocean basins on sub-seasonal, seasonal, and decadal timescales. On sub-seasonal timescales, the Madden-Julian Oscillation connects variability in three tropical oceans, affecting rainfall and tropical cyclones. The global impact of ENSO is well known on interannual time-scales. It is also now recognised that the Indian and Atlantic Oceans significantly impact the Pacific, and that these interactions are important for understanding ENSO properties. On decadal timescales similar two-way interactions occur. The influence of the Atlantic has recently drawn great attention for its role in the global warming hiatus. In addition, these interactions can explain decadal variations in African, Indian, and Asian monsoons. The representation of these interactions by climate models will be discussed.

O-P2-16 What's the role of Atlantic trans-basin forcing in Pacific decadal variability?

Kewei Lyu, Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart, Tasmania, Australia
Jin-Yi Yu, Department of Earth System Science, University of California, Irvine, California, USA
Presenter Email: kewei.lyu@csiro.au

Although it is generally believed that the Pacific decadal variability is mainly intrinsic to the Pacific basin itself, there are also observational and model evidences showing that climate impacts originated from the Atlantic Ocean could extend worldwide through atmospheric teleconnections. Such trans-basin forcing from the Atlantic has been suggested to explain the two-decade long unprecedented intensification of Pacific trade winds since the early 1990s. However, it is still unclear to what extent the Atlantic has contributed to the observed Pacific decadal variability over the historical period. In this study we aim to separate and quantify the Interdecadal Pacific Oscillation (IPO) and Pacific trade wind change signals internally generated in the Pacific and remotely forced by the Atlantic, using observations and partially coupled climate model experiment forced by observed Atlantic sea surface temperatures. We found that while Pacific internal processes dominate the IPO evolutions, trans-basin forcing from the Atlantic could account for ~20% of the Pacific trade wind year-to-year variations with increased contributions towards lower frequency timescales. Over the satellite altimetry period (1993-2012), one third of the Pacific trade wind intensification that was responsible for the rapid sea level rising in the western tropical Pacific can be attributed to the Atlantic forcing. By contrast, the Atlantic contribution to Pacific trade wind change was negligible for recent decade-long global surface warming slowdown period (2003-2012).

O-P2-17 Contrasting the Skills and Biases of Deterministic Predictions for the Two Types of El Nino

Fei Zheng, Institute of Atmospheric Physics, CAS
Jin-Yi YU, University of California, Irvine
Presenter Email: zhengfei@mail.iap.ac.cn

The tropical Pacific has begun to experience a new type of El Niño, which has occurred particularly frequently during the last decade, referred to as the central Pacific (CP) El Niño. Various coupled models with different degrees of complexity have been used to make real-time El Niño predictions, but high uncertainty still exists in their forecasts. It remains unknown as to how much of this uncertainty is specifically related to the new CP-type El Niño and how much is common to both this type and the conventional Eastern Pacific (EP)-type El Niño. In this study, the deterministic performance of an El Niño–Southern Oscillation (ENSO) ensemble prediction system is examined for the two types of El Niño. Ensemble hindcasts are run for the nine EP El Niño events and twelve CP El Niño events that have occurred since 1950. The results show that (1) the skill scores for the EP events are significantly better than those for the CP events, at all lead times; (2) the systematic forecast biases come mostly from the prediction of the CP events; and (3) the systematic error is characterized by an overly warm eastern Pacific during the spring season, indicating a stronger spring prediction barrier for the CP El Niño. Further improvements to coupled atmosphere–ocean models in terms of CP El Niño prediction should be recognized as a key and high-priority task for the climate prediction community.

O-P2-18 A simulating and theoretical investigation on the dynamics of the two types of ENSO

Xiang-Hui Fang, Department of Atmospheric and Oceanic Sciences & Institute of Atmospheric Sciences, Fudan University
Mu Mu, Department of Atmospheric and Oceanic Sciences & Institute of Atmospheric Sciences, Fudan University
Fei Zheng, Institute of Atmospheric Physics, CAS
Presenter Email: fangxh@fudan.edu.cn

Severe biases exist in state-of-the-art general circulation models (GCMs) in capturing realistic central-Pacific (CP) El Niño structures. At the same time, many observational analyses have emphasized that thermocline (TH) feedback and zonal advective (ZA) feedback play dominant roles in the development of eastern-Pacific (EP) and CP ENSO (El Niño–Southern Oscillation), respectively. In this work, a simple linear air–sea coupled model, which can accurately depict the strength distribution of the TH and ZA feedbacks in the equatorial Pacific, is first used to investigate these two types of El Niño. The results indicate that the model can reproduce the main characteristics of CP ENSO if the TH feedback is switched off and the ZA feedback is retained as the only positive feedback, confirming the dominant role played by ZA feedback in the development of CP ENSO. Further experiments indicate that, through a simple nonlinear control approach, many ENSO characteristics, including the existence of both CP and EP El Niño and the asymmetries between El Niño and La Niña, can be successfully captured using the simple linear air–sea coupled model. Next, a three-region conceptual model for central Pacific El Niño including zonal advective feedback is constructed. The simple zonal two-region framework of the recharge paradigm can accurately manifest the traditional EP type of ENSO, as its major warming center is located in the EP and the anomalous sea surface temperature (SST) changes monotonically from west to east along the equatorial Pacific.

However, it cannot fully depict the variations of the CP type of ENSO, whose major warming center is mainly situated in the CP. Therefore, to better investigate the characteristics of the CP type of ENSO, the recharge paradigm is extended to a three-region conceptual model to describe the entire western, central and eastern equatorial Pacific. The results show that the extended conceptual model can depict the different variations between the CP and EP well. Specifically, with increasing magnitude of the zonal advective feedback over the CP, i.e., imitating the situation for CP ENSO, the period of the system and SST magnitude over the CP and EP both decrease. However, the decreasing amplitude is more intense over the EP, indicating an enlargement of the SST differences between the CP and EP. These results are all consistent with the observational characteristics of CP ENSO.

O-P2-20 A new index for identifying different types of El Nino Modoki Events

Xin Wang, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Wei Tan, First Institute of Oceanography, State Oceanic Administration
Chunzai Wang, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: wangxin@scsio.ac.cn

El Nino Modoki events can be further classified into El Nino Modoki I and II in terms of their opposite impacts on southern China rainfall (Wang and Wang, J Clim 26:1322–1338, 2013) and the Indian Ocean dipole mode (Wang and Wang, Clim Dyn 42:991–1005, 2014). The present paper develops an index to identify the types of El Nino events. The El Nino Modoki II (MII) index is defined as the leading principle component of multivariate empirical orthogonal function analysis of the normalized El Nino Modoki index, Nino4 index and 850 hPa relative vorticity anomalies averaged near the Philippine Sea during autumn. The MII index exhibits dominant variations on interannual (2–3 and 4–5 years) and decadal (10–20 years) timescales. El Nino Modoki II events can be well identified by using the MII index value being larger than 1 standard deviation. Further analyses and numerical model experiments confirm that the MII index can portray the major oceanic and atmospheric features of El Nino Modoki II events. The constructed MII index along with previous ENSO indices can be used for classifying and identifying all types of El Nino events. Because of distinct impacts induced by different types of El Nino events, the implication of the present study is that climate prediction and future climate projection under global warming can be improved by using the MII index and other indices to identify the types of El Nino events.

O-P2-21 A simple view of ENSO complexity

Jin-Yi Yu, University of California, Irvine
Shih-Wei Fang, University of California, Irvine
Presenter Email: jyyu@uci.edu

Not all El Nino-Southern Oscillation (ENSO) events are the same. An El Nino (La Nina) event may be followed by a neutral state to result in an ENSO episode, by a La Nina (El Nino) event to result in an ENSO cycle, or by another El Nino (La Nina) event to result in a multi-year ENSO event. We develop a dynamical framework to study the source of ENSO complexity, which focuses on the seasonal footprinting (SF) and charged-discharged (CD) mechanisms. Both mechanisms are key coupling processes that affect how the ENSO onsets and evolves from one event to another. Using this framework, we find the SF mechanism in the extratropical Pacific works to increase ENSO complexity while the CD mechanism in the tropical Pacific acts to reduce the complexity. A key reason why the SF mechanism can contribute to the ENSO complexity is related to the fact that the positive and negative phases of SF mechanism are asymmetric. They respond differently to the ENSO. The asymmetry enables the SF mechanism to produce different ENSO evolution (i.e., ENSO episodes, ENSO cycles, or multi-year ENSO) as well as El Nino-La Nina asymmetries. The reason why the positive and negative phases of SF mechanism are asymmetric will be discussed.

O-P2-22 Asymmetric Tropical Ocean Responses to ENSO: In Observations and CMIP5 Models

Shan He, Sun Yat-sen University
Jin-Yi Yu, University of California at Irvine
Song Yang, Sun Yat-sen University
Shih-Wei Fang, University of California at Irvine
Presenter Email: heshan9@mail2.sysu.edu.cn

Sea surface temperature anomalies (SSTA) associated with El Niño-Southern Oscillation (ENSO) events during 1958-2004 are found to be stronger in the tropical North Atlantic than in the tropical Indian Ocean. It is shown that the atmospheric bridge mechanism (ABM) is a more important contributor to this asymmetric response than the tropospheric temperature mechanism. The ENSO-forced anomalous Walker circulation extends further into the Atlantic than into the Indian Ocean, enabling the ABM to produce an asymmetric response. Therefore, the asymmetric response is a reflection of how the tropical atmospheric circulation responds to ENSO and should be regarded as a key metric of model performance on ENSO simulation. Only five out of thirty-seven CMIP5 models examined realistically simulate the observed asymmetric responses. The multi-model mean overestimates the SSTA response in the Indian Ocean and underestimates it in the Atlantic. This reversed asymmetry is found to be related to the location of ENSO-associated SSTAs in the Pacific, which produce a Walker circulation response that has a stronger impact on the Indian Ocean than on the Atlantic. It is also found that the five models that produce a realistic asymmetric response do so via error cancellation. The error caused by the incorrectly located ENSO SSTAs is compensated for that by an incorrect

Walker circulation response stemming from an excessively cold Pacific cold tongue. Therefore, alleviating these model errors in the location of ENSO SSTAs and the strength of the cold tongue SSTs is critical for a realistic simulation of the ENSO impacts on the two neighboring tropical oceans.

O-P3-01 Mixing induced upwelling along a sloping boundary energized by the internal tide

Kraig Winters, Scripps Institution of Oceanography University of California San Diego
Presenter Email: kraig@coast.ucsd.edu

Recent theories of ocean mixing (Ferrari et al; [2016], McDougall and Ferrari; [2017]), based on buoyancy and volume budget analyses, argue that deep ocean mixing is characterized by diapycnal upwelling along sloping boundaries and almost-compensating diapycnal downwelling in the ocean interior. This view contrasts rather sharply with the long-standing Abyssal Recipes model (Munk, 1966) of interior upwelling of cold waters balanced by a downward turbulent heat flux. Axiomatic in these new theories, however, is an idealized picture of turbulent ocean boundary layers that are nearly well mixed and are characterized by turbulent diapycnal fluxes that increase with height from the bottom within the well mixed layer before decreasing further above in the overlying stratified waters. While the underlying mathematics appears quite general, this spatial structure of the turbulent fluxes appears to be an essential precursor to the theoretical result. Recent high-resolution, deep ocean measurements of tidally-driven turbulent boundary layers on continental slopes and seamounts (e.g. van Haren, 2006), however, show active turbulent boundary layers that remain stably stratified. Moreover, the inferred diapycnal fluxes are maximal close to the boundary and decay with height, altogether different from the theoretical boundary layers envisioned. These boundary layers have been hypothesized to contribute a substantial fraction of the total mixing in their adjoining basins. The objective of this work is to try to reconcile the theoretical framework with the characteristics of observed tidally driven boundary layers and determine whether turbulence-driven upwelling along sloping boundaries is a generic process or one limited to idealized situations similar to that postulated for the theoretical model.

O-P3-02 On quantifying small-scale turbulence in the ocean

Zhiyu Liu, Xiamen University
Presenter Email: zyliu@xmu.edu.cn

In this talk, I will introduce the state-of-the-art technology and mathematical models for quantifying small-scale turbulence in the ocean. Applications of the technology will be demonstrated with recent research examples. One example is on thermocline mixing in the North Pacific low-latitude western boundary current system (LLWBC), and the other is on estimating turbulent Reynolds stress in wavy aquatic environment.

O-P3-03 Wave-Turbulence Interaction in the Upper-Ocean Boundary Layer

Bing-Qing Deng, St Anthony Falls Laboratory and Department of Mechanical Engineering, University of Minnesota, USA
Anqing Xuan, St Anthony Falls Laboratory and Department of Mechanical Engineering, University of Minnesota, USA
Tianyi Li, St Anthony Falls Laboratory and Department of Mechanical Engineering, University of Minnesota, USA
Lian Shen, St Anthony Falls Laboratory and Department of Mechanical Engineering, University of Minnesota, USA
Presenter Email: lianshen@gmail.com

The turbulent flow in the upper ocean is an interactive process that involves waves, current and turbulence. Surface waves can significantly modify the characteristics of the turbulence in the ocean surface boundary layer, resulting in features such as Langmuir circulation and front filaments. In this study, we use advanced wave-phase-resolved simulation methods to simulate the Langmuir circulation under both the monochromatic and broadband surface waves, and investigate the wave effect on the turbulence underneath. For the monochromatic wave, we focus on the mechanisms of the turbulence distortion by the wave. It is found that the turbulence coherent structures and statistics vary with the wave phase as a result of the straining of wave orbital velocity. Further analyses of the vorticity dynamics and turbulence kinetic energy budget reveal that both the phase-averaged wave effect and the correlation between the wave phase and turbulence are important to the generation and evolution of Langmuir circulation. We have also developed a wave-directly-forcing method based on the Helmholtz's decomposition for accurate and efficient simulations of Langmuir circulation under realistic ocean conditions with broadband waves. The windrows generated by Langmuir circulation in the simulation agree with those observed by marine radars deployed in field. The upper-ocean boundary layer also features many submesoscale structures such as front filaments. These inhomogeneous structures interact with the boundary-layer turbulence and surface waves, leading to more complex dynamic processes. To study the upper ocean in the presence of a front filament, we use large-eddy simulation to capture the evolution of a submesoscale front filament and resolve the boundary-layer turbulence eddies at the same time. The influence of the filament on the surface wave is also investigated using our in-house phase-resolved wave simulation tool, which can simulate accurately and efficiently the nonlinear ocean waves above complex ocean currents. It is found that the sharp change of current velocity across the front filament generates a boundary separating smooth and rough ocean surface regions.

O-P3-04 Transect measurements by micro-probes in hydrodynamic turbulence: a numerical study

Enrico Calzavarini, Univ. Lille, Unité de Mécanique de Lille, UML EA 7512, F 59000 Lille, France
Yongxiang Huang, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, People's Republic of China
Francois G Schmitt, Univ. Lille, CNRS, Univ. Littoral Cote d'Opale, UMR 8187, LOG, Laboratoire d'Oceanologie et de Geoscience, F 62930 Wimereux, France
Lipo Wang, UM-SJTU Joint Institute, Shanghai JiaoTong University, Shanghai, 200240, People's Republic of China
Presenter Email: enrico.calzavarini@polytech-lille.fr

The temporal statistics of incompressible fluid velocity and passive scalar fields in three-dimensional homogeneous and isotropic turbulent conditions is investigated by means of direct numerical simulations along the trajectories of self-propelled point-like probes drifting in a flow. Such probes are characterised by a propulsion velocity which is fixed in intensity and direction however, they are continuously deviated by their intended course as the result of the local sweeping of the fluid flow. The recorded time-series by these moving probes represent the simplest realisation of transect measurements in a fluid flow environment. By means of time-series analysis we show how transect measurements display a non trivial combination of Lagrangian and Eulerian statistical properties and we quantify how the transition from these two behaviours occurs at increasing the propulsion velocity. Furthermore, our study of the intermittency of finite-time increments highlights in a striking way the opposite trends displayed by fluid velocity and passive scalar statistics, which are connected to their different spatio-temporal structures. The implications of this study on the interpretation of measurements of fluid flows and bio-geo-chemicals performed by micro-autonoumous underwater vehicles in the ocean will be discussed.

O-P3-05 Latitude-dependent finescale turbulent shear generations in the Pacific tropical-extratropical upper ocean

Zhiwei Zhang, Ocean University of China
Bo Qiu, University of Hawaii at Manoa
Jiwei Tian, Ocean University of China
Wei Zhao, Ocean University of China
Xiaodong Huang, Ocean University of China
Presenter Email: zzw330@ouc.edu.cn

Turbulent mixing, which is critically important for the equilibrium of ocean circulation, is controlled by finescale turbulent shear (S^2) of oceanic flows through shear instability. Although the relationship between S^2 and mixing is well understood, the latitude-dependent generation processes of S^2 remain poorly known due to the lack of

geographically extensive, long-term finescale velocity measurements. Here, using one-year ADCP data from 17 moorings along 143ºE, we first show that the upper-ocean S^2 and its resultant mixing rate have a W-shaped latitudinal distribution in the tropical-extratropical northwest Pacific with peaks at 0-2ºN, 12-14ºN, and 20-22ºN, respectively. Further analyses reveal that these S^2 peaks are caused by vertically-sheared equatorial currents, parametric subharmonic instability of diurnal tide, and anticyclonic eddy's inertial chimney effect, respectively. As climate model simulations are sensitive to the mixing parameterizations, our findings highlight the need to incorporate the latitude-dependent generation mechanisms of S^2 to improve climate models' prediction capabilities.

O-P3-06 Long-Range Radiation and Interference Pattern of Multisource M2 Internal Tides in the Philippine Sea

Zhenhua Xu, Institute of Oceanology, Chinese Academy of Sciences
Yang Wang, Institute of Oceanology, Chinese Academy of Sciences
Baoshu Yin, Institute of Oceanology, Chinese Academy of Sciences
Yijun Hou, Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: xuzhenhua@qdio.ac.cn

Long-range radiation and interference of M2 internal tides from multiple sources in the Philippine Sea are examined by driving a high-resolution numerical model. The M2 internal tides are effectively generated around the boundary area, which includes the Luzon Strait, Ryukyu Island chain, Bonin Ridge, Mariana Arc, and Izu Ridge, favoring the occurrence of complex interference patterns. The local sources (mainly Daito Islands and Palau Ridge) inside the basin contribute to a small portion (~5%) of total energy but enhance the geographical inhomogeneity of the baroclinic field. The mode-1 and mode-2 M2 tidal beams from boundary sources radiate a long distance into the basin but exhibit different interference-modulated geography variations. A 2-D line source model characterizing interference can reproduce the general baroclinic field. Two notable interference cases are investigated: (1) the superposition of internal tides from Luzon Strait and Miyako Strait bifurcates into several southeastward beams, consistent with previous numerical simulations and altimeter measurements, and (2) the interference between Tokara Strait and Bonin Ridge exhibits a multiscale spatial pattern, which is modulated by the local generated energy and bathymetry features. Energetic dissipation occurs both near the boundary sources and in the basin. A locally dissipated fraction q of ~0.4 is estimated at the Luzon Strait and Bonin Ridge with continuous bathymetry features, while q of ~0.6 is estimated at the Ryukyu Island chain and Mariana Arc with discrete topographic variability. A lower locally dissipated fraction indicates a stronger energy flux radiating into the basin, where enhanced dissipation coincides closely with the interference-modulated flux field.

O-P3-07 Langmuir Circulation With Explicit Surface Waves From Moving-Mesh Modeling

Peng Wang, University of Miami; University of California, Los Angeles
Tamay Ozgokmen, University of Miami
Presenter Email: pwang@atmos.ucla.edu

Using a moving-mesh, nonhydrostatic, spectral element model, we simulate Langmuir circulation with Navier-Stokes equations under explicit, freely propagating surface waves. For comparison, Langmuir circulation is also simulated with Craik-Leibovich (C-L) equations. In both simulations, the Langmuir circulations are very similar, including temporal formation progresses and spatial structures; however, the strength of Langmuir circulation in the C-L simulation is a bit weaker, which we suggest is due to the lack of Eulerian mean drift induced by fluid viscosity in the presence of explicit surface waves.

O-P3-08 Self-organized criticality in geophysical turbulence

William D. Smyth, College of Earth Ocean and Atmospheric Sciences, Oregon State University
James N. Moum, College of Earth Ocean and Atmospheric Sciences, Oregon State University
Jonathan D. Nash, College of Earth Ocean and Atmospheric Sciences, Oregon State University
Presenter Email: smyth@coas.oregonstate.edu

Turbulence in forced, stratified, parallel shear flows tends to organize itself so that the mean flow remains close to a stability boundary in parameter space. Roughly, this is the state in which gradients of velocity and buoyancy balance such that the Richardson number equals 1/4. That characteristic suggests self-organized criticality (SOC), a statistical property that has been identified in a range of complex phenomena including earthquakes, forest fires and solar flares. This this presentation explores the relationship between the properties of sheared, stratified turbulence and those of SOC. Self-organization to the critical state is demonstrated in a wide range of cases drawn mostly (but not entirely) from in situ observations of ocean turbulence. Turbulent events in the ocean also exhibit a second property associated with SOC: their sizes follow a power-law distribution indicating self-similarity. These results suggest a new conceptual foundation for the study of geophysical turbulence, an explanation for the mixing efficiency of ocean turbulence and a potential for cross-fertilization with other areas of geophysics.

O-P3-09 Scaling turbulence in the ocean

Francois G. Schmitt, CNRS, Laboratory of Oceanology and Geosciences, Univ. Lille, ULCO, Wimereux, France

Presenter Email: fg.schmitt@me.com

Turbulence is one of the main factors of variability of physical processes at small scales in the ocean. Several scaling properties have been experimentally found in the literature for velocity, passive scalars and also biologically active scalars. We will review here these results, with emphasis on Eulerian versus Lagrangian results. The focus will be on scaling properties in the Fourier domain, found through power spectral analysis, as well as intermittency study using the classical scaling structure functions analysis. On the other hand, several coastal time series possess strong forcing through daily, or tidal periodic influence. We discuss these periodic forcing which correspond to inputs of energy at some specific scales, and break the stochastic universal scaling properties. We also briefly discuss the influence of such intermittent and stochastic forcing on planctonic processes, such as phytoplancton growth, zooplankton contact rates and behavior.

O-P3-10 Cascade and Intermittency of the Sea Surface Temperature in the Oceanic System

Lipo Wang, Shanghai JiaoTong Univ.

Yongxiang Huang, Xiamen Univ.

Presenter Email: lipo.wang@sjtu.edu.cn

In this paper, we analyze the sea surface temperature obtained from the global drifter program. The experimental Fourier power spectrum shows a two-decade power-law behavior with a -7/3 scaling in the frequency domain. Dimensional argument suggests a two-dimensional-like Lagrangian forward cascade, in which the enstrophy dissipation is involved. Using the Hilbert-Huang transform and multi-level segment analysis, the measured high-order statistics and the corresponding singularity spectrum confirm the existence of the intermittency with a measured log-normal intermittency index about 0.10 , which is much weaker than the prediction by the conventional structure function method.

O-P3-11 Relative dispersion in quasi-geostrophic models of upper-ocean turbulence

Stefano Berti, Stefano Berti, Université de Lille, Unité de Mécanique de Lille, UML EA 7512, F-59000, Lille, France

Presenter Email: stefano.berti@polytech-lille.fr

We numerically study relative dispersion in a class of generalized two-dimensional turbulent flows including as limiting cases two models that are relevant for ocean dynamics, the barotropic quasi-geostrophic (QG) and the surface quasi-geostrophic (SQG)

one. Aiming at exploring the link between the locality of energy transfers and the statistical properties of dispersion we find that dispersion behaviors agree with expectations from local theories when the dynamics are close to SQG ones and initial pair separations are small enough. Non-local dispersion is instead observed for the QG model, a robust result when looking at relative displacement probability distributions.

O-P4-01 Northwestern Pacific Variability and its Connectivity to the South China Sea

Bo Qiu, Department of Oceanography University of Hawaii at Manoa
Presenter Email: bo@soest.hawaii.edu

Oceanic circulation variability in the open Northwestern Pacific ocean is subject to strong wind stress curl forcing connected to the Pacific decadal oscillations (PDOs). Specifically, for the westward-flowing North Equatorial Current (NEC), a positive (negative) phased PDO forcing generates Ekman flux divergence (convergence) in the western tropical Pacific Ocean of 8-18N and works to lower (increase) the regional sea level and shift the NEC's bifurcation northward (southward) along the Philippine coast northward. Upon impinging the Philippine coast, these sea level anomalies circulate clockwise and permeate into the South China Sea (SCS) as coastal trapped waves via the Celebes and Sulu Seas. The coastal wave guide acts as a low-pass filter, allowing interannual and longer-frequency open Pacific Ocean sea level anomalies to enter the eastern SCS.

A positive (negative) phased PDO forcing also generates Ekman flux convergence (divergence) in the western subtropical Pacific Ocean of 18-30N. This convergence sharpens the eastward shear of the Subtropical countercurrent (STCC) and leads to enhanced generation of mesoscale eddies along the STCC band. Upon reaching the coast of the Luzon Island, these mesoscale eddies modulate the transport of the northward-flowing Kuroshio. When cyclonic mesoscale eddies impinging on the Kuroshio, they tend to reduce the Kuroshio transport and

cause it to take a looping path to intrude into the Luzon Strait. Such mesoscale eddy mediated intrusions contribute to the intra-seasonal watermass and sea level exchanges between the western Pacific and the SCS.

O-P4-02 Island wakes in shallow water

Changming Dong, Nanjing University of Information Science and Technology
Presenter Email: cmdong@nuist.edu.cn

Island wakes in shallow water are investigated using the Regional Ocean Modeling System (ROMS). In contrast to deep water where bottom stress can be neglected in island wakes, shallow water implies that inhom- ogeneity in the bottom stress plays an important role in the wake vorticity generation. A series of numerical exper- iments are conducted to investigate wake formation and evolution in shallow water. It is found that the vertical structures of shallow-water and deep-water wakes are significantly different because of the presence of a density frontal jet, which results from the interaction between stratification and bottom topography. The frontal jet reaches its maximum within the bottom boundary layer over the shelf, giving rise to vorticity. The potential vor- ticity (PV) balance analysis reveals that frictional and diapycnal processes play different roles in the PV anomalies. With the absence of lateral stress (i.e., a sea mountain case), the surface vorticity becomes much weaker than that in the presence of an island.

O-P4-03 An irregularly shaped warm eddy observed by Chinese underwater gliders

Chunhua Qiu, Sun Yat-sen University
Huabin Mao, South China Sea Institute of Oceanology
Yanhui Wang, Tianjin University
Jiancheng Yu, Shenyang Institute of Automation
Presenter Email: qiuchh3@mail.syse.edu.cn

Mesoscale eddies are important in transporting oceanic energy and matter. We investigated the three dimensional structure of an irregularly shaped warm eddy using three Chinese underwater gliders and satellite data during May 2015 in the northern South China Sea. The warm eddy lasted for 2 months, and remained quasi-steady with a mean radius of ~70 km from May 10 to May 31. Along the two glider tracks, the heat content had a big difference of 2x109 J/m2/span which induced an imbalance of the geostrophic/tangential velocity. The geostrophic/tangential velocity decreased/increased with depth within the warm eddy. The maximum tangential velocities calculated from the two gliders were 0.8 m/s and 0.25 m/s, respectively. This confirms that the warm eddy was horizontally asymmetrical. Large errors could be generated when estimating transports of heat, energy, or matter for an irregular shaped eddy using a regular circular model. We suggest that more and better-designed intersecting glider tracks should be used to retrieve the three dimensional structures of eddy. The irregular shape of the warm eddy was likely induced by the oceanic currents, such as the wind-induced Ekman current. Further study is needed to reveal the eddy-current interactions and the mechanisms thereof.

O-P4-04 Composite eddy structures on both sides of the Luzon Strait and influence factors

Wen-Zhou Zhang, Xiamen University
Qinbiao Ni, Xiamen University
Huijie Xue, University of Maine
Presenter Email: zwenzhou@xmu.edu.cn

Combining Argo observations with satellite remote sensing data during the period of 2002-

2014, the mean three-dimensional structures of mesoscale eddies on both sides of the Luzon Strait (LS) were obtained via a composite method and analyzed to statistically examine the influences of background marine environment and the Kuroshio current on the eddy structures. The significant signals of temperature and salinity anomalies within the composite eddies extend much deeper in the region east of the LS (Zone E) than those in the region west of the strait (Zone W) because of stronger eddy intensity and larger vertical gradients of background temperature and salinity in the deep layer in Zone E. In the vertical structure of temperature anomaly within the eddies, two cores occur at around 200 and 400 dbar depths, respectively, in Zone E and only one core is centered at about 100 dbar in Zone W. There is a clear three-core sandwich pattern in the vertical structure of salinity anomaly within the eddies in Zone E. The Kuroshio water trapped in the eddy is responsible for abnormally positive salinity anomaly in the surface layer of the anticyclonic eddy center in Zone W. On both sides of the LS, an asymmetric dipole structure in the surface layer gradually turns into a monopole one at depths, resulted from the competition between horizontal advection effect and eddy pumping effect. The Kuroshio current influences the distribution patterns of isotherms and isohalines and enhances background temperature and salinity horizontal gradients on both sides of the LS, determining the orientations of dipole temperature and salinity structures within eddies.

O-P4-05 TOOSSE: the high resolution Two Oceans One Sea State Estimate

Chuanyu Liu, Institute of Oceanology, Chinese Academy of Sciences
Xiaowei Wang, Institute of Oceanology, Chinese Academy of Sciences
Fan Wang, Institute of Oceanology, Chinese Academy of Sciences
Armin Koehl, Institute of Oceanography, University of Hamburg
Presenter Email: chuanyu.liu@qdio.ac.cn

An eddy resolving general circulation model (MITgcm) of the low-latitude Pacific Ocean, Indian Ocean and South China Sea (hereafter Two Oceans One Sea: TOOS) is fit by constrained least squares to a large modern observational datasets during 2015–16. Data used include Argo float profiles, CTD data from Chinese observational system in the western Pacific and South China Sea, altimetric observations, and satellite sea surface temperature. A 4D-var (adjoint) model is used to determine descent directions in minimizing a cost function. The model is brought into near agreement with the data by adjusting its control vector, which consists of initial conditions, sea surface boundary conditions (air-sea fluxes), and background vertical mixing parameters. Preliminary results show that the adjusted ocean state of TOOS captures the multiple oceanic variabilities in this region, while the adjusted control variables provide optimal air-sea and oceanic fluxes that maintain the varying ocean state. Theories involving warm pool-cold tongue dynamics, ENSO dynamics, air-sea interaction over mesoscale eddies, intra-seasonal variability dynamics, the Indonesia Through Flow, and interaction between multi-scale

processes may then be tested and explored with this dynamically and thermodynamically consistent model solution.

O-P4-06 A subsurface-intensified mesoscale eddy train observed by a long-term mooring array in the northeastern South China Sea

Zhongbin Sun, Zhiwei Zhang, Wei Zhao, Jiwei Tian
Presenter Email: sunzb0811@126.com

A special type of mesoscale eddy train consisting of three subsurface-intensified anticyclonic and cyclonic eddy pairs was first observed in the northeastern South China Sea (NESCS) by a long-term mooring array. The maximum swirl velocity (temperature anomaly) caused by these subsurface-intensified eddies (SIEs) was located at 200-400 m (500-700 m) with the magnitude exceeding 14 cm/s (0.4 °C). Horizontally, the SIEs generally propagated westward, and their propagation speed (Cp) and length scale were estimated to be ~4.9 cm/s and ~250 km, respectively. Vertically, both the velocity and temperature structures of the SIEs were found to tilt southwestward with increasing depth. Given that the swirl velocity exceeded the propagation speed, the SIEs were highly nonlinear and could trap water mass within their velocity cores. Based on the radius and "trapping depth" (where Us=Cp) of the eddy core, we further estimated the volume of water trapped within the SIEs and found that it can cause an annual mean equivalent westward transport of 2.2 Sv in the intermediate layer (500-950 m). By synthetically analyzing the mooring observations, altimeter data and Hybrid Coordinate Ocean Model (HYCOM) products, we suggested that the SIEs most likely originated from the western Pacific. This argument was confirmed by the observed phenomenon that the SIEs were accompanied by the occurrence of low-salinity North Pacific intermediate water in the NESCS. Further energetics analysis demonstrated that after propagating into the NESCS, the SIEs got strengthened by draining energy from the baroclinic instability of the mean current.

O-P4-07 Global ocean modeling at kilometer scale mesh resolution for studying ocean eddies, fronts, and air-sea exchanges

Dimitris Menemenlis, California Institute of Technology
Presenter Email: menemenlis@me.com

Global, eddying numerical ocean simulations started to become computationally feasible some twenty years ago. In these early computations, carried out with 15-25-km horizontal grid spacing, the impact of tides on ocean transport and mixing was represented implicitly, e.g., by vertical diffusivity and viscosity coefficients. More recent computations, with horizontal grid spacing of 10 km or less, started to admit the gravest modes of the internal gravity wave spectrum. This spurred the development of simulations that are forced simultaneously by atmospheric fields and tides. The horizontally and time-varying

stratification in these combined ocean circulation and tides simulations lead to a better representation of internal tides. Conversely, the inclusion of tides lead to more accurate description of ocean transport and mixing. The Estimating the Circulation and Climate of the Ocean (ECCO) consortium recently used the Massachusetts Institute of Technology general circulation model (MITgcm) to carry out a global, kilometer-scale ocean simulation that includes sea-ice and tidal excitation, and that spans scales from planetary gyres to internal tides. This km-scale simulation is a virtual ocean that admits submesoscale and internal waves dynamics not normally represented in global calculations, extending simulated ocean behavior beyond broadly quasi-geostrophic flows and providing a preliminary example of a next-generation computational approach to explicitly probe the interactions between dominant energetic scales in the ocean and instabilities that are usually parameterized. Early science studies based on the ECCO/MITgcm km-scale simulation demonstrate the importance of resolving, on global scales, fine-scale ocean variability. In particular, fine scale ocean variability has significant impacts on air-sea exchanges and on vertical transports of heat and chemical properties in the upper ocean. These early studies reinforce the notion that resolving eddies and tides and admitting sub-mesoscale processes in numerical ocean models will lead to a significant boost in climate-model skill.

O-P5-01 Indonesian Throughflow in the eastern Indonesian seas during 2014-2017

Dongliang Yuan, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
Xiang Li, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
Zheng Wang, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
Yao Li, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
Jing Wang, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
Adhitya Wardana, Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia
Dewi Surinati, Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia
Adi Purwandana, Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia
Dirhamsyah, Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia
Zainal Arifin, Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia
Presenter Email: dyuan@qdio.ac.cn

The mooring observations deployed in the Maluku Channel of the Indonesian Seas during December 2012 through November 2016 show reversals of the thermocline zonal currents

from eastward to westward in the springs of 2014 and 2015. The meridional transports in the Maluku Strait are also found to reverse directions from northward to southward at about the same time. The reversals are suggested to be associated with significant shift of the Mindanao Current path, as evidenced by the mooring observations in the Talaud-Morotai Strait. The path shift is suggested to be forced by the westerly winds bursts through the westward propagation of the upwelling equatorial Rossby waves. Associated with the path shift of the Mindanao Current, anomalous transport of the Indonesian Throughflow is generated by the pressure anomalies at the entrance of the Indonesian seas. Upwelling equatorial Kelvin waves are generated to propagate from the western boundary to the east during the relaxation of the westerly winds bursts, which play the role of terminating the onset of the 2014 El Nino. Observations have shown that the reflected upwelling Kelvin waves in the summer of 2015 are much weaker than those in the summer of 2014, which explains the onset of the 2015-2016 strong El Nino. During the summer-fall of 2016, a northward increase of the Maluku Strait transport is observed, which is forced by the downwelling Kelvin waves from the equatorial Indian Ocean during the negative Indian Ocean Dipole in the summer-fall of 2016. The onset of the 2016-2017 La Nina is likely terminated by this Indian-Pacific oceanic channel process.

O-P5-02 Global and regional evolution of ocean heat content related to ENSO

Lijing Cheng, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

Presenter Email: chenglij@mail.iap.ac.cn

As the strongest inter-annual perturbation to the climate system, the El Niño-Southern Oscillation (ENSO) dominates the year-to-year variability of the ocean energy budget. Here we combine ocean observations, re-analyses, and surface flux data with Earth system model simulations to obtain estimates of the different terms affecting the redistribution of energy in the Earth system during ENSO events, including exchanges between ocean and atmosphere, among different ocean basins, lateral and vertical rearrangements. This comprehensive inventory allows better understanding of the regional and global evolution of ocean heat related to ENSO, and provides observational metrics to benchmark performance of climate models. Results confirm that there is a strong negative ocean heat content tendency (OHCT) in the tropical Pacific Ocean during El Niño, mainly through enhanced air-sea heat fluxes (Q) into the atmosphere driven by high sea surface temperatures. As well as this diabatic component, there is an adiabatic redistribution of heat both laterally and vertically (0-100m and 100-300m) in the tropical Pacific and Indian oceans that dominates the local OHCT. Heat is also transported and discharged from 20°S-5°N into off-equatorial regions within 5-20°N during and after El Niño. OHCT and Q changes outside of the tropical Pacific Ocean indicates the ENSO-driven atmospheric teleconnections and changes of ocean heat transport (i.e. Indonesian Throughflow). The tropical Atlantic and Indian oceans warm during El Niño, partly offsetting the tropical Pacific cooling for the tropical oceans as a whole. While there are distinct regional OHCT changes, many compensate each other resulting in a weak but robust net global ocean cooling during and after El Niño.

O-P5-03 Possible Role of the Diurnal Cycle of Land Convection in the Barrier Effect on the MJO by the Maritime Continent

Jian Ling, Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS)
Chidong Zhang, NOAA Pacific Marine Environmental Laboratory
Presenter Email: lingjian@lasg.iap.ac.cn

Possible effects of the diurnal cycle in convection on the eastward propagation of MJO over the Indo-Pacific Maritime Continent (MC) during boreal winter were investigated using high-resolution precipitation data. Individual MJO events were identified using a precipitation-tracking method and classified into two groups: those propagating across the MC (MJO-C) and those blocked by the MC (MJO-B). Before an MJO convection center moves into the MC, rain is more over land in the MC for MJO-C than MJO-B and most rain over land comes from diurnal convection. Once the MJO convection center enters the MC, the diurnal cycle over land is significantly weaker for MJO-C than MJO-B, possibly because higher surface soil moisture due to vanguard precipitation tends to suppress diurnal convection over land. This result provides observational evidence that fill a gap in a hypothesized chain of actions in which the diurnal cycle of land convection plays an active role in the barrier effect on the eastward propagation of MJO over the MC. Remaining gaps in this hypothesis are discussed.

O-P5-04 Atmospheric Energetics over the Tropical Indian Ocean during Indian Ocean Dipole Events

Jianping Li, College of Global Change and Earth System Sciences (GCESS), Beijing Normal University
Yuehong Wang, College of Global Change and Earth System Sciences (GCESS), Beijing Normal University
Yazhou Zhang, College of Global Change and Earth System Sciences (GCESS), Beijing Normal University
Qiuyun Wang, College of Global Change and Earth System Sciences (GCESS), Beijing Normal University
Jianhuang Qin, Institute of Oceanography, Shanghai Jiao Tong University
Presenter Email: ljp@bnu.edu.cn

The evolution of atmospheric perturbation potential energy (PPE) over the tropical Indian Ocean is analyzed during a composite positive IOD event using reanalysis datasets for the period 1948–2015. The IOD modulates the variation in PPE, which then affects

perturbation kinetic energy (PKE) through energy conversion. The PPE anomalies in the lower troposphere (1000–850 hPa) as the dominant layer of the PPE in the whole troposphere (1000–150 hPa) present a dipole pattern corresponding to the anomalous variation in SST during the IOD event. When cold SST anomalies (SSTAs) first appear in the eastern Indian Ocean (IOD-E), they cool the atmospheric PPE in the lower troposphere rapidly. The negative PPE anomalies lead to less energy conversion to PKE, restraining the surface wind convergence over the IOD-E and weakening the climatological Walker circulation. Meanwhile, the surface easterly wind anomalies strengthen, which depresses the thermocline to the west and gives warmer SSTAs in the western Indian Ocean (IOD-W). The PPE anomalies and energy conversion (CK) over the IOD-W are opposite to those over the IOD-E, the anomalous easterly wind continues to develop, and the positive SSTAs in the IOD-W reach a peak. Thus, the response of the Walker circulation over the Indian Ocean provides a positive feedback during the IOD event and explains the delayed effect of IOD-E SSTAs on IOD-W SSTAs.

O-P5-05 Indo-Pacific climate during the decaying phase of the 2015/16 El Nino: role of southeast tropical Indian Ocean warming

Zesheng Chen, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Yan Du, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Zhiping Wen, Institute of Atmospheric Sciences, Fudan University
Renguang Wu, Center for Monsoon System Research, Institute of Atmospheric Physics, Chinese Academy of Sciences
Chunzai Wang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: duyan@scsio.ac.cn

This study investigates the influence of southeast tropical Indian Ocean (SETIO) sea surface temperature (SST) warming on Indo-Pacific climate during the decaying phase of the 2015/16 El Nino by using observations and model experiments. The results show that the SETIO SST warming in spring 2016 enhanced local convection and forced a "C-shape" wind anomaly pattern in the lower troposphere. The "C-shape" wind anomaly pattern over the eastern tropical Indian Ocean consists of anomalous westerly flow south of the equator and anomalous easterly flow north of the equator. The anomalous easterly flow then extended eastward into the western North Pacific (WNP) and facilitates the development or the maintenance of an anomalous anticyclone over the South China Sea (SCS). Correspondingly, the eastern part of the Bay of Bengal, the SCS and the WNP suffered less rainfall. Such precipitation features and the associated "C-shape" wind anomaly pattern shifted northward about five latitudes in summer 2016. Additionally, the SETIO warming

can induce local meridional circulation anomalies, which directly affect Indo-Pacific climate. Numerical model experiments further confirm that the SETIO SST warming plays an important role in modulating Indo-Pacific climate.

O-P5-06 Oceanic Intraseasonal Variabilities associated with Central Indian Ocean Mode

Lei Zhou, Institute of Oceanography, Shanghai Jiao Tong University
Ze Meng, Second Institute of Oceanography, SOA
Presenter Email: zhoulei1588@sjtu.edu.cn

The intraseasonal variabilities (ISVs) with a period between 30 and 60 days are pronounced over the tropical Indian Ocean, especially over the eastern Indian Ocean, where is the exit region of the Indonesian Throughflow (ITF). It is well known that the Madden-Julian Oscillation (MJO) is the dominant component of ISVs in the atmosphere. As a result, the existing studies on the oceanic ISVs over tropical Indian Ocean mainly focus on the oceanic responses to the atmospheric forcing accompanied with the MJO. The air-sea interaction over the maritime continent on intraseasonal timescales also focus on the processes related to the MJO. The MJO propagates eastwards. Correspondingly, the eastward propagation of intraseasonal SST anomalies and intraseasonal ocean currents have been captured by observations. Their interactions with the maritime continent are also diagnosed in many previous studies. Recently, a Central Indian Ocean (CIO) mode is proposed on the intraseasonal timescales. Associated with the CIO mode, the oceanic ISVs show quite different features from the traditional ones, which are mainly attributable to the oceanic responses to the atmospheric forcing. The composite intraseasonal SST anomalies during the positive CIO mode propagate westward, instead of eastward, which is opposite to the direction of either the equatorial Kelvin waves or the MJO in the atmosphere. In addition, the composite net surface heat flux heat fluxes are not fully consistent with the SST variabilities, which indicates that the air-sea heat flux alone cannot explain the intraseasonal SST anomalies. Moreover, the composite intraseasonal sea surface height (SSH) anomalies show an eastward propagation. The inconsistent behaviors of the SST anomalies and SSH anomalies imply a separation between the dynamics and thermodynamics in the ocean, which is an omen for complex oceanic processes for the oceanic ISVs associated with the CIO mode. Overall, the westward-propagating intraseasonal SST anomalies and the oceanic dynamics behind are the target of this study. A mechanism analogous to the recharge-discharge theory for ENSO is proposed in this study, but for the ISVs. The upwelling off the Sumatra is a key component of the whole process. As a result, it is expected that the variabilities associated with the CIO mode over the eastern Indian Ocean may provide a new avenue to connect the ISVs over the maritime continent and the tropical Indian Ocean.

O-P5-07 Dynamics of eddy generation in the central Bay of Bengal

Xuhua Cheng, College of Oceanography, Hohai University
Julian P. McCreary, International Pacific Research Center, University of Hawaii at Manoa,
Bo Qiu, Department of Oceanography, University of Hawaii at Manoa
Presenter Email: xuhuacheng@hhu.edu.cn

Eddy activity in the central Bay of Bengal (BoB) is revealed using satellite observations and hydrographic data. Altimetric data show that eddies are generated near the eastern boundary, propagate southwestward, and have periods predominantly in the 30-120-day band. Temperature profiles from the RAMA buoy at 90E, 15N, have their highest amplitude in the depth range of the thermocline, indicating that the eddies are associated with a vertical motion of the thermocline. To investigate the cause of the eddies, we obtained a suite of solutions to nonlinear and linear versions of an 1.5-layer (reduced-gravity) model. They demonstrate that equatorial wind forcing, Myanmar bump and Andaman Island, and nonlinearity are all essential for eddy formation. Among the nonlinear terms, the advection terms are the primary cause.

O-P5-08 Madden–Julian Oscillation Enhances Phytoplankton Biomass in the Maritime Continent

Chiung-wen June Chang, Department of Atmospheric Sciences, Chinese Cultural University, Taiwan
H.-H Hsu, RCEC, Academia Sinica, Taiwan
W. Cheah, IOES, University of Malaya, Malaysia
W.-L Tseng, RCEC, Academia Sinica, Taiwan
L.-C. Jiang, RCEC, Academia Sinica, Taiwan
Presenter Email: c.june.chang@gmail.com

In addition to monsoon-driven rainfall, the Maritime Continent (MC) is subject to heavy precipitation caused by the Madden–Julian Oscillation (MJO), a tropical convection-coupled circulation that propagates eastward from the Indian to the Pacific Ocean. This study showed that riverine runoff from MJO-driven rainfall in the western MC significantly enhances phytoplankton biomass not only in coastal regions but as far as the nutrient-poor Banda Sea, located 1,000 km downstream of the riverine source. We present observational estimates of the chlorophyll-a concentration in the Banda Sea increasing by 20% over the winter average within an MJO life cycle. The enhancement of phytoplankton in the central Banda Sea is attributed to two coinciding MJO-triggered mechanisms: enhanced sediment loading and eastward advection of water with high sediment and chlorophyll concentrations. Our results highlight an unexpected effect of MJO-driven rainfall on the downstream oceanic region. This finding has significant implications for the marine food chain and biogeochemical processes in the MC, given the increasing deforestation rate and projections that global warming will intensify both the frequency and strength of MJO-

driven rainfall in the MC.

O-P5-09 Mixing in the Indonesian Seas

Robin Robertson, Xiamen University Malaysia
Paul Hartlipp, University of New South Wales, Canberra
Presenter Email: robin.robertson@xmu.edu.my

The Indonesian seas have been referred to as the Indonesian 'Mix-Master', since they transform the Pacific waters entering them into fresher, cooler Indonesian Throughflow water flowing out into the Indian Ocean. Tidal mixing due to the interactions of tides and the steep topography and sills of the Indonesian seas is believed to be the prominent mixing mechanism. However, there is also a mean flow coming through the region. The interactions of a mean flow and tidal currents modify the characteristics of the tidal mixing. To date, this has not been investigated or simulated for the Indonesian seas. We plan a combination modeling and observational program to investigate the tidal flow and the interactions of the mean flow with the tides and their impact on mixing and water mass transformation. The observational effort will be focused on Ombai and Lombok straits; however, additional data will be collected off Bengkulu. The observational data will be compared to the simulation to verify the model is properly replicating the water mass transformation and mixing. The performance of different mixing schemes will be evaluated.

O-P5-10 Tidal Mixing Signatures in the Southeast Asia Waters from High-Resolution Sea Surface Temperature Data

R. Dwi Susanto, University of Maryland, college Park, Maryland, United States
Richard D. Ray, NASA Goddard Space Flight Center, Greenbelt, Maryland, United States
Presenter Email: dwisusa@umd.edu

Southeast Asia waters play pivotal role in global ocean circulation and climate because they provide the only connection between tropical Pacific and Indian Oceans (known as Indonesian Throughflow/ITF) and center for atmospheric convection. The ITF directly impacts the basin mass, heat, and freshwater budgets of the Pacific and Indian Oceans with possible feedback to the ENSO and monsoon climate phenomena. Due to complex coastline geometry and narrow passages, Southeast Asian seas are known for strong tidal mixing. Along the pathways from the Pacific to Indian Oceans, waters undergo strong mixing and air sea interactions. Tidal mixing plays important roles in the transformation of Pacific water and ITF water which strongly influences sea surface temperature, air-sea interaction, and stratification to the Indian Ocean. Numerical models and limited in situ observations have confirmed the occurrences of tidal mixing in these regions. However, detailed spatial characteristics of nonlinear interactions between tidal signals and tide-induced mixing in the Southeast Asia water have been poorly understood. Multi Ultra High-

Resolution Sea Surface Temperature (MURSST) data are used to extract tidal mixing signatures. Nonlinear interactions between semidiurnal and diurnal signals generate fortnightly (spring-neap cycle) tidal signals that can be detected from high spatial and temporal resolution of SST. Our results show that mixing signatures Indonesia and Philippine seas mostly are localized in narrow passages such as Sulu Sills, Nusa Tenggara Island chain (from Bali to Timor islands), Lifamatola passage. Since semidiurnal signals are dominant in these regions, the fortnightly signal (MSf) with period of 14.77 days are stronger. Meanwhile, in the South China Sea, the tidal mixing signatures are along the coastline of China and Luzon Strait with near-fortnightly signal (Mf) with a period of 13.67 is stronger due to nonlinear interactions between diurnal signals.

O-C1-01 Export of Terrestrially-derived Organic Matter from Rivers to the Oceans as determined by ultrahigh resolution mass spectrometry and NMR

Patrick G. Hatcher, Department of Chemistry and Biochemistry, Old Dominion University
Hongmei Chen, Department of Chemistry and Biochemistry, Old Dominion University
Presenter Email: phatcher@odu.edu

Terrestrial organic matter existing as either dissolved (DOM) or particulate (POM) is traditionally considered to be attenuated greatly in its export to the oceans. Much of this dogmatic belief is grounded in stable carbon isotopic distributions and lignin phenol biomarkers along seaward transects. In some recent studies of DOM and POM from some major rivers by the combined analytical approaches involving ultrahigh resolution mass spectrometry and NMR spectroscopy, this dogmatic view has been challenged. The data show that it is possible for terrestrial DOM and POM to significantly contribute to oceanic sediments and waters. One plausible pathway for lignin-rich terrestrial material to contribute significantly to oceanic DOM and POM is via photochemical rearrangement of its structural motif such that it loses its biomarker characteristics and its isotopic signature. Accordingly, it is important that we re-examine the possible terrestrial carbon contribution to oceanic carbon reservoirs.

O-C1-02 Optical and Molecular Signatures of Dissolved Organic Matter in Xiangxi Bay and Mainstream of Three Gorges Reservoir, China: Spatial-temporal Variations and Environmental Implications

Kai Wang, Institute of Environmental and Biogeochemistry (eBig), School of Earth Sciences, Zhejiang University, Hangzhou 310027, China
Chen He, State Key Laboratory of Heavy Oil Processing, China University of Petroleum, Changping District, Beijing 102249, China
Penghui Li, Department of Ocean Science and Engineering, Southern University of Science and Technology, Shenzhen 518055, China
Shangbin Xiao, College of Hydraulic and Environmental Engineering, China Three Gorges

University, Yichang, 443002, China
Yongge Sun, Institute of Environmental and Biogeochemistry (eBig), School of Earth Sciences, Zhejiang University, Hangzhou 310027, China
Quan Shi, State Key Laboratory of Heavy Oil Processing, China University of Petroleum, Changping District, Beijing 102249, China
Ding He, Institute of Environmental and Biogeochemistry (eBig), School of Earth Sciences, Zhejiang University, Hangzhou 310027, China
Presenter Email: dinghe@zju.edu.cn
Dissolved organic matter (DOM) plays an important role in various biogeochemical processes. Thus, many investigations of DOM have been conducted in several aquatic ecosystems. Here we report the distribution and composition characteristics of DOM, particularly on the molecular level for the first time, in dry-wet period in a tributary named Xiangxi Bay and mainstream of the Three Gorges Reservoir (TGR), the largest reservoir in the world. A combined approach was conducted, including ion chromatography, UV absorbance spectroscopy, excitation and emission matrix (EEM) fluorescence spectroscopy and parallel factor analysis (PARAFAC) and Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS). The results showed both significant spatial and temporal variations of DOM in TGR. The compensation from mainstream to Xiangxi Bay was observed in dry period, which mainly controlled the distribution of hydrological gradients, resulting in the higher terrestrial and algal inputs but lower anthropogenic inputs in Xiangxi Bay than mainstream. No obvious spatial variability of DOM was observed in wet period. Additionally, the substantial effect on the quantity and quality of aquatic DOM in TGR resulted from the alterations of wet and dry periods were revealed. The origin differences such as the lower abiotic reactions inputs, higher algal inputs and the agricultural inputs in dry period were observed. Furthermore, DOM showed more terrigenous characteristics in wet period with a higher aromaticity and proportion of humic-like compounds than that in dry period. The positive correlation between aromaticity indices and DOM showed the influence of aromatic compounds on the DOM alterations, which suggest that the difference in terrigenous input caused by the anti-seasonal hydrological management made a major contribution to DOM seasonal dynamics in TGR. Thus, the spatial and temporal variations of DOM composition in TGR could be mainly caused by hydrogeological alterations and anthropogenic impacts, which illustrating the influence of dam construction on the fate of DOM and setting up a subtle insight into its further effect on global carbon cycle under the background of damming reservoirs booming all over the world.

O-C1-03 High-Frequency Monitoring of FDOM Dynamics in a Subtropical Estuary

Liyin Qu, Xiamen University
Weidong Guo, Xiamen University
Jing Xu, Xiamen University
Xiao-ling Zhang, Xiamen Standard Scientific Instrument Co., Ltd
Presenter Email: wdguo@xmu.edu.cn

Estuary is an important link for terrestrial and marine dissolved organic matter (DOM) cycles. The export of DOM from fluvial discharge into the coastal seas showed high temporal variation due to the dynamic change of both hydrology and DOM quantity and quality in the watershed, and the dynamic environments of estuary driven by the mixing of freshwater and seawater interactions. The routine cruise investigation schemes just cover very short period, making it difficult to observe the high-frequency variation of DOM dynamics in the dynamic estuarine environments. In this study, we made a high-frequency monitoring of DOM dynamics in subtropical Jiulong Estuary, Southeast of China from 2014-2017. Four-year time series fluorescence dissolved organic matter (FDOM) data were obtained by an in-situ EXO-2 water quality sonde equipped with a FDOM sensor, with a data aquisition mode of every half an hour. The temporal variation of FDOM in different time scales (tidal, daily, seasonal, annual) were discussed, with the focus on the influence of rainstorm events, and the extremely strong 2015-2016 El Nino event on FDOM dynamics.

O-C1-04 Molecular size distribution and size-dependent composition of a single DOM sample as characterized using FlFFF-EEM-PARAFAC coupling techniques

Laodong Guo, University of Wisconsin-Milwaukee
Hui Lin, University of Wisconsin-Milwaukee
Presenter Email: guol@uwm.edu

Dissolved organic matter (DOM) in aquatic systems is highly heterogeneous in molecular size and chemical composition, as characterized by the flow field flow fractionation (FlFFF) and other analytical techniques capable of simultaneous size-separation and chemical characterization. In addition, the fate, transport, and biological/chemical reactivity of natural DOM along the aquatic continuum are largely related to its molecular size and composition. Over the past decade, the fluorescence excitation-emission matrices (EEMs) coupled with parallel factor analysis (PARAFAC) have been widely used for the characterization of fluorescent DOM in natural waters, usually for a large set of samples to be statistically significant. However, characterization of molecular-size dependent chemical properties of DOM using the EEMs-PARAFAC technique remains challenging, especially for a single DOM sample. Here we present a newly-developed method coupling the FlFFF size fractionation with EEMs and PARAFAC analysis to elucidate the continuous changes in fluorescent DOM composition with molecular size from 0.3-kDa to 700-nm in a single DOM

sample. Based on the analysis of a single riverwater sample, results from FlFFF-EEMs coupling show that the humic-like components, including Peaks A and C, were mostly partitioned within the 3-100 kDa size fractions, while the protein-like components, Peaks B and T, were dominantly present in the >100 kDa size fractions. PARAFAC analysis on EEM spectra of different size fractions in the sample fractionated by FlFFF identified three humic-like fluorescent components (C1, C2 and C3), all presented mostly in the 0.3-20 kDa size ranges, and one protein-like component (C4) mostly in the molecular size range from ~30 kDa to >1000 kDa with increasing relative abundance with molecular size. The change in component ratios (C_4/C_{1-3}) with molecular size exhibited a bimodal distribution with high values in both the <0.3 kDa and >20 kDa size fractions, similar to the size distribution pattern observed for the fluorescence index ratios between biological index and humification index (BIX/HIX). These results indicated that protein-like DOM components were mostly autochthonous in nature and partitioned either in lower or higher molecular size ranges, while humic-like DOM components were mostly in the molecular size range of 0.3-10 kDa in the sample. New results derived from the FlFFF-EEM-PARAFAC coupling technique provide a holistic understanding of the size-dependent heterogeneity of DOM in a single sample and can be used to reveal the dynamic changes of DOM molecular size and composition in the aquatic continuum across the river-lake and river-sea interfaces.

O-C1-05 Ocean mixing and the removal of marine refractory dissolved organic carbon

Yuan Shen, Ocean Sciences Department, University of California, Santa Cruz, California, USA 95064 School of the Earth, Ocean and Environment, University of South Carolina, Columbia, South Carolina, USA 29208
Ronald Benner, School of the Earth, Ocean and Environment, University of South Carolina, Columbia, South Carolina, USA 29208
Presenter Email: yshen56@ucsc.edu

A large quantity of reduced carbon is sequestered in the ocean as refractory dissolved organic carbon (DOC) that persists through several circuits of global overturning circulation. Key aspects of the fate and removal of refractory DOC remain an enigma after decades of research. Herein we investigate mechanisms that remove refractory DOC using bioassay experiments with DOC isolated from surface, mesopelagic and deep waters of the Atlantic Ocean. The isolated DOC was refractory to degradation by native microbial communities, even at elevated concentrations. However, when the refractory DOC was introduced to a series of novel environmental conditions, including addition of labile substrate, microbial inocula from coastal waters and exposure to solar radiation, a substantial fraction (7-13%) was removed within 1.5 years. Our results suggest that while refractory molecules can persist in the ocean for millennia, removal is rapid when they encounter their fate. The observed and projected climate-induced slowdown of global

overturning circulation could reduce the exposure of refractory molecules to disparate removal processes. Assuming a constant rate of production, the reservoir size of refractory DOC could increase as overturning circulation slows, providing a negative feedback to rising atmospheric CO2.

O-C1-06 Phototransformation of dissolved organic matter to ammonium and new forms of nitrogen-containing organic compounds: the biogeochemical implications

Hongmei Chen, Old Dominion University, Norfolk, Virginia, USA
Presenter Email: chenhmxmu@163.com

Photochemical transformation of dissolved organic matter (DOM) has been well recognized as an important process impacting carbon cycling and nutrient dynamics across aquatic environments. Photo-degradation of DOM can release ammonium, termed as photoammonification, which is increasingly observed and reported from earlier studies in lakes, rivers, coastal and oceanic waters. This photoammonification process potentially can shape the remineralisation of organic nitrogen, although the molecular-level pathway is unclear. In this study, a DOM-rich blackwater sample from the Dismal Swamp, VA was subjected to photodegradation in the laboratory for an extended period of time (up to 60 days). Bulk analysis of carbon, nitrogen, and nutrients were conducted at multiple time points to track their dynamic changes during photo-irradiation. We have applied an array of advanced analytical techniques to examine the molecule evolution of DOM and photo-flocculated particulate organic matter through ultra-high resolution mass spectrometry, NMR, and x-ray adsorption spectroscopy. Besides photo-production of ammonium, we also observed neoformation of nitrogen-containing molecules that are associated with both aliphatic proteinaceous organic compounds (e.g., amide, peptides) and condensed aromatic compounds (e.g., black nitrogen). It is suggested that the photo-product ammonium and the intermediate products, e.g., small peptides, may promote the incorporation of nitrogen to DOM. We will propose the underlying pathways for this incorporation, which have important biogeochemical implications to the fate of organic nitrogen.

O-C1-07 Elucidating molecular level information of dissolved organic matter in aquatic environments using two novel advanced analytical instruments

Zhanfei Liu, The University of Texas at Austin
Presenter Email: zhanfei.liu@utexas.edu

Deciphering molecular structures of dissolved organic matter (DOM) components is key to understanding the formation and transformation of this globally important carbon pool in aquatic environments. Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) has been the key tool to providing molecular level information of DOM since

2000s owing to its ultrahigh resolving power that can offer accurate molecular formula. However, we still know little about the structural detail of DOM molecules. Such a task may have to depend on the integrated use of complimentary analytical techniques. We recently developed two novel techniques for DOM analysis: ion mobility quadrupole time of flight liquid chromatography mass spectrometry (IM Q-TOF LC/MS) and thermal slicing ramped pyrolysis gas chromatography mass spectrometry (TS-RP GC/MS). In this talk, I will use both published and preliminary data to show the power of these two techniques in DOM analysis. For example, the IM Q-TOF LC/MS provides multidimensional structural information of DOM molecules including the geometric conformation and isomers of DOM. Our results show that natural DOM molecules from several south Texas rivers and adjacent coastal waters have smaller geometric conformation compared with standard biomolecules, suggesting that environmental degradation may make DOM molecules become more compacted. Furthermore, of all DOM molecules resolved within the detection limit of IM-MS, about 10% had at least one but no more than four isomers. Using TS-RP GC/MS on ultrafiltered DOM from a wide range of rivers, our results clearly show that pyrolysis produced fragments, or pyrolyzates, tend to be more diverse in fresher DOM than those from relatively more refractory DOM as determined by amino acid degradation index, suggesting that molecule composition becomes more homogeneous as degradation proceeds. These two novel techniques show great promise in further deciphering molecular level information of DOM in rivers, coastal and open oceans.

O-C1-08 Radiocarbon ages of organic matter transported by major Chinese rivers - What we have learned?

Xuchen Wang, Ocean University of China
Presenter Email: xuchenwang@ouc.edu.cn

Radiocarbon ages of organic matter transported by major Chinese rivers - What we have learned Xuchen Wang1,2 1 Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao, China 2 Center for Isotope Geochemistry and Geochronology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China. Rivers are the major conduits for the transport of land materials to the ocean. Each year, the world rivers deliver about 900 Tg (Tg = 1 x 1012g) of terrestrial carbon to the ocean and half of this riverine carbon is organic carbon. It is essential important to understand the fate and sources of the riverine organic carbon in order to better understand the carbon cycle in the coastal oceans. Here, we report our recent isotopic studies of organic carbon transported in several major Chinese rivers including: the Changjiang, Zhujiang, Huanghe, Heilongjiang and two mountainous rivers in Taiwan. We measured both radiocarbon (14C) and stable carbon isotope (13C) compositions for dissolved organic carbon (DOC), particulate organic carbon (POC) and solid phase extracted (SPE) DOC fractions. We also isolated and measured the isotopic values for particulate black carbon (PBC) and dissolved black carbon (DBC) in the rivers, and compared the values with these in the coastal waters. Our results show that the radiocarbon values and ages of both DOC and POC varied significantly among the different rivers. The Changjiang, Zhujiang and Huanghe that are the largest three rivers together drain 30% of the China continent, carry old terrestrial OC. POC were older than DOC. The ages of POC in the Huanghe were the oldest reaching 4960 +/- 1690 yr BP. The 14C ages of DOC in the three rivers were around 1000 yr. In comparison, both POC and DOC carried by the Heilongjiang had modern ages that are significantly different than the three largest rivers. We also found that SPE-DOC had much younger 14C ages than bulk DOC, suggesting that riverine DOC is not homogeneous in terms of isotopic signatures. The 14C ages of DBC were much younger than the ages of the PBC in the rivers. Isotopic mass balance calculation indicates that the DBC contained a large fraction BC derived from biomass burning while the PBC comprised mainly fossil fuel combusted BC. The great age differences of the riverine OC indicate the different mobilization and transport time scales in rivers, and are controlled not only by the input of different sources and degradation status of terrestrial OC, but also different environmental settings of the drainage bases of the rivers.

O-C1-09 Chemodiversity of sediment porewater DOM in two contrasting sediment cores within the Chesapeake Bay, USA

Michael Gonsior, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory
Leanne Powers, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory
Laura Lapham, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory
Sairah Malkin, University of Maryland Center for Environmental Science, Horn Point Laboratory
Presenter Email: gonsior@umces.edu

Chesapeake Bay sediment cores were collected at an almost freshwater site in the upper Bay as well as in the middle of the Bay within the deep channel and pore water was extracted at various depth up to 65 cm depth. Pore water DOM was analyzed by ultrahigh resolution mass spectrometry, excitation emission matrix fluorescence, and DOC and TDN was measured. Results showed distinct differences in the chemodiversity of porewater DOM at these two contrasting sites and revealed that the porewater DOM reflected the terrestrially-derived origin of organic matter in the upper bay whereas the mid-Bay samples revealed an origin more in agreement with an algal source. Furthermore, the hydrosulfurization was tracked at the mid-Bay site throughout the sediment core and revealed an increase in chemodiversity of sulfurized porewater DOM with depth.

O-C1-10 Carbon isotope signature of amino acids in marine environments

Tiantian Tang, Xiamen University
Peihong Kang, Xiamen University
Han Zhang, Key Laboratory of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences
Zixiang Yang, Xiamen University
Qing Li, Xiamen University
Biyan He, Jimei University
Presenter Email: tiantian.tang@xmu.edu.cn

To better understand the behavior of estuarine labile organic matter, stable carbon isotope values of amino acids were investigated from the particles and sediment collected along a salinity transect in the Pearl River Estuary in the winter of 2016. Variation in amino acids d13C values was observed from the upstream stations to those adjacent to the shelf. A varied isotopic difference between amino acids and bulk organic carbon was found across the salinity transect, suggesting a mismatch in the carbon source between labile organic matter and the rest of bulk OM with a particular consideration of refractory terrestrial OM input to the estuary. A microbial degradation incubation provides further evidence that the changing isotope values in bulk organic carbon during phytoplankton decomposition mainly result from the change in relative abundance of amino acids and other organic components, rather than the isotopic changes in amino acids themselves. With an assumption of constant isotope difference between amino acids and other organic components from the same carbon source, a lability model was established to differentiate the relative contributions of three major portions of estuarine organic carbon: 1) amino acids and 2) other organic carbon originated from the estuarine phytoplankton as well as 3) terrestrial organic carbon. The model suggests a highly variable terrestrial OM contribution to the studied estuary. The model also manages to evaluate the changing lability of organic matter from the estuarine phytoplankton growth without the terrestrial OM interference.

O-C1-11 Exchange Process and Biodegradation Mechanisms of Dissolved Organic Carbon Derived by Kuroshio Intrusion in the Northern South China Sea

Xiaolin Li, Xiamen University
Zhanfei Liu, The university of Texas at Austin
Kai Wu, Xiamen University
Peng Jiang, Xiamen University
Shuai Gu, Xiamen University
Bangqin Huang, Xiamen University
Rui Zhang, Xiamen University

Hongmei Chen, Old Dominion University
Minhan Dai, Xiamen University
Presenter Email: xlli@xmu.edu.cn

Transfer and transformation of dissolved organic carbon (DOC) in marginal sea is a key component of carbon cycling in the ocean. However, we still need better understanding about transformation mechanisms of DOC and its impact to the carbon cycle in the marginal sea. This research focused on the exchange and transformation processes of DOC derived from Kuroshio intrusion in the norther South China Sea (SCS) during the cruise of summer 2014 and winter 2017. Basing on the isopycnal mixing model, we found that DOC distribution in the northern SCS was influenced by the Kuroshio intrusion in both seasons. And significant decomposition of DOC was observed during the mixing (up to 6-7 micro M) which accounting for about 10% of the DOC measured in the surface water of SCS. To better understand the transformation mechanisms of extraneous DOC in the SCS, on-board incubation experiments were carried out under different environmental context (e.g. microbial community, nutrient levels). We found that DOC derived from Kuroshio can be decomposed by the microbes from SCS, and DOC concentration decreased from 80 to 77 micro M within 14 days when the bacterial abundance doubled in the first two days of the experiment. The decomposition was stimulated by increasing the nutrients (nitrate and phosphate) levels to the same levels as what were measured in the 100m depth of SCS. The DOC level decreased from 80 to 73 micro M, and significant higher microbial decomposition rate and bioavailable DOC were observed in the incubation experiment. The decomposition rates and bioavailable DOC were found higher in the experiments when extraneous DOC decomposed by local microbial community than the local DOC decomposed by local microbial community. Our evidences indicated that the context of the microbial transformation, e.g. microbial community structure, nutrients levels, is essential that controlling the bioavailability of DOC. Depending on our estimation, the decomposition of DOC derived from Kuroshio intrusion could contribute 0.36 mmol N/m2/day which could be another important source of nitrogen comparing to nitrogen fixation and aerosol deposition in the SCS.

O-C1-12 Bioavailability and molecular structure of dissolved organic matter (DOM) in five south Texas rivers

Kaijun Lu, The University of Texas at Austin Marine Science Institute
Kai Wu, State Key Laboratory of Marine Environmental Science, Xiamen University
Zhanfei Liu, The University of Texas at Austin Marine Science Institute
Presenter Email: kaijun.lu@utexas.edu

Dissolved organic matter (DOM) represents one of the largest exchangeable C reservoirs on earth. However, molecular level information of DOM remains elusive due to its chemical complexity and our technical limitation in characterization. In this study, natural DOM

samples were collected from five South Texas rivers (Aransas, Lavaca, Mission, Nueces, and San Antonio Rivers) in summer (July) of 2016, and their molecular level changes through a microcosm incubation were investigated using high-resolution mass spectrometry: Ion Mobility Quadrupole Time Of Flight (Q-TOF) Liquid Chromatography Mass Spectrometry (IM QTOF LC/MS). The results showed that bioavailable DOC (BDOC) and bioavailable dissolved organic nitrogen (BDON) ranged from 0.3% to 6.1% and 8.6% to 15.1% respectively, with no significant difference among the five rivers. Liquid chromatography and high-resolution MS further revealed even though total DOC concentration did not change much throughout incubation, a significant shift in DOM community occurred. For instance, under ESI- mode, with many compounds disappearing through incubation, the averaged O/C ratio of the assigned formulas decreased while the H/C ratio increased, changing the DOM community to be more marine-like? This trend seems to be mostly driven by the disappearance of marine-like?compounds during the incubation. Geometric conformation and isomeric information of DOM were further investigated with the IM-MS function. Our data showed that natural DOM generally possess a more compacted geometric conformation compared with known standard biomolecules. Furthermore, geometric conformation of natural DOM did not present a significant change through the incubation. However, isomer percentage decreased from ca. 7% before incubation to ca. 4% after incubation, indicating that DOM community becomes more homogenous with incubation. The analysis is still on going, and more molecular-level data will be presented.

O-C1-13 Flux, chemical composition and reactivity of dissolved organic matter at the land-ocean interface of Minjiang River, SE China

Liyang Yang, College of Environment and Resources, Fuzhou University
Qiong Cheng, College of Environment and Resources, Fuzhou University
Wan-E Zhuang, College of Life Sciences, Fujian Agriculture and Forestry University
Hui Wang, College of Environment and Resources, Fuzhou University
Wei Chen, College of Environment and Resources, Fuzhou University
Presenter Email: yangly@fzu.edu.cn

The chemical composition and biogeochemical reactivity of DOM in the lower Minjiang River-Estuarine system were examined with absorption spectroscopy and fluorescence EEM-PARAFAC. The annual export of DOC from the Minjiang River was 5.48×1010 g yr-1, which was a largest river DOC flux adjacent to the Taiwan Strait. The freshwater absorption coefficient a280 and DOC-specific UV absorbance SUVA254 were much higher, while the spectral slope S275-295 was lower in summer than in winter. This indicated stronger flushing of aromatic and high molecular weight constituents from the watershed in the rainy season. Six fluorescent components were identified using EEM-PARAFAC, including three humic-like components C1-C3, two tryptophan-like components C4 and C6,

and one tyrosine-like component C5. The levels of four components (C1, C2, C4, and C6) in the freshwater were lower while that of C5 was higher in the wet season than in the dry season, suggesting contrasting seasonal variations of different DOM constituents. Photochemical degradation removed effectively CDOM and FDOM, which was stronger for large molecular weight constituents as indicated by an increase in S275-295 and for summer under stronger solar radiation than for winter. Microbial degradation generally showed little effect on DOC, and it had smaller impact on CDOM and FDOM in winter than in summer which might be partly related to lower temperature in winter. Overall, this study demonstrated evident seasonal changes in the chemical composition of DOM and different PARAFAC components. The results also showed the seasonal variability of DOM reactivity, and emphasized the significant effects of photo-degradation on the DOM characteristics.

O-C1-14 Modeling of riverine dissolved organic carbon (DOC) fluxes in the Changjiang River network: in coupling of in-stream degradation and river hydrology

Weijin Yan, Institute of Geographical Science and Natural Resources Research, Chinses Academy of Sciences
Lv Shucong, Institute of Geographical Science and Natural Resources Research, Chinses Academy of Sciences
Yu Qibiao, Institute of Geographical Science and Natural Resources Research, Chinses Academy of Sciences
Presenter Email: yanwj@igsnrr.ac.cn

Riverine dissolved organic carbon (DOC) is an important carbon pool in the global carbon biogeochemical cycle. DOC export from terrestrial system to marine system via river system can be determined by the DOC input from land to river system and the in-stream removal processes. DOC input from land to rivers depend on the land use or land cover in the watershed. And the DOC in-stream removal primarily involves the biogeochemical and hydrological processes. However, the quantification of its in-stream removal and DOC input from land to rivers are still not sufficiently expounded. In this study, we examined the relationships between DOC degradation in linking its chemical composition and characteristics in order to obtain an experimental value of DOC in-stream uptake velocity (Vf). Furtherly, by coupling the DOC in-stream uptake velocity and hydrological parameters based on Spiraling theory and river Strahler model, we established a synthesis model to quantify the DOC input from land to rivers (both point source and non-point source), in-stream removal and export through outlet of the basin in the Changjiang River basin according to land use, soil organic matter content, and socio-economic indicators. Our model predicted that about 4.11 - 7.41 Tg C yr-1 are released from land to rivers and about 1.57 - 2.16 Tg C yr-1 are exported by rivers to sea as DOC with an instream

removal proportion of more than 70% at the whole basin scale during 1985-2010, accounting for 0.44% - 0.93% of the global riverine DOC flux. The relative contribution of point source is only about 1.5% - 2.3%. In terms of spatial patterns, the sub-basin of Dongting Lake is the largest contributor to DOC input load from land to rivers. The followings were the sub-basins of Min-Tuo River, the Poyang Lake and the section between Yichang and Jiujiang of the main channel of the Changjiang River. These 4 sub-basins contribute more than 70% of DOC load of the whole river basin. Though there is still great uncertainty regarding DOC in-stream removal, our study provided an improved understanding of the in-stream removal processes of DOC and its flux.

O-C1-15 Distribution, and accumulation of micro plastics and organic additives in north western Mediterranean Sea

Richard Sempéré, Aix-Marseille Univ.; Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Marseille, France
Javier Castro Jimenez, Aix-Marseille Univ.; Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Marseille, France
Vincent Fauvelle, Aix-Marseille Univ.; Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Marseille, France
Melanie Ourgaud, Aix-Marseille Univ.; Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Marseille, France
Benjamin Oursel, Aix-Marseille Univ.; Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Marseille, France
Andrea Paluselli, Aix-Marseille Univ.; Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Marseille, France
Natascha Schmidt, Aix-Marseille Univ.; Université de Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Marseille, France
Presenter Email: richard.sempere@mio.osupytheas.fr

The worldwide production of plastics has increased considerably since the development of synthetic polymers in the middle of the 20th century, reaching 311 million tons of plastic produced globally in 2014 and giving rise to large emissions and the transport of plastic debris through rivers, sewage and the atmosphere to the Ocean. Plastic materials are dispersed by winds and currents, and significant amounts may either sink into the water column, incorporate into sediments or be assimilated by organisms. Most plastics contain a number of additives such as phthalic acid esters or phthalates (PAEs), bisphenols or organophosphate ester flame retardants (OPEs) that are used as plastic softeners or flame retardants and are considered priority pollutants by the US-EPA, the European Union (EU) and the Chinese water regulations due to their endocrine disruption and carcinogenic properties. In addition, Plastic debris in marine environment, contain additives such as phthalates and bisphenols as well as adsorbed organic and inorganic molecules from

surrounding seawater that can be transferred to different oceanic areas, assimilated and transferred into the marine food web. However, little is known about their real accumulation and impact in the marine food web. Here, we report distribution of microplastics, and organic contaminants in northwestern Mediterranean Sea as well as their accumulation in selected marine organisms including phytoplankton and zooplankton.

O-C1-16 Rolling in the Deep: Tectonically-triggered sediment and carbon export to the Hadal zone

Rui Bao, Harvard University
Michael Strasser, University of Innsbruck
Ann McNichol, National Ocean Science Accelerator Mass Spectrometry facility, Woods Hole Oceanographic Institute
Negar Haghipour, ETH Zurich
Cameron McIntyre, Scottish Universities Environmental Research Centre
Gerold Wefer, MARUM-Center for Marine Environmental Sciences, University of Bremen
Timothy Eglinton, ETH Zurich
Presenter Email: rbao@foxmail.com

The origin, nature and past variability of sediments accumulating in the abyssal ocean is a topic that has garnered the attention of many geoscientists. Sediment deposits in deep ocean trenches, one important type of hadal environment located in tectonically-active regions, hold great potential for understanding large-scale sediment remobilization and translocation processes triggered by major earthquakes, and for documenting the past history and frequency of such events. Establishing the chronostratigraphic framework for hadal zone sedimentary records constitutes a long-standing issue as they are deposited below the Calcite Compensation Depth (CCD), resulting in an absence of dateable (i.e. carbonate biominerals), thereby confounding traditional 14C dating methods. This is one of the most critical challenges that must be overcome in order to constrain the provenance and frequency of specific event deposits, and to link them to specific earthquakes. In this study, we present results from detailed radiocarbon-based investigation of the organic matter in a sediment core retrieved from the Japan Trench (> 7.5 km water depth), proximal to the giant Tohoku-oki earthquake and ensuing tsunami of 2011. Construction of a high temporal resolution bulk organic carbon (OC) 14C record reveals that sedimentation in the Japan Trench is interrupted by episodic deposition of sediments characterized by pre-aged OC. These sedimentary layers coincide with intervals that have been attributed to past, historically-recorded earthquakes. Moreover, we describe further 14C measurements on specific thermally-resolved organic matter fractions from ramped pyrolysis-oxidation of a subset of sediment samples that yield new chronological constraints in the context of past earthquake history in the Japan Trench. Our observations suggest translocation and burial of significant quantities of pre-aged organic carbon in the hadal environment,

shedding new light on the nature and dynamics of carbon supply to hadal zone, with important implications for the identification of gravity flow events triggered by non-known tectonic activity in the Japan Trench sediments, and potentially in other hadal zone sedimentary sequences lying below the CCD where lacking abundant microfossils for conventional radiocarbon dating and isotope stratigraphy.

O-C1-17 Monitoring of classical, oxidized, and heteroatomic naphthenic acids species in oil sands process water and groundwater from the active oil sands operation area

Rongfu Huang, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada, T6G 1H9
Pamela Chelme-Ayala, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada, T6G 1H9
Sarah A. Hughes, Shell Health - Americas, Shell Oil Company, Woodcreek E276K, 150 North Dairy Ashford Road, Houston, TX, USA, 77079
John V. Headley, Environment and Climate Change Canada, 11 Innovation Boulevard, Saskatoon, SK, Canada, S7N 3H5
Mohamed Gamal El-Din, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada, T6G 1H9
Presenter Email: rongfu@ualberta.ca

Oil sands process water (OSPW) is a mixture of organic and inorganic constituents generated after bitumen extraction process by the oil sands industry. OSPW is currently stored in tailings ponds for recycling back into the extraction process, and is not discharged into natural environment because bitumen-derived dissolved organic compounds (primarily naphthenic acids; NAs) are toxic to aquatic and terrestrial organisms through multiple modes of action, including narcosis, endocrine disruption, immunotoxicity, and carcinogenicity. NAs are a complex mixture of carboxylic acids and are considered to be the organic constituents of primary eco-toxicological concern in OSPW. The seepage of OSPW into groundwater was suspected to be a reason responsible for the NAs detected in the river water of the surrounding areas. In this work, the classical, oxidized, and heteroatomic NAs species were monitored in the OSPW and groundwater from the active oil sands operation area, using solid phase extraction sample preparation and high resolution mass spectrometry analysis. Groundwater samples include Pleistocene channel aquifer groundwater (PLCA) and oil sands basal aquifer groundwater (OSBA) from different depth of underground. The concentrations of Ox−NAs decreased from OSPW to PLCA, and then increased from PLCA to OSBA, which is deeper than PLCA. The NAs in PLCA mainly comprised of Ox−NAs and N−NAs and the percentage of S−NAs was negligible. Results revealed relative abundances of individual NA species in total NAs varies among different water layers and the potential environmental impacts are expected to be variable.

Principal component analysis results of O2−NAs or O4−NAs could be used for differentiation of water types. O2−NAs with n =12−16 and |Z| = 4−6, and O4−NAs with n = 14−20 and |Z| = 6−8, were identified as marker compounds that could serve as surrogates of the larger complex NA mixture for source differentiation. This work utilized a combination of sample preparation, instrumental analysis, and statistical analysis methods to obtain knowledge of the occurrence, composition, and transfer of NAs in the groundwater of the Alberta oil sands operation area.

O-C1-18 Nutrient budget and phytoplankton dynamics of the Rajang River-South China Sea continuum

Edwin Sia Sien Aun, Faculty of Computing, Engineering and Science, Swinburne University of Technology, Sarawak Campus, Jalan Simpang Tiga, 93350, Kuching, Sarawak, Malaysia
Zhu Zhuoyi, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Zhongshan N. Road 3663, Shanghai, 200062, China
Zhang Jing, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Zhongshan N. Road 3663, Shanghai, 200062, China
Jiang Shan, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Zhongshan N. Road 3663, Shanghai, 200062, China
Cheah Wee, Research Center for Environmental Changes, Academia Sinica, Academia Road, Nankang, Taipei 11529, Taiwan, R.O.C.
Gonzalo Carrasco, Center for Environmental Sensing and Modeling, Singapore-MIT Alliance for Research and Technology, 1 CREATE Way, #09-03 CREATE Tower, 138602, Singapore
Faddrine Holt Jang, Faculty of Computing, Engineering and Science, Swinburne University of Technology, Sarawak Campus, Jalan Simpang Tiga, 93350, Kuching, Sarawak, Malaysia
Aazani Mujahid, Department of Aquatic Science, Faculty of Resource, Science and Technology, University Malaysia Sarawak, 93400 Kota Samarahan, Sarawak, Malaysia
Moritz Müller, Faculty of Computing, Engineering and Science, Swinburne University of Technology, Sarawak Campus, Jalan Simpang Tiga, 93350, Kuching, Sarawak, Malaysia
Presenter Email: essia@swinburne.edu.my

Rivers are important drivers in altering the hydrography and consequently the biogeochemistry of oceans whereby the coastal ocean biogeochemistry is affected by fluvial systems which input nutrients. It is estimated that the concentrations of N and P in the majority of rivers worldwide have at least doubled due to anthropogenic inputs. However, understanding the dynamics of the Rajang river in which it largely passes through peat-domes and has mass discharge of organic matter caused by both natural and anthropogenic activities may be a challenge. Hence, in this study, the main aim is to determine the spatial and temporal variations in nutrient budgets of the Rajang river-sea continuum and its influence on the phytoplankton functional groups will be determined

along with the main drivers for such variations. Three sampling campaigns (August 2016, March 2017 and September 2017) were undertaken along ~300km of the Rajang river to study both spatial and temporal/seasonal distribution of nutrients as well as phytoplankton pigments (community) distribution. The analyses for nutrients encompass both inorganic (i.e Nitrate, NO3-, Nitrite, NO2-, Ammonium, NH4+, Phosphate, PO4- and Silicate. SiO4-) as well as organic (Dissolved organic nitrate and Dissolved organic phosphate) fractions which were carried out utilizing a SKALAR San++ continuous flow analyser. Moreover, the nutrients analyses obtained will be utilized for nutrient budget models (LOICZ) in order to interpolate the regional nutrients budget. Lastly, the phytoplankton pigments will be processed and analysed via GC-MS and the data will be processed utilizing the CHEMTAX software for seasonal and temporal phytoplankton community structure profiling and coupling with nutrient budgets. Early results of Spearman's Rank from the first cruise (August 2016) show that PO4- is moderately correlated to salinity (0.57) while NO3- and SiO44- are strongly negatively correlated to salinity (-0.90 and -0.97 respectively). Furthermore, NO3- is strongly correlated to SiO44- (0.86), indicating possible origin of NO3- and SiO44- from the perturbation of headwaters as compared to the river mouth (coastal region). Also, the Redfield's ratio from the averaged values of Dissolved inorganic nitrogen (DIN): Dissolved Inorganic Phosphate (DIP) indicates phosphate limitation within the rivers, which has implications for the phytoplankton community as well as primary productivity. While the initial results obtained are yet unable to project a complete understanding of the nutrient budgets and its dynamics within the phytoplankton community, it is an important baseline to further elucidate the contribution of materials from the Rajang River into the South China Sea.

O-C1-19 Low molecular organic acids--distributions, spatio-temporal variations,and their effects on carbon dioxide system of seawater in coastal area

Haibing Ding, Ocean University of China
Presenter Email: dinghb@ouc.edu.cn

Low molecular weight organic acids (LMWOAs) are important metabolites or intermediates in biochemical processes and widely observed in different environments. In China coastal area, three LMWOAs -- formic acid, acetic acid and lactic acid were identified in seawater. Their distributions and spatio-temproal variations were investigated. In general, their concentrations showed decreased trend from inshore to offshore area. In seawater, their contribution to DOC was up to about 20%. Many factors, including microbial activities, algal release, riverine input, human activities and etc. affect their spatio-temporal variations significantly. According to the formic-to-acetic acid ratio, the key factors controlling distributions patterns of the LMWOAs were attributed to active human activities around coastal area. High concentration of LMWOAs account for a large fraction of organic alkalinity (Org-Alk) in seawater. Considering the effect of LMWOAs on pH value of seawater, a new software Org TCO2TA was developed to calculated the pH value of coastal seawater based on alkalinity equation by separating Org-Alk into LMWOA Alk (LMWOA-Alk) and humic acid Alk (HA-Alk). In the calculations, all dissociation constants of organic acids were from previous literature. Our results showed that pH values obtained from the Org TCO2TA software were closer to the pH values from spectrophotometric measurement than those from the traditional CO2SYS program, indicating pH values of seawater can be influenced by high concentrations of LMWOAs. The Org TCO2TA software can calculate the pH values of coastal seawater more accurately by considering the effects of LMWOAs.

O-C1-20 Impact of Hurricane Harvey on polycyclic aromatic hydrocarbons and alkanes in surface sediments of Copano Bay and Aransas Bays

Zucheng Wang, Northeast Normal University
Xianbiao Lin, SUN YAT-SEN UNIVERSITY
Kaijun Lu, University of Texas at Austin
Amber Hardison, University of Texas at Austin
Zhanfei Liu, University of Texas at Austin
Presenter Email: wangzc100@nenu.edu.cn

Hurricane Harvey, as a category four, directly passed Aransas and Copano Bays in August 25, 2017 with wind over 130 mph, which caused tremendous resuspension and sediment redistribution within the bays. The impact of this hurricane on sedimentary geochemistry is important for evaluating the ecosystem. Using surface sediments (top 5 cm) collected before (June) and (October) after the hurricane, a series of geochemical parameters, including grain size, CHN contents, polycyclic aromatic hydrocarbons (PAHs), total hydrolyzable amino acids (THAA) and n-alkanes, were measured. The sediment grain size overall became much coarser after hurricane with certain stations increasing over 100 microns in median size. Together with the OC content, concentrations of PAHs decreased from the range of 59 to 1605 ng g-1 to 19 to 204 ng g-1, and 80-100% of the decrease were attributed to the loss of low molecular weight PAHs (2-3 rings). Similarly, concentrations of n-alkanes decreased from 1.3-19.9 to 1.1-9.3 μg g-1 after the hurricane. However, there was no obvious trend among the different n-alkanes, unlike PAHs. Among the 19 stations, the coefficients of variation of PAHs and alkanes became smaller after the hurricane, indicating that organic composition of surface sediments were more homogeneous after the hurricane. Overall, PAHs and n-alkanes are strongly correlated with grain sizes (such as clay, sand) in sediment, and these results suggest that the storm surge strongly resuspended fine sediment particles that were concentrated in PAH and alkane, leading to the loss of these fine sediment particles and associated organic matter, either suspended in the water column or exported to coastal ocean. While some analyses such as THAA are still on going, the preliminary data demonstrate the strong impact of Hurricane Harvey on sediment organic geochemistry of the Copano and Aransas Bays.

O-C1-21 Spatial variability of sedimentary organic carbon in the Yellow River Estuary

Yu Zhitong, Qian Xuesen Laboratory of Space Technology, China Academy of Space Technology
Wang Xiujun, Beijing Normal University
Yao Wei, Qian Xuesen Laboratory of Space Technology, China Academy of Space Technology
Presenter Email: yuzhitong@qxslab.cn

Studying the carbon dynamics of estuarine sediment is crucial to understanding of carbon cycle in the coastal ocean. This study is to evaluate the mechanisms regulating the dynamics of organic carbon in surface sediment of the Yellow River Estuary (YRE). Based on data of 15 surface sediment cores, we found that TOC (0.2-4.4 g kg-1) and TN (0.06-0.68 g kg-1) were generally higher to the north than to the south, primarily due to the differences in kinetic energy level (i.e., higher to the south). The C:N ratio ranged from 2.1-10.1, with highest value in the southern bay, and the lowest in the shallow water area near the river mouth. A considerable spatial variability in the δ13Corg values (-24.26‰ to -22.66‰) showed more negative near the river mouth and its adjacent south bay, and less negative far away from the river mouth and the coast line. Our analysis suggested that TOC was mainly from marine sources in the YER, except in the southern shallow bay where approximately 75% of TOC was terrigenous. Higher levels of TOC (with more negative δ13Ccarb) were not a result of local biological production. The current system would cause re-distribution of POC thus more TOC in the surface sediment. The overall low levels of TOC were due to profound resuspension that could cause enhanced decomposition. Further studies with integrative and quantitative approaches are needed not only to assess the spatial and temporal variations of major carbon forms in the water column and sediments, but also to quantify the contributions of various sources and transformations among the different carbon pools, which aims to better understand the carbon cycle in the YRE in the changing environment.

O-C2-01 Biogeochemistry of the river-dominated central northern Gulf of Mexico

Alan M. Shiller, Center for Trace Analysis University of Southern Mississippi 1020 Balch Blvd. Stennis Space Center, MS USA 39529
Presenter Email: alan.shiller@usm.edu

Coastal areas are key regions between the continent and open ocean, where land-derived chemical species transported by rivers and groundwater mix with seawater. These coastal areas are also highly productive but are particularly vulnerable to human activities. The central northern Gulf of Mexico (nGoM) provides a particularly interesting region to study the land-ocean interface. While seemingly dominated by the Mississippi River Delta, the

nGoM nonetheless has several physiographic regions including: the narrow shelf area near the Delta, which is dominated by Mississippi River outflow; the broad, shallow Louisiana Shelf wherein outflow of the Atchafalaya River is prevalent; and the less-studied Mississippi Bight (east of the Delta) where other fluvial sources are potentially important. Indeed, measurement of the oxygen isotope composition of nGoM surface waters allows us to see the different fresh water influences in this region with the surprising result that Mississippi River water typically plays only a minor role in the Mississippi Bight. Trace element distributions provide additional constraints on processes in the nGoM. Bottom water distributions of dissolved Ba, Mn, and V, in particular, reveal interactions with the sediments with inputs of Ba and Mn removal of V associated with hypoxia. Dissolved V can also show bottom water inputs, suggesting a seasonal change in the nature of the subsurface chemistry. Finally, in the Mississippi Bight, with naturally occurring radium isotopes, we observe a significant influence of submarine groundwater discharge (SGD) in bottom waters that is also correlated with hypoxic conditions. This relationship suggests that "bottom-up" influence of reduced substances on oxygen consumption can be an important contributor to hypoxia.

O-C2-02 Trace element cycling in coastal systems (GEOTRACES): riverine and benthic supplies and control by oxygen

Eric Achterberg, GEOMAR
Insa Rapp, GEOMAR
Lucia Vieira, GEOMAR
Mark Hopwood, GEOMAR
Stephan Krisch, GEOMAR
Tom Browning, GEOMAR
Martha Gledhill, GEOMAR
Jan Scholten, University of Kiel
Presenter Email: eachterberg@geomar.de

The distinctive physical-biogeochemical environment of shelf seas results in these regions being 3-4 times more productive than typical oceanic systems, supporting 90% of global fish catches. Deoxygenation is globally affecting many shelf seas, and glacier and sea-ice melt is influencing Arctic systems. However, our understanding of sources and controls on trace elements (incl Fe) in these systems is limited. Shelf sediments, rivers and glacier melt are major contributors of iron (Fe) and other bioessential trace metals to shelf seas and also adjacent ocean systems. Resolving the processes that determine trace metal supply, and also their stabilisation preventing loss by scavenging and precipitation, and facilitating off shelf transport is essential for our understanding of current and future ocean productivity. To this end, we will present a range of GEOTRACES studies in contrasting shelf systems (Peru, Namibia, Arctic) where we diagnose the supply and biogeochemical

processes using oxygen levels and tracers including Ra isotopes, Al, Mn, and assess implications for off shelf transport.

O-C2-03 Spatiotemporal variability of biogeochemical reactions in an intertidal beach aquifer

Kyra H. Kim, University of Delaware, Department of Geological Sciences
Holly Michael, University of Delaware, Department of Geological Sciences
William Ullman, University of Delaware, School of Marine Science and Policy
Presenter Email: kyrakim@udel.edu

Intertidal areas of sandy beaches host dynamic mixing zones between fresh groundwater and saline seawater. Fresh groundwater discharges seaward with an in-land hydraulic gradient, and mixes with saline seawater as it comes up the beachface during waves and tides. The mixing of nitrate-rich, hypoxic to anoxic freshwater with oxygen- and carbon-rich seawater promotes active biogeochemical reactions along the mixing interface, altering the concentrations of terrestrial nutrients prior to their coastal discharge. As hydrologic conditions and flowpaths change (tidal amplitude, freshwater flux), the delivery of solutes and gases to a given location within the aquifer is also altered, subsequently changing the spatial patterns of reactions. Over two years, we investigated the spatial relationship between chemical reaction zones within the intertidal circulation cell to its physical setting. Porewater samples were collected from multi-level wells along a transect perpendicular to the shoreline at Cape Shores, Lewes, Delaware. Samples were analyzed for particulate carbon and reactive solutes, and incubated to obtain rates of oxic respiration and denitrification. Porewater incubation results showed high oxic respiration in the landward mixing zone between freshwater and seawater within the circulation cell where oxygen availability was high. Denitrification was more active towards the seaward mixing zone closer to the discharge point, accumulating nitrogen gas within the intertidal circulation cell. High respiration rates did not correlate with particulate carbon concentrations in porewater, suggesting that dissolved organic carbon or particulate carbon trapped within the sediment can contribute to and alter bulk reactivity. A better understanding of beach aquifer reactivity and its potential impacts to the coastal environment in times of sea-level rise and aquifer salinization will improve our ability to predict nutrient fluxes to estuaries and oceans.

O-C2-04 Groundwater and biogeochemistry alter beach pore waters

Willard S. Moore, University of South Carolina, Columbia, SC, USA
Marc S. Humphries, University of the Witwatersrand, Johannesburg, South Africa
Claudia R. Benitez-Nelson, University of South Carolina, Columbia, SC, USA
Presenter Email: moore@geol.sc.edu

With each rise of the tide substantial sea water infiltrates beaches and returns to the ocean

as the tide ebbs. Run up of waves onto beaches adds to this massive worldwide circulation. Water reentering the ocean has been changed chemically through biogeochemical reactions within the beach and by mixing with terrestrial groundwater. Thus, what goes out is substantially different chemically from what came in from the ocean. This paper will focus on how radium isotope tracers can help elucidate these processes. Specifically I will demonstrate that beaches have a wide range of inputs of both high and low salinity groundwater. These external sources plus reactions within the beach supply nutrients to beach pore waters and to the ocean as the tide recedes. One important contribution of radium isotopes is to delineate the inputs of high and low salinity groundwater and associated nutrients to beaches. In some cases the radium isotopes can quantify the delivery of nutrients to the coastal ocean through beach circulation; in other cases they fail. I will discuss several case studies where such inputs provide a significant nutrient source for the beach and one example of where they do not.

O-C2-05 Submarine groundwater discharge and its associated chemical fluxes in the Pearl River Estuary

Guizhi Wang, Xiamen University
Shilei Jin, Xiamen University
Qing Li, Xiamen University
Shengyao Sun, Xiamen University
Moge Du, Xiamen University
Weizhen Jiang, Xiamen University
Minhan Dai, Xiamen University
Jianping Gan, Hong Kong University of Science and Technology
Presenter Email: gzhwang@xmu.edu.cn

Distributions of radium isotopes were investigated in the Pearl River Estuary (PRE) to quantify submarine groundwater discharge (SGD). The water in PRE is mainly a mixture of river water, ocean water and groundwater. Based on conservation of salinity and 226Ra, we set up a three-endmember mixing model to solve for the fraction of the river water, ocean water, and the groundwater. River water contributed 78±13% of the water mass in PRE, while the ocean water accounted for 19±13% and the groundwater accounted for 3±2%. Using a tidal prism model the flushing time was estimated to be 7.1±0.9 days. Based on the mass balance of 226Ra and 228Ra and the assumption of steady state, the flux of SGD was estimated to be 0.83±0.63-1.07±0.83×108 m3 d-1, which is equivalent to 16-20% of the concurrent Pearl River discharge. The net solute flux via SGD was calculated to be 3.13±2.78×108 mol d-1 for DIC, 1.56±1.96×107 mol d-1 for DOC, 7.35±14.9×104 mol d-1 for soluble reactive phosphorus (SRP), 2.81±2.44×107 mol d-1 for silicate, and 2.67±2.42×107 mol d-1 for dissolved inorganic nitrogen (DIN). The net SGD-associated solute flux accounts for 43% of the estuarine export flux for DIC, 6.69%

for SRP, 37% for silicate, and 32% for DIN and is equivalent to 58% of the riverine flux for DIC, 6.99% for SRP, 33% for silicate, and 27% for DIN.

O-C2-06 Marsh crab impacts on hydrology and biogeochemistry alter coastal carbon cycling

Julia A. Guimond, University of Delaware
Holly A. Michael, University of Delaware
Presenter Email: jguimond@udel.edu

Carbon sequestration in tidal marshes is a valuable carbon sink on the global scale, yet these ecosystems are threatened by climate change and anthropogenic influences. Large uncertainties in the present-day salt marsh carbon budget and mechanisms mediating the magnitude and direction of carbon fluxes limit the efficacy of conservation efforts, investment in tidal wetlands for long-term carbon storage, and our ability to predict carbon budget feedbacks with anthropogenic and climatic change. In an effort to mechanistically link ecosystem components and enhance future carbon budget predictions, we assess the interactions between crab activity, water movement, and biogeochemical conditions in a mid-Atlantic salt marsh. Field analyses show that crab burrows enhance vertical and horizontal carbon exports through physical and chemical changes. Burrows raise the permeability of the marsh platform in the summer by an order of magnitude, increasing horizontal exchange between the carbon-rich marsh and the creek. Burrow-enhanced vertical connections between surface and subsurface increase the depth of the oxic zone where carbon oxidation more readily occurs, reducing the capacity for marsh sequestration of organic carbon. Thus, we identify a positive feedback mechanism between crab activity and carbon efflux. On the global scale, we calculate that crab burrows are responsible for a 0.04-4.4% decline in salt marsh carbon burial, a number that could grow to 9% in the coming century.

O-C2-07 Insights from spatial distributions of inorganic carbon parameters in the Chesapeake Bay: a bay-wide buffering mechanism via carbonate mineral precipitation and dissolution

Weijun Cai, University of Delaware
Jean Broedeur, University of Delaware
Jianzhong Su, University of Delaware
Baoshan Chen, University of Delaware
Najid Hussian, University of Delaware
Presenter Email: weijun.cai@gmail.com

We present results from a comprehensive study of inorganic carbon parameters along the main stem Chesapeake Bay, allowing evaluation of the carbonate system behaviors and coastal acidification status in this large, urban, eutrophic, and coastal plain estuary. Ten

cruises were conducted from March to December, 2016, and samples of pH, dissolved inorganic carbon (DIC), total alkalinity (TA) and calcium concentration were analyzed in order to describe spatial and seasonal patterns. DIC was removed due to strong biological production in the surface and enriched due to both aerobic and anaerobic respiration and carbonate dissolution in subsurface. A DIC mass balance analysis reveals that the Chesapeake Bay is a net CO2 sink and is net autotrophic, in great contrast to the paradigm that globally most estuaries are CO2 sources and net heterotrophic. In contrast to other estuarine studies where alkalinity is largely conservative, alkalinity was frequently non-conservative in the Chesapeake Bay, with large removals in the upper bay and releases in the subsurface of the mid- and lower bays. The recovery of submerged aquatic vegetation (SAV) across the Susquehanna Flats in the upper bay where very high pH conditions have promoted the precipitation of calcium carbonate may provide an important buffering resource via transport of the minerals to the low pH mid- and lower bays. This mechanism provides a bay wide shelf-regulated acid-buffering mechanism in response to eutrophication and acidification.

O-C2-08 Air-water gas exchange in a shallow, microtidal estuary

Bryce Van Dam, Florida International University
Craig Tobias, University of Connecticut
James Edson, WHOI
Presenter Email: bvandam@fiu.edu

We combine a direct, eddy covariance determination of CO2 flux with in-situ pCO2 measurements in an effort to better refine gas transfer parameterizations in microtidal estuaries. Due in part to large variability in pCO2, our parameterization does not differ significantly from literature ones when assessed over annual scales. Over diel time scales, however, our measurements of gas transfer velocity diverge from literature values. In particular, we demonstrate large differences in measured gas transfer velocity between day and night. We discuss the importance of water-side convection on gas transfer, and asses the impact of different parameterizations on calculated CO2 evasion rates over different time scales.

O-C2-09 Remotely sensing of Chla and its application on hypoxia and pCO2 monitor in coastal water

Chengfeng Le, Ocean College, Zhejiang University
Presenter Email: chengfengle@zju.edu.cn

Hypoxia and air-sea CO2 flux are the two main concerns to the scientific community and environment management agencies. These two processes are all related to eutrophication in coastal waters. Monitor dynamics of bottom water hypoxia and surface water pCO2 are important to better understand the biogeochemical process in coastal waters, and improve the managing policy for these waters. Here, we generated a long-term chlorophyll a concertation (Chla) time series from satellite observations by developing a local empirical algorithm for the Louisiana continental shelf (LCS). Then, the Chla product was used to monitor hypoxia and pCO2 variation in the coastal water. Our results show that eutrophication only controls 50% variation of hypoxia on the LCS, and the other 50% is controlled by variability in river plume dispersal. For the pCO2, satellite could monitor its variation with acceptable accuracy on the LCS. Our studies suggest that with accuracy of Chla observation, ocean color remote sensing could monitor many important biogeochemical parameters in coastal waters.

O-C2-10 Distribution patterns of nitrogen-cycling bacterial groups between pristine and human-impacted sites of coastal northern Bay of Bengal

Anwesha Ghosh, Integrative Taxonomy and Microbial Ecology Research Group, Department of Biological Sciences, Indian Institute of Science Education and Research Kolkata

Punyasloke Bhadury, Integrative Taxonomy and Microbial Ecology Research Group, Department of Biological Sciences, Indian Institute of Science Education and Research Kolkata

Presenter Email: anweshag91@gmail.com

Increased addition of nitrogenous compounds from land run-off into coastal oceans has been recorded since the industrial revolution. The process of remineralization of increasing concentrations of nitrogen in coastal oceans requires a better understanding of the resident bacterioplankton populations. Presence of specific nitrogen-cycling bacterial groups within the total bacterioplankton communities could act as proxy for changing nitrogen profiles due to human activities in coastal regions. Three pristine and three highly human-impacted coastal regions in northern Bay of Bengal were analyzed to understand the potential influence of increased nitrogen on bacterioplankton community structure. The three pristine regions representing low-nitrogen areas were Thakuran, Matla and Harinbhanga estuaries located with the Sundarbans mangrove ecoregion with an average dissolved nitrogen concentration of 29 µM. One site each from the Mooriganga estuary, Chemaguri Creek and Junput which are located in densely human populated areas served as high nitrogen areas with an average nitrogen concentration of 45 µM. The 16S rDNA V3-V4 region sequence data generated using next-generation sequencing was processed using QIIME and taxonomic affiliation was performed to elucidate the members of the bacterioplankton communities. This information was further used to predict abundance and type of nitrogen transporters harboured by these bacterioplankton. Interestingly, only 1% of the total bacterioplankton community from all studied stations showed affiliated with published sequences of Nitrospira, Lentisphaerae, Chloroflexi and Planctomycetes which are known to play a crucial role in nitrogen cycling. Correlation analysis did not show any

direct relation between the dissolved inorganic nitrogen concentrations (dissolved nitrate and dissolved ammonium) with the abundance of nitrogen-fixing bacterioplankton. Incidentally, the abundance profile of surface expressed nitrogen (both nitrate and ammonium) uptake transporter systems showed a gradual decline from low to high nitrogen sites. This indicated the possible presence of greater abundance of high-affinity nitrogen transporters in the low-nitrogen areas. Such observations involving abundance and functional level information on members of bacterioplankton communities could become crucial in understanding ecosystem level processes such as nitrogen cycling in coastal regions.

O-C2-11 Production of a non-hydroxyl radical oxidant during oxygenation of mackinawite (FeS)

Jie He, 1 Key Laboratory of Drinking Water Science and Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China. 2 UNSW Water Research Centre, School of Civil and Environmental Engineering, UNSW Sydney, NSW, 2052, Australia.
Christopher J. Miller, UNSW Water Research Centre, School of Civil and Environmental Engineering, UNSW Sydney, NSW, 2052, Australia.
Richard Collins, UNSW Water Research Centre, School of Civil and Environmental Engineering, UNSW Sydney, NSW, 2052, Australia.
Dongsheng Wang, Key Laboratory of Drinking Water Science and Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.
T. David Waite, UNSW Water Research Centre, School of Civil and Environmental Engineering, UNSW Sydney, NSW, 2052, Australia.
Presenter Email: hejie10@mails.ucas.ac.cn

Iron sulfides are an intrinsic and essential part of the global biogeochemical sulfur and iron cycles. Understanding of the formation and subsequent transformations of iron sulfides is central to our understanding of the evolution of the Earth's surface environment. The oxygenation of mackinawite (FeS) frequently occurs at anoxic-oxic interfaces in both natural and engineered systems but has been rarely investigated, especially with regard to the nature and dynamics of any intermediate oxidants that may be produced. In this study, one organic compound was chosen as the probe for any oxidants produced during FeS oxygenation. Intriguingly, one compound, rather than the oxidation products by hydroxyl radical, was identified as the major oxidation product in the FeS oxygenation system but not in the hydroxyl radical-dominated systems. Both the yield order and the rate constants of the oxidation products varied dramatically in the FeS oxygenation system from those produced in the hydroxyl radical-dominated systems. We thus conclude that one or more strong oxidants that were fundamentally different from hydroxyl radical were

produced during FeS oxygenation. The approximately 0.1 % yield of the total oxidant(s) produced could well be of broad environmental significance in view of the ubiquitous presence of FeS in the subsurface environment.

O-C2-12 The effect of coastal restoration on CO2 and CH4 fluxes in a Spartina salt marsh and brackish Phragmites marsh in Massachusetts

Jianwu Tang, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA, USA
Faming Wang, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA, USA
Kevin Kroeger, United States Geological Survey Woods Hole Science Center. Woods Hole, MA, USA
Presenter Email: jtang@mbl.edu

Coastal salt marshes play an important role in global and regional carbon cycling. Tidally restricted marshes reduce salinity and provide a habitat suitable for Phragmites invasion. We measured greenhouse gas (GHG) emissions (CO2 and CH4) continuously with the eddy covariance method and biweekly with the static chamber method in a Spartina salt marsh and a Phragmites marsh on Cape Cod, Massachusetts, USA. We did not find significant difference in CO2 fluxes between the two sites, but the CH4 fluxes were much higher in the Phragmites site than the Spartina marsh. Temporally, tidal cycles influence the CO2 and CH4 fluxes in both sites. We found that the salt marsh was a significant carbon sink when CO2 and CH4 fluxes were combined. Restoring tidally restricted marshes will significantly reduce CH4 emissions and provide a strong ecosystem carbon service.

O-C2-13 Spatial-temporal variations of water column nitrogen in the tidal freshwater zone of the Aransas River, South Texas

Hengchen Wei, University of Texas Marine Science Institute, Port Aransas, TX
Xin Xu, University of Texas Marine Science Institute, Port Aransas, TX
Allan E Jones, Department of Geological Sciences, University of Texas at Austin, Austin, TX, USA
Kevan B. Moffett, School of the Environment, Washington State University Vancouver, Vancouver, WA, USA
Amber K Hardison, University of Texas Marine Science Institute, Port Aransas, TX
James W McClelland, University of Texas Marine Science Institute, Port Aransas, TX
Presenter Email: hwei@utexas.edu

Riverine nitrogen (N) loadings are responsible for eutrophication in many coastal and marine waters. However, estimates for riverine N loadings generally do not account for the biogeochemical processing in tidal freshwater zones (TFZs), which may alter amounts and forms of N at the river/estuary interface. In this research, we studied the potential role of TFZs as hotspots for N losses and transformations by measuring concentrations and

building budgets for N in waters above (non-tidal) and within the TFZ of the Aransas River in South Texas. Sampling was conducted during two winters and two summers in 2015-2017. Dissolved inorganic nitrogen (DIN) concentrations were higher in winter than summer, whereas particulate organic nitrogen (PON) concentrations were not significantly different between seasons. PON concentrations increased from non-tidal to TFZ waters during both seasons. These increases in PON were accompanied by large decreases in DIN. Dissolved organic nitrogen (DON) decreased from non-tidal to TFZ, but remained stable within the TFZ. Mass balances were built for the TFZ with regards to different forms of N. On average, during baseflow conditions (i.e. excluding storm events) the Aransas TFZ received 12,263 kg TN (8,724 kg DIN, 2,906 kg DON, 633 kg PON) from upstream, and delivered 5,518 kg TN (2,860 kg DIN, 1,453 kg DON, 1,205 kg PON) to estuarine waters downstream of the TFZ, which represented 55% removal for TN (68% DIN, 50% DON, -90% PON). Overall, these results suggest that the TFZ removed more than half of the TN and transformed DIN into PON at the river/estuary interface. Continuing to overlook TFZ systems could lead to large errors in N concentrations and forms when calculating riverine N export to estuaries.

O-C3-01 Selective collection of iron-rich dust particles by natural Trichodesmium colonies

Yeala Shaked, Hebrew University of Jerusalem and Interuniversity Inst. for Marine Sciences, Israel
Rachel Zvoluni-Armoza, Hebrew University of Jerusalem and Interuniversity Inst. for Marine Sciences, Israel
Subjahit Basu, Hebrew University of Jerusalem and Interuniversity Inst. for Marine Sciences, Israel
Siyuan Wang, Hebrew University of Jerusalem and Interuniversity Inst. for Marine Sciences, Israel
Peter Weber, Physical and Life Sciences, Lawrence Livermore National Laboratory, Livermore, CA, USA
Rhona Stuart, Physical and Life Sciences, Lawrence Livermore National Laboratory, Livermore, CA, USA
Nivi Kessler, Hebrew University of Jerusalem and Interuniversity Inst. for Marine Sciences, Israel
Presenter Email: yeala.shaked@mail.huji.ac.il

Dust is considered an important source of iron (Fe) to vast region of the oceans in which Fe scarcity limits phytoplankton growth. Trichodesmium, a globally important, N2-fixing cyanobacterium, establishes large surface blooms in ocean regions that receive high dust fluxes. Trichodesmium holds special adaptations for utilizing dust as a source for Fe, including efficient dust capturing within their intricate colony morphology, dust shuffling to

the colony core, and active dust dissolution. In this study we explored various components of the interaction between natural and cultured Trichodesmium and dust with an emphasis on the role of Fe in these interactions. SEM and NanoSIMS images of natural Trichodesmium colonies from the Gulf of Aqaba revealed dust and Fe-rich particles in their core, possibly hinting at selective collection of Fe-rich particles. Trichodesmium culture, IMS101 did not form any stable interactions with dust when grown as single filaments, regardless of its growth phase or Fe status. However, when single filaments were induced to form colonies under Fe limitation, the colonies readily adsorbed dust, suggesting that IMS101 can regulate it adhesiveness towards dust. Dust collection by natural colonies also seems to be regulated as the adhesiveness of the colonies towards dust gradually shifted over an entire bloom season. In depth characterization of the interaction between particles and over 600 natural colonies during 24 hr incubations revealed surprisingly complex behavior with regards to particle collection, translocation and retention within the colony core. Defining individual behavioral parameters, we assigned each with a scoring scheme, and probed for differences in the colony behavior with respect to Fe-free and Fe-rich particles. Strong preference for Fe-rich particles over Fe-free particles was observed in all behavioral parameters for both individual colonies and the whole population, throughout the whole season. The preference for Fe-rich particles was evident even during initial particle collection (15 min after addition) and it increased further as the interaction progressed and the colonies kept on collecting and shuffling Fe-rich particles to their center. Fe-free particles were not only collected to a smaller degree, but were also actively discarded from some of the colonies that initially collected them. These intriguing findings hint at yet unexplored, highly sophisticated particle collection systems in natural Trichodesmium involving chemical sensing of Fe and complex behavioral patterns; and as such contribute to Trichodesmium's efficient utilization of dust as a source for Fe.

O-C3-02 Marine nitrogen fixation: Environmental and nutrient controls

Lei Chou, Service de Biogeochimie et Modelisation du Systeme Terre, Universite Libre de Bruxelles (ULB), 1050 Brussels, Belgium

Xuefeng Li, Service de Biogeochimie et Modelisation du Systeme Terre, Universite Libre de Bruxelles (ULB), 1050 Brussels, Belgium Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel (VUB), 1050 Brussels, Belgium Present address: Sea Area & Islands Office, National Ocean Technology Center (NOTC), Tianjin 300112, PR China

Debany Fonseca-Batista, Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel (VUB), 1050 Brussels, Belgium Present address: Department of Biology, Dalhousie University, Halifax, Nova Scotia B3H 4R2, CANADA

Nathalie Roevros, Service de Biogeochimie et Modelisation du Systeme Terre, Universite Libre de Bruxelles (ULB), 1050 Brussels, Belgium

Frank Dehairs, Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel

(VUB), 1050 Brussels, Belgium
Presenter Email: Lei.Chou@ulb.ac.be

Biological nitrogen (N2) fixation represents the major source of new nitrogen input to the ocean. Diazotrophic activity has thus great implications in the biogeochemical cycling of nitrogen and plays an important role in marine primary productivity. A better understanding of the major environmental factors as well as the nutrient status governing the extent of N2 fixation is highly required. Iron (Fe) and phosphorus (P) are considered to be co-limiting factors in most regions and the deposition of mineral dust is believed to promote N2 fixation through increasing availability of both Fe and P. Laboratory bioassays (+Fe, +P, +Dust) via incubation experiments performed on Trichodesmium IMS101, show that the addition of Fe, P or desert particles could stimulate the growth and N2 fixation of this cyanobacteria. In addition, during a field study using natural phytoplankton assemblages from the temperate Northeast Atlantic Ocean the key role of dissolved Fe (DFe) has been furthermore highlighted by the remarkably enhanced N2 fixation rate observed after the addition of DFe under low temperature and P-depleted conditions. Recently, the effects of ongoing climate change (ocean warming and acidification) on N2 fixation has been intensively studied but controversial conclusions have been reached. Semi-continuous dilution growth experiments were conducted on Trichodesmium IMS101 under two pCO2 (400 and 800 µatm) and temperature (24 and 28 °C) conditions. The results indicate that higher pCO2 and therefore ocean acidification may be beneficial for Trichodesmium growth and N2 fixation. However, Fe or P limitation in oligotrophic seawaters may offset the stimulation induced on Trichodesmium IMS101 resulting from ocean acidification. In contrast, ocean warming may not play a crucial role in Trichodesmium growth and N2 fixation with a 4 °C increase from 24 °C to 28 °C. Nevertheless, ocean warming is predicted to cause a shift in the geographical distribution of Trichodesmium species towards higher latitudes, extending its niche to subtropical ocean regions and potentially reducing its coverage in tropical ocean basins.

O-C3-03 Mutual quest for mineral and dust Fe by Trichodesmium and associated bacteria

Subhajit Basu, Interuniversity Institute for Marine Sciences in Eilat, POB 469, Eilat 88103, Israel The Fredy and Nadine Herrmann Institute of Earth Sciences, Edmond J Safra Campus, Givat Ram, Hebrew University of Jerusalem, Jerusalem, 9190401 Israel
Martha Gledhill, GEOMAR Helmholtz Centre for Ocean Research Kiel, Wischhofstrasse 1-3, 24148 Kiel, Germany
Yeala Shaked, Interuniversity Institute for Marine Sciences in Eilat, POB 469, Eilat 88103, Israel The Fredy and Nadine Herrmann Institute of Earth Sciences, Edmond J Safra Campus, Givat Ram, Hebrew University of Jerusalem, Jerusalem, 9190401 Israel
Presenter Email: subhajit.basu@mail.huji.ac.il

We studied the interactions between natural colonies of the ecologically significant nitrogen fixing marine cynaobacterium *Trichodesmium* and their associated bacteria during mineral and dust-iron utilization. Dust is a significant potential iron source to phytoplankton in the open ocean, but its biological use is restricted by rapid sinking of particles and low dust-Fe solubility. Many marine bacteria have the genetic knowhow of excreting siderophores, strong iron chelators capable of solubilizing dust and mineral iron. We hypothesize that bacteria associated with *Trichodesmium* play a role in solubilizing dust-iron by releasing siderophores. Using advanced separation and identification techniques we detected and partially quantified large array of siderophores from naturally occurring *Trichodesmium* blooms of Red Sea and Arabian Sea. We examined the differential ability of the colony members to acquire iron from minerals by incubating fresh natural populations with radiolabelled ferrihydrite and separating *Trichodesmium* from its associated bacteria. By adding active and inactivated siderophores (extracted from bacterial isolate) to paired experiments, we probed for the effect of siderophores on Ferrihydrite solubilization and uptake. The added siderophores enhanced ferrihydrite solubilization and iron uptake by both *Trichodesmium* and its associated bacteria, suggesting that their quest for dust-iron is mutual.

O-C3-04 Speciation of trace metals in the boundary layer surrounding phytoplankton cells: Implications for trace metal bioavailability

Fengjie Liu, Department of Earth Science and Engineering, Imperial College London
Qiao-Guo Tan, College of the Environment & Ecology, Xiamen University
Dominik Weiss, Department of Earth Science and Engineering, Imperial College London
Claude Fortin, Institut national de la Recherche scientifique, Centre Eau Terre Environnement, Quebec, Canada
Peter G. C. Campbell, Institut national de la Recherche scientifique, Centre Eau Terre Environnement, Quebec, Canada
Presenter Email: fengjieliu2012@gmail.com

Over the last 40 years, a general consensus has developed that the best predictor of the biological uptake of waterborne trace metals by phytoplankton is the concentration (or activity) of the free metal ion in the ambient water. However, an important but untested assumption of the current paradigm is that metal speciation in the boundary layer surrounding the phytoplankton cells is identical to ambient bulk water. The measured chemical conditions (e.g., pH and redox status) in this micro-space significantly differ from those in bulk water; in such cases the speciation of trace metals in the boundary layer would be changed, as indicated by equilibrium modelling calculations. Moreover, experiments with both marine and freshwater phytoplankton suggest that trace metal uptake can be markedly influenced by the boundary layer effect. The observation of the boundary layer effect should be of great interest to researchers in the fields of Biological

Oceanography, Environmental Sciences and Aquatic Sciences who seek to predict the effects of climate change and ocean acidification on planktonic primary production.

O-C3-05 A reduction-dependent copper uptake pathway in an oceanic diatom

Liangliang Kong, McGill University, Montreal, Canada
Neil M. Price, McGill University, Montreal, Canada
Presenter Email: kongliangl@gmail.com

Conventional models of metal uptake by phytoplankton describe the dependence of uptake on the concentration of hydrated metal ions or kinetically labile species (Morel and Hering 1993). Chemical speciation of metals in the environment thus strongly influences metal accumulation by biota and their physiological and ecological effects. Some of the earliest work in the field showed how Cu toxicity in diatoms and dinoflagellates depended on the concentration of free cupric ions (Sunda and Guillard 1976; Anderson and Morel 1978). Studies that are more recent suggest that organically complexed Cu may also be bioavailable and that, for these forms of Cu, a cell surface reduction step may be required before Cu is transported (Hudson 1998; Quigg et al. 2006; Semeniuk et al. 2015; Walsh et al. 2015). We studied Cu reduction and uptake in a model oceanic diatom, Thalassiosira oceanica, a species that has an elevated Cu requirement for growth compared to related coastal species (Peers and Price 2006). Inorganic Cu and Cu complexed by EDTA were reduced extracellularly by T. oceanica and reduction rate was up-regulated in Cu-limited compared to Cu-replete cells. Addition of a Cu reductase inhibitor, oxidized platinum salt (K_2PtCl_6), and a Cu(I) trapping agent, bathocuproinedisulfonic acid (BCDS), decreased Cu uptake rate by 97% and 75%, respectively. Addition of BCDS also inhibited cell growth at low Cu concentration (1 nM) and significantly reduced cellular Cu quota by 75% in short-term growth assays. Thus at low and high Cu, a cell surface reduction step was part of the Cu uptake mechanism. The results show that a cell surface Cu reduction step precedes Cu uptake in T. oceanica and provide further support for the presence of a Cu(I) uptake pathway in this oceanic diatom.

O-C3-06 Growth response of phytoplankton under CO2 and trace metal enrichment from an upwelling system, SE coast of Arabian Sea.

Diksha Sharma, CSIR-National Institute of Oceanography, India
Haimanti Biswas,
Saumya Silori,
A.U.R. Shaik,
D. Bandyopadhyay,
Presenter Email: dsharma@nio.org

The Arabian Sea (AS), (0-25°N; 45 -80°E), a land locked tropical basin in the North Indian Ocean, is one of the highest upwelling induced productive regions in the global ocean, and supports huge fisheries resources to its surrounding countries. This basin is also characterized by the existence of the persistent mid-depth oxygen minimum zone (120-1000m). The reversal of Indian monsoon winds strongly impacts its surface currents, hydrographical characteristics and biogeochemical processes, and creates high seasonal variability. The ongoing climate change with multiple stressors (e.g. increasing CO2, warming, and trace metal input) can have significant impact on the phytoplankton community from this productive basin and monitoring their responses are imperative to know the ecosystem service potential in future.

The present study was conducted as a pilot study on board [R.V. Sindhu Sadhana, SSD40] during a monsoon [Aug' 2017] cruise. Our preliminary observations showed high spatial variability in terms of physicochemical and biological parameters along the East coast of AS. During the peak monsoon, the upwelling signature (high biomass coupled with nutrient concentrations) was noticed in the south west coast of India. Surface water pCO2 variability was correlated to both physical and biological parameters.

Phytoplankton responses under CO2 and trace metal [copper (Cu) and zinc (Zn)] enrichment were monitored on board. A nutrient enriched diatom bloom [dominated Leptocylindrus sp; Nitzschia sp.] was initiated on board and was grown under ambient and high CO2 levels (»800matm) in combination with different Cu concentrations for three days. Phytoplankton community composition, cell count, biochemical composition, particulate organic carbon (POC), biogenic silica (BSi) production, stable isotopes of carbon (d13CPOM) were analyzed. There was a significant change noticed in the phytoplankton community composition both in response to CO2 and Cu. But no considerable change in per cell quota of carbon or BSi was seen between the treatments. In the second experiment (dominated by Chaetoceros sp), trace amount of Zn was added under both ambient and high CO2 levels. Zn did not show any growth stimulating impact, rather was seen to be deleterious under high CO2 +Zn treatments. Cell count was significantly decreased under high CO2 and Zn treated samples. However, total POC production did not show any statistically significant difference between Zn added or CO2 enriched samples. d13CPOM showed depleted values under high CO2+Zn treated samples and could be due to slow growth which was indicated in low cell count. Some dominant diatom species from this upwelling system might have some strong adaptability to such variability and could be less susceptible to the ongoing/future changes. Inclusion of temperature impact in combination with the presently studied stress factors may show some different responses and needs to be considered in future studies.

O-C3-07 The interrelationship between cell size, cellular cadmium and cadmium-carbonic anhydrase in marine diatoms

Weiying Li, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Haizheng Hong, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Dalin Shi, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: lwy@stu.xmu.edu.cn

The discovery of cadmium-carbonic anhydrase (CDCA), the only known biological function of cadmium (Cd), provides a link between the biogeochemical cycles of carbon and Cd. Previous studies indicate that cellular Cd concentration of phytoplankton likely correlates positively with their size. However, it remains unclear if such a relationship involves CO2 acquisition facilitated by CDCA. In this study, we investigated the interrelationship between cell size, cellular Cd concentration, and CDCA in three centric marine diatom species (i.e., *Thalassiosira pseudonana*, *Thalassiosira weissflogii* and Ditylum brightwellii) spanning a range of cell sizes of 50 to 6000 um3. Larger diatoms did have higher cellular Cd:C ratios at a given growth rate, and for a similar increase in growth rate as a result of Cd addition, CA activity increased by 21%, 56% and 88%, respectively in T. pseudonana, T. wesfloggii and D. brightwellii. In addition, the gene transcription and protein expression of CDCA were found to increase along with CA activity upon Cd addition. Taken together, our study showed that larger diatom cells would need more Cd to enhance CA activity to support inorganic carbon acquisition for growth.

O-C4-01 Coupling between oceanic microbial interactions and atmospheric biological aerosol composition

Yinon Rudich, Weizmann Institute
Miri Trainic, Weizmann Institute
Ilan Koren, Weizmann Institute
Assaf Vardi, Weizmann Institute
Presenter Email: yinon.rudich@weizmann.ac.il

The contribution of oceanic microbial activity to sea spray aerosol (SSA) is not fully established. We assessed aerosolization of the calcite units (coccoliths) that compose the exoskeleton of the abundant bloom-forming coccolithophore, Emiliania huxleyi. Airborne coccolith emission occurs in steady-state conditions and increases by an order of magnitude during E. huxleyi infection by E. huxleyi virus (EhV). Airborne to seawater coccolith ratio is 1:110, providing estimation of airborne concentrations from seawater concentrations. The coccoliths‘ unique aerodynamic structure yields a slow settling velocity suggesting enrichment of the coccolith fraction in the atmosphere. This enrichment

suggests that close to areas with bloom demise, coccoliths may be key contributors to coarse mode SSA surface area, comparable with sea salt aerosols. In addition, using a laboratory-based setup, we will show that the dynamic of aerial emission of the EhV virus is strongly coupled to the host virus dynamic in the culture media. In a complementary field campaign we recovered EhV DNA from atmospheric samples collected over an E. huxleyi bloom in the North Atlantic, providing evidence for aerosolization of marine viruses in their natural environment. Together, these studies suggest a strong coupling between key oceanic microbial interactions and fundamental atmospheric processes.

O-C4-02 The formation mechanism of atmospheric PM2.5 and haze pollution in the fall and winter of Beijing

Min HU, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Dongjie Shang, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Yao Xiao, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Xin Fang, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Shiyi Chen, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Keding Lu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Song Guo, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Zhijun Wu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Limin Zeng, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Yuanhang Zhang, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Presenter Email: minhu@pku.edu.cn

Severe regional haze problem in the megacity Beijing and surrounding areas, caused by fast formation and growth of fine particles, has attracted much attention in recent years. After 5 years air pollution control primary emission decreased, while secondary pollution becomes prominent. The days of heavy pollution decreased by 35 days within five years, and the incidence of heavy pollution decreased significantly. PM2.5 also decreased significantly year by year from 89.5 $\mu g/m^3$ in 2013 to 58 $\mu g/m^3$ in 2017. The spatial distribution of the whole Beijing area was still high in the south and low in the north, but

the gap between the north and the south decreased. The continuous improvement of air quality requires full understanding of formation mechanism of secondary air pollution, based on regional city clusters. The Intensive field campaigns were conducted in the fall and winter of 2017 in the north China Plain. Four pollution episodes were observed. The new particle formation and subsequent growth resulted in haze phenomenon. The formation mechanism of secondary components, such as nitrate, sulfate and SOA, was also discussed. The preliminary study has drawn the conclusions: SO_2 and sulfate in PM decreased obviously due to coal burning control and using natural gas. Particulate nitrate became increasingly prominent due to daytime photochemistry. The liquid-phase particles, which provide efficient chemical reaction vessels, may facilitate the mass transfer of reactive gaseous precursors and subsequent multiphase reactions and further accelerate both secondary inorganic and organic aerosol formation. Mass loading of aerosols and their absorption and scattering coefficients would be enhanced after taking up water, thus amplifying the visibility degradation.

O-C4-03 Marine Fine Aerosols in South China Sea - Chemical Characteristics and Source Apportionment

Chung-Shin Yuan, Institute of Environmental Engineering, National Sun Yat-sen University
Chung-Min Hung, Institute of Environmental Engineering, National Sun Yat-sen University
Zong-Mou Yang, Institute of Environmental Engineering, National Sun Yat-sen University
Po-Hung Cheng, Institute of Environmental Engineering, National Sun Yat-sen University
Presenter Email: ycsngi@mail.nsysu.edu.tw

This study aims to explore the chemical characteristics and source apportionment of marine PM2.5 in South China Sea. Regular and intensive sampling of PM2.5 were conducted simultaneously at the Dongsha Islands and the Nansha Islands from August 2017 to April 2018. Chemical composition including water-soluble ions (WSIs), metallic elements, carbonaceous contents, anhydrosugars, and organic acids were further analyzed to characterize the chemical fingerprint of marine PM2.5 in South China Sea. Furthermore, backward trajectory simulation and chemical mass balance (CMB) receptor modelling were applied to identify the potential sources of marine PM2.5 and their contribution in each season. Field sampling results indicated that high concentrations of marine PM2.5 were observed in winter and spring. During the northeastern monsoons periods, anthropogenic PM2.5 from northern region was brought to South China Sea, resulting in significant increase of PM2.5 concentration. Chemical analytical results showed that secondary inorganic aerosols (NO_3^-, SO_4^{2-}, and NH_4^+) dominated WSIs, accounting for 47.6-70.4% of WSIs in winter and spring. Crustal elements (Ca, K, Mg, Fe, Al) dominated the metallic elements in PM2.5. The concentrations of trace metals (V, Cr, Mn, Ni, Zn, and Cd) were emitted from anthropogenic emissions since fall. Moreover, organic carbon (OC) was the

dominant carbonaceous species during the sampling periods, and OC/EC ratios increased during the northeastern monsoon periods. The concentrations of levoglucosan at the sampling sites were ordered as DS>NS. The highest levoglucosan concentrations of 13.73 ng/m3 were observed at the Dongsha Islands. Organic acids of PM2.5 at the Dongsha Islands were higher than those at the Nansha Islands. Oxalic acid was the abundant organic acids in PM2.5. The concentrations of oxalic acid at all sampling sites ranged from 5.1 to 189.4 ng/m3. The mass ratios of malonic and succinic acids (M/S ratios) in PM2.5 ranged from 0.99 to 1.41, showing that PM2.5 was mainly attributed from secondary organic aerosols (SOAs). Sea salts, fugitive dusts, and mobile sources were the major sources at two sampling sites, but the contribution of anthropogenic sources (i.e. incinerators, petrochemical industries, industrial boilers, secondary sulfate and nitrate, and organic carbon) and biomass burning rose up since fall.

O-C4-04 Identification of the chemically distinct groups of Atlantic aerosol particles based on K-means cluster analysis

Shan Huang, Jinan University
Laurent Poulain, Leibniz Institute for Tropospheric Research
Zhijun Wu, Peking University
Wolfram Birmili, Federal Environment Agency
Hartmut Herrmann, Leibniz Institute for Tropospheric Research
Alfred Wiedensohler, Leibniz Institute for Tropospheric Research
Presenter Email: shanhuang_pku@163.com

The marine aerosol plays an important role in global climate regulation and marine biogenic system. Aerosol particles in the marine boundary layer (MBL) are seldom from exclusively marine origins. Complex sources and atmospheric processes determine the chemical and physical properties of aerosol particles. In this study, chemically distinct groups are identified by k-means clustering, in an exploratory way, on chemical composition (provided by a High Resolution Time of Flight Aerosol Mass Spectrometer, HR-ToF-AMS) and particle number concentration (PNC) of MBL aerosol particles, and linked to the air mass origins. The analysis is based on physical and chemical measurements performed on board the German research vessel Polarstern during 4 research cruises over the Atlantic Ocean in 2011 and 2012, covering spatial range from 53°S to 53°N in two seasons (spring and autumn). In total 12 variables were used for clustering, including PNC of aerosol particles and 11 chemical components (ammonium, nitrate, chloride and BC directly provided by instruments, plus 5 organic components and 2 sulfate components with identified sources given by source apportionment models). With this algorithm, 9-cluster solution was selected as the best result and further combined to 4 groups with distinct chemical composition including 2 marine groups and 2 continental ones. The spatial distribution of these 4 chemically distinct groups can well correspond to the air

mass origins. The resulting clusters are repeatable in the same season along the similar ship tracks, which makes the method useful for modelization on predicting physicochemical properties of MBL aerosol.

O-C4-05 Iron Reoxidation in Photochemical Cycling

Jing Dou, ETH Zurich, Switzerland
Beiping Luo, ETH Zurich, Switzerland
Peter A. Alpert, Paul Scherrer Institute, Switzerland
Pablo Corral Arroyo, Paul Scherrer Institute, Switzerland
Markus Ammann, Paul Scherrer Institute, Switzerland
Ulrich K. Krieger, ETH Zurich, Switzerland
Thomas Peter, ETH Zurich, Switzerland
Presenter Email: jing.dou@env.ethz.ch

Iron (Fe(III)) carboxylate complexes in aerosol particles absorb light below about 500 nm followed by ligand to metal charge transfer (LMCT) which reduces Fe(III) to Fe(II) and oxidizes carboxylate ligands[1]. When O_2 is present, production of radicals, peroxides and oxygenated volatile organic compounds (OVOC) ensues. Importantly, radicals (e.g., OH^-, HO_2^- and RO_2^- reoxidize Fe(II) to Fe(III) and can then complex with neighboring acid groups closing a photocatalytic cycle. We investigated iron carboxylate catalyzed photochemistry by tracking mass and size changes of single, levitated organic aerosol particles in an electrodynamic balance (EDB) under visible (473 nm) light irradiation as a function of relative humidity (RH). Particle had an around 10 µm radius and contained Fe(III)-citrate in aqueous citric acid with a mole ratio of 0.05. A mass loss was observed during Fe(III)-citrate photochemistry due to the evaporation of volatile (e.g., CO_2) and semi-volatile (e.g., ketones) products. To quantify Fe(II) to Fe(III) reoxidation we first exposed the particle to N_2 and light until all Fe(III) reduced to Fe(II), and then switched off light and introduced O_2. At 48% RH, we found that 10 hours exposure to O_2 was sufficient for all Fe(II) to be reoxidized while at 24% RH, complete reoxidation after 25 hours was not yet achieved. We attribute the differences in recovery time to the O_2 diffusion limitations (i.e., limited O_2 availability for reoxidation) at lower RH. To better understand the interplay of photochemical reaction pathways and molecular diffusion in our system, we developed a numerical model to simulate Fe(III)-citrate photochemical cycling in single particles. Molecular diffusion coefficients of CO_2 and O_2 as a function of RH, and the oxidation rate of Fe(II) by O_2 directly were derived using our model. With these well-defined and physically constrained parameters, we predict the evolution of products as well as organic acids degradation in the condensed phase under atmospheric conditions.

O-C4-06 Aerosol hygroscopicity in East Asian from continental to marine environments

Yu Wang, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University Now at: Centre for Atmospheric the Science, School of Earth and Environmental Sciences, The University of Manchester
Zhijun Wu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Shan Huang, Institute for Environmental and Climate Research, Jinan University
Alfred Wiedensohler, Leibniz Institute for Tropospheric Research
Min Hu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University
Presenter Email: yu.wang@manchester.ac.uk

The water uptake of atmospheric aerosols plays an important role in aerosol chemistry, visibility degradation, cloud formation, and human health. Particle hygroscopicity measurement has been deployed in various environments worldwide, including urban, rural, marine, forest, remote areas, mainly in Europe and USA. In the past 20 years, the particle hygroscopicity measurement in Eastern Asia was largely enriched. This study summarized the outcomes of the hygroscopicity of the sub-micrometre particles measured by H-TDMA (Hygroscopicity-Tandem Differential Mobility Analyzer) from continental to marine environments in Eastern Asia. To avoid the influence of kelvin effect on the growth factor, the single parameter (k) was used to characterize particle hygroscopicity. k=0 means hydrophobic (e.g. black carbon), while the k of atmospheric-relevant inorganics such as $(NH_4)_2SO_4$ and NaCl are 0.50 and 1.27 respectively. The mean k of urban aerosols were roughly 0.10~0.33, while, the mean k for rural aerosols was slightly higher with 0.15~0.40. The mean k at a mountain site (Huangshan, China), a forest site (Wakayama, Japan), a near-coastal site (Hongkong, China) and a marine site (Cape Hedo, Okinawa, Japan) were 0.20~0.30, 0.20~0.40, 0.20~0.40 and 0.45-0.55 respectively. The mean k of aerosols in North Pacific Ocean was 0.4~0.6 when the air mass sourced from marine/volcano-Japan, while the mean k ranged 0.2 to 0.4 when the air mass was influenced by polluted continental areas. Typically, urban and rural aerosols showed 2~3 hygroscopic modes (nearly-hydrophobic, less-hygroscopic, more-hygroscopic mode), indicating an external mixing state of atmospheric particles. However, high frequency of a single mode (hydrophilic mode) was observed in the mountain site, indicating internal mixing state of aerosols. Besides, when the air mass was from marine sources, sea salt/sulfuric acid mode was observed in the marine site and ship measurement. Based on particle hygroscopicity and chemical composition measurements in various environments, a linear relationship between particle hygroscopicity (k) and the organic mass fraction (Forg) was established. Interestingly, measurements from all the continental areas

(including polluted & clean urban, rural areas, mountain site) and the marine environment influenced by continental air mass shared the same parameterization equation: k = (-0.492±0.007) * Forg + (0.505±0.004). However, the marine environment influenced by marine air mass showed a different parameterization equation: k = (-2.120±0.023) * Forg + (0.987±0.006). These findings are essential to improve our understanding of particle hygroscopicity in Eastern Asia and extend the mapping of hygroscopic measurements globally.

O-C4-07 Hygroscopicity of marine aerosols and its link with chemical composition

Zhijun Wu, Peking University
Shan Huang, Jinan University
Laurent Poulain, Leibniz Institute for Tropospheric Research
Hermann Hartmut, Leibniz Institute for Tropospheric Research
Alfred Wiedensohler, Leibniz Institute for Tropospheric Research
Presenter Email: zhijunwu@pku.edu.cn

The hygroscopicity of marine aerosols is a key factor determining the aerosol optical properties and the ability of particles to serve as CCN, and further, playing an important role in direct and indirect global radiative forcing3. Moreover, the particle hygroscopicity can be used to indirectly infer the particle chemical composition. For the range of water supersaturations typical of marine boundary layer (MBL) clouds and the chemical composition of marine aerosols, the CCN population is dominated by particles between 40 and 300 nm in diameter 4. The particle mass concentration of this size range (40-300 nm) is typically quite low, especially in the remote marine atmosphere. The hygroscopicity measurements may provide an insight into the chemical composition, thus, identify the sources. Therefore, understanding hygroscopicity of marine aerosols is vital to describe their climate effects and further explain the physicochemical processes in the marine atmosphere. In the our study, metadata were obtained during three cruises measurements onboard “Polarstern” research vessel carried out over Atlantic Ocean. We will present: (1) Spatial and seasonal variations of particle hygroscopicity; (2) The effects of meteorological parameters, especially wind speed, on particle hygroscopicity; (3) Link the particle hygroscopicity and the high-time resolution chemical composition. This study will provide a deep insight into the hygroscopicity of marine sub-micrometer particle and it’s link with chemical composition.

O-C4-08 Spatio-temporal variability and transformation of dimethylsulfide (DMS) and dimethylsulfoniopropionate (DMSP) in the East China Sea

Gui-Peng Yang, Ocean University of China
Hong-Hai Zhang, Ocean University of China
Qian-Yao Ma, Ocean University of China
Presenter Email: gpyang@ouc.edu.cn

Spatio-temporal variations of dimethylsulfide (DMS) and its precursor dimethylsulfoniopropionate (DMSP), including dissolved (DMSPd) and particulate fractions (DMSPp) were determined in the East China Sea from 1993 to 2017. DMS and DMSP concentrations exhibited pronounced seasonal variations with the maxima in spring/summer and the minima in winter. The spatial distributions of DMS and DMSP in the East China Sea were obviously influenced by the Yangtze River effluent and the Kuroshio water. Both DMS and DMSPp concentrations were significantly correlated with chlorophyll a concentrations in the most cruises, suggesting that phytoplankton biomass might play an important role in controlling DMS production in the East China Sea. Over the past several decades, the N/P ratio in the study area increased dramatically due to the enhanced dissolved inorganic nitrogen discharges, while the Si/N ratio decreased. The long-term changes in nutrients could be responsible for the shift in the phytoplankton community structure in the East China Sea. The percentage of diatoms decreased while dinoflagellates increased over the past several decades. This shift in phytoplankton community has caused a significant increase in DMS concentrations from 2.9 nmol/l in 1993 to 4.8 nmol/l in 2017. In addition, transformation of DMS and DMSP on three major marine interfaces and their control factors were studied in the East China Sea during spring and summer. Regarding loss processes, bacterial consumption contributed nearly 50% of total DMSP loss, approximately 38% of which was converted into DMS in spring. Microbial consumption, photolysis and ventilation accounted for 56%, 34%, 10% in spring and 49%, 44%, 7% in summer of DMS removal processes, respectively. Moreover, the low positive sediment-to-water column flux of DMS suggests that sediment is a potential source for DMS. Finally, the East China Sea was identified as a hotspot for atmospheric DMS because the sea-to-air flux of DMS was approximately five times as many as the global average.

O-C4-09 Biogeochemical linkage between marine organic aerosols and surface seawater in the North Pacific: Sea-to-air transfer of dissolved organic carbon and nitrogen

Yuzo Miyazaki, Institute of Low Temperature Science, Hokkaido University
Presenter Email: yuzom@lowtem.hokudai.ac.jp

Ocean-derived atmospheric aerosols can affect radiative forcing via acting as cloud condensation nuclei and ice nuclei as well as affecting biogeochemical cycle of bioelements. Marine atmospheric aerosols largely consist of organic matter (OM)

associated with phytoplankton and dissolved organic matter in seawater. In recent years, much effort has been devoted to examining linkages between the chemistry of sea spray aerosols (SSAs) and the biological and chemical conditions of surface seawater (SSW). However, recent field studies have suggested that there are missing chemical and biological processes affecting marine aerosol production in current emission parameterizations, such as chemical/biochemical forms of OM associated with microbial activity in SSW.

We have investigated the chemical transformation organic carbon and organic nitrogen during the SSW-to-SSA transfer of OM based on the cruise measurements in the Pacific Ocean. Direct comparison of chemical characteristics between SSA and SSW measured by fluorescence spectroscopy in combination with stable carbon isotope analysis, demonstrated that the ratios of humic-like and protein-like substances in the SSAs were significantly larger than those in the bulk SSW. The results suggest significant decomposition of protein-like dissolved organic carbon (DOC) on a timescale of a half to one day and/or preferential production of humic-like substances in the atmospheric aerosols regardless of the particle size. Furthermore, comparison between organic aerosol mass and particulate organic carbon (POC) in SSW linked to the development/aging of diatom bloom indicates that the mass fraction of OM in submicrometer SSA is likely linked with aging of diatom bloom.

These studies provided unique insights into the complex transfer of biologically-derived OM from the ocean surface to the atmosphere. Brief overview of the research activities will be presented on the cruise measurements in the North Pacific with some major findings on biogeochemical linkage in the ocean-atmosphere interface via particulate OM.

O-C4-10 Composition of surfactants in sea-surface microlayer, sub-surface water and atmospheric aerosols in selected coastal areas in Peninsular Malaysia

Mohd Talib Latif, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
Royston Uning, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
Suhana Shaharom, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
Kai Ling Yu, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
Sze Yin Cheng, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
Mohd Talib Latif,
Presenter Email: talib@ukm.edu.my

This study aims to determine the concentrations of surfactants in the surface microlayer

(SML), subsurface water (SSW) and atmospheric aerosol at selected coastal areas in Peninsular Malaysia. The concentrations of anionic and cationic surfactants were determined through colorimetric methods as methylene blue active substances (MBAS) and disulphine blue active substances (DBAS), respectively. Water-soluble ions, for the determination of atmospheric aerosol sources, were determined using ion chromatography (IC) for anions (SO_4^{2-}, NO_3^-, Cl^- and F^-) and cations (Na^+, K^+, Ca^{2+} and Mg^{2+}). Principal component analysis (PCA), combined with multiple linear regression (MLR), was used to identify the possible sources of surfactants in aerosol. The results showed the concentrations of anionic surfactants as MBAS dominated the concentration of SML and SSW. The enrichment factors (Efs) ratios between MBAS and DBAS in the SML and SSW were more than 1. The station that is located near to tourism and industrial activities recorded the highest concentrations of surfactants in SML and SSW. Among potential sources of surfactants in aerosol were biomass burning, secondary inorganic aerosol and sea spray. This study suggests anthropogenic sources are main contributors to the concentrations of surfactants in SML, SSW and atmospheric aerosols.

O-C4-11 Modelling the effect of atmospheric deposition on phytoplankton growth during the on-board incubation experiments conducted in South China Sea

Qiang Chu, 1Key Laboratory of Marine Environment and Ecology, Ministry of Education; Ocean University of China, Qingdao, China
Huiwang Gao, 1Key Laboratory of Marine Environment and Ecology, Ministry of Education; Ocean University of China, Qingdao, China 2Laboratory for Marine Ecology and Environmental Sciences, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266071, China
Presenter Email: hwgao@ouc.edu.cn

In situ incubation experiment is a popular method in the study of impact of atmospheric deposition on marine ecosystem. However, it cannot be easily used to reveal the processes in the experiment. In this study a nutrient-phytoplankton-detritus biogeochemical box model (NPD model) was applied to to simulate the nutrient and phytoplankton dynamics during the onboard incubation experiments conducted in South China Sea. The NPD model is able to reproduce the chlorophyll and nutrient variation for most of the incubation experiments. The insufficient reduction in dissolved inorganic phosphorus (DIP) along with increasing of Chl a suggested a possible utilization of organic phosphorus (DOP) in this oligotrophic low-productivity sea area. For this purpose, we propose a DOP utilization scheme for the NPD model, which significantly improves the simulation ability of the model. This study provides a reference for the parameterization of organic nutrient utilization in the future ecological modelling research.

P-C4-12 Influence of biomass burning on marine aerosols over the South China Sea

Senchao Lai, South China University of Technology
Junwei Song, South China University of Technology
Yan Zhao, South China University of Technology
Yingyi Zhang, South China University of Technology
Pingqing Fu, Tianjin University
Presenter Email: sclai@scut.edu.cn

Atmospheric aerosols in the marine boundary layer play important roles in air quality and climate change from regional to global scale. The level and composition of marine aerosols are strongly influenced by marine production, secondary reactions and continental contribution via long-range transport. The South China Sea (SCS) is a marginal sea surrounded by fast-developing regions, leading to a rapid increase of pollutants from various sources such as power plants, industrial sources, and biomass burning etc.. Here we present the results of our observation on atmospheric aerosols over the SCS. During the sampling campaigns, total suspended particle samples were collected and various techniques were applied for chemical characterization. Chemical components including water-soluble ions (WSI), organic carbon (OC), elemental carbon (EC), organic species and stable carbon isotope ratios ($\delta^{13}C_{TC}$) were measured. The results suggest that biomass burning had strong influence on the enhancements of organic pollutants over the SCS. This finding is supported by the concurrent elevations of biomass burning tracers and organic aerosols, values of stable carbon isotope ratios as well as the analysis of back-trajectories and satellite fire spots. Moreover, the connection between biomass burning and chloride depletion was also observed and will be discussed in this contribution.

O-C4-13 The Significant Relationship between Isoprene and Monoterpenes Sea-to-air fluxes at the Tropical Air-sea Interface

Royston Uning, The National University of Malaysia
Mohd Talib Latif, The National University of Malaysia
Haris Hafizal Abd Hamid, The National University of Malaysia
MD Firoz Khan, The National University of Malaysia
Mohd Shahrul Mohd Nadzir, The National University of Malaysia
Suhaimi Suratman, Universiti Malaysia Terengganu
Presenter Email: uningroyston@gmail.com

Photochemistry of the sea surface microlayer (SML) as the air-sea interface releases biogenic volatile organic compounds (BVOCs), which affects the atmospheric chemistry, predominantly by forming tropospheric ozone (O_3), modifying the oxidative capacity of the atmosphere, and contributing to secondary organic aerosol (SOA). To date, however, there is limited understanding of BVOCs sea-to-air fluxes at the air-sea interface level and next

to no substantial data to be represented in the marine and atmospheric numerical models. In this study, we aim to determine BVOCs: isoprene and monoterpenes (α-pinene, β-pinene and limonene) sea-to-air fluxes at the tropical air-sea interface off the east coast of Malaysian Peninsula in the Southern China Sea. Sea-to-air fluxes were measured using a newly developed, tested and optimised technique consist of a floating flux chamber coupled with sorbent tubes. BVOCs emitted from the air-sea interface was trapped in the floating chamber and sampled into sorbent tubes before analysed using thermal desorption coupled with gas chromatography mass spectrometry (TD-GCMS) in the laboratory. This study shows mean sea-to-air fluxes of isoprene was 19.8 ± 7.3 $*10^7$ molecules cm^{-2} s^{-1} while monoterpenes (α-pinene, β-pinene, limonene) 3.6 ±2.6 $*10^7$, 5.6 ± 2.9 $*10^7$, 1.9 ± 0.9 $*10^7$ molecules cm^{-2} s^{-1} , respectively. The fraction of total BVOCs sea-to-air fluxes at the air-sea interface shows isoprene accounted for 64 %, which is higher compared to monoterpenes 36 % (α-pinene 12 %, β-pinene 18 %, limonene 6 %) (P-value = 0.0002). More importantly, this study observed strong and significant correlation between isoprene and monoterpenes sea-to-air fluxes at the air-sea interface (R^2 = 0.54, P-value = 0.0003). The measurement of BVOCs sea-to-air fluxes at the air-sea interface is expected to improve the estimation of the ocean fluxes.

O-C4-14 Short-term dynamics of sea surface pCO2 in a large subtropical estuary system

Yangyang Zhao, State Key Laboratory of Marine Environmental Science, Xiamen University
Yi Xu, State Key Laboratory of Marine Environmental Science, Xiamen University
Xianghui Guo, State Key Laboratory of Marine Environmental Science, Xiamen University
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: yyzhao@stu.xmu.edu.cn

The constraint of air-sea CO_2 fluxes and their variability in coastal oceans at different timescales and spatial scales is at the base of the controversy concerning their role in the global carbon cycle. The lack of high-resolution sampling of the partial pressure of CO_2 (pCO_2) would largely underestimate monthly air-sea CO_2 fluxes, even reverse the direction of the fluxes at annual level. However, mechanistic understanding towards the diurnal to weekly dynamics of pCO_2 remains challenging due to the complicated interaction of biogeochemical and physical forcings in coastal waters. Here we examined the short-term variability of sea surface pCO_2 recorded by a Battelle Seaology pCO_2 Monitor amounted on a buoy located in the outer Pearl River estuary, a large subtropical estuary system in the northern South China Sea, from July 2 to August 11, 2015. Surface seawater pCO_2 was highly variable, ranging from 78 to 640 µatm with an average of 279 µatm, mostly ~100 µatm lower than the atmospheric pCO_2. On diel timescales, pCO2 changes of ~40-100 µatm occurred in response to diurnal primary production and respiration; temperature and

tidal effects played a minor role. Over longer timescales, pCO_2 was influenced by atmospheric forcing, physical advection and biological metabolism. For example, a surface cooling of ~3 °C and increase in pCO_2 of ~110 μatm occurred after Typhoon Linfa passed near Hong Kong on July 9, 2015. The increase in pCO_2 probably resulted from enhanced upward mixing of high-salinity, rich-inorganic carbon subsurface water. Subsequently, intense plume due to typhoon-induced strong freshwater discharge, coupled with elevated biological productivity, reduced pCO_2 back to the pre-typhoon level. Overall, freshwater inputs, wind-driven upwelling and biological processes were the main drivers of short-term variability of pCO_2 in the subtropical estuary, in contrast to temperate coastal ecosystems mostly subject to the thermal and tidal effects. Net fluxes of CO_2 for the observation period (-4.8 mmol CO_2 m^{-2} d^{-1}) were directed from atmosphere to ocean, but with a wide range from ~-30 to +20 mmol CO_2 m^{-2} d^{-1} depending largely on wind speed. We also found that gas exchange direction between the air-sea interface was closely related to wind direction when strong wind events occurred. Therefore, careful consideration of the short-term variability of surface seawater pCO_2 and wind regime was needed to accurately estimate air-sea CO_2 fluxes in the subtropical estuary system.

O-B1-01 In situ HAB observations with biosensors: a decade of challenges, accomplishments, and insights

Donald M. Anderson, Biology Department, Woods Hole Oceanographic Institution
Michale L. Brosnahan, Biology Department, Woods Hole Oceanographic Institution
Bruce A. Keafer, Biology Department, Woods Hole Oceanographic Institution
Presenter Email: danderson@whoi.edu

The dinoflagellate *Alexandrium catenella* (=A. fundyense) and diatoms in the genus Pseudo-nitzschia cause frequent harvesting closures of shellfish resources in the Gulf of Maine region of the U.S. due to the threat of paralytic shellfish poisoning (PSP) and amnesic shellfish poisoning (ASP). Blooms can be widespread, covering hundreds of km of coastline, or localized in small embayments and estuaries. In recent years, our studies of harmful algal bloom (HAB) dynamics in both of these systems have incorporated two novel biosensors – the Environmental Sample Processor (ESP) and the Imaging FlowCytobot (IFCB). The ESP uses molecular assays to detect and analyze cells and toxins whereas the IFCB is an automated underwater microscope. Each has presented logistical challenges of different types, requiring new mooring and platform designs, communication protocols, and deployment strategies. This talk will review a decade of deployments, highlighting how these instruments have augmented HAB research in the two hydrographic systems over multiple bloom seasons, emphasizing the unique nature of the data each sensor can provide, correlations with other data such as shellfish toxicity measurements, as well as the engineering and scientific obstacles that were overcome. These studies have taught us that previous laboratory studies produced surprisingly bad estimates of rates and

behaviors that are fundamental to predicting bloom dynamics, suggesting that our ability to understand and forecast HABs requires characterization of critical rates and behavioral patterns in natural populations, generated, whenever possible, through in situ observations. Furthermore, given the temporal and spatial patchiness of HABs, we need higher-level strategies that can place sensors where the cells are, rather than putting the instruments in fixed locations, hoping that the HABs will come to us. Mobile and portable platforms, particularly those that enable adaptive, targeted sampling for addressing temporal as well as spatial patchiness, offer great promise for characterizing the evolution of populations through time, and several of these will be described here. In situ sensors can play a major role in HAB research and monitoring, but approaches need to be strategic and flexible in order to meet the challenges posed by highly dynamic blooms.

O-B1-02 The biology and ecology of typical marine parasitic dinoflagellates

Caiwen Li, Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences,
Meng Li, Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences,
Tiantian Chen, Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences,
Shuqun Song, Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences,
Yun Liu,
Presenter Email: cwli@qdio.ac.cn

Parasitic dinoflagellate represents a broad class of dinoflagellates living and proliferating inside hosts of phytoplankton, crustacean, ciliates etc., and they are widely distributed throughout eutrophic coastal waters as well as in oligotrophic oceanic waters. Parasitic dinofalgellates are important components of marine food webs, and their ecological significances have been gradually recognized in latest years by researchers around the world. Among these parasitic dinoflagelllates, the extracellular parasitic dinoflagellate Hematodinium had severely impacted various stocks of commercial valuable crustacean fisheries worldwidely. While, the intracellular parasitic dinoflagellate Amoebophrya can infect specific types of bloom-forming marine dinoflagellates, and plays a top-down control role to their host populations. Lately, these two types of parasitic dinoflagellates have been identified and reported along the coastal lines of China. However, very limited studies had been conducted on parasitic dinoflagellates, with a few limited to the molecular detections and identification of parasitic dinoflagellates, nevertheless the ecological significance of parasitic dinoflagellates in marine ecosystem. Over the last few years, my group studied the distribution and genetic diversity of Amoebophrya in the coastal waters of China through large-scale ecological survey. A typical strain of the parasites was isolated and

cultured in laboratory, its infectivity and effect to host dinoflagellates was further investigated to assess the impacts of Amoebophrya infections during dinoflagellate blooms. We also investigated the life cycle of Hematodinium infecting the Chinese Swimming crab Portunus trituberculatus. Its epidemiology, pathogenic and transmission mechanism, and host-parasite interaction were comprehensively studied. Our results manifested the ecological significance of parasitic dinoflagellates in controlling the population of host organisms, and promote the fundamental understanding on the parasitic life style of marine dinoflagellates.

O-B1-03 Ecosystem state change in the Arabian Sea linked to shrinking snow caps of the Himalayan-Tibetan Plateau

Joaquim I. Goes, Lamont Doherty Earth Observatory at Columbia University, Palisades, New York
Hongzhen Tian, Tianjin Polytechnic University, Tianjin, P.R. China
Helga do Rosario Gomes, Lamont Doherty Earth Observatory at Columbia University, Palisades, New York
Xiaojian Jiang, Huaiyin Normal University, Jiangsu, 223300, China
Hao Luo, Xiamen University, Xiamen, China
Khalid Al-Hashimi, Sultan Qaboos University, Al-Khod, Sultanate of Oman
Presenter Email: jig@ldeo.xolumbia.edu

The recent trend of global warming has exerted a disproportionately strong influence on the Eurasian land surface causing a steady decline in winter snow cover extent over the Himalayan-Tibetan Plateau region. Here we show that this loss of snow is undermining convective mixing responsible for nutrient enrichment of diatom blooms during the boreal winter component of the monsoonal cycle in the Arabian Sea and is instead, fostering an ecosystem state change which is fueling the rapid range expansion of *Noctiluca scintillans* blooms. Since their advent in early 2000s, Noctiluca blooms have become increasingly more pervasive and widespread during winter, superseding the basin-wide biomass of autotrophic phytoplankton during the more productive summer upwelling season. Although Noctiluca blooms are non-toxic, they can cause fish mortality by exacerbating seawater oxygen deficiency and ammonification of seawater. Noctiluca are not a preferred food for zooplankton and therefore their continued range expansion represents a significant and growing threat for regional fisheries and the welfare of coastal communities bordering the Arabian Sea.

O-B1-04 Toxic and allelopathic effects of *Alexandrium leei*

(Dinophyceae) tested with zooplankton (Rotifer and *Artemia*), fish (*Oryzias melastigma*) and phytoplankton (*Akashiwo sanguinea*)

Li-Xia Shang, Institute of Oceanology, Chinese Academy of Sciences
Yang-Bing Xu, Fisheries College, Ocean University of China
Danielle Saunders,
Zhang-Xi Hu, Institute of Oceanology, Chinese Academy of Sciences
Po Teen Lim, University of Malaya
Chui Pin Liaw, University of Malaya
Ying-Zhong Tang, Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: lxshang@qd.ac.cn

Many dinoflagellates form harmful algal blooms and produce phytotoxins, which may cause massive losses in aquaculture and fisheies, serious deleterious impacts on ecosystems, tourism and recreational activities, and even human illness. The genus Alexandrium is well known for including many species that produce paralytic shellfish toxins (PST) and these toxins have sometimes been implicated in association with fish killing. Non-PST based ichthyotoxicity has also been reported from PST-producing species as well as from A. monilatum, a non-PST producing species. *Alexandrium leei*, with a distribution spanning the tropical waters of South East Asia to the temperate waters of North East Asia, has been reported to be non-toxic, containing low level of PST for a Vietnamese strain, but highly toxic to fingerlings for a Singapore strain. This study reports the toxic and allelopathic effects of a strain of A. leei isolated from Malaysia on zooplankton (Rotifer and *Artemia*), fish (*Oryzias melastigma*) and phytoplankton (*Akashiwo sanguinea*), as well as the potential mechanisms of the toxicity and allelopathy. The toxicity of A. leei was dependent on target animals (size), as the most and least potent toxicity was observed in Rotifer and fish bioassays. The initial culture of A. leei exhibited to be dramatically more potent in toxicity (per cell) than did the equivalent doses of intracellular (extracted by f/2 medium after ultrasonic disruption) and extracellular (cell-free culture medium) fractions. The toxic activity of A. leei (3000 cells/mL) also depended on the growth stages of culture, with the culture at stationary growth stage being more potent than that of the cultures at early and late-exponential phases, while the minimum mortalities of Rotifer were observed when exposed to the culture at late-exponential phase for both the extracellular and intracellular fractions. Survivals of animals exposed to cultures and cell-free culture medium were significantly decreased with the increase of A. leei cell density up to 3000 cells/mL. The toxicity of initial culture, cell-free culture medium, and the intracellular fraction were all dependent on cell density in a manner of linear relationship between the mortality of animals and the logarithm of cell density. The allelopathic effects of A. leei culture on the target *Akashiwo sanguinea* included loss of motility, deformation of cell morphology and cell mortality at higher dosage. These results together indicate that the Malaysia isolate of A. leei has potent toxicity to zooplankton, fish and allelopathy to other

microalgae, which may pose threat to aquaculture industry and fisheries.

O-B1-05 Fish Kill Events in Singapore Coastal Waters

Sandric Chee Yew Leong, St. John's Island National Marine Laboratory, Tropical Marine Science Institute, National University of Singapore

Presenter Email: tmslcy@nus.edu.sg

Southeast Asia (SEA) coastal environments are increasingly affected by regular harmful algal blooms (HABs). In Singapore, several HABs have caused massive fish kills and great economical losses. During early 2015, two major dinoflagellate blooms occurred along the north-eastern coast of Singapore and wiped out both farmed fish and wild fish. In 2016, a prolong dinoflagellate bloom of more than three months was observed. The increase in frequencies of HABs have led to enhanced interests in monitoring and detecting of such blooms. To better protect coastal economies and human health, improved HABs monitoring and prediction are necessary. Currently, there is an array of tools ranging from autonomous vehicles, portable instruments, optical sensors to remote sensing platforms that could be utilized for generating high-resolution data. These advanced technologies and tools are contributing to new and high-resolution data, which could be incorporated in models for predicting and forecasting bloom events. In the present study, an integrated approach involving laboratory analysis, advanced technique and tools was utilized to study and monitor HABs. High-resolution surface maps of blooms were generated using the measurements collected from an autonomous surface vehicle (ASV). Distinct biological and environmental patterns were observed from the ASV measurements. Portable molecular instruments were used and tested for detecting a targeted toxic dinoflagellate. We have successfully used real-time PCR method to detect dinoflagellate *Karenia mikimotoi* in the field. Nutrient supply was relatively high during the bloom period. In Singapore setting, blooms were generally formed during the neap tide and under favorable physical settings. The eutrophic conditions could be the driving force for bloom to be sustained along Johor Strait. Moreover, the variability of phytoplankton abundance in this area was significantly driven by nutrient and rainfall.

O-B1-06 Metatranscriptomic signatures associated with regime shift from diatom dominance to a dinoflagellate bloom

Yaqun Zhang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China

Xin Lin, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China

Xinguo Shi, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China;b. College of Biological Science and Engineering, Fuzhou University, Fuzhou, 350108, China

Lingxiao Lin, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Hao Luo, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Ling Li, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Senjie Lin, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China;Department of Marine Sciences, University of Connecticut, Groton, CT 06340, USA
Presenter Email: yaqunzhang@xmu.edu.cn

Diatoms and dinoflagellates dominate coastal marine phytoplankton communities as major players of marine biogeochemical cycles and their seasonal succession often leads to harmful algal blooms (HABs). What regulates their respective dominances and the development of the HABs remains elusive. Here we conducted time-sequential metatranscriptome profiling on a natural assemblage that evolved from diatom dominance to a dinoflagellate bloom to interrogate the underlying major metabolic and ecological drivers. Data reveals similarity between diatoms and dinoflagellates in exhibiting high capacities of energy production, nutrient acquisition, and stress protection in their respective dominance stages. The diatom-to-dinoflagellate succession coincided with sharp declines in silicate and phosphate availability, concomitant with the transcriptomic shift from expression of silicate uptake and urea utilization genes in diatoms to that of genes for diversified phosphorus acquisition and autophagy-based internal nutrient recycling in dinoflagellates. Furthermore, the diatom-dominant community featured strong potential toof carbohydrate metabolism and a strikingly high expression of trypsin potentially promoting frustule building. In contrast, the dinoflagellate bloom featured elevated expression of xanthorhodopsin, and antimicrobial defensin genes, indicating potential importance of energy harnessing and microbial defense in bloom development. This study sheds light on mechanisms potentially governing diatom- and dinoflagellate-dominance and regulating bloom development in the natural environment and raises new questions to be addressed in future studies.

O-B1-07 Population genetic structure of domoic acid producing diatom *Nitzschia navis-varingica* (Bacillariophyceae) in the Western Pacific region

Suh Nih Tan, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya
Chui Pin Leaw, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya
Haifeng Gu, Third Institute of Oceanography, Xiamen
Changping Chen, School of Life Sciences, Xiamen University

Yuichi Kotaki, School of Marine Biosciences, Kitasato University
Yahui Gao, School of Life Sciences, Xiamen University
Chunlei Gao, Research Center of Marine Ecology, First Institute of Oceanography, Qingdao
Hong Chang Lim, Tunku Abdul Rahman University College
Sing Tung Teng, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak
Po Teen Lim, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya
Presenter Email: danielle_tsn0421@hotmail.com

Nitzschia navis-varingica is a pennate diatom that widely distributed in the Western Pacific region. This species, like some species of Pseudo-nitzschia, produces domoic acid (DA) and the isomers. While DA is known to be responsible for Amnesic Shellfish Poisoning (ASP) by Pseudo-nitzschia in marine mammals and humans, no poisoning cases have been related to N. navis-varingica thus far. Previous studies have demonstrated wide distributions of N. navis-varingica in the tropical and subtropical mangrove areas of Western Pacific. However, genetic relationships among the populations throughout this large geographic locality have not been assessed. In this study, a total of 322 strains of N. navis-varingica were isolated and identified based on the frustule morphology by electron microscopy and genetic characterization of the nuclear large subunit ribosomal gene (LSU rDNA). The LSU rDNA data set revealed high sequence homogeneity among all strains examined (0 to 0.9%). To understand the population dynamics of N. navis-varingica in the Western Pacific region, genetic diversity of N. navis-varingica was investigated using the ITS2 rDNA marker. The ITS2 phylogenetic inferences identified eight distinct clades, with high sequence heterogeneity ranging from 0.5 to 9.7%; analysis of haplotype diversity recovered 44 haplotypes. Our results showed strong gene flow among N. navis-varingica populations in the Western Pacific region (AMOVA, total percentage of variation = 0.48095). However, isolates from Vietnam and Japan formed a distinct haplotype H3 (FST, 0.4 to 1.00) suggesting possible genetic structuring between the water bodies of northwestern Pacific and the South China Sea (SCS). It is speculated that ocean current circulations (e.g. SCS currents and Kuroshiro current) may play a role in this allopatric differentiation of N. navis-varingica. Keywords: N. navis-varingica; DA; LSU rDNA; ITS2 rDNA; Population structure

O-B1-08 The effect of increasing temperature and acidification on the growth and competitive success of toxic *Alexandrium catenella* from the Gulf of Maine

Drajad Seto, School of Marine Sciences, University of Maine, Orono, ME 04469 USA
Lee Karp-Boss, School of Marine Sciences, University of Maine, Orono, ME 04469 USA
Mark L. Wells, School of Marine Sciences, University of Maine, Orono, ME 04469 USA
Presenter Email: mlwells@maine.edu
Climate driven increases in ocean temperature and pCO2 are projected to affect the growth and prevalence of Harmful Algal Blooms (HABs), but there has been little systematic study of how these climate drivers affect HAB organisms within the context of their coastal plankton assemblages. We tested the individual and combined effects of increased temperature and acidification on the growth of the dinoflagellate *Alexandrium catenella*, the organism responsible for paralytic shellfish poisoning in the Gulf of Maine, both in monocultures and mixed cultures containing non-toxic dinoflagellates. Our findings show that *Alexandrium catenella*, isolated from mid-coastal waters off the Maine coast, had significantly lower growth rates when temperature was increased from 15 degree C, near present day levels, to 20 degree C. In contrast, the mono-culture growth rates of two other dinoflagellates, Scrippsiella sp. and Amphidinium carterae often observed to co-occur with A. catenella in Gulf of Maine waters, increased significantly at the higher temperature. By comparison, increasing ocean acidification (pH 8.1 to pH 7.8) had no measureable influence on the growth rates of these three species under either ambient or elevated temperatures. This pattern of growth responses with changing temperature and pH were unchanged when A. catenella was grown in mixed cultures with either Scrippsiella sp. or Amphidinium carterae, indicating that allelopathic or other interacting effects were not important under the experimental conditions. However, the negative response of A. catenella to increased temperature in our amended natural seawater medium was more muted when seawater collected in late spring was used in media preparation than with seawater collected in late-summer and fall, suggesting that differences in micronutrients or organic constituents might modify the response of A. catenella to these climate drivers. Overall, our findings suggest that A. catenella will become less competitive against other dinoflagellates as coastal seawater temperatures increase, perhaps leading to less intense and frequent toxic HABs in the Gulf of Maine in the coming decades. A. catenella is a globally distributed toxic species that may exhibit significant strain variability. Future studies should address how broadly the findings here are valid for A. catenella strains in other temperate and tropical waters.

O-B1-09 Molecular mechanisms of temperature acclimation and adaptation in marine diatoms

Yue Liang, Department of Mathematics and Computer Science, Mount Allison University,

Sackville, New Brunswick, Canada
Julie A. Koester, Department of Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC, USA
Justin D. Liefer, Environmental Science Program, Mount Allison University, Sackville, New Brunswick, Canada
Andrew J. Irwin, Department of Mathematics and Computer Science, Mount Allison University, Sackville, New Brunswick, Canada
Zoe V. Finkel, Environmental Science Program, Mount Allison University, Sackville, New Brunswick, Canada
Presenter Email: yliang@mta.ca

Ocean temperatures are projected to increase over the coming century, with dramatic consequences for the marine biosphere. However, we lack the information necessary to predict how primary producers, such as the diatoms, are likely to acclimate and adapt to changes in temperature anticipated over the next centuries. Diatoms are important contributors to marine primary production and the ocean carbon cycle. Here we grew two strains of Chaetoceros sp. that had been isolated from different regions of the oceans with different average temperature to three experimental temperatures: their optimum temperature for growth and a cooler and warmer temperature that corresponded to approximately half their maximum growth rate. We extracted RNA once the strains had been acclimated to temperature for a minimum of 10 generations and analyzed the transcriptome-wide response to temperature using RNAseq. Low translational efficiency, slow protein turnover, decreased membrane fluidity, and excessive ATP, NADPH and acetyl-CoA are the main physiological challenges at colder temperatures, while high translation efficiency versus relatively slower protein processing in the ER, heat-induced protein misfolding and aggregation, and insufficient energy and metabolites for high growth rate are the main challenges for success at warmer temperature. Our results indicate that diatoms have adapted to different optimal growth temperatures through transcriptional frontloading (elevated baseline expression level) or divestment (lowered baseline expression level) of genes and pathways that maintain metabolic, redox and energetic homeostasis in the face of temperature-induced shifts in the ratio of photosynthesis and biosynthetic demand under their respective optimal growth temperatures. As a result of evolutionary change in gene expression, the colder- and warmer-adapted species have largely different transcriptional responses to growth under sub- and supra-optimal temperature. In aggregate these results suggest that short-term acclimation to temperature will species-specific, shaped by evolutionary history. Projecting phytoplankton responses to century-scale climate change should take the species-specific evolutionary history into account.

O-B1-10 Ocean acidification and nutrient limitation synergistically reduce growth

and photosynthetic performances of a green tide alga *Ulva linza*

Guang Gao, State Key Laboratory of Marine Environmental Science, Xiamen University
John Beardall, School of Biological Sciences, Monash University
Menglin Bao, Jiangsu Key Laboratory for Coastal Resources and Eco-environment, Huaihai Institute of Technology
Can Wang, Jiangsu Key Laboratory for Coastal Resources and Eco-environment, Huaihai Institute of Technology
Wangwang Ren, Jiangsu Key Laboratory for Coastal Resources and Eco-environment, Huaihai Institute of Technology
Juntian Xu, Jiangsu Key Laboratory for Coastal Resources and Eco-environment, Huaihai Institute of Technology
Presenter Email: biogaoguang@126.com

Large-scale green tides have been invading the coastal zones of the western Yellow Sea annually since 2008. Eutrophication is deemed to be the first cause that drives green tides. Meanwhile, oceans are becoming more acidic due to continuous absorption of anthropogenic carbon dioxide, However, little is known about the combined effects of nutrient and ocean acidification on the eco-physiology of green tide algae. We cultured *Ulva linza* for 9-16 days under two levels of pCO2 (400 and 1000 μatm) and four treatments of nutrients (nutrient repletion, N limitation, P limitation, and N-P limitation) to investigate the physiological responses of this green tide alga to the combination of ocean acidification and nutrient limitation. For both sporelings and adult plants, elevated pCO2 did not affect the growth rate when cultured under nutrient-replete conditions but reduced it under P limitation; N or P limitations by themselves reduced growth rate. P limitation resulted in a larger inhibition in growth for sporelings compared to adult plants. Sporelings under P limitation did not reach the mature stage after 16 days of culture while those under P repletion became mature by day 11. Elevated pCO2 reduced net photosynthetic rate for all nutrient treatments but increased nitrate reductase activity and soluble protein content under P-replete conditions. N or P limitation reduced nitrate reductase activity and soluble protein content. These findings indicate that ocean acidification and nutrient limitation would synergistically reduce the growth of Ulva species and may thus hinder the occurrence of green tides in a future ocean environment.

O-B1-11 Cyanate Utilization and Identification of Cyanase Gene in Toxic Dinoflagellate *Alexandrium pacificum*

Xuewei Mao, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100, China

Yunyun Zhuang, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100, China
Huan Zhang, Department of Marine Science, University of Connecticut, Groton, CT 06340, USA
Guangxing Liu, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100, China
Presenter Email: maoxuewei_ouc@163.com

Cyanate is a potential nitrogen source in marine environment, which is the by-product of urea decomposition. The acquisition and utilization of cyanate have been characterized in cyanobacteria, but remain elusive in eukaryotic phytoplankton. In this study, we integrated the physiological and transcriptional data to explore the cyanate utilization in a toxic dinoflagellate *Alexandrium pacificum*, a HABs causative species. We monitored the growth, photosystem II Fv/Fm and cell diameter of A. pacificum grown on five concentrations of cyanate, nitrate and under N-depleted condition. At the concentration of 50, 100 and 200μM, cyanate promoted the growth of A. pacificum, while at the concentration of 400 and 800 μM, cyanate significantly depressed growth and caused irreversible damage to the cells. No significant difference was detected between the growth rate, Fv/Fm, cell diameter of cyanate- and nitrate-grown cells at the concentration of 100μM N during the early logarithmic phase. Transcriptome profiling revealed a gene encoding cyanase in A. pacificum (ApcynS), the enzyme hydrolyzes cyanate to ammonium and CO2. We isolated the full-length cDNA of ApcynS (653bp). The deduced protein was 173 amino acids with a predicted molecular mass of 18.7 kDa, which is in the range of most documented cyanase. By screening the existing datasets, we found cyanase-encoding genes in a variety of eukaryotic phytoplankton and phylogenetic analyses support the transfer of cynS between cyanobacteria and dinoflagellates. However, unlike that in cyanobacteria, the expression of ApcynS was not regulated by N sources. Transcriptome profiling also revealed that cyanate induced the up-regulation of several ATP-binding cassette transporters, potentially related to cyanate uptake or permeation. Our results showed that the growth of A. pacificum could be supported by cyanate as the sole source of external N, which might provide competitive advantage for this species in HABs formation and maintenance.

O-B1-12 Uncovering links between sediment and stoichiometry of nitrogen and phosphorus in water and its role in triggering red tide.

Yiyong Zhou, Chunlei Song Xiuyun Cao
Presenter Email: zhouyy@ihb.ac.cn

Red tide is one of the most serious environmental problems worldwide,however, the key

factor driving occurrence of red tides remains unclear. In particular, roles of nutrition, such as nitrogen (N) and phosphorus (P), in triggering red tide are inadequately studied. Xiamen bay and Pingtan area of Fujian coast in China sea was chosen as study regions. Phytoplankton community, concentrations of N and P with different forms and extracellular alkaline phosphatase activities (APA) were analyzed. In the same time, occurrence of extracellular alkaline phosphatase on cell membrane of phytoplankton was detected using enzyme labelled fluorescence(ELF) technique. Additionally, P fractionation and its sorption behaviors were also studied in sediment, together with potential denitrifying activity (PDA). Emphasis was placed on the impact of stoichiometry of N and P on algal growth in relation to couplings between their biogeochemical cyclings in sediment. N appears less representative of a key element limiting algal growth compared to P, as illustrated by a significantly positive relationship between concentrations of chlorophyll-a (chl a) and total P (TP) rather than any N species. P limitation was strengthened by a significantly negative relationship between APA and concentration of soluble reactive phosphorus (SRP). In addition, from the perspective of stoichiometry, N enrichment would further aggravate the deficiency of P. Thus, there existed a significantly positive relationship between APA and rations of N to P (N/P) such as ammonium nitrogen(NH4+-N) to SRP and dissolved inorganic nitrogen (DIN) to SRP. Spatially, the Xiamen bay had significantly higher concentrations of SRP, TP and dissolved TP(DTP) relative to those in Pingtan area that gave a significantly higher concentrations of total N (TN). In parallel, N/P (TN/TP and DTN/DTP) were significantly higher in Pingtan area, where APA was higher and ELF labeling was given by diverse algal species including Prorocentrum sp, a typical red tide causing species, whose density was significantly higher there. Contrastingly, far less ELF labeling was observed in the Xiamen bay. Moreover, trophic states of water were strongly dependent on biogeochemical cyclings of N and P in sediment. In details, iron bond phosphorus in sediment was significantly and positively relative to TP concentration, and negatively relative to TN/TP in water. What is more, it gave a linear increase in the PDA of sediment. Noticeably, comparing to the Xiamen bay, the Pingtan area had significantly lower PDA and equilibrium phosphorus concentration (EPC0) that indicates higher P retention capacity in the sediment. Higher P retention yielded less upward P flux and adversely affected denitrification and nitrogen removal. As a consequence, N concentration increased greatly coupled with a decreased P concentration in terms of higher N/P in water, which exacerbated the negative impact of low P availability to phytoplankton, thereby inducing alkaline phosphatase and triggering blooms of the phytoplankton species with the strong ability to utilize organic P by means of enzymatic hydrolysis.

O-B1-13 Intragenomic polymorphism of ribosomal DNAs in *Gambierdiscus* (Dinophyceae) and its implications in molecular species delineation

Chui Pin Leaw, Bachok Marine Research Station, Institute of Ocean and Earth Sciences,

University of Malaya, Bachok, Malaysia
Hong Chang Lim, Faculty of Applied Sciences, Tunku Abdul Rahman University College, Johor, Malaysia
Haifeng Gu, Third Institute of Oceanography, Xiamen, China
Leo Lai Chan, State Key Laboratory in Marine Pollution, City University of Hong Kong, China
Chung-Kuang Lu, National Research Institute of Chinese Medicine, Ministry of Health and Welfare, Beitou District, Taipei 1121, Taiwan
Douding Lu, Shenzhen Key Laboratory in Sustainable Use of Marine Biodiversity, Research Centre for the Oceans and Human Health, City University of Hong Kong, Shenzhen, China
Matthias Wolf, Department of Bioinformatics, Biocenter, University of Wuerzburg, 97074 Wuerzburg, Germany
R Wayne Litaker, National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science, Beaufort Laboratory, Beaufort, NC 28516, USA
Patricia A Tester, Ocean Tester LLC, 381 Gillikin Road, Beaufort, NC 28516, USA
Po Teen Lim, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, Bachok, Malaysia
Presenter Email: cpleaw@um.edu.my

Recent molecular phylogenetic studies of the benthic harmful dinoflagellate *Gambierdiscus* flagged several new species and genotypes, leading to revitalizing its systematics. The phylogenetic analyses revealed by the primary sequence information of nuclear-encoded ribosomal RNA genes (nrDNA), however, can sometimes be equivocal, as nrDNA intragenomic sequence heterogeneity can be problematic for phylogenetic reconstruction and lead to ambiguous identity. In this study, we explored the extent of rDNA intragenomic variability in the regions of small and large subunits (18S and 28S) of representative species of *Gambierdiscus* and to determine if the variability obscures species boundaries. Gene amplification of 18S and 28S rDNA was performed on the genomic DNA extracted from clonal cultures of *Gambierdiscus*, and sequence variability determined using standard cloning and Sanger sequencing. Our results revealed intraspecific and intragenomic polymorphism in all *Gambierdiscus* species tested with numerous variants discovered (nucleotide divergence: SSU, <2.4%; LSU, <3.6%). The SSU rDNA phylogenetic inferences incorporating the sequence-structure information generally supported the species monophyly, but the rDNA genotypes in most of the culture strains within species were unresolved. It is thus crucial to examine as many strains/populations as possible and to assess multiple gene markers to avoid misleading inferences for species boundaries in *Gambierdiscus*.

O-B1-14 Insights into the Multiple Roles of Programmed Cell Death Markers at

Different Growth Stages and Diel Cycle in Toxic Dinoflagellate *Karenia brevis*

Yida Gao, The University of Texas at Austin
Deana Erdner, The University of Texas at Austin
Presenter Email: yida.gao@utexas.edu

Historically, marine phytoplankton were presumed to replicate indefinitely by binary fission. However, drastic changes in environmental conditions have been shown to induce Programmed Cell Death (PCD) in algal cells, and may greatly affect development of phytoplankton populations. The Gulf of Mexico (GoM), a vast region with extensive shellfish resources, is subject to frequent toxic blooms of the dinoflagellate *Karenia brevis*. Although the formation process of K. brevis blooms have been extensively investigated, mechanisms of bloom decline and termination are not well known. Here we used established PCD markers, such as reactive oxygen species (ROS) and caspase-like activity, to define stress-related death processes at different growth stages in K. brevis under oxidative stress, and elucidate the variation of PCD markers in a diel cycle under controlled environment. ROS and caspase activity were found associated with the death process of K. brevis. Similar stress responses were observed at different growth stages, even though vulnerability to oxidative stress increased as the culture ages. In untreated cells, however, percentages of ROS and caspase fluctuated strongly, but did not correlate with cell death, which may indicate variable ROS scavenging process and quiescence preparation. The prevalence of ROS increased significantly in night phase, and could result from the activities of mitochondria generating energy for cell division at night. Our research revealed the multiple roles of PCD markers in K. brevis, highlighting the need of using cell cycle patterns to understand cellular stress responses.

O-B2-01 The utility of data closure in quality control and investigation of optical data

Emmanuel Boss, University of Maine
Presenter Email: emmanuel.boss@maine.edu

Optical (e.g. backscattering, chlorophyll fluorescence, beam-attenuation), physical (temperature, depth, salinity) and biogeochemical properties (e.g. POC, TSM, Size distributions, chlorophyll) in the ocean are not independent from each other. Hence, looking at multiple properties as well as their change in times provide for opportunities to QA/QC of data as well as to assess if anomalous conditions are occurring in the data we are investigating (which, if all sensors are working, can provide for new scientific insights). In this talk, I will provide several examples of such inter-comparisons and their utility to assess data quality as well as constrain observed processes. Example from ocean buoy time-series, data obtained with in-line systems and BGC-Argo profiling-floats will be used to illustrate the procedures associated with performing closure.

O-B2-02 The changing perspective of phytoplankton dynamics thanks to profiling floats.

Emmanuel Boss, University of Maine
Presenter Email: emmanuel.boss@maine.edu

Float equipped with optical sensors have different time-space sampling characteristics compared to satellites and cruise-based observations of phytoplankton. As a result, our understanding of phytoplankton annual cycles and the contrasting dynamics of chlorophyll and biomass are changing. Through several case studies I will illustrate how observations with profiling floats have changed our understanding of phytoplankton dynamics.

O-B2-03 Seasonal cycles of optical properties at the Australian Integrated Marine Observing System Southern Ocean Time Series

Christina Schallenberg, Antarctic Climate and Ecosystems CRC, University of Tasmania
James Harley, Antarctic Climate and Ecosystems CRC
Peter Jansen, Antarctic Climate and Ecosystems CRC
Diana M. Davies, Antarctic Climate and Ecosystems CRC
Thomas W. Trull, CSIRO Oceans and Atmosphere
Presenter Email: Tom.Trull@utas.edu.au

Seasonal biomass cycles provide insight into the importance of physical versus ecological controls of ocean productivity and export, and potential responses to climate change. The Southern Ocean Time Series is a set of moorings serviced annually that observes these dynamics at for four (NPZD) trophic levels commonly used in biogeochemical models: Nutrient depletions and Phytoplankton community structure from automated sample collections; Zooplankton from four-frequency acoustics; POC and ballast mineral Detrital fluxes from sediment traps, as well as net community production (NCP) from O_2/N_2. Chlorophyll fluorescence and optical backscatter show persistent seasonality, with the chlorophyll fluorescence to particulate optical (700 nm) backscatter ratio increasing in summer. Using calibrations of fluorescence to chlorophyll and backscatter to POC, and phytoplankton counts and cell volumes from microscopy, we evaluate multiple working hypotheses for the origins of this seasonality, including trophodynamic changes in the ratios of detritus to phytoplankton; per cell chlorophyll content responses to light levels, and phytoplankton seasonal successions.

O-B2-04 FluoSieve: A novel fluorescence imaging flow cytometer for high-throughput phytoplankton analysis

Jianping Li, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences
Mark Luk, Xcube Technology Ltd
Tao Chen, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences
Peng Liu, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Qinmu Peng, Huazhong University of Science and Technology
Presenter Email: jp.li@siat.ac.cn

High-throughput quantitation and characterization of phytoplankton in natural seawater is of fundamental significance for oceanography sciences and environmental monitoring. Imaging flow cytometry (IFC), with FlowCAM and IFCB as representative instruments, can extract multi-parameter statistical information of water samples by analyzing numerous phytoplankton images captured while they flow through an optical interrogation area, thanks to its high-throughput capability in acquiring phytoplankton images with cellular resolution and processing digital images for quantification and classification. However, taking fast yet accurate measurement of diverse natural phytoplankton with extreme heterogeneity remains challenging for current IFC instruments. Some fundamental issues such as lack of sensitivity and resolution for detecting picophytoplankton, compromises between imaging throughput and imaging quality due to motion/defocusing blurring for analyzing larger microphytoplankton, and trade-off between analyzing throughput in terms of water sample volume with statistical accuracy, still limited their application in practice especially in field scenarios, such as on a research vessel or in a coastal observatory, where autonomous and long-time operation is preferred.Combining light-sheet microscopy with axial flow-through detection, a new fluorescence IFC named FluoSieve has been devised and developed recently. This new imaging sensor uses lasers as light source and has demonstrated several advantages over shortcomings associated with traditional IFCs for phytoplankton analysis. FluoSieve uses single objective lens with high magnification, suppresses much out-of-focus photon noise, has higher excitation power density and integrates more in-focus photons, all together facilitate great enhancement in phytoplankton imaging quality in terms of resolution, signal-to-noise, size coverage and throughput. Based on foundations built in laboratory settings, we have upgraded FluoSieve from an indoors bench-top prototype into a field applicable instrument system recently. This new development is to promote the technology towards more field applications, such as time series observation on coastal stations and underway observation onboard a research vessel. In this talk, we will report the instrumentation progress and preliminary measurements. Through these developments and application collaboration with oceanography scientists, the FluoSieve technology is anticipated to find its niche in more applications and that demand automated phytoplankton analysis.

O-B2-05 A simple formula for empirical ocean color algorithms for absorption coefficient or chlorophyll concentration applicable from clear to turbid waters

Shaoling Shang, State Key Lab of Marine Environmental Science, Xiamen University, Xiamen 361005, China
Zhongping Lee, School for the Environment, University of Massachusetts Boston, Boston, MA 02125

Gong Lin, State Key Lab of Marine Environmental Science, Xiamen University, Xiamen 361005, China
Presenter Email: slshang@xmu.edu.cn

In the past decades for quick and easy production of chlorophyll concentration (Chl) from remote sensing reflectance spectrum (Rrs), a wide range of empirical algorithms have been developed, where separate algorithms were proposed for clear and turbid waters. Thus, if there are both clear and turbid waters in an ocean color image, an empirical switch scheme has to be designed in order to obtain a continuous image product, which usually results in jump or discontinuity of the product value at the clear-turbid boundary. To avoid this arbitrary switch and to obtain robust estimation of absorption coefficient or Chl from ocean color, we propose a simple formula (termed as OCmax2) for the empirical retrieval of Chl or absorption coefficient from Rrs. It is found that, compared to the widely used OC4-type algorithm, OCmax2 can improve the coefficient of determination (R^2) from ~0.88 to 0.99 for a(440) (the total absorption coefficient at 440 nm) in a range of ~0.01-20.0 m^{-1} (equivalent Chl is roughly ~0.01 > 500 mg m^{-3}). Especially, the sensitivity of OCmax2 to the change of a(440) is more than tripled compared to OC4 type of algorithm for a(440) > 0.3 m^{-1} (Chl roughly > 5 mg m^{-3}). These results indicate its robustness and seamless applicability from clear to highly turbid coastal areas that cover nearly all natural waters. Applications of OCmax2 to both in situ data and satellite images in coastal areas are further demonstrated, and advantages and limitations of OCmax2 are also presented.

O-B2-06 Numerical modeling of tidal dynamic in the South Shetland Islands adjacent sea, Antarctic

Xiangqian Zhou, Shanghai Ocean University,College of Marine Science master candidate
Presenter Email: xiangqianzhou@outlook.com

Abstract

The adjacent sea area of South Shetland Islands (SSI) is a hot-pot of bio-physical process around the Antarctic continent, with a large amount of scientific investigations and oceanic stations. The past researches of physical oceanography process in this area are often focusing on some mesoscale temporal or special phenomenon, such as the changing of seasonal ice melting, circulation, water mass. Based on the difficulty of observation and analyzation, there are few research to the tidal dynamic to drive the biological process, compare with the aforementioned physical process. The adjacent sea of SSI comprises South Shetland Trough, Bransfield Strait, north-west Antarctic Peninsula continental shelf and SSI plateau, which result in a complex terrain area. The complex terrain and saltation bathymetry generate tidal dynamic to be an important process in near-shore and slope. By using a three dimension high-resolution oceanic numerical model (FVCOM), we simulate the tide in the adjacent sea area of SSI (52-64W, 60-65S). The dominated residual current is K_1 and O_1 tidal diurnal constituents along the isobaths around the SSI plateau and near

the shore of SSI in barotropic condition. Two Idealized simulations are the linear stratify and the thermocline stratify condition, to experiment the effect to the residual current by temperature and salinity of water mass. By using dye tracer, we find tidal dynamic can transport the nutrients from deep sea to near surface, and have three structures. The first one is westward from Weddle Sea through Antarctic Sound add Bransfield Strait water to north-west Antarctic Peninsula continental shelf, the second is anti-clockwise along the south slope and north near shore of SSI, and the third is westward along the north slope between the SSI plateau and South Shetland Trough. These structures can be comparative study with optics chlorophyll.

O-B2-07 Possible explanations for the unexpected lack of phytoplankton biomass in naturally iron fertilized waters near Heard and McDonald islands in the Southern Ocean

Bozena Wojtasiewicz, CSIRO Oceans and Atmosphere
Thomas W. Trull, CSIRO Oceans and Atmosphere
Diana M. Davies, Antarctic Climate and Ecosystems CRC
Christina Schallenberg, Antarctic Climate and Ecosystems CRC
Lesley Clementson, CSIRO Oceans and Atmosphere
Nick. J. Hardman-Mountford, CSIRO Oceans and Atmosphere
Presenter Email: Tom.Trull@csiro.au

Satellite remote sensing of ocean color reveals high chlorophyll biomass extending more than 1000 km downstream in the Antarctic Circumpolar Current from the Kerguelen Plateau. Oceanographic voyages have verified this to be increased phytoplankton biomass stimulated by natural inputs of iron, the limiting nutrient in the Southern Ocean. Putative iron supply mechanisms include resuspension of sediments on the plateau and terrestrial inputs from the the islands at each end of the central plateau of the Kerguelen islands in the north and Heard and McDonald islands (H&M) in the south. H&M are volcanically active, and H also has glaciers that reach from the top of its Big Ben central volcanic peak to terminate in the sea. Surprisingly, close to H&M, satellite images indicate a halo of low biomass. During 2016, the Heard Earth Ocean Biosphere Investigation studied this region in detail - high iron levels were confirmed and fast repetition fluorometry indicated high photosynthetic competence in the diatom dominated phytoplankton community. So, why is the halo present? This presentation will combine sensor observations of radiation, fluorescence, backscatter, and absorption with physiochemical data to address several possibilities: i) satellite imaging does not see the biomass because of other light absorbing materials in the water ii) deep mixing near the islands dilutes the biomass iii) horizontal advection moves waters away from the islands faster than biomass can accumulate and iv) phytoplankton are rapidly removed by grazing or other mechanisms.

O-B3-01 Small but mighty - the role that marine microbes play in mediating our climate

Naomi M Levine, University of Southern California
Elizabeth Teel, University of Southern California
Meagan He, University of Southern California
Emily Zakem, University of Southern California
Presenter Email: n.levine@usc.edu

Microscopic single celled organisms in the ocean (marine microbes) are the engines that drive marine carbon cycling. They are responsible for approximately half of all photosynthesis on the planet and play a critical role in in regulating our climate by mediating the sequestration of CO_2 in the ocean. As such, it is important to determine how marine microbes will adapt and evolve to a changing climate in order to understand and predict how the global carbon cycle may change, and predict pivotal feedback responses that might impact future climate states. To untangling the complex interactions between climate and biology, we utilize pioneering interdisciplinary approaches combining observations, theory, and numerical models. This research demonstrates that the inclusion of dynamic bacterial remineralization can significantly impact surface phytoplankton blooms, and picophytoplankton primary production rates. Model dynamics also indicated that variable C:N ratios are critical for the depiction of both DOC production and remineralization. In addition, this work suggests that explicitly including heterotrophic bacterial dynamics in global ecosystem models may be important for accurately representing carbon cycle responses to climate perturbations.

O-B3-02 Developmental threshold model: linking phenology and biogeography of marine zooplankton populations

Rubao Ji, Woods Hole Oceanographic Institutions
Presenter Email: rji@whoi.edu

For individual organisms to complete their life cycles, a series of developmental stage transitions need to be achieved without major interruptions. A developmental threshold model predicts the rate of development from one life stage to another under a dynamically changing environmental condition. The model would allow ecologists to examine the timing of developmental events (phenology) and further estimate the spatial distribution of suitable habitats (biogeography) that allow successful transitioning of developmental stages. This type of model has been increasingly applied to study terrestrial populations in recent years, but not so much for marine populations. In this presentation, I will introduce the concept of developmental threshold modeling, explain the linkage between phenology and biogeography, and discuss the model’s applicability in marine systems. I will present a case study on the zooplankton populations in the Arctic Ocean to illustrate how critical development thresholds can be linked to the biogeography of different species, and how

climate change can impact the probability of successful developmental transitions.

O-B3-03 Seasonal succession of microalgal blooms from diatoms to dinoflagellates in the East China Sea: A numerical simulation study

Zhengxi Zhou, Institute of Oceanology, Chinese Academy of Scineces
Rencheng Yu, Institute of Oceanology, Chinese Academy of Scineces
Mingjiang Zhou, Institute of Oceanology, Chinese Academy of Scineces
Presenter Email: zxzhou@qdio.ac.cn

The sea area adjacent to the Changjiang River estuary is the most notable region for harmful algal blooms (HABs) of dinoflagellates in China. Large-scale blooms of dinoflagellates (ig. Prorocentrum donghaiense and *Karenia mikimotoi*) started to appear in this region at the beginning of the 21st century, and the mechanisms for the occurrence of dinoflagellate blooms have become an intriguing issue since then. In previous studies, an apparent succession of microalgal blooms from diatoms to dinoflagellates, due to their competition and the different adaptive strategies to environmental variations, have been found in late spring. Therefore, a better understanding on the succession of different microalgal blooms would help to elucidate the mechanisms of the large-scale dinoflagellate blooms. In this study, a zero-dimensional numerical model was established to simulate the succession of microalgal blooms based on the field inves1[1]tigation data in 2005 and 2011. The model could well reproduce dynamics of the diatom and dinoflagellate blooms. Using this model, analyses were performed under different scenarios to analyze the effects of temperature, light intensity and nutrients on the succession of microalgal blooms. The results suggest that temperature and light have little effects on the succession. Phosphorous stress is the most critical factor controlling the succession of microalgal blooms, while nitrate plays an important role in affecting the scale of dinoflagellate bloom. The results further improved the current understandings on the mech1[1]anisms of large-scale dinoflagellate blooms in the East China Sea, and would help to develop prevention strategies against HABs in this region.

O-B3-04 The biological-physical interaction in the open ocean: based on the nitrogen-based ecological model

Moge Du, State Key Laboratory of Marine Environmental Science (Xiamen University), China
Shuh-Ji Kao, State Key Laboratory of Marine Environmental Science (Xiamen University), China
Presenter Email: dmg@stu.xmu.edu.cn

Having differential responses to light and substrates, the vertical microorganism community structure may change correspondingly when nutrients supply from subsurface is strengthened. The bloom of algae may magnify light attenuation, consequently, the ecological structure (the niche of microorganisms) would be further changed. Thus, in the upper ocean, the kinetic processes of the light-sensitive microorganisms involved nitrogen cycle, e.g., the ammonia sink terms of oxidation and assimilation, may interconvert their dominated role. Previous ecological models embedding new and regenerated production analytical expression have been conducted. Among them, the CoSiNE model, presenting the nitrogen cycle by source and sink processes of the ammonia, nitrate and detrital nitrogen: uptake, excretion, nitrification and sinking, can reproduce the general biogeochemical features observed. However, the two stages of nitrification, ammonia oxidation and nitrite oxidation, performed by the microorganisms with different ecological traits are not included, therefore, the vertical distribution of nitrite with nanomole magnitude was missed. In this study, we upgrade the the CoSiNE ecological model with sophisticated nitrification process in the upper ocean and validate the model with field observed and experimental data, trying to bridge the gap of simulated results and realistic mechanism. On this basis, we aim to discuss the fluctuation of new and regenerated production under the biological-physical multiple effects.

O-B3-05 Modeling seasonal and inter-annual variability of trophic transfer and 15N stable isotope enrichment within the planktonic food chain

Sherwood. Lan Smith, Research and Development Centre for Global Change Research, JAMSTEC, Yokohama, Japan
Yoshikazu Sasai, Research and Development Centre for Global Change Research, JAMSTEC, Yokohama, Japan
Chisato Yoshikawa, Department of Biogeochemistry, JAMSTEC, Yokosuka, Japan
Presenter Email: lanimal@jamstec.go.jp

The stable isotope ^{15}N is widely used an indicator of trophic level, and has been incorporated into ecosystem models in order to understand nitrogen cycling and trophic transfer. However, such studies typically consider only the average enrichment per trophic level. We present a recently developed Trophic Level Variability (TLV) model of the dynamic fractionation of the stable isotope ^{15}N in lower-trophic ecosystems of the North Pacific. The model accounts for the dynamics of trophic transfer from nutrients (nitrate and ammonium) to phytoplankton, and to two idealized zooplankton compartments representing herbivores and carnivores, respectively. The ^{15}N signal of herbivores tracks that of phytoplankton, with a nearly constant offset, i.e., enrichment by a nearly constant factor. However, the modeled ^{15}N difference between carnivores and herbivores varies seasonally, and depends on the mortality rate (turnover time or effective lifespan) of the carnivores. Seasonal variations of modeled ^{15}N signals differ with trophic level because

carnivores integrate the signal from their ^{15}N uptake over longer timescales compared to herbivores. Thus, the model reproduces the lower observed variability of ^{15}N for carnivorous zooplankton (chaetognaths) and the more variable ^{15}N for largely herbivorous zooplankton (copepods). Our results imply that for interpreting observed ^{15}N values, it is important to consider not only the average enrichment per trophic level, but also the dynamics of ^{15}N fractionation and the timing of observations. We will also present some simulations illustrating how this modeling framework can be used to project changes in trophic transfer under climate change scenarios.

O-B3-06 Size-depending response of phytoplankton growth to increasing ocean CO2 concentration

Qi Zhang, College of Ocean and Earth Science, Xiamen University
Ya-Wei Luo, College of Ocean and Earth Science, Xiamen University
Presenter Email: qizhang@stu.xmu.edu.cn

The increasing CO2 concentration in the seawater can potentially stimulate photosynthesis of phytoplankton, as the low diffusivity of CO2 can limit its supply to phytoplankton. Although it is often considered that large phytoplankton benefit most from increasing CO2, we analyzed historical experimental data and found that the growth rate response (GRR, relative increase of growth rate) of phytoplankton maximizes at medium cell size. In this study, we establish a numerical model representing CO2 concentrating mechanism (CCM) of phytoplankton cells, and simulate GRR of different-size phytoplankton under seawater CO2 concentration from 10 μM (LC) to 20 μM (HC). The model includes two pathways of inorganic carbon supply to phytoplankton, including CO2 diffusion and energy-consuming bicarbonate (HCO3-) uptake. The model also reveals an optimal cell size for GRR. When cell diameter is very small, CO2 diffusion is sufficient to support cell growth under both LC and HC and GRR is 0. With increasing cell size, cell under LC needs energy to take up HCO3-, and GRR increases until reaching a maximum at a cell diameter when cell under HC also starts to need HCO3-. Larger than that, phytoplankton under both LC and HC cost energy to take up HCO3-, CO2 diffusion becomes less important with increasing cell size, and GRR declines. Numerical experiments further show that the predicted optimal cell diameter is the most sensitive to rates of cell carbon requirement and CO2 leakage. Future work should explore the impact of various processes of the model and integrate with laboratory experiments.

O-B3-07 Global and localized impact of river nitrogen export on ocean primary productivity and oxygen

Xiao Liu, Princeton University
Charles A Stock, NOAA GFDL
John P Dunne, NOAA GFDL

Minjin Lee, Princeton University
Elena Shevliakova, Princeton University
Sergey Malyshev, Princeton University
Chris Milly, USGS
Presenter Email: xiao.liu@noaa.gov

The marine environment is increasingly threatened in a high carbon dioxide, urbanized world. Coastal and oceanic stressors, such as occurrences of harmful algal blooms and oxygen deprivation, are forecast to intensify over the next century owing to the combined effects of global warming and enhanced nutrient inputs. As a major terrestrial source of nutrients to the ocean, rivers play a critical yet poorly quantified role in driving both coastal biogeochemical processes and global carbon cycle. In this study we investigate the global-scale and localized impact of river nitrogen export through application of a state-of-the-art, high-resolution global ocean-ice-ecosystem model (MOM6-SIS2-COBALT) with time varying river nitrogen inputs derived from an offline land model (LM3-TAN). Focused on ocean chlorophyll and oxygen, our century-long model simulations depict a global view of river impacted zones with boundaries extended up to thousands of kilometers from their discharge points. At regional scales, we show that intensity and distribution of coastal extremes (i.e. blooms and hypoxia) in some coastal systems are strongly influenced by temporal variability of river nitrogen loading, while these events are driven more by climate and oceanic dynamics in other systems. Our results emphasize that future prediction of marine ecosystem tipping points requires resolution of both oceanic and terrestrial (e.g. riverine) drivers of ocean change.

O-B3-08 End-to-end models: Linking physics and biogeochemistry to fish

Kenneth A Rose, University of Maryland Center for Environmental Science (Horn Point Lab) USA
Presenter Email: krose@umces.edu

End-to-end models are receiving increasing attention as a quantitative tool for investigating marine ecosystem responses to management actions, effects of stressors, and climate variation. End-to-end models typically combine submodels of physics (hydrodynamics), lower trophic levels (nutrient-phytoplankton-zooplankton, NPZ), and upper trophic levels (fish, birds, fishers) into a single modeling framework. Such models are attractive because they can simulate a wide variety of effects, including ecosystem responses to interannual environmental variation, changes in fishing, and episodic and long-term trends in climate conditions. Two emerging areas with end-to-end modeling are how to link the biogeochemistry to the fish and how to represent the behavioral movement of the organisms. Most nutrient-phytoplankton-zooplankton (NPZ) models include biogeochemistry but simulate zooplankton to achieve realistic chlorophyll and nutrient dynamics. End-to-end models require NPZ models that represent zooplankton from the

perspective of prey for fish and are predictive of the biomass and spatial dynamics of the zooplankton. In addition, many important fish species consume benthos, which are often not included in NPZ models. The second emerging area is the behavioral movement that becomes important when life stages of zooplankton and fish are included that move and migrate unrelated to passive transport. I will discuss recent advances in modeling in both of these emerging areas, with a focus on the new data available for model development and testing. I will include several recent efforts at end-to-end modeling that use 3-D hydrodynamics coupled to NPZ coupled to fish to illustrate these issues and offer potential solutions. These examples include climate effects on sardine and anchovy dynamics in the California Current and prediction of the effects of wide-spread hypoxia on croaker population dynamics in the Gulf of Mexico.

O-B3-09 Aquaculture site prospecting: Using ocean observing platforms, remote sensing, and numerical modeling to inform sustainable ecological aquaculture expansion

Damian Brady, University of Maine
Emmanuel Boss, University of Maine
Carter Newell, Shellfish Research and Development
Dana Morse, Maine Sea Grant
Andrew Thomas, University of Maine
Nicholas Keeney, University of Maine
Presenter Email: damian.brady@maine.edu

As the global demand for marine protein has increased, so to has our reliance on aquaculture systems. The vast majority of marine aquaculture production still occurs in nearshore estuarine habitats, although offshore and land based facilities continue to make strides. In the U.S., Maine leads the country in marine aquaculture production but only engages a small proportion of its 5,600 km of tidal shoreline in this activity. By combining multiple observing platforms with linked hydrodynamic-biogeochemical models, we are identifying new areas for shellfish aquaculture expansion, characterizing important feedbacks that alter carrying capacity, and incorporating climate related factors into to future aquaculture growing area projections. Perhaps one of the more unique characteristics of this new observing-modeling platform is the incorporation of new nearshore remote sensing products (e.g., LandSat 8 and Sentinel 2A/B) capable of monitoring temperature, chlorophyll, turbidity (an indicator of suspended particulate matter in these systems), and chromophoric dissolved organic matter (an indicator of the influence of freshwater flow) at 20-30 meter resolution. The increased resolution of these products allow them to be used to inform farm scale decisions for the first time. These elements are being linked to growth models that parse the coast in to optimal areas for American oyster, blue mussel, and sea scallop growing areas with future plans to expand

applicability to finfish and sea vegetables. Finally, the use of process-based water quality models for aquaculture site selection provides growers with better estimates of nutrient uptake and incorporation, changes in nutrient recycling in bottom sediments, a more accurate estimate of food resources that include detritus, and the ability to explore alternative growth scenarios based on resource management decisions or environmental change.

O-B3-10 Modeling the shifts of phytoplankton phenology and composition on the Northwest Atlantic Shelf

Zhixuan Feng, Biology Department, Woods Hole Oceanographic Institution
Rubao Ji, Biology Department, Woods Hole Oceanographic Institution
Changsheng Chen, School for Marine Science and Technology, University of Massachusetts-Dartmouth
Cabell Davis, Biology Department, Woods Hole Oceanographic Institution
Presenter Email: zfeng@whoi.edu

The Northwest Atlantic Shelf is among the world's fastest warming regions in the recent 3-4 decades. The rapidly changing ocean environments could impact marine ecosystem across multiple trophic levels and have important socioeconomic implications. To understand interannual variability and decadal trends in phytoplankton bloom phenology (timing) and relevant physical-biological drivers, we synthesize satellite ocean color data, and also conduct numerical experiments using an intermediate-complexity lower trophic level ecosystem model. We assess the sensitivity of phytoplankton bloom magnitude and timing on temperature-dependent phytoplankton growth and zooplankton grazing versus nutrient and light availability. Additionally, we also examine the corresponding changes in the composition of phytoplankton size groups. The findings from this study allow a better holistic understanding of the pelagic shelf ecosystem and its driving mechanisms under both short-term environmental variability and long-term climate change.

O-B3-11 Modeled phytoplankton response to the offshore transport of the Pearl River Plume

Peng Xiu, South China Sea Institute of Oceanology
Bingxu Geng, South China Sea Institute of Oceanology
Fei Chai, Second Institute of Oceanography
Presenter Email: pxiu@scsio.ac.cn

An anomalously large phytoplankton bloom, which is about 500 km long and 100 km wide, was captured in the northern South China Sea (SCS) by satellite chlorophyll images. A

coupled physical-biological model was built for this region and used to investigate the underlying dynamics. We found that the existence of a mesoscale eddy along the continental slope can entrain the plume water of the Pearl River at the eddy edge and transport it to the deep basin of the SCS. The phytoplankton bloom was observed along the path of this offshore transport. Numerical experiments indicated that the advected freshwater from the Pearl River was largely responsible for the phytoplankton bloom especially at the surface. The mesoscale cyclonic eddy transported high nutrients from the continental slope to the deep ocean at the subsurface. The advected freshwater at the eddy edge created a surface salinity front that was accompanied with strong submesoscale upwelling consequently injecting subsurface nutrient to the surface layer and enhancing the phytoplankton growth.

O-B3-12 Cascading while diminishing: modeling biological-physical responses to Southern Annular Modes in the Southern Ocean

Meibing Jin, University of Alaska Fairbanks and Nanjing University of Information, Science and Technology
Rubao Ji, Woods Hole Oceanographic Institution
Yun Li, University of South Florida
Presenter Email: mjin@alaska.edu

Southern Annual Modes (SAM), the dominant atmospheric variability in the Southern Hemisphere, appears to be linked to large-scale anomalies of both physical and biogeochemical variables, most evident along a zonally asymmetric belt. How is the SAM signal propagated along the bottom-up cascading pathway from physics to biology? What are the relationships between SAM and variability of multiple environmental factors including sea ice, water column properties, nutrients and primary productivity? Addressing those questions in a highly dynamic system is important yet challenging. We used the reanalysis data-forced run of coupled ice-ocean-ecosystem modules of the global Community Earth System Model (CESM) to investigate the different responses of ocean physics and biology to the SAM variations in the Southern Ocean (SO). Pelagic and sea ice algal biological modules are embedded in the coupled sea ice model (CICE) and Parallel Ocean Program (POP). The model was validated with in-situ, Argo and remote sensing data. The modeled mixed layer depth (MLD) and sea surface temperature (SST) showed similar seasonal and spatial patterns to the observed responses to SAM, whereas the nutrients and primary production responded to SAM in different ways. The macronutrients (e.g. nitrate) showed direct response to variations of MLD, but the response of iron (a limiting micronutrient) and chlorophyll did not show clear large-scale spatial patterns related to the SAM-induced MLD variations. Our model results revealed that the SAM signal, represented by its spatial and temporal variability, diminishes before it reaches the primary producer level, largely due to the additional sources of variability affecting the

availability of iron. Additionally, the strong and nonlinear Fe-phytoplankton interactions could prevent the detection of relationship among the associated biophysical variables. The findings have important implication for a better understanding of the impact of large-scale forcing.

O-B3-13 Multiple causes of hypoxia in the East China Sea: Some notes from observations and modelling

Feng Zhou, Second Institute of Oceanography, SOA
Presenter Email: zhoufeng@sio.org.cn

Patch-like hypoxic zones have been observed in the East China Seas, ranging from the Changjiang Estuary (CJE) to the offshore of the Zhejiang coast and the west of the Cheju Island. Compared to the general knowledge on generation of hypoxia, multiple factors may affect the evolution and distribution of hypoxia in the East China Sea due to complex circulations, different sources of organic matter and low-oxygen water etc. A coupled physical-biogeochemical model was applied to diagnose the spatial-temporal characteristics of hypoxia. The model suggested that hypoxic extent off the CJE is highly variable in largely accordance with the Changjiang diluted water and could be partially influenced by the advection of the Kuroshio intruded water at bottom. Comparatively, the hypoxia and quasi-hypoxia conditions along the Zhejiang coastal water and west of the Cheju Island seem to be caused mostly by the cross-shelf intrusion of the Kuroshio. A few numerical experiments on the boundaries and lagrangian tracking will be discussed.

O-B3-14 Model-guided quantification of the Three Gorges Dam's impact on Changjiang estuary's hydrodynamics and ecosystem

Jianzhong Ge, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Ricardo Torres, Plymouth Marine Laboratory
Richard Bellerby, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Lijun Hou, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Changsheng Chen, School of Marine Science and Technology, University of Massachusetts-Dartmouth
Presenter Email: jzge@sklec.ecnu.edu.cn

The Changjiang Estuary is characterized as strong river discharge into the inner shelf of the East China Sea with abundant sediment load, which indicates dominant influences from the Changjiang River. There were increasing constructions of reservoir and dam along the Changjiang River during last several decades, which strongly regulates the river discharge, sediment and nutrients into the Changjiang Estuary, especially during the dry season. The variations of sediment, nutrients, and their influenced ecosystem have been simulated through a comprehensive modeling system, which integrated a multi-scale current-wave-sediment FVCOM model and generic marine biogeochemistry and ecosystem ERSEM model through The Framework for Aquatic Biogeochemical Models (FABM). This model system has successfully revealed the seasonal and decadal variations of sediment, nutrients transport around the inner shelf of the East China Sea. The spring and autumn peaks of phytoplankton growth were correctly captured by simulation. The model system has revealed the hydrodynamic and ecosystem variations under the scenarios of no-Three-Gorges-Dam case (I), Three-Gorges-Dam case (II) and Three-Gorges-Dam (in 2030) case. Additionally, three typical hydrology boundary conditions, high-flow, low-flow and median-flow discharges, are applied on these three scenarios. The results indicate the Three-Gorge Dam has a time-shifting influence on freshwater spreading from the river mouth to outer shelf, showing the most influenced salinity variation occurs from Oct to November in river and mouth, and November in the inner outer shelf. This time-shifting pattern also happens on nutrients dynamics, indicating decrease of nitrate, ammonium and phosphate, and increase of silicate from mouth to shelf. The phytoplankton growth remains low productivity around the turbidity-maximum zone with strong sediment coverage, however, it has small decrease in the inner shelf region.

O-G1-01 River Delta Response to a Massive Increase in Sediment Supply: The Influences of Sediment Supply, Waves and Tidal Currents

Jonathan Warrick, U.S. Geological Survey
Presenter Email: jwarrick@usgs.gov

The geomorphic responses of depositional landforms, such as river deltas, to changes in sediment supply are a fundamental interest of geoscience research. Yet, field-based observations of deltas before, during and after changes in sediment supply are unusual owing to the challenges of forecasting these events and collecting pertinent time-series data. Here we provide field-based observations of the geomorphic response of a coastal delta to a massive increase in sediment supply to better understand delta morphodynamics and the controls of sediment supply, waves and tidal currents on sediment transport and morphology. In response to the 2011 鈥?014 removal of two dams on the Elwha River, Washington, USA, river sediment supply increased ~100-fold, resulting in ~19 Mt of sediment discharge to the coast during the first 5 yr following the removal project. Using semiannual and annual topographic and bathymetric surveys, aerial photographs collected approximately monthly, and multi-year oceanographic time-series of waves and currents, we document how the increases in supply changed the sediment budget of the delta from net erosional to net depositional. Additionally, we document the alteration of the coastal geomorphology in response to this supply, including the emplacement of recently discharged sediment in river mouth bars, and the subsequent across- and along-shore

movement of this sediment around the delta as waves and currents acted upon it. These data suggest that the morphology of the intertidal portion of the delta, which consisted of mixed sand and gravel sediment, was dominated by fluvial sediment supply and subsequent reworking by waves. Sediment dispersed farther offshore was subjected to strong, spatially variable tidal currents capable of transporting sand, pebbles, and cobbles with kelp holdfasts. This suggests that different processes can dominate the sediment transport regime and morphology of a delta depending on location and sediment grain size.

O-G1-02 Mega Changjiang (Yangtze) estuary morphodynamics: source-to-sink of sediments

Zhijun Dai, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai
Xuefei Mei, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai
Wen Wei, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai
Presenter Email: zjdai@sklec.ecnu.edu.cn

Knowledge of estuarine morphodynamics and associated sediment source-to-sink systems is very significant to understand the physical, chemical and biological processes on the Earth’s surface. Based on long-term records of water discharge, sediment, riverbed morphology and estuarine hydrology along the mega-Changjiang estuary are holistically presented. The estuary bifurcates at four islands, Chongming, Hengsha, Changxing and Jiuduan Shoal, forming a 3-tiered branching delta that has 4 distributary mouths debouching in the East China Sea (North Branch, North Channel, North Passage, and South Passage).

(1) The results indicate that morphodynamic process of the Changjiang estuary has experienced greatly changes in recent 50 years. The North Branch (NB), a tidally-dominated distributary of the Changjiang estuary, has displayed distinct morphological patterns. Two basic morphological patterns have characterized the evolution of the NB in the last 50 years. The dominant pattern is a reduction of the entire channel volume, accompanied with erosion at the estuary mouth, and aggradation of the tidal bars. The second pattern represents variations in channel volume below -5 m. The 70% reduction of the Changjiang sediment load seems not having an impact on the NB morphology, while reclamation of the intertidal area along the NB is directly responsible for the reduction of the NB tidal prism. Enhanced flood-tidal currents have possibly carried sediments into the NB between 1958 and 2013 reducing the channel volume below 0 m. Enhanced tidal asymmetry due to lower water depths has likely favored tidal pumping, one of the main processes responsible for silting.

(2) North Channel (NC), the largest bifurcated estuary of the Changjiang River, Channel capacity of the entire NC has been decreasing during the period 1880-2013. Although the upper reach (inner side of the mouth bar) has exhibited significant erosion in channel volume below −5 m during 1970-2013, this is overruled by the dramatic deposition in the lower reach (mouth bar area and its outer side). Bathymetric variations of the NC are dominated by both the upstream sediment availability and the relative strength between the river discharge and local tidal force. While the recent period, erosion in the upper reach is attributed to riverine sediment declining, particularly since 2003 when the TGD was established. In contrast, deposition along the lower reach since 2003 can be explained by landward sediment transport due to the flood-tide force increasing under the combined effects of a decrease in TGD-induced river discharge and land reclamation induced lower reach narrowing.

(3) The North Passage (NP), where the main shipping channel of the Changjiang waterway is located, has been continually dredged from the average depth less than 7 m to the present day 12.5 m using trailing-suction hopper dredgers. Our findings show that there are two modes of bathymetric changes. The first mode represents 85% of the variability, which includes the deposition in the peripheral groin fields along the shipping channel and deepening of the shipping channel, which is primarily due to the channel maintenance. The second mode represents 6% of the variability of the river-mouth shoal (seaward migration and size reduction), attributable to the declining sediment discharge of the Changjiang due to the Three Gorges Dam, and the enhancement of the ebb flow as the result of dredging.

(4) Morphological evolution of the South Passage (SP) could be divided into two stages: between 1987 and 1997, the SP had a single stable channel with closure of a cross-channel. Between 1997 and 2012, SP displayed southeastward elongation of a spit into the main channel, and westward shoal incision by a cross channel. The opening of the SP developed a two-channel morphology, which stabilized and showed infilling during 2003-2012. The average deposition rate was 10 cm/yr. In the past 30 years, the most dominant morphological changes of SP included the deposition around the upstream opening of the channel. The second most important pattern of morphological change was related to the downstream elongation, retreat, and lateral migration of the spit of the Jiangyanan Shoal, which resulted in the two channel configuration of the SP. Additionally, these morphological changes were not triggered by the decline of the distal sediment source from the upstream, but due to the input of proximal sources of the shoal at the upstream opening of the SP and spill-over sediment from the North Passage via a short-cut channel.

We conclude that rising sea levels and frequent storms may terminate landward sediment transport, aggravating estuary erosion and inducing seaward sediment transport. It can be expected that erosion could occur in the near future in the Changjiang estuary delta.

O-G1-03 Source-to-Sink processes and environment variations in the East Siberia Sea since the last deglaciation

Xuefa Shi, 1 Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China 2 Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, 266061, China Oceanography, State Oceanic Administration, Qingdao 266061, China
Limin Hu, 1 Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China 2 Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, 266061, China
Jianjun Zou, 1 Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China 2 Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, 266061, China
Shuqing Qiao, 1 Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China 2 Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, 266061, China
Yangguang Liu, 1 Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China 2 Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, 266061, China
Anatolii Astakhov, V.I.Il'chev Pacific Oceanological Institute, Far East Branch of Russian Academy of Science, (FEB of RAS) Vladivostok, 690041, Russia
Presenter Email: xfshi@fio.org.cn

The East Siberia Sea with one of the widest continental shelf in the world ocean has undergone dramatic changes in past environment, accompanied by diminished sea ice covers, increased river runoff, intensified melting of permafrost and strengthened coastal erosion. Here, we investigate both source-to-sink processes and environment changes in the East Siberia Sea since the last deglaciation on the basis of data and samples collected during the Sino-Russia Joint Expedition in 2016, in combination with published results. Our results suggest that amounts of terrigenous material is delivered to the East Siberia Sea from river and coastal erosion. In particular, the old carbon associated with permafrost formed during ice ages is erodedand transported to the East Siberia Sea. On average, modern sedimentation rate is ~1.4mm/yr on the continental shelf of the East Siberia Sea, which is lower on the continental slope. Presently, the surface sediments mainly consist of fine-grained fraction on the East Siberia Sea shelf. Wave-induced

sediment transport mainly occurs in coastal areas, whereas sea ice dominates the cross-shelf transport of sediments.

Exposed East Siberia Sea shelf during the last glacial sea-level lowstand was re-submerged with rising sea level since the last deglaciation. Subsequently, processes related to sediment deposition and biogeochemistry on the shelf are mainly controlled by both oceanic circulation and sea ice. In addition, the spatial distributions of sediments are also affected by coastal erosion with rising sea level besides the fluvial input. It is found that higher TOC input from the permafrost during the early Holocene than that of the last deglacial period , which is mainly related to rapid warming and enhanced coastal erosion. Totally, The sedimentation rates varies greatly in space. The main factors controlling the sediment processes and environmental evolution changesduring the transition from the last deglaciation to the Holocene. Both rivers and sea level are dominated during the last deglacial interval, while sea ice became to play a more pronounced role during the Holocene and become a key factor linking land-ocean-atmosphere-biosphere interactions.

O-G1-04 Marine Records of Himalayan Erosion and Monsoon Climate Change in Southwest Asia

Peter Clift, Department of Geology and Geophysics, Louisiana State University, Baton Rouge, Louisiana, USA

Peng Zhou, Department of Geology and Geophysics, Louisiana State University, Baton Rouge, Louisiana, USA

Denise Kulhanek, nternational Ocean Discovery Program, Texas A&M University, 1000 Discovery Drive, College Station, TX 77845-9547, USA

Daniel Stockli, Jackson School of Geosciences, The University of Texas as Austin, Texas 78712-0254, USA

Jurek Blusztajn, Department of Geology and Geophysics, Woods Hole Oceanographic institution, Woods Hole, Massachusetts, USA

Presenter Email: pclift@lsu.edu

International Ocean Discovery Program (IODP) drilling in the Arabian Sea has recovered a relatively continuous sequence of sediments dating back to 11 Ma that when combined with industrial drilling close to the Indus River mouth provides a record of erosion, chemical weathering and environment stretching back into the middle Miocene. Nd isotope data show a progressive modest increase in flux from the Karakoram until around 10 Ma followed by a reverse towards Himalayan sources until the present day. Zircon U-Pb detrital ages confirm that the dominant source is from the Indus River with relatively little material from peninsular India. Erosion of the Lesser Himalayas increased sharply after 5.7 Ma but especially since 1.9 Ma as the crystalline inner Lesser Himalaya were exposed across the basin. The shift to more Himalayan compositions occurs at a time of weakening monsoon. Reduced chemical weathering accompanies the change in vegetation in

Southwest Asia from C3 to C4 dominated, indicating drier conditions starting after 8 Ma. Since 1.9 Ma the composition of the deep-water sands has been similar to the modern river but not that seen at the Last Glacial Maximum, suggesting that most of the erosion in the basin occurs when the monsoon is strong during interglacial times. Sediment is however stored in the delta and on the continental shelf during sea level highstands and is reworked into the deep basin as sea level falls resulting in a lag time of around 100 k.y. in the recent geologic past. Monsoon intensity appears to be the primary control over the rate of erosion on such timescales, yet faster erosion in the Lesser Himalayas occurred when the monsoon weakened, which we attribute to a southward shift in the maximum rainfall band of the summer monsoon, as well as the building of an imbricate thrust stack over a basement ramp within the basal Himalayan thrust during the Miocene and Pliocene.

O-G1-05 Tectonic and Oceanographic Controls on Sediment Dispersal and Accumulation off the Ayeyarwady River Delta

Steven Kuehl, Virginia Institute of Marine Science - Xiamen University
Joshua Williams, Virginia Institute of Marine Science
Courtney Harris, Virginia Institute of Marine Science
Paul Liu, North Carolina State University
Da Wa Aung, University of Yangon
Presenter Email: kuehl@vims.edu

The Ayeyarwady Delta is the third largest delta system in the world in terms of sediment supply, and second in terms of carbon delivery, however, the fate of sediment in the offshore portion of this system has been largely unstudied. We report here on a recent investigation of the shelf area off the Ayeyarwady, including data from a research cruise conducted in December 2017. Sediment dispersal and accumulation in the adjacent Andaman Sea and Bay of Bengal are forced by: seasonal variations in sediment input; reversing monsoon winds and circulation patterns; strong forcing by tides and waves; and tectonic uplift/subsidence west/east of the N-S trending Sagaing fault that bisects the delta. Maximum sediment accumulation rates of ~10 cm/y are observed in the foreset region of a subaqueous delta that is prograding into the Martaban Depression east of the Sagaing fault. Accumulation rates in other areas of the shelf surrounding the delta are typically ~1 cm/y. The extensive shallow (topset) region of the eastern Gulf of Martaban is characterized by deep (up to a meter) physical mixing of the seabed and reduced net accumulation rates. Frequent and deep re-oxidation of pore waters by tide and wave sediment resuspension likely forms the distinctive reddish-brown coloration of the sediments. Carbon burial in this area is also likely to be minimal as a result of frequent disturbance an oxidation of terrestrial and marine organic carbon. The shelf (ramp) off the western mouths of the Ayeyarwady Delta is characterized by a relatively narrow nearshore (<40 m water depth) mud belt with higher sand and silt content offshore. This area of the

delta is subject to extreme tidal currents and wave resuspension (SW monsoon), which may be energetic enough to winnow most of the fine-grained sediments delivered by the river mouths, and transport this material eastward to the Gulf of Martaban. The western most area adjacent to the Bay of Bengal is characterized by a mud drape extending across the entire shelf to slope, and perhaps into the deep basin. As evidenced by its distinct provenance signatures and regional numerical modeling simulations, this area could represent the distal portion of the Ganges-Brahmaputra sediment dispersal system, with some addition from the Ayeyarwady that is transported westward during the NE monsoon. It appears that off-shelf escape of sediment to the Bay of Bengal occurs, however, there is no evidence of escape through the Martaban submarine canyon to the deeper portions of the Andaman Sea, as has been previously reported. A centennial sediment budget for the area indicates efficient sediment trapping in the Andaman Sea region.

O-G1-06 Comparison study of late-Quaternary small-river deltaic systems across the Taiwan Straight

Daidu Fan, State Key Laboratory of Marine Geology, Tongji University
Shuai Shang, State Key Laboratory of Marine Geology, Tongji University
James T. Liu, Department of Oceanography, National Sun Yat-sen University
Rick J. Yang, Department of Oceanography, National Sun Yat-sen University
Presenter Email: ddfan@tongji.edu.cn

The development of river-mouth systems is controlled by tectonics and sea-level and climate change in the long run. Due to obvious difference in tectonic activities between the western Taiwan coast and the eastern Zhe-Min coast, coastal evolution patterns in response to late-Quaternary sea-level and climate change are quite different across the strait, resulting in different depositional systems along their present river deltas. We take Ou and Zhoushui River deltas as their representatives to explore their different coastal behaviors and resultant depositional strata in the late Quaternary.
The Ou River drains an area of ~1.80×10^4 km2 in the northeastern Zhe-Min Uplift zone with the headwater elevation of 1856.7 m and total river length of 388 km. It carries mean annual water and sediment discharges of 1.67×10^{10}m3 and 2.22×10^6 tons, respectively. The Zhuoshui River drains an area of 3157 km2 in central Taiwan with the headwater elevation of ~3400 m and total river length of 187 km. It carries mean annual water and sediment discharges of 0.61×10^{10} m3 and 54×10^6 tons, respectively. In comparison, the Zhuoshui River has an average sediment yield of ~17000 tons/km2, two orders of magnitude higher than that of the Ou River (~120 tons/km2). The former produces a coarse-grained (coarse sand and gravel dominated) fan delta in the river mouth, while the latter creates a tide-dominated delta with silt and fine-sand predominance.
Core strata show MIS 3 deposition in the present Zhoushui River Delta is over 50 m thick, formed in a foreland basin with a rapid subsidence rate of 1.2 mm/yr. They are composed

of more than four fluvial channel-floodplain cycles, potentially registering Heinrich cycles and fluvial channel switch events. In contrast, MIS 3 strata are usually less than 20 m thick in a relative stable coast. They consist of a transgressive system tract in the lower, topped by a several meter thick paleosol formed during the MIS 2 lower sea level. An elevated MIS 3 highstand sea level is therefore indicated to reach up to -24 m.
Holocene strata in the Zhoushui River Delta are also thicker and coarser than those in the Ou River Delta. The latter received abundant fine-grained sediments from the Yangtze River by alongshore current. Both river watersheds and deltaic coasts are significantly influenced by typhoon and East Asian monsoon activities. For the Zhoushui River Delta, it is majorly shaped by river flood events induced by typhoons and summer monsoon. However, the Ou River Delta is greatly shaped by coastal erosion induced by typhoons and alongshore sediment replenishment by winter monsoon.

O-G1-07 Dynamics of settling particles revealed by a non-sequential sediment trap mooring

James T. Liu, Department of Oceanography, National Sun Yat-sen University
Rick J. Yang, Department of Oceanography, National Sun Yat-sen University
Anchun Li, Institute of Oceanography, Chinese Academy of Science
Steven C. Chien, Department of Oceanography, National Sun Yat-sen University
Xiaoqin Du, School of Ocean Science and Technology, Zhejiang Ocean University
Chih-Chien Su, 4Institute of Oceanography, National Taiwan University
Yu-Shin Lin, Department of Oceanography, National Sun Yat-sen University
Presenter Email: james@mail.nsysu.edu.tw

An instrumented mooring was deployed off the mouth of Oujiang River in water depth of 25 m from Feb. 18 to March 18, 2014 over two spring-neap tidal cycles. It was configured with an SCTD, a downward-looking ADCP, and a non-sequential sediment trap whose opening was about 7 m above the seabed. Upon retrieval, the sediment trap had captured about 15-cm thick sediment. After returning to the lab, the trap sediment was first scanned through Multi-sensor Core Logger for physical attributes such as gamma-density, fractional porosity, and mass magnetic susceptibility. Samples were then extruded from the trap liner as 1-cm slices for the following analyses: grain size distribution, total 210Pb, TOC, TN, 未 13C13, mineral content including mica or illite, kaolinite, chlorite, quartz, k-feldspar, plagioclase, and calcite. Examination of the down-trap variability of these sediment variables showed two general patterns: a secular trend and cyclical trend. The down-trap correlation (standardized co-variability) of the measured trap variables was analyzed using a multivariate technique EOF. The results show that the fist three modes explain 73.5% of the correlation. Mode 1 explains 43.4% of the data revealing the hydraulic sorting effect on the settling sediment, which separated clay from silt and sand. This mode also shows dominance of terrestrial signals that are associated with clay, including organics, total 210Pb, and clay minerals. Mode 2 explains 15.9% of the data, is dominated by provenance contrast between weathered granites from Zhe Min region and non-granitic sources from Changjiang. Mode 3 explains 14.3% of the data that reveals the contrast between terrestrial sourced coarse clastic sediment and silty organic marine material. In general, the co-variability of captured sediment was influenced by transport process and provenance.

O-G2-01 Past changes in the tropical Indo-Pacific climate: State of the art and outstanding issues

Mahyar Mohtadi, MARUM-Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany
Presenter Email: mohtadi@uni-bremen.de

Climate models predict a slowdown of the atmospheric circulation over the tropics for the twenty-first century with severe consequences for global climate. However, debate exists on the appropriate interpretation of historical records and observations over the twentieth century and necessitates longer records of past changes in tropical circulation to test the model results. Reconstructions of past changes in the hydrological cycle of the Indo-Pacific Warm Pool (IPWP) suggest that various forcing and feedbacks are involved at different timescales, and that the spatiotemporal response of the IPWP is not uniform. Climate model simulations underscore the sensitivity of tropical circulation to temperature change but remain equivocal and in part, inconsistent with paleo-reconstructions. Untangling the (competing) impacts of different forcings on tropical hydroclimate, and whether and how these are reflected by different proxies at different sites, remains a critical task for both paleoclimate reconstruction and simulation.

O-G2-02 El Niño evolution during the Holocene revealed by a biomarker rain gauge in the Galapagos Islands

Zhaohui Zhang, Ocean College, Zhejiang University
Guillaume Leduc, Kiel University, Institute of Geosciences, Kiel, Germany
Julian P.Sachs, University of Washington, School of Oceanography, Seattle
Presenter Email: zhaohui_zhang@zju.edu.cn

The El Niño-Southern Oscillation (ENSO) represents the largest perturbation to the climate system on an inter-annual time scale, but its evolution since the end of the last ice age remains debated due to the lack of unambiguous ENSO records lasting longer than a few centuries. Changes in the concentration and hydrogen isotope ratio of lipids produced by the green alga Botryococcus braunii, which blooms during El Niño rains in the Galápagos Islands, indicate that the early Holocene (9200–5600yr BP) was characterized by alternating extremes in the intensity and/or frequency of El Niño events that lasted a century or more. Our data from the core of the ENSO region thus calls into question earlier

studies that reported a lack of El Niño activity in the early Holocene. In agreement with other proxy evidence from the tropical Pacific, the mid-Holocene (5600–3500yr BP) was a time of consistently weak El Niño activity, as were the Early Middle Ages (~1000–1500yr BP). El Niño activity was moderate to high during the remainder of the last 3500 years. Periods of strong or frequent El Niño tended to occur during peaks in solar activity and during extended droughts in the United States Great Plains linked to La Niña. These changing modes of ENSO activity at millennial and multi-centennial timescales may have been caused by variations in the seasonal receipts of solar radiation associated with the precession of the equinoxes and/or changes in solar activity, respectively.

O-G2-03 Deep-water Carbonate Ion Concentrations in the Western Tropical Pacific Since the Mid-Pleistocene: A Major Perturbation during the Mid-Brunhes

Bingbin Qin, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China
Tiegang Li, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China
Zhifang Xiong, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China
Thomas J. Algeo, Department of Geology, University of Cincinnati, Cincinnati, OH 45221-0013, USA
Qi Jia, First Institute of Oceanography, State Oceanic Administration, Qingdao 266061, China
Presenter Email: bbqin@fio.org.cn

We present a new deep-water carbonate ion concentration ([CO32-]) record, reconstructed from the size-normalized weight (SNW) of the planktonic foraminifer Neogloboquadrina dutertrei in core MD06-3047B, representing a mid-depth site (2.5 km) in the western tropical Pacific since 700 ka. On glacial-interglacial timescales, deep-water [CO32-] exhibits an inverse relationship with global sea-level elevations, consistent with the coral reef hypothesis that the deep Pacific carbonate system responded to variations in shelf-carbonate production through the past 700 kyr. On longer timescales, a decoupling between deep-water [CO32-] and δ13C around the globe can be explained by a combination of continental weathering and nutrient inputs. During the mid-Brunhes interval (~600-200 ka), [CO32-] reached a maximum of ~100 mmol/kg at the marine isotope stage (MIS) 12/11 boundary, followed by a steep decrease to a minimum of ~40 mmol/kg during mid-MIS 11, representing the largest-amplitude change in [CO32-] over the past 700 kyr. The [CO32-] maximum records the largest deglacial oceanic carbon release since 700 ka, and the [CO32-] minimum was a response to a global increase in pelagic carbonate production. From MIS 3 to 2 and from early to mid-MIS 13, [CO32-] showed rising trends opposite to those at water depths greater than 3.4 km, implying

enhanced Pacific stratification during these intervals. These findings provide new insights into the Pleistocene evolution of the carbonate system in the Pacific Ocean.

O-G2-04 Paleoenvironmental changes in the NW South China Sea over the Last Glacial-Interglacial Cycle inferred by fossil diatom assemblages

Jinpeng ZHANG, Guangzhou Marine Geological Survey
Michal Tomczak, University of Szczecin
Andrzej Witkowski, University of Szczecin
Jan Harf, University of Szczecin
Hongjun Chen, Guangzhou Marine Geological Survey
Presenter Email: jinpenggmgs@sina.com

The paleoclimatic and paleoceanographic records during interglacial and glacial cycles in the East Asian monsoon zone are one of cutting edge in the marine geosciences. In this one of the most climatically sensitive regions shaped by the land-ocean-atmosphere interactions between the western Pacific and eastern Indian Ocean systems the fossil record of diatoms preserved in biofacies help to reconstruct environmental changes over the last glacial-interglacial cycle that took place at the continental margin of the northwestern South China Sea (SCS). The results of a diatomolgical investigation of a piston core (111 PC) shown diatom flora dominated by tropical-subtropical planktonic and coastal species, that could be classified into 6 diatom assemblage zones, coinciding with oxygen isotope stages inferred by foraminifera assemblages (correlated to LR04, Lisiecki & Raymo, 2005). The diatom biostratigraphy based on the indication of key diatom species among their assemblages and oxygen isotopic stages. Shifting of diatom abundances and species in the core profile response to the glacial and interglacial climate fluctuations in this sea area. Concentrations of diatom covers were relatively high in the late Warm glacial stage and then decaying during the mid-Warm glacial stage and postglacial stage (Marine Holocene). While the abundances were significantly lower during the Riss glacial stage and early Warm glacial stage. The characteristic of diatom abundance distribution in northwest SCS differ to southwest SCS, and in extent is similar to northeast SCS. Fossil diatom recorded climatic changes during the turning stage between Riss glacial stage and Riss-Warm interglacial stage, although this mechanism is not fully explained. Species distribution revealed an in the middle Warm glacial stage early warm period present. The irregular distributions of diatom species in the core reflected dynamic oceanographic conditions and sedimentary environments during specific geological periods, particularly in the period of late MIS 4 to early MIS3 and the transition of MIS 3 to MIS 2 in last glacial stage. This study provides a detailed record of regional paleoenvironmental changes and their impact on the silicious organisms (mainly diatoms), that has a key importance in marine and near coast ecosystems. Keywords: Diatom, NW South China Sea, Glacial-Interglacial cycle. References: Lisiecki, L. E., Raymo, M. E. A Pliocene-Pleistocene stack of

57 globally distributed benthic d18O records, Paleoceanography, 2005, 20, PA1003.

O-G2-05 The Neogene Warmth of the Western Pacific Warm Pool

Yige Zhang, Texas A&M University
Xiaoqing Liu, Texas A&M University
Presenter Email: yige.zhang@tamu.edu

Establishing long-term sea surface temperature (SST) records from the western equatorial Pacific is critical for us to understand the evolution of the western warm pool (WPWP), the warmest and largest surface water body on Earth. However, such records are scarce due to the limited availability of high-quality samples and reliable proxies. Benefited from the sediments retrieved by a recent IODP Expedition (363), here we report multi-proxy (TEX86 and Uk'37), multi-site (U1482, U1488, U1490, and 803) SST reconstructions of the WPWP since the mid-late Miocene. The SSTs show a clear cooling trend in the late Miocene - Pliocene, consistent with the previous TEX86-derived SSTs from Sites 806, 1143 and 796, and the seawater Mg/Ca-adjusted Mg/Ca-based SSTs. The 7-5 Ma cooling, however, was much milder in the WPWP relative to the middle and high latitudes, which implies major changes of the meridional temperature gradients. Climate models were then used to explore the relationship between increased temperature gradients and the intensification of deep-water upwelling and the "biogenic bloom" seen in many parts of the world's ocean.

O-G2-06 Summer monsoon-induced upwelling dominated coastal SST variations in the northern South China Sea over the last two millennia

Wing-Man Lee, Department of Earth Sciences, The University of Hong Kong, Hong Kong, China
Kit-Chi Poon, Department of Earth Sciences, The University of Hong Kong, Hong Kong, China
Deming Kong, Guangdong Province Key Laboratory for Coastal Ocean Variation and Disaster Prediction, Guangdong Ocean University, Zhanjiang, China
Roderick J. Sewell, Hong Kong Geological Survey, Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong, China
Yongqiang Zong, Department of Earth Sciences, The University of Hong Kong, Hong Kong, China
Yancheng Zhang, Department of Earth Sciences, The University of Hong Kong, Hong Kong, China
Zhonghui Liu, Department of Earth Sciences, The University of Hong Kong, Hong Kong, China
Presenter Email: ychzhang@hku.hk

The South China Sea (SCS), situated to the north of the Indo-Pacific Warm Pool (IPWP), is under the strong influence of the Asian monsoon system. However, coastal sea surface

temperature (SST) records from the SCS, which are of vital importance to explore ocean-atmosphere-land interactions behind the Asian monsoon system, remain scarce. Here, we use a sediment core collected at the coast of northern SCS to investigate alkenone-SST variations over the past two millennia. On multi-centennial timescale, SST changes in our record exhibit an opposite pattern to that of Northern Hemisphere temperature and solar irradiance, e.g., relatively cool SST during the Medieval Warm Period (MWP) and warm conditions during the Little Ice Age (LIA). Together with alkenone content and existing records, we suggest that the regional SST changes result from a strengthening (weakening) of wind-driven coastal upwelling, associated with variability of the Asian summer monsoon intensity during the MWP (LIA).

O-G2-07 Climate Variability during the Holocene as seen in Sediments from the Southeastern Arabian Sea

Yoganandan Veeran, Assistant Professor
SivaChandiran Alagudurai, Research Scholar
Selvaraj Kandasamy, Professor
Presenter Email: yoganandan1@gmail.com

The Indian summer monsoon (ISM) system is a key component of the global climate, and has a significant role in the socioeconomic life of the people of the Indian subcontinent and also in some parts of SW China. Here our goal is to reconstruct the Holocene history of the ISM and for that we used a high resolution marine sediment core SK-313/GC-1 retrieved from off Cochin in the southeastern Arabian Sea. We examined 291 subsamples for abundances of benthic and planktonic foraminifera to understand paleomonsoon-related surface productivity changes in the study area during the Holocene. The chronology of the core is based on five Accelerator Mass Spectrometry radiocarbon (AMS 14C) dates on mixed planktonic foraminifera. Seasonal changes in the oceanography are reflected in benthic and planktonic foraminiferal productivity. We identified benthic and planktonic foraminifera, characteristic of specific environments, to understand the Holocene monsoonal variability. We focused on oceanographically important benthic and planktonic foraminifera species such as Buliminamarginata, Bolivinaspathulata,Globigerina bulloides, Globigerinoidesruber ,Neogloqudrinadutertrei, Uvigerinaperigrina, Uvigerinaproboscidea, etc. Higher population of mixed layer species Globigerinoides ruber coincides with low contents of species of upwelling indicator, Globigerina bulloides. The population flux of planktonic foraminifera Globigerina bulloides and Neogloqudrina dutertrei suggests that phases of weak summer monsoons prevailed during the early to middle Holocene, whereas a strong summer monsoon during the late Holocene; the pattern is opposite to the monsoon pattern inferred from G. bulloides abundances in the western Arabian Sea.

O-G2-08 Toward a 5 Million Year Record of the Greater Agulhas Current System

Ian R. Hall, School of Earth and Ocean Sciences, Cardiff University, Park Place, Cardiff Wales, CF10 3AT, United Kingdom
Sidney R. Hemming, Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, Palisades, New York 10964, USA
Leah LeVay, International Ocean Discovery Program, Texas A&M University, College Station TX 77845, USA
Expedition 361 Scientists,
Presenter Email: hall@cardiff.ac.uk
International Ocean Discovery Program Expedition 361 drilled six sites on the southeast African margin and in the Indian-Atlantic ocean gateway, southwest Indian Ocean, from 30 January to 31 March 2016. In total, 5175 m of core was recovered, with an average recovery of 102%, during 29.7 days of on-site operations. The sites, situated in the Mozambique Channel, at locations directly influenced by discharge from the Zambezi and Limpopo River catchments, the Natal Valley, the Agulhas Plateau, and the Cape Basin were targeted to reconstruct the history of the Greater Agulhas Current System over the past ~ 5 Ma. The Agulhas Current is the strongest western boundary current in the southern hemisphere transporting some 70 Sv of warm and saline surface waters from the tropical Indian Ocean along the East African margin to the tip of Africa. Exchanges of heat and moisture with the atmosphere influence southern African climates including individual weather systems such as extra-tropical cyclone formation in the region and rainfall patterns. Recent ocean model and paleoceanographic data further point at a potential role of the Agulhas Current in controlling the strength and mode of the Atlantic Meridional Overturning Circulation (AMOC) during the late Pleistocene. Spillage of saline Agulhas water into the South Atlantic stimulates buoyancy anomalies that act as a control mechanism on the basin-wide AMOC, with implications for convective activity in the North Atlantic and global climate change. The main objectives of the expedition were to establish the sensitivity of the Agulhas Current to climatic changes during the Plio-Pleistocene, to determine the dynamics of the Indian-Atlantic gateway circulation during this time, to examine the connection of the Agulhas leakage and AMOC, to address the influence of the Agulhas Current on African terrestrial climates and potential links to Human evolution. Here we highlight some of the expedition successes and ongoing post-cruise research to show how it has made major strides toward fulfilling each of these objectives. The recovered sequences allowed complete spliced stratigraphic sections to be generated that span the interval of 0 to between ~0.13 and 7 Ma. These sediments provide an exceptional opportunity to generate decadal to millennial-scale climatic records that will resolve key paleoceanographic and paleoclimatic questions from a region poorly represented in the database of scientific drill sites.

O-G2-09 Variations in coccolithophore productivity off South Africa over the last

five glacial cycles

Deborah Tangunan, MARUM Center for Marine Environmental Sciences, University of Bremen
Karl-Heinz Baumann, Department of Geosciences, University of Bremen
Christina Fink, Department of Geosciences, University of Bremen
Presenter Email: tangunan@uni-bremen.de

Here we present a 500-kyr coccolithophore productivity record off the South African continent from assemblage composition and geochemical-based coccolithophore proxies from sediment cores obtained from the southwestern Indian Ocean (MD96-2077) and the eastern South Atlantic Ocean (ODP Sites 1264/1266). Our multiproxy reconstruction highlights how hydrodynamic and astronomical processes controlled variations in the coccolithophore productivity record. We interpreted the productivity changes to be driven by the migration of the subtropical front (STF) and the strength of the prevailing westerlies. Fluctuations in the records also show prominent glacial/interglacial variations at 100-kyr orbital periodicity. Here two assemblage groups are recognized: cooler water dominated by Gephyrocapsa muellerae suggestive of the northward shift of the STF and warm water taxa, including Syracosphaera pulchra, Rhabdosphaera clavigera, Umbilicosphaera foliosa, U. sibogae, Calciosolenia spp., Oolithotus fragilis, Umbellosphaera tenuis and Calcidiscus leptoporus, indicative of the Agulhas Current warm water transport to the South Atlantic. We propose that the frontal shifts have modulated the Agulhas Current in the Indian Ocean and the Benguela Current upwelling in the South Atlantic, and played a key role in the water column physico-chemical characteristics of these regions. The equatorward migration of the STF during glacial periods resulted in a reduced intensity of the Agulhas Current and a stronger Benguela Current upwelling, as revealed by similar long-term productivity patterns between the Natal Valley (MD96-2077) and off Namibia (ODP Site 1082), showing enhanced surface water productivity during the glacial periods. By contrast, productivity in the Walvis Ridge (ODP Site 1266), shows opposite patterns, i.e., enhanced productivity during the interglacial periods indicating that the nutrient-rich upwelled waters off Namibia could be transported via seaward lateral advection during the weakening of the upwelling process in the coastal region or by the entrance of cold nutrient-rich southern sourced water.

O-G2-10 High-and low-latitude forcing of the East African climate since the Last Glacial Maximum

Xiting Liu, Ocean University of China
Presenter Email: liuxiting@gmail.com

High-resolution of geochemical scanner profiles have improved time resolution of sampling, which allowed us to obtain continuous sediment sequences with high temporal resolution marine records. To date, unlike the well study on the western north tropical

Africa, only few studies on marine sediments off East Africa, demonstrating inland climatic conditions since the Last Glacial Maximum (LGM), have been carried out. We present X-Ray Fluorescence (XRF) Scanner measurements from a 6 m long sediment core (GeoB12624-1) on the upper slope of Tanzania to reconstruct the climatic evolution in East Africa since the Last Glacial Maximum (LGM). Log-ratios of Fe/Ca and Ti/Ca are indicative for sediment discharge of the Rufiji River, which is controlled by climatic conditions in the Rufiji catchment area. The data set records distinct precipitation peaks during the early Holocene. This corresponds a maximum in the Northern Hemisphere (NH) summer insolation and results in a transition from the arid LGM to the humid early Holocene. Our geochemical record also indicates that this climatic transition was interrupted by two severe droughts that occurred during NH cold intervals: the Heinrich stadial 1 (HS1) and the Younger Dryas (YD). Through a comparison with other nearby paleoclimatic records, we suggest that arid climatic conditions only occurred in East Africa north of 8-10 ˚S, whereas in southern East Africa around 15-20 ˚S increased humidity during the HS1 and YD prevailed. We thus conclude that these two drought events were caused by a southward migration of the Intertropical Convergence Zone (ITCZ) which was fostered by the NH cooling during the HS1 and YD. Hence, our new geochemical record clearly documents that the East African climate not only responded to low-latitude insolation forcing on sub-orbital time scales, but also, was strongly influenced by high-latitude cooling during the HS1 and YD periods.

O-G2-11 Australian shelf sediments reveal shifts in Miocene Southern Hemisphere Westerlies

Jeroen Groeneveld, Alfred Wegener Institute for Polar and Marine Research, Telegrafenberg A43, D-14473 Potsdam, Germany
Jorijntje Henderiks, Department of Earth Sciences, Uppsala University, Villavägen 16, 75236 Uppsala, Sweden
Willem Renema, Naturalis Biodiversity Center, PO Box 9517, 2300 RA Leiden, Netherlands
Cecilia McHugh, School of Earth and Environmental Sciences, Queens College (City University of New York), 65-30 Kissena Boulevard, Flushing, NY 11367, USA
David De Vleeschouwer, Center for Marine Environmental Sciences (MARUM), University of Bremen, Klagenfurter Strasse, D-28359 Bremen, Germany
Beth Christensen, Environmental Studies, Adelphi University, 1 South Avenue SCB 201, Garden City, NY 11530, USA.
Presenter Email: jgroeneveld@uni-bremen.de

The expansion of the Antarctic ice sheet (AIS) ~14 million years ago (Ma) impacted global atmospheric circulation, including the strength and position of the Westerlies and the Intertropical Convergence Zone (ITCZ). We present new sediment records off western Australia (IODP Exp. 356, Sites U1459 and U1464) providing evidence linking high latitude

cooling around Antarctica to climate change in the (sub)tropics during the Miocene (Groeneveld et al., Science Adv. 2017). We show that western Australia was arid during the middle Miocene. Southwest Australia became wetter during the late Miocene, while northwest Australia remained arid throughout. Precipitation and river runoff in southwest Australia gradually increased from 12 to 8 Ma, which we relate to a northward migration of the Westerlies possibly due to increased sea ice in the Southern Ocean. Abrupt aridification indicates that the Westerlies shifted back to a position south of Australia after 8 Ma. Our mid-latitude Southern Hemisphere data are consistent with the inference that expansion of sea ice around Antarctica resulted in a northward movement of the Westerlies. This in turn may have pushed tropical atmospheric circulation and the ITCZ northward, shifting the main precipitation belt over large parts of southeast Asia including the South China Sea.

O-G2-12 Glacial-interglacial variations in opal and organic carbon accumulation in the eastern equatorial Indian Ocean

Selvaraj Kandasamy, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China
Peng Yang, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China
Cheng Jin, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China
Zhiqiang Wang, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China
Huawei Wang, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China
Qianqian Liu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, PR China
Stephan Steinke, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China
Mahyar Mohtadi, Center for Marine Environmental Sciences (MARUM), University of Bremen, Germany
Presenter Email: selvaraj@xmu.edu.cn

Marine silica cycle has a tight link with the carbon cycle on glacial-interglacial timescales along the coastal and equatorial upwelling regions and other high productivity areas. Estimation of carbon burial in the eastern equatorial Indian Ocean, in particular areas off Sumatra and Java, has been suggested to hold between 0.1% and 7.1% of the global annual carbon burial. Nonetheless, the role of biogenic silica productivity/ burial and its relation to carbon burial on glacial-interglacial timescales in this region are unknown. Here we investigate opal and total organic carbon (TOC) contents in two, radiocarbon-dated sediment cores (GeoB-10029-4 and GeoB-10038-4) from the eastern equatorial Indian

Ocean to understand the link between their accumulation rates and mechanisms responsible for their variations over the past ~40 thousand years (kyr). Both opal and TOC contents were roughly two times higher in core GeoB-10029-4 than in core GeoB-10038-4, though the location of the former is not affected by the seasonal upwelling at present, indicating that the monsoon-induced seasonal upwelling may not be the main driver of opal and organic matter accumulation in this area. Low opal and TOC values during the glacial period than the deglacial and Holocene intervals were however consistent with high productivity during the warm interglacials. Our records show increased and decreased diatom productivity during Last Glacial Maximum (LGM) and deglacial intervals, respectively, suggesting a strong sea level control over the preservation of opal and organic matter in the study area. Consistently, atomic Si/C ratios were more or less similar in sediments accumulated during glacial and Holocene intervals in both cores, but these ratios were relatively higher in sediments deposited during the LGM and deglacial intervals, especially at the non-upwelling location, implying a better preservation and/or weaker dissolution of opal when the core location became an enclosed basin during these intervals due to low and increased sea level. Overall, opal accumulation rates were higher than TOC since the LGM at the non-upwelling site, whereas an opposite trend between their accumulation rates was mostly evident at the upwelling site for the last ~40 kyr. This study will therefore address the mechanisms for the differential burial and behavior of opal and organic carbon on glacial-interglacial timescales between these two hydrographically dissimilar sites.

O-G2-13 Perturbation of the silicon cycle during the PETM: new insights from silicon isotopes

Guillaume Fontorbe, Lund University, Department of Geology, Lund, Sweden
Patrick J. Frings, GFZ Potsdam, Potsdam, Germany
Christina L. De La Rocha,
Katharine R. Hendry, School of Earth Sciences, University of Bristol, Bristol, UK
Daniel J. Conley, Lund University, Department of Geology, Lund, Sweden
Presenter Email: guillaume.fontorbe@geol.lu.se

The Paleocene Eocene Thermal Maximum (PETM) is a geologically rapid perturbation of the global carbon cycle that occurred around 56 million years ago, which is marked by a negative carbon isotope excursion (CIE) and an increase in global temperature. The CIE is thought to result from the rapid release of 13C-depleted carbon, however, the source(s) of carbon, the rate of release, internal and/or external triggers, and the mechanisms by which the climate system recovered are still heavily debated. Many of the proposed mechanisms for both onset and recovery of the PETM make testable hypotheses about impacts on the marine silicon cycle, which can potentially be recorded in siliceous microfossils. We analyzed the Si isotopic composition of marine siliceous microfossils

covering the PETM and observed a decrease in δ30Si coeval with the CIE, indicating an immediate response to the silicon cycle during the PETM. Using a simple box model we investigated the sensitivity of oceanic δ30Si to a set of perturbations in ocean circulation, weathering intensity, and magmatic events; all of which are plausible mechanisms occurring during the PETM. Combining this model with our new Si isotopes record, we provide additional constraints for investigating the processes involved during the different phases of this event.

O-G2-14 Reconstructing the upper ocean thermal structure in the western Philippine Sea over the past 700 kyr

Qi Jia, First Institute of Oceanography, State Oceanic Administration
Tiegang Li, First Institute of Oceanography, State Oceanic Administration
Zhifang Xiong, First Institute of Oceanography, State Oceanic Administration
Presenter Email: jiaqi0604@163.com

We present δ18O and Mg/Ca data of upper-thermocline dwelling planktonic foraminifera Pulleniatina obliquiloculata from the International Marine Global Change Study Program (IMAGES) Core MD06-3047B (17 °00.44'N, 124 °47.93'E, 2510 m water depth), located in the northwestern tropical Pacific Ocean. Then the thermocline temperature (TWT) and the differences between the sea surface temperature (SST) from our previous study and TWT records were estimated in order to discuss the changes in the upper ocean thermal structure in the northwestern tropical Pacific over the past 700 kyr. On glacial-interglacial timescale, we found that SST and TWT records show relatively different characters, such as, with earlier increase in TWT than SST during glacials. And our analysis of the records indicate smaller (larger) vertical thermal gradient and thus deeper (shallower) thermocline depth during glacials (interglacials) in the northwestern tropical Pacific. In addition, we also found a long-term change tendency of the vertical thermal gradient in our study area. And the variation of the East Asian Monsoon may be an important influencing factor for the changes in upper ocean thermal structure on glacial-interglacial and longer timescales.

O-G3-01 Comparative metatranscriptomes reveal the adaptive potential of coral holobionts under thermal stress

Monica Medina, Penn State University
Viridiana Avila, Penn State University
Bishoy Kamel, Penn State University
Michael DeSalvo, Thermo Fisher
Roberto Iglesias-Prieto, Penn State University
Hiroaki Kitano, Sony Research Labs
Monica Medina, 1968
Presenter Email: momedinamunoz@gmail.com

Elevated sea surface temperatures pose a threat for coral reefs. Evaluating adaptive potential becomes increasingly important under the threat of climate change. Using a phylogentic framework, we have performed a controlled bleaching experiment on three different coral species. Through a comparative metatranscriptome analysis, we uncovered genes that have maintained conserved expression over evolutionary time that may have undergone expression level adaptation. Our analyses reveal both host and algal gene candidates with a potential adaptive expression involved in key metabolic functions such as protein processing, vesicle mediated transport, apoptosis, carbon concentration mechanisms, cell division and chlorophyll biosynthesis. In addition, we observed that coexistent coral holobiont microbial associates display different responses and metabolic capabilities under high temperature stress. We find that each member has a unique response that can influence the holobiont's ability to cope with thermal stress. Thermotolerance may be explained the redundancy and the maintenance of key metabolic pathways from different microbial partners. These microbial functional contributions to coral holobionts can have conspicuous evolutionary and ecological outcomes under climate change.

O-G3-02 The physiological responses of juvenile *Platygyra* to diurnal pCO2 fluctuations

Hui Huang, Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences,, Guangzhou, China Tropical Marine Biological Research Station in Hainan, Chinese Academy of Sciences, Sanya, Hainan, China
Lei Jiang, Fourth Institute of Oceanography, State Oceanic Administration, Beihai, Guangxi, China
Presenter Email: huanghui@scsio.ac.cn
Diurnal pCO2 fluctuations have the potential to modulate the biological impact of ocean acidification (OA) on reef calcifiers, yet little is known about the physiological and biochemical responses of scleractinian corals to fluctuating carbonate chemistry under OA. Here, we exposed newly settled *Pocillopora damicornis* for 7 days to ambient pCO2, steady and elevated pCO2 (stable OA) and diurnally fluctuating pCO2 under future OA scenario (fluctuating OA). We measured the photo-physiology, growth (lateral growth, budding and calcification), oxidative stress and activities of carbonic anhydrase (CA), Ca-ATPase and Mg-ATPase. Results showed that while OA enhanced the photochemical performance of in hospite symbionts, it also increased catalase activity and lipid peroxidation. Furthermore, both OA treatments altered the activities of host and symbiont CA, suggesting functional changes in the uptake of dissolved inorganic carbon (DIC) for photosynthesis and calcification. Most importantly, only the fluctuating OA treatment resulted in depressed calcification with concurrent upregulation of Ca2+-ATPase and Mg2+-ATPase, implying

increased energy expenditure on calcification. Consequently, asexual budding rates decreased by 50% under fluctuating OA. These results suggest that diel pCO2 oscillations could modify the physiological responses and energy budget of coral recruits under future OA, and that fluctuating OA is more energetically expensive for the maintenance of coral recruits than stable OA.

O-G3-03 Limited functional redundancy and more complementarity of herbivorous fish on shaping benthic community in coral reefs of South China Sea

Sheng Liu, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Xianzhi Lin, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Simin Hu, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Hui Huang, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: shliu@scsio.ac.cn

As one of the most critical functional groups in coral reef ecosystem, a wide variety of herbivorous fish species were all recognized to play important roles in balancing the competition between coral and algae. Hence, this kind functional redundancy, occupying the same ecological niche, was considered to be important for enhancing resistance of coral reef. However, it remains unclear how this functional redundancy worked among different herbivorous fish species because of the limits on identifying algae food accurately, especially for the complex turf algae community or EAM (Epilithic algal matrix). To better understand the functional roles of herbivorous fish and their interspecific trophic interactions, the food spectrum of six herbivorous fish species in the coral reef of South China Sea was revealed by high-throughput sequencing method. More than 347 genera of food were detected totally. Brown algae, dinoflagellates, red algae, green algae and Arthropoda constituted the main dietary resources of these fishes. Food overlap among these fish was frequent in the group of algae, mainly from phylum of Ochrophyta, Rhodophyta and Dinoflagellata, indicating considerable functional redundancy of herbivorous fishes on phylum level. However, seen from the 144 trophic links between fishes and representative food items (relative abundance > 1%) constructed by Bipartite Webs analysis, only 30 genera were shared by two or more fish species, and the brown algae Sphacelaria sp. were the only food item consumed by all 6 fish species. Our results here suggested that herbivorous fish showed limited functional redundancy at a finer scale compared with previous conclusion from coarse food categorizations. Conversely, considerable food separation between different fish species, a higher functional complementary, may play a more important role in shaping benthic community, and indicated that each species of herbivorous fish is an indispensable part in maintaining the balance between coral and algae in coral reef ecosystem. Keywords: Herbivorous reef fish, Functional redundancy, complementary, Phase shift, bipartite food webs

O-G3-04 Illuminating the dark depths inside coral

Chichi Liu, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China.
Shuk Han Cheng, Department of Biomedical Sciences, City University of Hong Kong, Hong Kong, China
Senjie Lin, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China
Presenter Email: liuchichi@xmu.edu.cn

The ability to observe in situ 3-D distribution and dynamics of the endosymbionts in corals is crucial for gaining mechanistic understanding on coral bleaching and reef degradation. Here we report the development of a tissue-clearing (TC) coupled light sheet fluorescence microscopy (LSFM) method for 3D imaging of the coral holobiont at single-cell resolution. Initial applications of the technique have returned unprecedented quantitative information of endosymbiont abundance and distribution within corals. With specific fluorescent probes or assays, the TC-LSFM method also reveals distribution and dynamics of physiological conditions such as cell proliferation, apoptosis, and hypoxia response in the coral holobiont. This tool will prove powerful for in situ and in-depth data acquisition to illuminate coral symbiosis and health conditions in the changing marine environment, providing fundamental information for coral reef conservation and restoration.

O-G3-05 The shielding effect of coral reefs to create unusually low radiation environment on the surface of the earth

Wuhui Lin, Coral Reef Research Center of China, Guangxi University
Kefu Yu, Coral Reef Research Center of China, Guangxi University
Yinghui Wang, Coral Reef Research Center of China, Guangxi University
Tianlai Fan, Coral Reef Research Center of China, Guangxi University
Xueyong Huang, Coral Reef Research Center of China, Guangxi University
Presenter Email: linwuhui8@163.com

Variable intensity of ionizing radiation occurs from the surface environment to the interior of the Earth. High background radiation area (HBRA) had been widely investigated from the perspectives of uranium/thorium mineral resource searching and radiation dose-cancer effect interaction. In the present study, we exhibited unusually low radiation in the coral reef regions, the opposite endmember of HBRA, based on a three-dimensional viewpoint. From the horizontal perspective, extremely low radiation was observed in 12 locations of coral reefs in the South China Sea (SCS). From the vertical perspective, the natural gamma radiation derived from the field-based NaI gamma spectrometry and the natural radionuclides calculated from the laboratory-based HPGe gamma spectrometry also had extremely low values for a long coral core (928 m) located in the Xisha Island, SCS. It was noted that the mean radioactive level in the atoll reefs (3.97 Bq/kg) was less than 5% of

that in global average soil (108.70 Bq/kg) and was <10% of that in HBRA (~104 Bq/kg). The reason for this low radioactivity is that coral skeletons and other biogenic carbonate skeletons (bivalve, Halimeda, coralline algae, foraminifera, etc.) have low radioactivity relative to high radioactivity of terrigenous minerals originating from Earth's interior followed by a series of geological processes. All in all, coral reefs with low radioactivity behave like a white cap to shield high radioactivity from the rock and mineral in Earth's crust. Coral reefs are probably the lowest radiation area on the surface of the Earth. The unique label of unusually low radioactivity in coral reefs was proposed and illustrated in addition to other traditional labels (good water quality, high biodiversity, high productivity, etc.).

O-G3-06 The short-term plasticity of Hong Kong's *Platygyra* sp. corals: a new insight on coral in-situ metabolism and ex-situ manipulations

Walter Dellisanti, 1. State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong S.A.R., China 2. Department of Biomedical Sciences, City University of Hong Kong, Hong Kong, S.A.R., China 3. Shenzhen Key Laboratory for the Sustainable Use of Marine Biodiversity, Research Centre for the Oceans and Human Health, City University of Hong Kong, Shenzhen Research Institute, Shenzhen, China
Ryan HL Tsang, 4. Marine Science Laboratory, Chinese University of Hong Kong, Shatin, Hong Kong SAR, China
Put Ang Jr, 4. Marine Science Laboratory, Chinese University of Hong Kong, Shatin, Hong Kong SAR, China
Jiajun Wu, 1. State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong S.A.R., China 3. Shenzhen Key Laboratory for the Sustainable Use of Marine Biodiversity, Research Centre for the Oceans and Human Health, City University of Hong Kong, Shenzhen Research Institute, Shenzhen, China
Leo Chan, 1. State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong S.A.R., China 2. Department of Biomedical Sciences, City University of Hong Kong, Hong Kong, S.A.R., China 3. Shenzhen Key Laboratory for the Sustainable Use of Marine Biodiversity, Research Centre for the Oceans and Human Health, City University of Hong Kong, Shenzhen Research Institute, Shenzhen, China
Presenter Email: wdellisan2-c@my.cityu.edu.hk

Physiological rates of corals have been an object of investigation for a long time and different tools have been developed both for field and laboratory studies. The use of new diver-portable respirometers designed to measure coral respiration and photosynthesis by in-situ analysis of dissolved oxygen, pH and temperature variations is now under investigation. Hong Kong coral communities are frequently exposed to acute temperature and heavy rainfall events during the wet season (summer). They may not have subjected to tissue mortality since they are adapted to light intensity fluctuations and increased

feeding rates. However, the increase in the frequency and severity of acute stress events in coastal waters provides an additional stress for corals surviving at the edge of their environmental and physiological tolerances, even with slow growth and physiological rates. Unfortunately, how corals metabolically response to local perturbations (such as warming, heavy rainfall, and bleaching events) in their natural environment is still poorly understood. Coral in-situ metabolism of *Platygyra* sp. colonies has been investigated in Port Island, Hong Kong, during summer 2018. Simultaneously, several single stress ex-situ experiments have been carried out to better understand the physiological tolerance at the threshold limit of high temperature and low salinity. Here we show the first results from our strategy to evaluate the coral health by combining classic scientific diving techniques with novel technologies. The aim is to provide a better definition of coral health by integrating the complexity of the coral holobiont and the co-influence of biotic and abiotic factors in a changing climate scenario.

O-G3-07 Nutritional musings on coral evolution

David M. Baker, The University of Hong Kong The Swire Institute of Marine Science
Presenter Email: dmbaker@hku.hk

Since the 1970s it's been debated that coral colony and polyp morphology are related to corals trophic position. Larger polyps and massive skeletons are considered traits common to heterotrophic corals, whereas small polyps and branching morphologies are attributed to autotrophy. Moreover, heterotrophic corals appear more resilient in the face of climate change with observations of bleaching resistance attributed to provisioning via heterotrophy. In this talk, I will argue that morphology and nutrition share a common phylogenetic history, and that polyp and skeletal surface area:volume are optimized for autotrophy in fast-growing and highly competitive species. Yet, times are changing. The oceans are warmer and more eutrophic than ever before. In this Anthropocene, autotrophic corals are succumbing to starvation and disease as their over-investment in autotrophy becomes their Achilles heel?

O-G3-08 Genetic diversity and large-scale connectivity of the scleractinian coral *Porites lutea* in the South China Sea

Wen Huang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Ming Li, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China

Kefu Yu, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Yinghui Wang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Jingjing Li, College of Oceanography, Hohai University, Nanjing, 210098, China
Jiayuan Liang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Yanqiu Luo, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Xueyong Huang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Zhenjun Qin, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Guanghua Wang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China School of Marine Sciences, Guangxi University, Nanning 530004, China
Presenter Email: wenhuang@gxu.edu.cn

In light of recent declines in scleractinian communities worldwide, research on the genetic structure of and connectivity amongst coral populations has assumed importance. However, the genetic structure of corals in the South China Sea(SCS) has remained largely neglected by studies. The genetic structure of the broadcast spawning coral *Porites lutea* was examined using 482 specimens from 20 sites in the SCS spanning 13° of latitude. Analyses of two nuclear markers congruently revealed that genetic diversity was high in most populations, with relatively lower diversity in Daya Bay (DY). However, we identified a recent bottleneck in P. lutea populations, which may be in accordance with recent coral community declines. Pairwise FST values and principal coordinates analyses indicated large-scale (~1500 km) genetic homogeneity among SCS P. luteapopulations, possibly attributed to their reproductive strategy (spawning vs. brooding) and historical changes in population sizes. However, populations in DY were highly differentiated from the others, which Coalescent migration analyses of ITS rDNA markers revealed high levels of gene flow (Nm > 100) among all adjacent populations except between DY and Taiwan. the

northward migration of the species in response to global warming. We concluded that populations of P. lutea in the SCS comprise one large panmictic meta-population. However, the lower-diversity, more differentiated northern marginal populations in DY are probably more vulnerable than others to the adverse effects of anthropogenic activities. Additionally, universally asymmetrical northward gene flow was identified, possibly reflecting.

O-G3-09 RNA-seq profiling of *Symbiodinium kawagutii* in response to different trace metals

Xin Lin, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China
Tangcheng Li, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China
Liying Yu, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China
Irene B. Rodriguez, Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan
Tung-Yuan Ho, Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan
Senjie Lin, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China
Presenter Email: xinlin@xmu.edu.cn

Symbiodinium spp. is the essential symbiont in corals, providing the host with vital photosynthesis product. In the past decades, global warming and anthropogenic activities has become the major threats to cause coral bleaching events which is attributed to the expulsion of symbionts. There is evidence that availability of trace metal to symbiont is linked to the coral anti-stress capacity, because they are cofactor required by antioxidative enzymes. In this study, we applied RNA-seq to generate a general gene expression profile of S. kawagutii, cultured under different trace metal concentration. Five trace metals Fe^{2+}, Zn^{2+}, Cu^{2+}, Mn^{2+}, Ni^{2+}, were examined in this work. The aim of this study is to provide insights to interpret how trace metal availability modulate the gene transcription, metabolism network, and the antioxidant capacity of *Symbiodinium*.

O-G3-10 Stressful Times: The Biology, Chemistry and Application of Bleaching Signatures in Coral Skeletons.

Anne Cohen, Woods HoleOceanographic Institution
Presenter Email: acohen@whoi.edu

Ocean warming threatens the survival of coral reef ecosystems. When water temperatures exceed a threshold, corals bleach, rejecting the algal symbionts that feed them. Prolonged

bleaching causes starvation and eventually, death. And yet, despite multiple global scale bleaching events within the last 4 decades, coral reef futures under 21st century global warming are difficult to predict, due in large part to a paucity of bleaching observations across space and back in time. Here I present new biological and geochemical data in support of a coral reef bleaching proxy that we are using to fill these gaps in knowledge. Skeletal stress bands, visualized in 3-D CT scan images of coral cores, are discrete, anomalously high density bands long associated qualitatively with coral bleaching. By tracing individual coral colonies through a bleaching event, I show that skeletal stress bands form during periods of prolonged bleaching-induced starvation and that their fine-scale characteristics reflect the rate of onset, severity and duration of bleaching. Compositionally, stress bands are anomalous relative to that of skeleton accreted during non-bleaching years, in a way that is consistent with chronic reduction in the pH and aragonite saturation state of the coral's calcifying fluid. Critically, our study of 12 coral reef ecosystems in the Pacific and Atlantic Oceans reveals the proportion of stress bands in the population of massive corals increases as the severity of bleaching in the coral community increases. Using examples, I will demonstrate how stress bands are being applied to evaluate the response of coral communities to episodes of extreme thermal stress, to identify where thermal thresholds are shifting over time, and to locate heat-tolerant reef communities that have the best chance of surviving future warming.

O-G3-11 Trophic strategy drives bleaching resistance in corals

Inga Elizabeth Conti-Jerpe, The Swire Institute of Marine Science and the School of Biological Sciences, The University of Hong Kong, Hong Kong Special Administrative Region, China
Philip Douglas Thompson, The Swire Institute of Marine Science and the School of Biological Sciences, The University of Hong Kong, Hong Kong Special Administrative Region, China
Cheong Wai Martin Wong, The Swire Institute of Marine Science and the School of Biological Sciences, The University of Hong Kong, Hong Kong Special Administrative Region, China
Nara Lina, Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Ilh´eus, BA, Brazil
Nicolas Noël Duprey, Department of Biogeochemistry, Max Planck Institute for Chemistry, Mainz, Germany
Molly A. Moynihan, Earth Observatory of Singapore, Interdisciplinary Graduate School, Nanyang Technological University, Singapore and Asian School of the Environment, Nanyang Technological University, Singapore
David M. Baker, The Swire Institute of Marine Science and the School of Biological Sciences, The University of Hong Kong, Hong Kong Special Administrative Region, China

Presenter Email: ingacontijerpe@gmail.com
The hypothesis that speciation is driven by niche partitioning to avoid direct competition with co-occuring species for limiting resources has been supported across many taxa. However, for reef-building corals, defining a trophic niche has proven elusive as the structure and function of morphological characters such as colony and polyp morphology are confounded by the highly co-evolved symbiosis with symbiotic algae (zooxanthellae). By sharing resources, corals and zooxanthellae afford flexibility in their trophic niche, ranging across autotrophy and heterotrophy, but impede our ability to define the trophic niche of a species through traditional observational methods (feeding behaviors and diet studies). Using Stable Isotope Bayesian Ellipses in R (SIBER) analysis, we compared the isotopic niche placement of paired hosts and symbionts in 7 genera. Our results revealed a range of trophic strategies: in some genera (Acropora and Goniopora) the host and symbiont had nearly 100% overlap of their isotopic niches implying shared nutritional resources, while in others (Favites, *Platygyra*, and Turbinaria) there was no overlap. Finally, some genera (Pavona and Porites) have partial overlap suggesting a flexible symbiosis. These patterns were driven by nitrogen, not carbon; indeed, the difference between the $\delta^{15}N$ values of host and symbiont was positively correlated with corallite area, suggesting that smaller polyps evolved to support obligate symbioses while larger polyps enable corals to meet their nutritional requirements through heterotrophic feeding. To investigate linkages between trophic strategy and bleaching resistance, we subjected 8 coral species (A. samoensis, A. pruinosa, F. abdita, G. lobata, P. decussata, P. lobata, P. carnosus, and T. peltata) to a warming experiment. We found a significant correlation between the difference between host and symbiont $\delta^{15}N$ and the degree heating weeks at which >50% of individuals within a species bleached. We were able to demonstrate a similar relationship between bleaching resistance and corallite area using data collected in situ during a 1997 bleaching event off the eastern coast of Africa. These data support the hypothesis that bleaching in corals results from CO_2 limitation, and that heterotrophic corals can prolong symbiosis by supplying their symbionts with CO_2 from respiration fueled through feeding. Our results not only elucidate the trade-offs leading to trophic niche partitioning in corals, but also hold important implications for which coral species will be "winners" and "losers" as climate change progresses.

O-G3-12 A numerical model of coral symbiosis, photosynthesis, respiration and calcification processes

Yi Xu, State Key Laboratory of Estuarine and Coastal Research
Jing Zhang, State Key Laboratory of Estuarine and Coastal Research
Presenter Email: xuyi@sklec.ecnu.edu.cn
The coral-zooxanthellae symbiotic relationship, involving the recycling of nutrients and close coupling between different trophic levels, is an evolutionary success of coral reefs

ecosystem. Understanding the dynamics of this symbiosis is essential to predict how corals respond to environmental stressors, such as changes in nutrients availability, water temperatures and irradiance. Given the ecological scale that the processes in coral ecosystem cover from molecular to ecosystem level, numerical modeling is an effective way to put the coral-reef system into a real environmental condition and evaluate its responses to environmental changes. A numerical model was developed to describe coral symbiosis and the system photosynthesis, respiration and calcification processes. The energy transfer between symbiotic algae and host animal was explored as well as the system physiology variability with respect to different nitrogen sources and under different light regimes.

O-G3-13 Nucleation of aragonite in aqueous solutions: implication for coral biomineralization

Zeing Long, State Key Laboratory of Geological Process and Mineral Resources, China University of Geosciences, Beijing 100083, China
Al Katz, Department of Physics, CCNY, CUNY, New York, NY 10583, USA
Chen Zhu, Key Laboratory of Surficial Geochemistry, Nanjing University, Nanjing 210093, P.R. China
Liang Zhao, Key Laboratory of Surficial Geochemistry, Nanjing University, Nanjing 210093, P.R. China
Zhengrong Wang, Department of Earth and Atmospheric Sciences, CCNY, CUNY, New York, NY 10583, USA
Presenter Email: zwang1@ccny.cuny.edu

Although marine organisms can secrete both calcite (e.g. mollusks) and aragonite (e.g. corals) to make their skeletons, only metastable aragonite naturally precipitated from supersaturated modern seawater inorganically. Previous studies suggest that Mg/Ca is one of the most important factor to determine the ca-carbonate minerals phases in seawater. In this study, we systematically investigate how solution chemistry (including Mg/Ca, salinity, temperature and other impurities) affects the nucleation dynamics. Experiments were conducted to nucleate calcite, aragonite, vaterite and amorphous Ca-carbonates. In each experiment, about 3.0 ml of solution was mixed in a 3.5 ml semi-micro polystyrene cuvette from CaCl2/MgCl2, NaHCO3, and NaOH with known concentrations. Solutions were oversaturated relative to calcite/aragonite. Experiments were carried out over a range of saturation states, (Ca + Mg)/CO32- and Mg/Ca activity ratios between 15 and 40 oC, and the turbidity and pH of the solution were continuously monitored using a fiber optic spectrometers coupled with a CCD detector (measured at 700 nm wavelength), and a pH micro-probe, respectively. Induction time in each experiment was deduced from the turbidity variation with time. The saturation state of the solution and ion speciation were calculated using PHREEQC program and measured pH values. Using these information, the

surface energy of precipitates can be extracted from the correlation between induction time and saturation states. Over the course of the experiments, precipitates were observed under SEM and mineral phases were determined by XRD method. Our experimental results show analyses based on turbidity results provide a more accurate estimate of the induction-time compared with those based on pH data. Our precipitation experiments with similar metal (Ca or Mg)/CO32- activity ratios are consistent with classical nucleation theory (CNT), while the surface energy derived from CNT varies with temperature, mineral phases, Ca/CO32-, Mg/Ca, and some other impurities in solution.

O-G3-14 Biological modulation of coral growth responding to long-term climate change

Yi Liu, Tianjin University
Shicheng Tao, Guangxi University
Kefu Yu, Guangxi University
Chen-Feng You, National Cheng Kung University
Presenter Email: Yi Liu

Chemical conditions at the site of calcification of corals play a key role on fast biogenic carbonate accretion, but how it responds to climate change is largely unknown. Here, we present multiple, century-long records of pHcf and DICcf of calcifying fluid (cf) in corals from the South China Sea using the δ11B and B/Ca techniques. The cf chemistry and growth parameters of 6 massive Porites colonies show consistent changes in response to high-frequency climatic oscillations over the past ~550 years, with lower DICcf and growth rate, higher pHcf and Ω cf during colder intervals and vice versa. Inferred from the paired records cf chemistries and growth rates, these tropical corals may have acclimatized and/or adapted a highly variable climate during their long evolutionary history through modulating their cf chemistry to optimize calcification rates. Moreover, SCS corals have taken advantage of global warming and their growth rate has increased substantially since the end of Little Ice Age, and been largely unaffected by ocean acidification so far.

O-M1-01 Solubility controls carbonate chemistry with local modifications in North American ocean margins

Wei-Jun Cai, School School of Marine Science and Policy, University of Delaware
Yuanyuan Xu, School School of Marine Science and Policy, University of Delaware
Richard A. Feely, NOAA Pacific Marine Environmental Laboratory
Leticia Barbero, NOAA Atlantic Oceanographic and Meteorological Laboratory
Simone Alin, NOAA Pacific Marine Environmental Laboratory
Jessica Cross, NOAA Pacific Marine Environmental Laboratory
Adrienne Sutton, NOAA Pacific Marine Environmental Laboratory

Kumiko Azetsu-Scott, Department of Fisheries and Oceans, Canada, Bedford Institute of Oceanography
Bror Johnson, University of New Hampshire, Ocean Process Analysis Laboratory
Presenter Email: wcai@udel.edu
The increase of anthropogenic CO2 in the atmosphere has acidified the ocean and affected the health of organisms and ecosystems therein. While studies have demonstrated greater ocean acidification (OA) and more complex processes in coastal waters than open oceans, mechanisms controlling large spatial distribution patterns in coastal oceans are still not well understood. We report here recently measured carbonate parameter distributions in North American ocean margins and show that carbonate saturation state (omega) and total dissolved inorganic carbon (DIC) distributions in the US and Canadian eastern, Gulf of Mexico, and Gulf of Alaska coastal waters demonstrate a remarkable consistency with predictions from a solubility control mechanism which dictates more atmospheric CO2 uptake and drives carbonate (CO32-) and omega low in cold northern waters and less so in warm southern waters while there exist large local variabilities in pH and CO2 partial pressure (pCO2). The solubility driven mechanism is greatly modified by upwelling and biological production in the California Current System along the US West Coast with upwelling leading to high pCO2 and low omega and pH and biological production to the opposite distributions. We further show that contrasting features between solubility-controlled DIC and omega and local process-controlled pH and pCO2 are determined by the nature of marine acid-base equilibrium, with bicarbonate (HCO3-) and CO32- being the major components, which are insensitive to short-term local processes, and H+ and [CO2] being minor components and most sensitive to short-term local processes. The large signals observed in coastal oceans may foreshadow future OA in open oceans and emphasize the needs for understanding contrasting organismal responses to omega and pH under a higher CO2 and warmer future ocean scenario.

O-M1-02 Biological and physical processes driving the biological pump in the California Current Ecosystem

Michael Stukel, Florida State University
Tom Kelly, Florida State University
Presenter Email: mstukel@fsu.edu
The California Current Ecosystem (CCE) is a complex region in which ecological interactions at multiple trophic levels, physical currents at several scales, and multiple limiting nutrients interact to create a complex mosaic of plankton communities. The efficiency of the biological pump is highly variable in this heterogeneous region. Protistan and metazoan taxa produce, consume, and re-shape particles and marine snow in the epi-

and mesopelagic regions leading to a variety of different particle types that vary in their sinking speeds and resistance to degradation by microbes or grazers. Meanwhile, coastal and wind-stress curl upwelling, mesoscale fronts and eddies, and submesoscale jets interact to transport organic carbon (and entire communities) tens to hundreds of kilometers between its formation and eventual export. In this abstract, we combine in situ biogeochemical and genomics data with physical circulation models to investigate factors controlling carbon export and remineralization across scales in the CCE.

O-M1-03 Towards predicting the largest Louisiana hypoxic area: an analysis of a coupled physical-biogeochemistry model results from 1985-2009

Yang Feng, South China Sea Institute of Oceanography & NASA Jet Propulsion Laboratory
Steven F. DiMarco, Texas A&M University, College Station
Karthik Balaguru, Marine Sciences Laboratory, Pacific Northwest Laboratory, Sequim, Washington, USA
Katja Fennel, Dalhousie University
Presenter Email: yfeng1982@126.com

The extent of hypoxic area on the Louisiana shelf has been measured once per year during July since 1985. The measured area was presumed to be the seasonal maximum in different years and was used to derive a relationship with the Mississippi-Atchafalaya riverine nitrogen loading and to make management strategies. However, the measured hypoxic area may or may not be the largest of the year, which complicated the nutrient-hypoxia relationship. In this study, we analysed 25 years of simulations from a coupled physical-biogeochemical numerical circulation model. An EOF analysis on the model-derived hypoxic fields reveals that the dominant pattern is east-west, with strong seasonality in June, July and August. A single linear regression model was performed to examine the explained power of nutrients to hypoxia. It shows that nutrients can explain about 30%-45% measured hypoxia, less than 50%-70% maximum hypoxia. The recent Gulf of Mexico Hypoxia Task Force set a goal to reduce the 5-yr moving average size of the Gulf hypoxic zone to less than 5000 km2 by 2035 and suggested that a 20% reduction in nitrogen loading by 2025 to reach that goal. Our result suggested that the 20% reduction might need a re-estimation once the real largest hypoxic area could be known. A further cross-correlation analysis suggested that potential predictors for largest hypoxia are: 3-months lagged Mississippi River discharge; 2-months lagged shelf-wide surface chlorophyll maximum; 1-month lagged wind direction; 0-month lagged wind intensity; 0-month lagged surface salinity, all of which are readily available from satellite observations.

O-M1-04 Nutrient cycling in the Eastern Mediterranean Sea: An inland sea which behaves like an ocean gyre

Michael Krom, Department of Marine Biology, Haifa University, Israel

Tal Ben-Ezra, Department of Marine Biology, Haifa University, Israel
Anat Tsemel, Department of Marine Biology, Haifa University, Israel
Presenter Email: m.d.krom@leeds.ac.uk

The Eastern Mediterranean Sea (EMS) is a unique oceanic ecosystem. Although it is an inland sea with similar external anthropogenic nutrient supply, it behaves like a mid-oceanic gyre with very low primary productivity (PP) and nutrient concentrations, with important lateral supply of inorganic nutrients and ~25% of the PP supported by dissolved organic matter. The major reason for these unusual properties is its unusual anti-estuarine circulation. In addition the entire water column is P starved and previous studies on the pelagic system have shown that it is P limited in winter and switches to N &P limitation in summer. Almost all previous studies of nutrient distribution in the surface waters of the EMS have used frozen unfiltered samples, which have been shown to be unreliable. In this study we present experimental data to determine the sampling and analytical conditions required to obtain valid nutrient data in the ultra-oligotrophic photic zone. Based on these studies, we present the first reliable seasonal (monthly) nutrient data from both the offshore pelagic system and the first reliable data of any kind on the Israeli shelf, a region where the ultra-oligotrophic pelagic waters are modified by interactions from both the adjacent land and by recycling processes in the sediment. The seasonal results show the nutrient succession related to winter phytoplankton bloom which demonstrate evidence of the phytoplankton succession from diatoms to pico/nanoplankton even in this nutrient starved system. Contrary to previous studies, it was concluded that the coastal system like the pelagic system, is P limited in winter and N&P co-limited in summer; in winter the nitrate in the photic zone was 0.5-1 uM while the phosphate was close to the detection limit of 2 nM, while in summer both nitrate and phosphate were at or below detection limits. The system is P starved with DOP values of ~50 nM which shows little variability implying the DOP is almost entirely refractory. Ammonia levels were generally in the low nanomolar range except for occasional peaks when nitrification was observed in the upper water column. These nutrient results will be used to constrain for the first time, the microbial biogeochemical processes in the photic zone of this ultra-oligotrophic system.

O-M1-05 Understanding CaCO3 cycling in the Yellow Sea

Weidong Zhai, Institute of Marine Science and Technology, Shandong University
Di Qi, Key Laboratory of Global Change and Marine-Atmospheric Chemistry of State Oceanic Administration (SOA), Third Institute of Oceanography, SOA
Cenglong Li, Institute of Marine Science and Technology, Shandong University
Tianqi Xiong, Institute of Marine Science and Technology, Shandong University
Presenter Email: wdzhai@sdu.edu.cn

Based on numerous field surveys of carbonate system parameters carried out from 2011 to 2016, we found that one third of the Yellow Sea suffered from severe bottom seawater

acidification (with araganite saturation state values of <1.5) during summer and autumn, bringing much stress on local benthic fauna community. The seasonal subsurface acidification mostly resulted from the community respiration induced CO2 accumulation in the cold water mass of the Yellow Sea. To chemically quantify the stress of the seasonal acidified seawater on local calcified organisms and benthic communities, we tried to calculate summertime net calcification rate in the North Yellow Sea cold water mass in 2011. The net calcification rate declined to nearly zero when the seawater aragonite saturation state reached a critical level of 1.5-1.6. This is much different from a recently published coral reef case observed by Bradley et al. (2018, Science), which suggest that the seawater aragonite saturation state threshold of net calcification rate reaching zero should be 2.5-3.0 in coral reef systems. Much remains to be investigated in order to quantitatively evaluate the effect of ocean acidification on marine CaCO3 cycles. To further understand CaCO3 cycling in the Yellow Sea, we investigated the dissolved calcium dataset obtained in China Seas in 2011. The results suggested that terrestrial sources only accounted for a part of the Yellow Sea's high calcium salt ratio. Therefore this report implies that net dissolution of calcium carbonate may occur all over the Yellow Sea, changing the proportion of seawater major elements to some extent. These changes may affect many fundamental issues of oceanography, such as the definition and measurement of salinity.

O-M1-06 Realized niches explain spatial gradients in seasonal abundance of phytoplankton groups in the South China Sea

Wupeng Xiao, Xiamen University
Lei Wang, Third Institute of Oceanography, State Oceanic Administration, Xiamen, China.
Edward Laws, Department of Environmental Sciences, School of the Coast & Environment, Louisiana State University, Baton Rouge, Louisiana 70803, USA.
Yuyuan Xie, Xiamen University
Jixin Chen, Xiamen University
Xin Liu, Xiamen University
Bingzhang Chen, Ecosystem Dynamics Research Group, Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan.
Bangqin Huang, Xiamen University
Presenter Email: xiaowupeng1@163.com

A basic albeit elusive goal of ocean science is to predict the structure of biological communities from the multitude of environmental conditions they experience. Estimates of the realized niche-based traits (realized traits) of phytoplankton species or functional groups in temperate seas have shown that response traits can help reveal the mechanisms responsible for structuring phytoplankton communities, but such approaches have not

been tested in tropical and subtropical marginal seas. Here, we used decadal-scale studies of pigment-based phytoplankton groups and environmental conditions in the South China Sea to test whether realized traits could explain the biogeographic patterns of phytoplankton variability. We estimated the mean and breadth of the phytoplankton realized niches based on responses of the group-specific phytoplankton composition to key environmental factors, and we showed that variations of major phytoplankton groups in this system can be explained by different adaptive trade-offs to constraints imposed by temperature, irradiance, and nutrient concentrations. Differences in the patterns of trade-offs clearly separated the dominant groups from one another and generated four sets of realized traits that mirrored the observed biogeographic distribution patterns. The phytoplankton realized niches and their associated traits that we characterized in the present study could help to predict responses of phytoplankton to changes in environmental conditions in the South China Sea and could be incorporated into global biogeochemical models to anticipate shifts in community structure under future climate scenarios.

O-M1-07 Using triple oxygen isotopes to constrain organic carbon production rates and nutrient regeneration in the marginal sea

Zhuoyi Zhu, State Key Lab of Estuarine and Coastal Research, East China Normal University, Shanghai, 200062, PR China
Daniel A. Stopler, Department of Earth and Planetary Science, University of California, Berkeley, CA 94720, USA
Jun Wang, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration, Hangzhou, 310012, PR China
Su-Mei Liu, Key Laboratory of Marine Chemistry Theory and Technology Ministry of Education, Ocean University of China/ Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266100, PR China
Shan Zheng, Jiaozhou Bay Marine Ecosystem Research Station, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China
Gui-Ling Zhang, Key Laboratory of Marine Chemistry Theory and Technology Ministry of Education, Ocean University of China/ Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266100, PR China
Xiao-Xia Sun, Jiaozhou Bay Marine Ecosystem Research Station, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China
Dong-Feng Xu, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration, Hangzhou, 310012, PR China
Meng Zhou, Institute of Oceanography, Shanghai Jiao Tong University, Shanghai, 200030,

PR China
Presenter Email: zyzhu@sklec.ecnu.edu.cn

On two cruises in the slope regions of northern South China Sea, in October, 2014 (autumn) and June, 2015 (spring), we measured gross oxygen production (GOP) and net oxygen production (NOP) in the mixed layer (ML) of station L07 (mean: 115.34E, 19.72N). We also constrained the effect of respiration effect on nutrient regeneration in the nitracline. GOP was estimated using triple oxygen isotopes of the dissolved O2, and the ML depth history was achieved by modeling to improve the precision of gas exchange term in GOP calculation process. GOP for October and June were 169 mmol O2/m2/day and 189 mmol O2/m2/day, respectively. Compared with the measurements of carbon fixation using 14C incubations (114C-P), we found a GOP/14C-P ratio of 6.1 for spring and 4.9 for autumn, respectively. Based on O2/Ar ratio, NOP at station L07 was 1.4 mmol O2/m2/day (autumn) and 8.0 mmol O2/m2/day (spring). In June, 2015, we encountered a warm eddy event which promoted downwelling whereas in Oct., 2014 there were no clear meso-scale features. Further, given the higher NOP/GOP ratio in Jun., the efficiency of organic carbon export out of ML is proposed to have been higher in June, 2015 relative to that in October, 2014. Beneath the ML, respiration discriminates against 18O. The apparent fractionation factor, deduced from a Rayleigh plot, is 0.988±0.001. Nutrient regeneration was related to water column respiration, reflected in covariation between nutrient concentration and AOU or 18O.

O-M1-08 High pCO2 conditions in San Francisco Bay originate from coastal upwelling from the California Undercurrent

James W. Murray, School of Oceanography, University of Washington, Seattle WA, USA
Presenter Email: jmurray@u.washington.edu

The eastern boundary upwelling system off the west coast of North America is more acidic than the open ocean. High NO3, high pCO2 conditions exist in the Salish Sea driven by upwelling of low O2, high NO3 and high pCO2 water from the California Undercurrent (CU). Similar conditions exist in San Francisco Bay. Scientists from NOAA and the USGS collected a time series of data for temperature, salinity, oxygen and pCO2 from March 2013 to June 2015 at the Exploratorium Wired Pier in San Francisco. pCO2 ranged from 550 to 1000 µatm and was always higher than atmospheric values. There was an inverse relationship between salinity, O2 and pCO2. pCO2 increased when O2 decreased and salinity increased. These properties are due to upwelling from the CU. The main process is natural aerobic respiration in the region where the CU originates, which is the oxygen minimum zone in the eastern tropical North Pacific. The properties in San Francisco Bay can be compared with properties in the CU south and north of San Francisco Bay, collected during Wecoma Cruise W0705A. These sections show that the core of the CU is located at the shelf break at depths of 175m to 250m. This water was last at the sea surface at approximately 50°S;

150°W in the west-central South Pacific and reached the US west coast via the Pacific Equatorial Water (PEW). As the CU flows poleward along North America, it mixes laterally with colder, fresher, younger Pacific Subarctic Upper Water (PSUW) which outcrops in the NW North Pacific (near 50°N, 170°E). The contribution of the low O2 PEW southern end-member decreases poleward and off the central California coast the CU has nominal contributions of 50% PEW and 50% PSUW. The anthropogenic "ocean acidification" contribution to DIC in the source waters of the California Undercurrent is presently ≤ 20% of the total increase in DIC, but it will increase in importance in the future. The remaining increase in DIC is due to natural aerobic respiration.

O-M1-09 Reconstructing the Baltic physical-biogeochemical state during the period 1993-2016

Ye Liu, Swedish Meteorological and Hydrological Institute
Lars Axell, Swedish Meteorological and Hydrological Institute
Anette Jonsson, Swedish Meteorological and Hydrological Institute
Presenter Email: ye.liu@smhi.se

Recently, the numerical biogeochemical models for the Baltic sea are well developed in improving resolution and the simulation accuracy. Furthermore, the coverage and amount of the biogeochemical observations have become large enough, especially in the Baltic subsurface. Therefore, the confidence for evaluating the Baltic biogeochemical state becomes high. It is of interest and importance to estimate the variability of biology variables and its associated uncertainty over a long time period and estimates the limits of applicability of long-term reanalyses or reconstructed data.
A multi-year physical-biogeochemical state is reconstructed in the Baltic Sea during the period 1993-2016. The model system is based on the Swedish coastal and ocean biogeochemical model (SCOBI) coupled to the NEMO-Nordic circulation model. A weak coupled data assimilation system based on a sequential ensemble interpolation kalman filter (SEIK) is adopted to merge the information of model and observations. The high resolution remote sensing sea surface temperature, salinity and temperature profiles, oxygen and nutrient profiles measurements are assimilated into the NEMO-SCOBI. In order to produce consistent analysis, both physical and biogeochemical observations are assimilated in the same time. Based on the numerical experiment with and without data assimilation, the inter-comparison is implemented to validate the reanalysis results. The model can reproduce the variability of ocean and biogeochemical parameters in important dynamic processes (e.g. the inflow process). However, the model simulation shows obvious biases, especially in the deep layers. As expected, the assimilation process is found to impart significantly positive impacts on the physical and biogeochemical simulation. For example, with the comparison with observations, the oxygen, nutrients, temperature and salinity biases in reanalysis at the Baltic proper are significantly reduced

relative to reference run. Furthermore, the reanalyzed hypoxia in the Baltic Sea is better than the free run relative to the observed one. The results denote that as a consistent reconstructing of physical and biogeochemical state for the Baltic Sea, the output data set of this reanalysis can inform the management of the Baltic Sea ecosystem. For example, the analysis or prediction of the trend and reason of oxygen deficiency in the Baltic water and its potentially threatening. Moreover, for projections of future climate and for nutrient load abatement scenario simulation, this reconstructed record has very high scientific value as a reference data set for the historical period of the climate simulations.

O-M1-10 Time of emergence of ocean acidification in ocean margins

Hongjie Wang, School of Marine Science and Policy, University of Delaware, Newark, Delaware, USA
Wei-Jun Cai, School of Marine Science and Policy, University of Delaware, Newark, Delaware, USA
Presenter Email: hwangde@udel.com

Time of Emergence (ToE) is the time when a signal emerges from the noise of natural variability, or signal-to-noise equal to a threshold value of 2. The ToE provides important information for decision making regarding observing system optimization or risk reduction activities. Previous studies have reported that the changes in the rate of anthropogenic carbon uptake can be directly observed in open ocean between 2020 and 2050. However, owing to much larger CO_2 variability in ocean margins than in open ocean, the ToE of fCO_2 (fugacity of CO_2) change is still unclear in ocean margins. This study will determine the ToE of fCO_2 change with statistical approaches based on open access dataset Surface Ocean CO_2 Atlas Version 5 (SOCAT V5). The preliminary results show that ToE of fCO_2 change was 24.1±17.0 years across the global ocean margins, while the ToE of sea surface temperature and sea surface salinity was 92.7±46.4, and 30.7±15.6 years, respectively. Therefore, the rates of ocean acidification significantly outpace the temperature change with regards to moving the system outside of its "natural" envelope. In addition, we also found some areas, for example, the river-dominated ocean margins (i.e., mouth of Chesapeake Bay and northern Gulf of Mexico) had a much longer ToE than other ocean margins, which may result from the extensive anthropogenic nutrients loading. More results and mechanistic interpretation will be presented by including ToE of pH and carbonate saturation state in an effort to better understand ocean acidification rate in ocean margins.

O-M1-11 POC export regulated by plankton community structure in a subtropical marginal sea

Yong Qiu, Fujian Provincial Key Laboratory of Coastal Ecology and Environmental Studies, State Key Laboratory of Marine Environmental Science, College of the Environment and

Ecology, Xiamen University, Xiamen 361102, China. College of Oceanology and Food Science, Quanzhou normal university, Quanzhou 362000, China.
Yuyuan Xie, Fujian Provincial Key Laboratory of Coastal Ecology and Environmental Studies, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen 361102, China.
Edward Laws, Department of Environmental Sciences, College of the Coast and Environment, Louisiana State University, Baton Rouge, Louisiana, USA.
Bangqin Huang, Fujian Provincial Key Laboratory of Coastal Ecology and Environmental Studies, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen 361102, China.
Presenter Email: bqhuang@xmu.edu.cn

Floating sediment traps were deployed at the marginal sea of the South China Sea in the western Pacific to studied POC flux in shelf, slope and basin ecosystems, in the summers between 2014 and 2017. As the biomass of phytoplankton community decreased gradually, the aggregate and zooplankton fecal pellets were both the main contributors of POC flux in the shelf and slope upper layer. Nevertheless, the main contributor to POC flux was zooplankton fecal pellets in the slope depth layer and basin. The contribution of zooplankton fecal pellets to the POC flux increased as the depth increased in shelf, slope and basin ecosystems. The cylindrical fecal pellets produced by the dominant zooplankton group copepods were the main types of zooplankton fecal pellets POC fluxes in the shelf, slope, and basin ecosystems. The dominated group of phytoplankton chlorophyll a biomass in sinking phytoplankton from traps were diatoms groups in all ecosystems. Phytoplankton regulated POC flux by aggregation and repackaging, while influencing aggregates and zooplankton fecal pellets production and sinking export.

O-M1-12 Impact of human disturbance on the biogeochemical silicon cycle in a coastal sea revealed by silicon isotopes

Zhouling Zhang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, 361102 Xiamen, China
Xiaole Sun, Baltic Sea Center, Stockholm University, 106 91 Stockholm, Sweden
Minhan Dai, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, 361102 Xiamen, China
Zhimian Cao, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, 361102 Xiamen, China
Guillaume Fontorbe, Department of Geology, Lund University, 223 62 Lund, Sweden
Daniel J. Conley, Department of Geology, Lund University, 223 62 Lund, Sweden

Presenter Email: zlzhang@stu.xmu.edu.cn

The silicon (Si) cycle in coastal seas have been strongly influenced by human activities in the past decades, which in turn alters primary production and nutrient export efficiency to the open ocean. It is crucial to understand how and to what degree the coastal Si cycle responds to environmental change caused by human activities. In this study we present a field investigation conducted in March 2016 on the distribution of stable Si isotope of dissolved silica (δ30SiDSi) in a highly eutrophic coastal system, the Baltic Sea. A box model was used to simulate variations in DSi concentration and δ30SiDSi values and examine the impact of different human disturbances including damming, eutrophication and stratification, on the coastal Si cycle for the first time.

Under the influence of both physical mixing and different stages in the spring diatom growth, δ30SiDSi values in the mixed layer decreased gradually from the shallow straits in the west (~ +2.2 ‰) to the deep central basin in the east (~ +1.4 ‰). An uncommon vertical distribution pattern of DSi was observed with heavier δ30SiDSi in the deep waters (+1.57 to +1.95 ‰) than in the surface waters (+1.24 to +1.68 ‰) in the central basin. Based on our box model, we show that although damming had an impact on the δ30SiDSi values, such a pattern was mainly attributed to the strong internal recycling of Si driven by eutrophication. Intensive diatom production exported highly fractionated Si from the surface to deep waters, and subsequently, strong benthic recycling brought heavier δ30SiDSi back into the deep water due to the fractionation during authigenic clay formation. Our findings provide solid evidence on the response of Si cycling to environmental changes and important implications for future development of the Si cycle in coastal systems and changes in nutrient export to the ocean under high human pressures and global warming.

O-M1-13 On dynamics of the vertical exchange among the three-layer circulations in the South China Sea

Zhongya Cai, Department of Mathematics, Hong Kong University of Science and Technology

Jianping Gan, Department of Ocean Science & Department of Mathematics, Hong Kong University of Science and Technology

Presenter Email: zycai@ust.hk

The South China Sea (SCS) circulation features with three-layer cyclonic-anticyclonic-cyclonic (CAC) structure in the upper (<750m), middle (750-1500m) and deep (>1500m) layers. The vertical exchange dynamically links and sustains the layered circulation in the basin. This study investigated the three dimensional structure and seasonal variability of the water exchange among the layers in the CAC circulation and explored the underlying

dynamics. The exchange over the varying slope regions largely determines the basic vertical exchange pattern in the SCS and is mainly controlled by the bottom cross-isobath geostrophic transport (CGT). In the central deep basin (CDB) (> 3000m), the convergence of water induced by deep water intrusion generates the prevailing upwelling among three layers. In summer, the subduction of the upper layer water can occur along the northern and western slope due to off-shore CGT and near the Mindoro Strait due to bottom frictional effect. The deep layer water upwells to the middle layer in the northern CDB and western slope as a result of on-shore CGT. During winter, the subduction of upper layer water is enhanced along the northern slope, while the upwelling of deep water is reduced in northern DSB and western slope due to the stronger/weaker upper/deep intrusion through Luzon Strait. The vorticity dynamics reveal that the bottom CGT are formed by the joint effects of the surface wind stress curl and the nonlinear advection and beta effect of circulation in both three layers. The vertical vorticity fluxes associated with the vertical exchanges play significant role in the vorticity balance in the middle and lower layer. The negative vorticity of the anti-cyclonic circulation in the middle layer is provided by the deep layer and the upper layer in the summer and winter, respectively.

O-M1-14 Dynamics of dissolved inorganic carbon in the South China Sea: a modeling study

Chuanjun Du, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China & Department of Ocean Science and Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong, China
Jianping Gan, Department of Ocean Science and Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong, China
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Chiwing Rex Hui, Department of Ocean Science and Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong, China
Zhongming Lu, Department of Ocean Science and Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong, China
Xiaozheng Zhao, Department of Ocean Science and Department of Mathematics, Hong Kong University of Science and Technology, Hong Kong, China
Presenter Email: cjdu@stu.xmu.edu.cn

Using a three-dimensional coupled physical-biogeochemical model, this study examines the dynamics of dissolved inorganic carbon (DIC) in the South China Sea (SCS). The model well simulates observed DIC distributions and identifies characteristically DIC enhancement from the Western Philippine Seas (WPS) to the northern SCS by up to 140 μmol kg^{-1} in the upper layer. Such an increasing pattern in DIC continues from northern SCS to southern SCS but with a much less degree (< 40 μmol kg^{-1}). Overall, both the spatial and temporal

variations of DIC in the SCS are significantly modulated by both the intrinsic dynamics and extrinsic exchanges via various straits including Luzon Strait (LS), a major gateway linking SCS and WPS. The influx of DIC to the SCS through LS occurring in the upper layer (h < 700 m) is 12×10^6 mol s-1 associated with the Kuroshio intrusions and is 1.8×10^6 mol s^{-1} at the deep layer (h > 1800 m) along with the SCS overflow from the deep WPS. The export fluxes of DIC are 6.8×10^6 mol s^{-1} through Mindoro and Balabac Straits and 2.9×10^6 mol s^{-1} through the SCS intermediate water outflow (700 m < h < 1800 m) via LS. The net extrinsic intake of DIC is primarily balanced by the shelf-ward transport across the 100 m isobath, accounting for 4.8×10^6 mol s^{-1}. Terms balance of DIC suggests that while physical transport plays a predominated role in modulation of the DIC dynamics in the SCS, the biogeochemical process is also crucial, particularly in the upper ocean. We will also examine the fluxes ratio between DIC and nutrients and their implications on the air-sea CO2 fluxes.

O-M2-01 The biological boundary between phosphorus and iron limitation in an oligotrophic ocean

Ricardo M Letelier, College of Earth, Ocean, and Atmospheric Sciences Oregon State University
Presenter Email: letelier@coas.oregonstate.edu

Nutrient supply into the well lite upper layers of the water column through mixing, diffusion, advection and dust deposition, regulates the productivity of subtropical oceanic oligotrophic regions. Changes in the relative strength of these distinct input mechanisms can cause shifts in the elemental ratio of the nutrient supply, leading to shifts in the proximate elemental control of the pelagic ecosystem productivity. Multi-decadal observations in the North Pacific Subtropical Gyre reveal that the pelagic microbial assemblage oscillates between phosphorus (P) sufficiency and limitation on sub-decadal time-scales, indicating shifts in the proximate elemental control of primary productivity and nitrogen fixation. These fluctuations display a significant correlation with the Pacific Decadal Oscillation (PDO) suggesting that a common atmospheric forcing modulates both the PDO and P-sufficiency. Using in situ observations and model simulations we explore how different mechanisms contributing to the input of nutrients in the NPSG respond to Climate forcing. Our results indicate that inter-annual oscillations in P availability in the Eastern North Pacific Subtropical Gyre are strongly correlated to shifts in the Sea Level Pressure in the western subarctic (r > 0.8). Furthermore, regional dust transport models suggest that climate-induced variations in Asian iron-rich dust transport and deposition across the North Pacific contribute significantly to the observed oscillation in P-limitation; while periods experiencing enhanced dust deposition, corresponding to positive PDO phases, are characterized by a microbial ecosystem capable of removing P as to become limiting (below 50 nM), periods with diminished dust deposition are characterized by a P-sufficient environment, suggesting that other nutrient - probably iron - becomes the proximal elemental control of microbial productivity during negative PDO phases. These results highlight the critical need to include both atmospheric and ocean circulation variability when modeling the evolution of open ocean pelagic ecosystems under different climate change scenarios.

O-M2-02 The ecology and biogeochemistry of nitrogen-fixing microorganisms in the subtropical North Pacific

Matthew J. Church, Flathead Lake Biological Station, University of Montana
Presenter Email: matt.church@umontana.edu

Nitrogen-fixing microorganisms (termed diazotrophs) play key roles in plankton ecology and biogeochemistry in the subtropical North Pacific. Through their physiological activities, diazotrophs influence cycling of key bioelements, rates of new production, and export of material from the upper ocean to the interior waters of the sea. Based on a combination measurements at Station ALOHA, the field outpost for the Hawaii Ocean Time-series (HOT) program, approximately half of the material export to the deep sea in the subtropical North Pacific is supported by diazotroph supply of nitrogen to the upper ocean. Distinct groups of cyanobacteria appear to dominate diazotroph assemblages in this region, including both small unicellular and larger filamentous microorganisms. Time series measurements of abundances indicate seasonally-variable contributions of several of these cyanobacterial diazotrophs to plankton biomass. In particular, members of unicellular cyanobacteria termed UCYN-A appear most dominant in the winter and spring, while members of the genus Crocosphaera display punctuated increases in abundance during the late summer and early fall. Time-variable changes in diazotroph abundance co-vary with changes in upper ocean temperature and appear partly regulated by mesoscale physical variability. This presentation will highlight on-going research exploring the ecology and biogeochemistry of diazotrophs in the oligotrophic waters of the North Pacific Ocean.

O-M2-03 Upper Ocean Biogeochemistry in the Ocean Desert

Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Chuanjun Du, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Zhiyu Liu, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Zhimian Cao, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Presenter Email: mdai@xmu.edu.cn

The oligotrophic ocean, mostly located in subtropical regions occupies ~40% of the Earth surface and has been conventionally regarded as an ocean desert. It is characterized by permanent stratification, nutrient depletion and extremely low net biological production, and hence, contributes little to carbon export from surface to deep waters at per unit area. Emerging evidence has shown that this oceanic system has a much larger dynamic range of nutrient inputs from different sources in addition to those from depth. These differently sourced nutrients with differing stoichiometry may stimulate biological productions in different community structures and drive the carbon export at various depth horizons within the sunlit euphotic zone (EZ). Hence, the EZ is better characterized by a two-layered structure with a nutrient-depleted layer (NDL) above the nutricline and a nutrient replete layer (NRL) across the nutricline to the base of the EZ. Based on simultaneous turbulence microstructure and high-resolution chemical measurements, we quantified diapycnal fluxes of nitrogen, phosphorus, silicon, and carbon in the oligotrophic South China Sea showing a negligibly low diapycnal dissolved inorganic nitrogen (DIN) flux in the NDL where other nutrient supplies sustain the new production. Here, higher phosphate and silicate fluxes relative to DIN than Redfield stoichiometry further indicate N-limited biological productivity and additional removal of DIN by diatoms. In the NRL, the DIN flux is sufficiently large in supporting the export production therein. Here, higher dissolved inorganic carbon (DIC) flux relative to DIN than Redfield stoichiometry further infers DIC excess in the upper ocean of oligotrophic nature. Considering the new understanding of the biogeochemistry of the oligotrophic ocean, we attempt to propose an improved framework of nutrient-determined and biologically mediated carbon export in the ocean desert.

O-M2-04 Where is the downward export flux of dissolved organic carbon important in the global ocean?

Weilei Wang, University of California at Irvine
Frédéric A. C. Le Moigne, GEOMAR, Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
Francois W. Primeau, University of California at Irvine
J. Keith Moore, University of California at Irvine
Presenter Email: weilei.wang@gmail.com

We here extrapolate the observed thorium-234 (^{234}Th) into the global ocean by combining a global 3-D inverse circulation model with phosphorus and thorium cycling models, and estimate the global flux of particulate and dissolved organic carbon (POC and DOC). Our model shows that POC export is low in the subtropical gyres, high in eastern equatorial Pacific and east coast of the South Atlantic Ocean, and intermediate to low in the Southern

Ocean. Our model also shows that DOC export is high in the Southern Ocean and high-latitude North Atlantic, intermediate in the eastern equatorial Pacific, and low in subtropical gyres. Globally, the model predicts a total carbon export (POC+DOC) of 9.61 (median, 95% CI: 9.00-10.10) Pg C/yr at 110 m, of which 64.11% (median, 95% CI: 51.05-70.27%) is due to POC export. The DOC export is spatially correlated with the difference between the winter and summer mixed-layer depth, indicating that the mixed- layer pump plays an important role in exporting DOC from the euphotic zone. Our study emphasizes on the role played by DOC export flux (mainly physical) as a means of transporting organic C out of the surface ocean.

O-M2-05 Particulate carbon and silica export meditated by cyclonic eddies at Station ALOHA

Kuanbo Zhou, State Key Lab of Marine Environmental Science, Xiamen University
Jie Huang, Ministry of Education Key Laboratory for Earth System Modeling, and Department of Earth System Science, Tsinghua University
Peng Xiu, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology
Claudia Benitez-Nelson, School of the Earth, Ocean & Environment, University of South Carolina
Zhenyu Sun, State Key Lab of Marine Environmental Science, Xiamen University
Minhan Dai, State Key Lab of Marine Environmental Science, Xiamen University
Presenter Email: kbzhou@xmu.edu.cn

Mesoscale eddies may mediate the influx of nutrients into the photic zone and ultimately the downward export of particles to depth. In this study, we diagnosed all cyclonic eddies during 1989-2014 that passed by the Station ALOHA using satellite altimetry, and export fluxes measured by floating traps were found to be documented in 24 eddies. The seasonality of the eddy export followed a similar pattern with that of the climatology. Significant submesoscale variability of export fluxes anomaly (eddy flux minus monthly average) was observed within those eddies if they were normalized into a standard eddy. Higher particle fluxes are tended to be occurred at the edge region when eddies are under their maturity. However, if we combine all eddy flux together and compare to corresponding references, modest enhancement of carbon fluxes (1.1-1.3-fold) is found while that of silica flux was more elevated (1.2-3.8-fold). Such estimate of the flux enhancement was believed to be more robust as it included a 4-D spatial and temporal variability. It thus may be implied that eddy-induced carbon flux might not be as significant as previously thought. Instead, eddies may exert as a more significant silica pump. Further examination revealed a mean of 6±3% of the export efficiency (e-ratios) within the eddies, similar to those in typical oligotrophic settings.

O-M2-06 Fate of atmospheric aromatic hydrocarbons into the oligotrophic ocean

Belen Gonzalez-Gaya, 1 Institute of Environmental Assessment and Water Research, IDAEA-CSIC; Barcelona, Catalunya, Spain. 2 Institute of Organic Chemistry, IQOG-CSIC; Madrid, Spain. 3 Plentzia Marine Station of Basque Country University EHU/UPV, Plentzia, Basque Country,Spain

Alicia Martinez-Varela, Institute of Environmental Assessment and Water Research, IDAEA-CSIC; Barcelona, Catalunya, Spain.

Maria Vila-Costa, Institute of Environmental Assessment and Water Research, IDAEA-CSIC; Barcelona, Catalunya, Spain.

Begoña Jiménez, Institute of Organic Chemistry, IQOG-CSIC; Madrid, Spain.

Jordi Dachs, Institute of Environmental Assessment and Water Research, IDAEA-CSIC; Barcelona, Catalunya, Spain.

Presenter Email: belen.gonzaelez@ehu.eus

Polycyclic aromatic hydrocarbons (PAHs), and other semivolatile aromatic-like compounds (SALCs), are an important and ubiquitous fraction of organic matter in the environment which fate in the ocean remains uncharacterized. Here, we report a global assessment of the occurrence and atmosphere–ocean fluxes of 64 PAHs analyzed in paired atmospheric and seawater samples from the Atlantic, Pacific and Indian Oceans. The global atmospheric input of PAHs to the ocean is estimated at 0.09 Tg per month, four times greater than the Deepwater Horizon spill. The environmental concentrations of total SALCs were 102–103 times higher, with a relevant contribution of an aromatic unresolved complex mixture. These concentrations drive a global deposition of carbon estimated at 400 Tg C yr-1, around 15% of the oceanic carbon uptake due to CO_2. Furthermore, we identify the biological pump and microbial degradation as key sinks of aromatic hydrocarbons in the oceans. Plankton and seawater samples showed lower concentrations of the hydrophobic compounds in the seawater when plankton biomass was higher, consistent with the relevance of the biological pump. However, the mass balance for the global oceans showed that settling fluxes of aromatic hydrocarbons in the water were 2 orders of magnitude lower than atmospheric deposition. This imbalance was even higher for low molecular weight hydrocarbons. These observations show the relevance of PAHs degradation processes in the oligotrophic oceans. Firstly, photochemical degradation may affectc in the photic layer, with negative correlations found between the dissolved concentrations of the lighter PAHs and light. Nevertheless, these correlations were weak explaining the concentrations variability, and the diagnostic ratios used for photochemistry were neither correlated with solar radiation. Alternatively, microbial degradation appeared to be the key factor for the depletion of the bioavailable hydrocarbons. We quantified the relative abundance of PAHs-degrading genes by analyzing the frequency of the alpha and beta subunits of RHD (specific biomarkers of PAH degradation) in the public metagenomic database of the oceanographic expedition Tara Oceans. Degradation genes for PAHs were

found to be ubiquitous. The several lines of evidence provided support a relevant microbial degradation of PAHs, and also relevant for the largest SALCs organic carbon pool. It has been reported that large oligotrophic oceanic regions are heterotrophic, requiring sources of allochthonous organic matter. According to this work, degradation of atmospheric inputs of aromatic compounds is quantitatively relevant for the marine carbon cycle, and could help explain the observed heterotrophy of the oligotrophic oceans.

O-M2-07 Quantum yield of photosynthesis in oligotrophic gyres and its application to estimate primary production from remote sensing

Zhongping Lee, School of the Environment, University of Massachusetts, Boston, MA, USA
Maria Laura Zoffoli, Mer Molecules, Facultes des Sciences et Techniques, University de Nantes, Nantes, France
John Marra, Department of Earth and Environmental Sciences, Brooklyn College (CUNY), Brooklyn, NY, USA
Presenter Email: zpli2015@xmu.edu.cn

Quantum yield of photosynthesis (Phi) expresses the efficiency of phytoplankton for Carbon fixation given certain amount of absorbed light. This parameter is key to obtain reliable estimates of primary production in oceans based on remote sensing products (PPsat). Several works have shown that Phi changes temporally, vertically and horizontally in the water column, where the primary factor ruling its variability is light intensity. In this work, we estimated Phi utilizing long time-series of in situ data in the North Subtropical Oligotrophic Gyres, at HOT and BATS stations (Pacific and Atlantic oceans, respectively). Then, Phi m (the maximum quantum yield) and K Phi (light intensity at half Phi m) were calculated from Phi. Median annual of in situ Phi m was found as 0.020 and 0.063 mol C mol photons^{-1} at HOT and BATS, respectively, with higher values in winter. K Phi values were 7.6 and 10.8 mol photons m^{-2} d^{-1} for HOT and BATS, respectively. Temporal variability in K Phi showed the highest values in summer. We further proposed dynamical parameterizations for both regions using independent environmental factors as proxies: temperature for Phi m and light intensity for K Phi. Such parameterizations were finally included in PPsat models based in phytoplankton absorption (PPsat-aphy-based) and a comparison was made with the conventional VGPM model, the widest used PPsat model based in chlorophyll concentration (PPsat-chl-based). Our findings showed that the PPsat-aphy-based model coupled with dynamical parameterization improves PP estimates. While PPsat-chl-based underestimated PP with differences of 62.8% at HOT and 37.8% at BATS, PPsat-aphy-based showed a similar magnitude with in situ PP and differences of 7.7% at HOT and 26% at BATS. PPsat-aphy-based was also able to better reproduce the seasonal cycle of PP in both areas. These results further advocate the use of phytoplankton absorption and quantum yield for the estimation of basin scale primary production via

ocean color remote sensing.

O-M3-01 The Arctic/Sub-Arctic Freshwater Cycle's Impact on North Atlantic Ocean Circulation

Thomas Haine, Johns Hopkins University
Jan-Erik Tesdal, Lamont-Doherty Earth Observatory
Martha Buckley, George Mason University
An Nguyen, University of Texas at Austin
Presenter Email: thomas.haine@jhu.edu

Freshwater changes in the Arctic and subpolar North Atlantic have strong implications for climate, including their influence on deep water formation in the North Atlantic and the Atlantic Meridional Overturning Circulation (AMOC). There have been significant changes in the freshwater content of both the Arctic and the subpolar North Atlantic in the last 25 years. The Arctic has freshened and the subpolar North Atlantic has undergone a period of salinification, followed by a period of freshening. Furthermore, climate change is expected to significantly increase the liquid freshwater content of both the Arctic and subpolar North Atlantic, as the result of both an intensification of the water cycle and the loss of ice and glacial melting. Major research challenges are to (1) determine the mechanisms for freshwater changes in the Arctic and subpolar North Atlantic over the last 25 years and (2) understand how these freshwater systems will evolve due to anthropogenic forcing in the next 25+ years. This talk will review the state of knowledge on these issues and discuss future prospects.

O-M3-02 Rapidly Changing Arctic Climate System and Arctic-Midlatitude Climate and Weather Linkages

Xiangdong Zhang, International Arctic Research Center and Department of Atmospheric Sciences, University of Alaska Fairbanks
Presenter Email: xzhang9@alaska.edu

Rapid climate change has occurred in the Arctic, which is representatively indicated by a decade-long accelerated decline of sea ice extent and volume and an amplified warming trend at a rate of almost twice the global average. Along with these changes, extreme climate events of sea ice cover loss also occurred in summer 2007, 2012, and 2016. At the same time, dramatic changes have also occurred in broader areas of the Northern Hemisphere, including a spatial shift of the maximum surface air temperature warming trends from the Eurasian continent to the central Arctic Ocean, an enhancement of poleward oceanic and atmospheric heat transport from either the North Atlantic or North Pacific Ocean into the Arctic, a poleward shift of storm tracks and an intensification of

Arctic storm activities, and a widespread of extreme cold weather and snow storms from the US east coast to Europe and Asia. Many aspects of these changes are obviously beyond the scope of conventional climate fluctuations, and also could not be solely accounted for by greenhouse-gas-emissions forcing. In this presentation, we will introduce our research progresses integrated from data analysis and model simulations towards improving systematic understanding of the rapid changes in the Arctic and the enhanced linkage between Arctic and midlatitude climate and weather. The recent strong debates on Arctic impact on midlatitude climate and weather will be highlighted.

O-M3-03 Circulation and water properties of the northeastern Chukchi Sea in summer

Peigen Lin, Woods Hole Oceanographic Institution
Robert S. Pickart, Woods Hole Oceanographic Institution
Presenter Email: plin@whoi.edu

Shipboard measurements spanning a 37-year period are used to characterize the general hydrographic structure and circulation patterns in the northeastern Chukchi Sea during summer, including the effects on the distribution of nutrients. The data come from eight synoptic surveys of the region from 2003-2017, which include velocity measurements, and from the Pacific Marine Arctic Regional Synthesis (PacMARS) historical data base from 1981-2013. We track the spreading of both Pacific summer waters and Pacific winter water as they progress northward from Bering Strait into Barrow Canyon over the summer months. Using the vessel-mounted acoustic Doppler current profiler data, a background circulation pattern is deduced in the absence of wind-forcing. This is contrasted to conditions when there are strong northeasterly winds, which fundamentally alters the background flow. Nitrate concentrations are generally higher on the southeastern side of Hanna Shoal due to the character of the Pacific winter water there. This helps explain the enhanced biological activity observed in this region.

O-M3-04 Circulation of Pacific Winter Water in the western Arctic Ocean

Wenli Zhong, Ocean University of China
Presenter Email: wlzhongouc@ouc.edu.cn

Pacific Winter Water (PWW) enters the western Arctic Ocean from the Chukchi Sea; however, the physical mechanisms that regulate its circulation are still not clear. Here, we investigate the interannual variability of PWW with a comprehensive dataset over a decade. We quantify the thickening and expansion of PWW during 2002-2016, as well as its changing pathway. The total volume of PWW in the Beaufort Gyre (BG) region is estimated to have increased from 3.48±0.04×1014m3 during 2002-2006 to 4.11±0.02×1014m3 during 2011-2016, an increase of 18%. We find a redistribution of PWW in recent years toward the Chukchi Borderland associated with the spin up of the BG.

We also find that the deepening rate of the lower bound of PWW is almost double that of its upper bound in the northern Canada Basin, a result of lateral PWW intrusion in addition to the vertical Ekman pumping. Of the 70 m of deepening of the lower bound of PWW observed over 2003-2011 in the northwestern basin, 43% resulted from lateral PWW intrusion from the Chukchi Borderland. The different partition of freshwater budgets in the Ekman layer versus in the PWW layer also suggests that the redistribution of PWW is largely a result of the westward shift of the overlying wind-driven BG. We hypothesize that a recently observed increase of lower halocline eddies in the BG might be explained by this redistribution through a compression mechanism of PWW over the Chukchi Borderland.

O-M3-05 Multi-decadal Trends in Arctic Ocean Carbon Chemistry

Ryan Woosley, Massachusetts Institute of Technology
Frank Millero, University of Miami, RSMAS
Presenter Email: rwoosley@mit.edu

Perhaps nowhere is climate change more evident than the Arctic Ocean. Temperatures, ice melt, runoff from land, and dissolved inorganic carbon (DIC) are all increasing dramatically. In addition, the perturbations to the carbon cycle in the Arctic are unique when compared to the other oceans. While the decreasing pH and increasing DIC elsewhere are dominated by the uptake of anthropogenic carbon from the atmosphere, the Arctic is more complicated. There, DIC is modified not only by anthropogenic CO2 uptake, but also by increased freshwater inputs and reduced buffering capacity. Utilizing data collected from three repeat cruises covering 1994-2015, multi-decadal trends in the Arctic DIC pool are explored. The sources of these trends are identified as atmospheric CO2 uptake and inputs of freshwater from melting sea ice and glacial runoff. A higher influx of freshwater has lowered the total alkalinity (TA) significantly, altering Arctic carbon chemistry beyond just atmospheric CO2 uptake. The decreased TA lowers the buffering capacity of seawater, amplifying ocean acidification and decreases in CaCO3 saturation state. The effects of further decreased pH has widespread implications for marine organisms.

O-M3-06 A numerical study of the impacts of storm on upper ocean in the Canada Basin of the Arctic Ocean during summer

Xuezhi Bai, Hohai University
hengling Leng, Hohai University
Yayu Yang, Hohai University
Presenter Email: xuezhi.bai@hhu.edu.cn

The impacts of storm on sea ice and the upper ocean in the Canada Basin of the Arctic Ocean during summer 2010 was examined using a high-resolution regional coupled ice-ocean model (MITgcm). Model results suggest that enhanced vertical mixing induced by

storm is limited within the upper 15m. The mixing results in sea surface cooling of up to 2C over the open water. There is no obvious change in the interface water temperature under ice cover. For the subsurface, large responses (mainly warming) occur in the upper halocline (40m-60m) and the thermocline between the cold Pacific water and warm Atlantic Water(100-300m). Ekman pumping associated with storms is responsible for the subsurface water temperature changes.

O-M3-07 Emerging oceanic changes during summer in the central and eastern Chukchi Sea, 1974-2017

Yayu Yang, Hohai university, Nanjing, China
Xuezhi Bai, Hohai university, Nanjing, China
Hengling leng, Hohai university, Nanjing, China
Presenter Email: yy.young@hhu.edu.cn

Observed hydrographic data from World Ocean Database 2013 and Chinese National Arctic Research Expedition are used to document oceanic changes in the Chukchi Sea affected by global warming and sea ice retreat. Results show obvious warming and freshening signals in the eastern Chukchi Sea since 1974. Significant warming in surface occupies most of the eastern Chukchi Sea except for the central channel south of 69°N due to effect of the Pacific inflow. Warming rate in northern Chukchi Sea is much larger than the southern part. For the water below 30m, changes in temperature and salinity along the whole central channel are insignificant, while significant warming and freshening signals are observed in the Alaska Coastal Water. Analysis of a multi-year observed meridional section along 169°W shows a deeper and weaker thermocline after 1997 with large warming and freshening located in the thermocline (15-25m). The data also show evidence of changes in characteristics of various water masses in the Chukchi Sea.

O-M3-08 Overturning in the Nordic Seas

Kjetil Våge, University of Bergen
Presenter Email: kjetil.vage@gfi.uib.no

Dense water masses formed in the Nordic Seas flow southward across the Greenland-Scotland Ridge and provide a major contribution to the lower limb of the Atlantic Meridional Overturning Circulation. The largest of these overflow plumes passes through Denmark Strait between Greenland and Iceland. Here we document recent progress to identify the sources of the dense overflow waters and their pathways into Denmark Strait. Two distinct overturning circulations transform the warm Atlantic inflow into the Nordic Seas into dense water masses and supply the Denmark Strait overflow. North of the strait a moored array was deployed to quantify the relative importance of these overturning circulations. High-resolution hydrographic and velocity surveys along Greenland and Iceland have detailed the properties of the water masses that form the overflow and the currents that transport them. A retreating ice edge along east Greenland is impacting the

formation of dense water, but it remains to be clarified whether this will weaken the overturning in the Nordic Seas.

O-M3-09 The early collapse of the 2017 Lincoln Sea Ice Arch in response to thin ice and anomalous wind forcing

Kent Moore, University of Toronto Mississauga
K. McNeil, University of Toronto Mississauga
Presenter Email: gwk.moore@utoronto.ca

One of the most dramatic indicators of climate change is the reduction in the extent and thickness of Arctic sea ice. As a result of this reduction, there has been increased sea ice mobility in response to surface wind forcing that has implications for the Arctic sea ice mass budget. In addition, recent winters in the Arctic have also been unusually warm. The winter of 2017 was characterized not only by warmer temperatures but also by a reversal in the seasonal surface winds and ice motion in the western Arctic that has not been observed previously. During late April and early May of 2017, satellite observations indicated that the ice arch that forms along the boundary between Nares Strait and Lincoln Sea collapsed. Typically, this collapse occurs in July or August each year allowing thick multi-year sea ice to exit the Arctic through Nares Strait. Here we use satellite and in-situ meteorological data, as well as atmospheric model fields to argue that the early collapse during 2017 was due to thin ice in the Lincoln Sea that was the result of the anomalous wind forcing during the preceding winter as well as an unusual Nares Strait wind regime characterized by intermittent strong northerly flow. If the ice in the region continues to thin, there may be a secular trend towards an earlier arch collapse even under climatological wind forcing. Early collapses hold consequences for the Arctic sea ice mass budget as well as downstream climate, ecosystem and maritime hazard impacts.

O-M3-10 Dynamics of the high-frequency variability in Denmark Strait

R.S. Pickart, Woods Hole Oceanographic Institution, Woods Hole, USA
M.A. Spall, Woods Hole Oceanographic Institution, Woods Hole, USA
P. Lin, Woods Hole Oceanographic Institution, Woods Hole, USA
D. Matropole, Woods Hole Oceanographic Institution, Woods Hole, USA
H. Valdimarsson, Marine and Freshwater Research Institute, Reykjavik, Iceland
T.W.N. Haine, Johns Hopkins University, Baltimore, USA
M. Almansi, Johns Hopkins University, Baltimore, USA
Presenter Email: rpickart@whoi.edu

The nature and dynamics of the mesoscale variability in Denmark Strait is investigated using a combination of mooring data, satellite data, and a numerical model. We describe a newly-indentified mesocale process in the strait whereby warm water from the Irminger Sea flows northward through the center of Denmark Strait, displacing the normal equatorward flow of dense overflow water. This process, which occurs roughly 10 times

per year, is termed a flooding event. The satellite and model fields reveal that flooding events are associated with a westward propagation of the North Icelandic Irminger Current, which brings the warm water into the center of the strait. Two other types of mesoscale processes in Denmark Strait have been described previously in the literature, known as boluses and pulses. In the former case, a thick lens of dense water passes through the strait which raises the interface height of the overflow water. In the latter case, the interface height drops and the thin layer of overflow water accelerates. Our study reveals that flooding events occur in conjunction with pulses. Furthermore, the model reveals that all three mesoscale processes are dynamically related and tied to the behavior of the hydrographic front in the strait. The model also shows that the hydrographic front is maintained by a balance between frontogenesis by the large scale flow and frontolysis by baroclinic instability. Our study provides a general framework for understanding the dominant variability of Denmark Strait Overflow Water entering the Irminger Sea.

O-M3-11 Interaction between Arctic Sea Ice and Atlantic-Pacific teleconnection

Xichen Li, Institute of Atmospheric Physics
Presenter Email: lixichen@mail.iap.ac.cn

Due to its active role in the atmosphere-ocean interactions and in the global climate variability , the surface wind regime over the North Pacific Ocean has been receiving increased attention. To untangle the mechanism and the impacts of these wind changes, we combine observations, reanalysis datasets, and a hierarchy of climate model simulations. Analysis reveals a high pressure anomaly center over the North Pacific, which intensifies the sub-tropical highs and weakens the Aleutian Low. While the altered winds can contribute to the observed sea surface temperature (SST) changes in mid-latitude North Pacific and sea ice distribution around the Bering strait, they are not driven by the regional Pacific SST changes. Instead, the wind changes are mostly caused by remote influences originated from the tropical Atlantic SST changes through stationary Rossby waves. The surface wind changes, represented by a strong anticyclonic circulation anomaly around the Bering strait, changes the sea ice distribution through the thermal advection and the mechanical forcing. On the other hand, sea ice changes over the Arctic also initiate Rossby waves and thus changes the surface wind over the North Pacific. The whole processes forms an air-ocean-sea ice coupling linking the Atlantic, the Arctic, and the Pacific Ocean.

O-M3-12 Arctic Sea Ice Melt Onset Analysis

Hongjie Liang, Ocean University of China
Jie Su, Ocean University of China
Presenter Email: daniel_liang@outlook.com

Melt onset, which has a potential effect on energy budget through positive ice-albedo-

feedback, could act as one of the representative features indicating the changes of Arctic sea ice. Based on previous studies, some new characteristics of melt onset are further reflected in this research. Nowadays, there are two public available remote retrievals based on the algorithm of AHRA from Drobot and Anderson (2001) and PMW from Markus et al., (2009), respectively. Like previous researches, sea ice melt onsets are generally evaluated by the surface air temperature. Different from existing researches, the two melt onset datasets, from NSIDC and NASA Cryosphere, are compared with POLES surface air temperature, which has been proved to perform better than NCEP R1 and CFSR by the validation of Weather Underground observation. Comparison shows that melt onset results from NASA Cryosphere are more consistent with POLES. Then it is used to analyze the characteristics and mechanisms of melt onset. Probability distribution function shows that strength of concentrated melting increased from 1979 to 2016, which means the Arctic changes more consistently in broader region. For example, from 1979 to 1987, the probability basically keeps below 0.2 based on 10-day groups, but it could almost reach to 0.3 from 2007 to 2016. Upon the annual variability, another dominant phenomenon happened during the end of 1980s when the Pacific Arctic region experienced obviously earlier sea ice melt onset, which reached to about 20 days earlier in two years and was consistent with previous research about the abrupt changes caused by the shift of AO.

O-M3-13 On the Nature of Wind-Forced Upwelling in Barrow Canyon

Maria N. Pisareva, Shirshov Institute of Oceanology, Russian Academy of Sciences, Russia
Robert S. Pickart, Woods Hole Oceanographic Institution, USA
Paula S. Fratantoni, Woods Hole Oceanographic Institution, USA; Present Address: Northeast Fisheries Science Center, USA
Thomas J. Weingartner, University of Alaska Fairbanks, USA
Peigen Lin, Woods Hole Oceanographic Institution, USA
Presenter Email: mnpisareva@gmail.com

Barrow Canyon is a known biological hotspot and major conduit for shelf-basin exchange between Chukchi Sea shelf and the Arctic basin. As such it is critical to understand the dynamical processes that influence the water mass properties, mixing, and associated fluxes of biogenic materials. Using timeseries from a mooring deployed from 2002-4 near the head of the canyon, together with atmospheric and sea ice data, we investigate the seasonal signals in the canyon as well as aspects of upwelling and the wind-forcing that drives it. In total, 52 upwelling events were identified, which occur when the Beaufort High is strong and the Aleutian Low is deep. Some events bring dense water onto the shelf, while others advect lighter water from the basin. More than 80% of the upwelled flow consisted of cold Pacific-origin winter water, which dominated during the warm season. Upwelling of Atlantic water occurred during the cold season, consistent with previous

studies on the Beaufort slope. A statistically significant relationship was found between the strength of the northerly winds and the occurrence of upwelling. The strongest events advect Atlantic water to the head of the canyon. Oftentimes multiple events are induced by a prolonged northerly wind event, bringing both heavier and lighter waters up the canyon. The effect of pack ice on the upwelling is discussed as well.

O-M4-01 The chemistry of microbiomes/holobionts: High resolution tailored metabolomics in environmental research

Philippe Schmitt-Kopplin, 1. Helmholtz Zentrum Muenchen, Analytical BioGeoChemistry, Oberschleißheim, Germany 2. Technische Universität München, Analytical Food Chemistry, Freising/Weihenstephan, Germany 3. University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, USA.
Presenter Email: schmitt-kopplin@helmholtz-muenchen.de

From a traditional definition "metabolomics" measures the concentrations of the large numbers of naturally occurring small molecules (called metabolites), that are produced as intermediates and end-products of all metabolic processes in living systems. They are analyzed from biological samples and body fluids such as urine, saliva, blood plasma, tissue sample or complex endogen microbiota; even the simple breath (exhaled breath condensates) can carry the information about the state of health of the considered organisms or holobionts. In environmental samples the information retrieved from small molecule analysis cover the residual biosignatures of various (micro)biomes active in the analyzed geo-samples in addition to the signature of their relatively transformed biomolecules in decay and biotic/abiotic geochemical processes. The total number of different metabolites is still unknown; some estimation range from few ten thousands to about one million, but even this latter estimate may be conservative; including plant and bacterial metabolites that are not necessary to keep the organism alive, also referred to as secondary metabolites, the number is enormously larger. The probable number of metabolites is also considerably larger than the number of corresponding genes, so it seems that the currently available databases cover at best 5% of the total number of existing metabolites. With our integrated analytical approaches (LC-MS, NMR and ICR-FT/MS) data we annotate from databases around 10% of the experimental signals. Environmental metabolomic, as the comprehensive study of metabolic reactions in the environment (e.g. soil sediments, surface and marine waters), is growing very rapidly and integrates the knowledge of earlier developed Omics-branches including the metagenome information. Especially ICR-FT/MS describes highly complex mixtures in complex systems on the level of the elementary composition distribution and is shown in this presentation as an dedicated and innovative mass spectrometry tool to understand the composition and processes on a molecular level in various environmental systems with a a focus on marine systems .

O-M4-02 Environmental effects on the diversity and functional activities of microbes along estuarine gradients

Barbara Campbell, Clemson University
Presenter Email: bcampb7@clemson.edu

Bacteria dominate in abundance, diversity and potentially metabolic activity in most environments. Our current knowledge on the influence of specific individual taxa on biogeochemical processes involving DOM is largely lacking. We chose to examine a variety of microbial populations in estuaries, because they are a natural habitat of continuous spatial as well as seasonal environmental change. We hypothesize estuarine microbes are greatly influenced by DOM type. Size fractionated samples were collected from surface water along the salinity gradient of the Delaware Bay during March, August and November of 2014 and in April and August 2015 from the Chesapeake Bay. Both DNA and cDNA were sequenced by JGI from 24 selected samples from low, mid and high salinity sites within the bay. We characterized the abundance, distribution, replication rates and differential gene expression patterns of several metagenome assembled genomes (MAGs), phylogenetically associated with the SAR11 clade, Rhodobacterales order and Bacteroidetes phylum. Overall, the most change in abundance and gene expression of individual populations occurred between seasons and salinities, with lesser amounts of differential replication and gene expression between size fractions. Time of day had variable numbers of genes differentially expressed, depending on the taxon. Many genes were differentially expressed in taxa associated with the Rhodobacteriales as well as the SAR11 and Bacteroidetes groups. Additionally, we observed niche specificity in gene content and expression, especially in the SAR11 clade. Our results demonstrate the breadth of both functional potential and functions of individual bacterial populations in estuarine environments. Furthermore, our results indicate that abundance and activity of estuarine microbial populations change due to differences in DOM content, as evidenced by the different nutrient uptake and utilization genes expressed between seasons and salinities.

O-M4-03 Responses of marine bacterial community to dissolved organic matter released from viral lysis of picocyanobacteria - is there a correspondence between bacterial populations and molecular signatures of DOM?

Zhao Zhao, Xiamen University
Michael Gonsior, University of Maryland Center for Environmental Science
Yuanchao Zhao, University of Maryland Center for Environmental Science
Rui Zhang, Xiamen University
Nianzhi Jiao, Xiamen Univeristy
Feng Chen, University of Maryland Center for Environmental Science

Presenter Email: zhaozhao28@foxmail.com

Picocyanobacteria make up half of ocean primary production, and they are subjected to frequent viral infection. Viral lysis of picocyanobacteria is a major driving force converting biologically fixed carbon into dissolved organic carbon. Viral-induced dissolved organic matter (vDOM) released from picocyanobacteria provides complex organic matter to bacterioplankton in the marine ecosystem. In order to understand how picocyanobacterial vDOM are transformed by bacteria and the impact of this process on bacterial community structure, viral lysate of picocyanobacteria was incubated with a coastal water for 90 days. The transformation of vDOM was analyzed by ultrahigh-resolution mass spectrum and the shift of bacterial populations was analyzed using high-throughput sequencing technology. Addition of picocyanobacterial vDOM introduced abundant nitrogen components into the coastal water, which were largely degraded during the 90 days incubation period. However, some DOM molecules were accumulated and the total assigned formulae number increased. In contrast to the control (no addition of vDOM), bacterial community enriched with vDOM changed dramatically with increased biodiversity indices. The network analysis shows that certain bacterial OTUs form specific relationship with particular vDOM components, suggesting a potential correspondence between bacterial populations and DOM molecules. We demonstrate that coastal bacterioplankton are able to quickly utilize and transform lysis products of picocyanobacteria, meanwhile, bacterial community varies with changing chemical property of DOM.

O-M4-04 Effect of viral lysis of microorganisms on the organic matter continuum and microbial activity in the ocean

Markus G. Weinbauer, LOV, Villefranche-sur-mer, France
Presenter Email: wein@obs-vlfr.fr

Viral lysis is now considered as one of the main factors causing mortality of microorganisms (bacteria, archaea, protists and phytoplankton) in the ocean. During viral lysis, the cell content is set free and cell wall fragments are produced resulting in a change of dissolved organic matter (DOM) composition (e.g. amino acids and carbohydrates) as well as colloid concentrations. Lysis products are largely (and highly) bioreactive, i.e. they are readily used by bacteria. Typically, this results in a higher bacterial carbon demand and lower growth efficiency thus, increasing the conversion of DOM into $CO2$ (respiration). Conversion of cells into DOM and rapid respiration of this material should result in more efficient use of DOM in the surface ocean. However, lysis products can also increase the formation of organic aggregates (marine snow), probably because they are sticky, and hence shift the organic matter continuum from DOM to organic aggregates. This should prime the biological pump. Recent research showed that the chemical composition of lysis products differs between bacterial isolates and that this can have differential effects on bacterial diversity and activity. Therefore, microbial diversity is not only influenced by specific infection and lysis (mortality) but also by changes in the organic matter continuum. This processes could also result in shifts of readily utilizable and recalcitrant/refractory DOM and hence influence the microbial carbon pump. For a better understanding of the interactions between DOM and microorganisms, initiatives are required to better constrain the effect of viral lysis on DOM composition and microbial activity and diversity.

O-M4-05 Squeezing out understanding from sequences: Genome to Phenome Connections in Viruses of Microbes

K. Eric Wommack, Univ. of Delaware, Delaware Biotechnology Inst. Newark, DE, USA
Shawn Polson, Univ. of Delaware, Delaware Biotechnology Inst. Newark, DE, USA
Barbra Ferrell, Univ. of Delaware, Delaware Biotechnology Inst. Newark, DE, USA
Daniel Nasko, Univ. of Maryland Inst. for Advanced Computer Studies, College Park MD, USA
Jessica Chopyk, Univ. of Maryland School of Public Health, College Park MD, USA
Eric Sakowski, Johns Hopkins University Dept. of Environmental Health & Engineering, Baltimore MD, USA
Rachel Marine, Centers for Disease Control, Atlanta GA, USA
Amelia Harrison, Univ. of Delaware, Delaware Biotechnology Inst. Newark, DE, USA
Jacob Dums, Univ. of Delaware, Delaware Biotechnology Inst. Newark, DE, USA
Ryan Moore, Univ. of Delaware, Delaware Biotechnology Inst. Newark, DE, USA
Presenter Email: wommack@dbi.udel.edu

Enigmatic and often vilified, viruses are now known to play important and possibly indispensable roles in the biology and ecology of cellular organisms. Evidence of viral impacts are everywhere. Animal and plant genomes are littered with genes of viral origin. Ecosystems contain large numbers of viruses, an estimated global population of 10e31 individuals, dwarfing co-occurring microbial abundances. Most viruses observed within ecosystems infect microbes. During infection, viruses can alter the phenome of host cells in ways that change the population biology of microbial communities and the flow of nutrients and energy within ecosystems. While we have a high-level view of viral impacts, the details are largely a mystery. These details matter as viral impacts on ecosystems are the net result of hundreds or thousands of interacting populations of viruses and microbial hosts. The mechanistic underpinnings of viral effects on ecosystems can only be fully appreciated through a greater understanding of the phenomic features of viral-host interaction networks. Genomic data have shown that viral genetic diversity is vast and largely unknown. Often less than half of the genes within a dsDNA viral genome can be

assigned a function based on homology. This situation is worse for viral metagenomes (viromes). Predicting important phenomic features of an unknown virus based on genomic information alone is not currently possible. However, we have identified three genes DNA polymerase A, ribonucleotide reductase (RNRs), and chaperonins which appear to demonstrate particularly strong links to the phenomic characteristics of viruses of microbes (VoMs). Mutations within PolA appear to be predictive of whether a virus has a lytic or lysogenic life cycle and polA genes seem to be critical in determining the broader suite of genes involved in viral genome replication. The class and sub-group of RNR genes carried by a virus appear to predict the environmental conditions most favorable to lytic viral production. The propensity of a virus to carry chaperonin genes may predict its genome size and its capability for altering, more generally, the protein folding machinery within infected cells. Viral chaperonins within viromes have also demonstrated the existence of unknown viruses infecting marine archaeal populations. Ultimately, uncovering genome to phenome links within ecologically-important VoM-host systems will improve the predictive utility of viral genomic and metagenomic data for advancing scientific understanding on the role of viruses within ecosystems.

O-M4-06 Insight into microbial metabolisms in the deepest seawater on earth

Jiwen Liu, Ocean University of China
Yanfen Zheng, Ocean University of China
Jiwei Tian, Ocean University of China
Xiao-Hua Zhang, Ocean University of China
Presenter Email: xhzhang@ouc.edu.cn

The Mariana Trench is the deepest place on Earth, reaching a depth of ~11,000 m at the Challenger Deep. Its hadal waters (>6,000 m) constitute 45% of the vertical depth gradient1. Recent studies demonstrate that hadal waters harbor distinct microbial planktonic communities2,3. However, the ecological capacity of microbial communities within the hadal zone are poorly understood. Here we show an abrupt increase in the relative abundance of hydrocarbon-degrading bacteria from waters at 9,600 to >10,000 m in the Challenger deep of the Mariana Trench. These bacteria were represented mainly by Oleibacter, Thalassolituus and Alcanivorax (~25% of the metagenome), all of which include species that can consume aliphatic hydrocarbons4-7. This community shift towards hydrocarbon degraders was accompanied by an enrichment for genes involved in alkane degradation. Correspondingly, two Alcanivorax species that were isolated from 10,400 m, in addition to a reference Oleibacter strain, were able to efficiently degrade a wide range (C11-C36) of n-alkanes. n-alkanes (dominated by medium-chain lengths of C15-C23), derived from complex sources, were detected in both the sinking particles and surface sediment (~10,910 m), suggesting that these compounds support this hydrocarbon-degrading bacterial population. Overall, these results reveal an unexpected and unique biosphere dominated by hydrocarbon catabolism in the deepest seawater on earth, shedding new light on biological processes in extreme environments.

O-M4-07 Deciphering associations between dissolved organic molecules and microbial communities in the Pearl River Estuary

Wei Xie, School of Marine Sciences, Sun Yat-sen University
Penghui Li, South China University of Science and Technology
Chen He, China University of Petroleum
Ding He, School of Earth Sciences, Zhejiang University
Quan Shi, China University of Petroleum
Chuanlun Zhang, South China University of Science and Technology
Presenter Email: xiewei9@sysu.edu.cn

populated and economically developed region, and discharging into the South China Sea through the Pearl River Estuary (PRE). The Estuary can be considered as a large-scale, natural biogeochemical laboratory, characterized by pronounced physicochemical gradients of nutrients, salinity, terrestrial organic matter inputs, and other parameters. In this study, high throughput sequencing targeting 16S rRNA genes was conducted to reveal the changes of microbial communities along the environmental gradient of PRE. At the same time, the molecular composition of solid-phase extraction (SPE) dissolved organic matter (DOM) along PRE gradient were analyzed by negative-ion electrospray ionization (ESI) Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS). The results from SPE-DOM exhibited a total of 65 heteroatom class species assigned from a single mass spectrum, in which CHO class species were dominant. The aromatic index (AI), which was used to identify the polyaromatic hydrocarbons in DOM, was negatively correlated with salinity, suggesting the gradually dilution or biological degradation of those polyaromatic hydrocarbons during the migration from the river to the sea. Pearson's correlation analysis for the community structures and DOM molecular compositions revealed that Sphingomonadales and Burkholderriale were the most two significant bacteria that showed positively correlated with AI, suggesting those bacteria might live on those polyaromatic hydrocarbons. Collectively, our study shed light on exploring the complex relationship between microbes and DOM in estuarine environments.

O-M5-01 Nitrite oxidation exceeds reduction and fixed nitrogen loss in anoxic Pacific waters

Andrew R. Babbin, Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
Carolyn Buchwald, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, USA Department of Oceanography, Dalhousie University, Halifax, Nova Scotia B3H 4R2 Canada

François M. M. Morel, Department of Geosciences, Princeton University, Princeton, New Jersey 08544, USA
Presenter Email: babbin@mit.edu

Although the microbial oxidation of nitrite (NO_2^-) has been known for over a century, studies of the pathways and microbes involved have generally proceeded under the assumption that nitrite oxidation to nitrate requires dioxygen (O_2). Fundamentally, however, dioxygen is not required as the oxygen atom added to the NO_2^- to form nitrate (NO_3^-) derives from water in aerobic cultures. Anaerobic NO_2^- oxidation until now has been conclusively shown only for anammox bacteria, albeit only as a limited sink for NO_2^- in their metabolism. Here, using direct experimental techniques optimized for anoxic conditions, we show that anaerobic NO_2^- oxidation is substantial, widespread, and consistent across the oxygen deficient zones of the eastern tropical Pacific Ocean. We hypothesize this reaction occurs with an oxidant other than O_2. Additionally, anaerobic NO_2^- oxidation rates are up to an order of magnitude larger than simultaneous N_2 production rates for which these zones are known, and cannot be explained by anammox rates alone. Higher rates of NO_2^- oxidation over reduction in anoxic waters are paradoxical but help resolve the balance of anammox and denitrification rates and the calculation of the global fixed nitrogen loss budget.

O-M5-02 Novel processes in microbial nitrogen cycle: methane-driven nitrate reduction and oxygenic denitrification

Baoli Zhu, Helmholtz Zentrum Muenchen, German research center for environmental health
Presenter Email: baoli.zhu@helmholtz-muenchen.de

Microbial nitrogen cycling has been intensively investigated for over a century and was thought to be rather well understood. Yet recent discoveries of novel processes and microbes involved in the nitrogen cycle, e.g., methane-dependent nitrite- and nitrate-reduction, complete ammonia oxidation to nitrate (comammox), have demonstrated that our understanding of microbial nitrogen cycling may be far from complete. Here I would like to discuss two projects that we have been doing in the last few years, revealing novel microbes and microbial processes in nitrogen cycle. Using lab-scale bioreactors, enrichment culture performing methane driven nitrate reduction was successfully obtained. The dominant archaea (AAA) were identified as a member of ANME (anaerobic methanotrophic archaea), which, in consortium with sulfate reducing bacteria (SRB), are known to mediate sulfate-dependent methane oxidation. Physiology and metagenomics analysis indicates that AAA could perform dissimilatory nitrate reduction to ammonia (DNRA) and oxidize methane via reverse methanogenesis. AAA-related rRNA sequences have been retrieved from various ecosystems, but the ecological importance of these archaea and their contribution to global carbon and nitrogen cycling is still not known. Additionally, nitric oxide dismutation (NOD) is a peculiar oxygen-forming process, recently proposed in the nitrite-dependent anaerobic methanotrophic NC10 bacterium. In contrast to canonical NO reduction, via NOD, NO is suggested to be disproportionated directly into N2 and O2, bypassing the ozone-depleting potent greenhouse gas nitrous oxide. Moreover, the formed O2 theoretically enables microbial aerobic catabolism in anoxic habitats, providing ecophysiological advantage for microbes to thrive on recalcitrant substrates in O2-limited environments. Thus the process could be ecologically important. After developing specific molecular tools targeting the enzyme, NO dismutase (Nod), that catalyze NO dismutation, we recovered diverse nod genes from various environments, including contaminated aquifers and wastewater treatment plants. One of our ongoing projects suggests that NOD microbes are involved in hydrocarbon degradation in one BTEX-contaminated aquifer in Germany. These data indicate that NO dismutation is widely spread in diverse microbes, however, currently little is known about the process and microorganisms with this capacity.

O-M5-03 Temperature plays a crucial role in regulating sedimentary nitrogen removal and the associated N2O release

Ehui Tan, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Wenbin Zou, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Jicong Xu, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Zhenzhen Zheng, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Ting-Chang Hsu, Earth System Science Program, Taiwan International Graduate Program, Academia Sinica, Taipei, Taiwan
Moge Du, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Li Tian, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Shuh-ji Kao, State Key Laboratory of Marine Environmental Science, Xiamen University, China
Presenter Email: ehuitan@stu.xmu.edu.cn

Denitrification and anaerobic ammonium oxidation (anammox) are two dominant processes for reactive nitrogen removal. In the context of global warming, temperature may serve as the primary forcing function to tune the microbial metabolism thus the community distribution, yet, how the community change and associated nitrogen removal pathways respond to warming remains a knowledge gap in prediction of nitrogen cycling and potential climate feedbacks. By using ^{15}N isotope pairing technique, we measured the potential rates of sedimentary denitrification, anammox, and associated N_2O production at a temperature gradient ranging from 1-35℃ in various aquatic systems, including estuary, aquaculture pond, tidal flat and freshwater creek. The optima temperature and apparent activation energy for the denitrification were systematically and significantly higher than those for anammox. The N_2O production rate was stimulated by temperature increase. While the N_2O/N_2 of denitrification exhibited a bimodal structure with higher values at both 1-15℃ and 30-35℃. Combined our experimental results with global compilation of the existing data on *in situ* sedimentary denitrification, anammox, N_2O release and N_2O/N_2 temperature dependence in various aquatic systems, we inferred that (1) denitrifying communities adapt to a higher and a wider temperature range, while the anammox bacteria were relatively cold-adapted; (2) N_2O reductase was more easily to be suppressed than other enzymes participating the N_2O production outside the habitable temperature.

O-M5-04 Nutrient-limitation and response to increasing CO2 of diazotrophic cyanobacteria in the South China Sea

Zuozhu Wen, State Key Laboratory of Marine Environmental Science (Xiamen University)
Wenfang Lin, State Key Laboratory of Marine Environmental Science (Xiamen University)
Rong Shen, State Key Laboratory of Marine Environmental Science (Xiamen University)
Jian Pang, State Key Laboratory of Marine Environmental Science (Xiamen University)
Tianli He, State Key Laboratory of Marine Environmental Science (Xiamen University)
Haizheng Hong, State Key Laboratory of Marine Environmental Science (Xiamen University)
Dalin Shi, State Key Laboratory of Marine Environmental Science (Xiamen University)
Presenter Email: wenzuozhu2014@stu.xmu.edu.cn

We examined short-term (72h) responses of natural diazotrophic cyanobacteria to nutrient (Fe and P) amendments and ocean acidification (OA) in on-deck incubation experiments conducted between May 2016 and August 2017 in the North South China Sea (NSCS) and the upstream Kuroshio. Nutrient amendment experiments revealed distinct nutrient limitation patterns of N2 fixation between the Kuroshio and the NSCS, with P-limitation in the Kuroshio and Kuroshio-affected stations and Fe and P co-limitation in the NSCS. The results suggested that in the Kuroshio and Kuroshio-affected regions extra inputs of Fe

should exist to support high standing stocks of Trichodesmiun and drive the systems to P-limitation. In acidification experiments, Trichodesmium was the dominating phylotypes based on the qPCR amplification of planktonic nifH genes, and N2 fixation rates were significantly decreased under acidified conditions in five of the six experiments. In the station where no OA effect OA was observed, hydrological data showed that it was under the strong influence of the Kuroshio instruction and thus likely received sufficient Fe, which may have greatly promoted N2 fixation and mitigated the negative effect of OA. Our study demonstrated that N2 fixation by natural Trichodesmium populations in the NSCS was suppressed by OA, and the negative effects can be modulated by the availability of nutrients.

O-M5-05 Surface nitrification and its climatic effect in oligotrophic ocean

Xianhui Wan, State Key Laboratory of Marine Environmental Science, Xiamen University
Hua-Xia Sheng, State Key Laboratory of Marine Environmental Science, Xiamen University
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University
Yao Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University
Dalin Shi, State Key Laboratory of Marine Environmental Science, Xiamen University
Shuh-Ji Kao, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: wanxh@xmu.edu.cn

The supply and cycling of nitrogen play an essential role in regulating ocean's ability in absorbing atmospheric carbon dioxide (CO2) and releasing nitrous oxide (N2O). In oligotrophic ocean, the primary production and its subsequent exporting (termed as biological pump) is largely limited by nitrogen, competition of nitrogen by phytoplankton and microbe thus determines the flow of nitrogen towards driving CO2 uptake or N2O production. By investigating the competition of ammonium by phytoplankton and ammonia oxidizers and measuring the N2O production rate in the oligotrophic South China Sea and subtropical Western Pacific, we find that ambient nitrate acts as a key variable to bifurcate ammonium flow through assimilation or oxidation, and the depth of the nitracline represents a robust spatial boundary between ammonium assimilators and oxidizers in the stratified ocean. Phytoplankton assemblages in nitrate depleted regimes have higher ammonium affinity than nitrifiers. In nitrate replete conditions, by contrast, phytoplankton reduce their ammonium reliance and thus enhance the success of nitrifiers. Accordingly, active N2O production is observed below the nitracline and peaked at the base of euphotic zone. These findings demonstrate that the intimate coupling of carbon and nitrogen cycling in the upper ocean not only act as a CO2 sink but also a N2O source. Therefore, the offset of CO2 absorbing by N2O production must be considered in future study to a reach comprehensive understanding of the role of ocean in Earth's climate.

O-M5-06 Coupled effect of substrate and light on assimilation and oxidation of

regenerated nitrogen in the euphotic ocean

Min Nina Xu, 1. State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, 361102, China
Xiaolin Li, Earth Sciences, Xiamen University, Xiamen, 361102, China
Dalin Shi,
Yao Zhang,
Minhan Dai,
Tao Huang,
Patricia M. Glibert,
Shuh-Ji Kao,
Presenter Email: minxu@stu.xmu.edu.cn

Nitrogen (N), as a critical element for microbial metabolisms, recycles rapidly in the euphotic ocean. Oxidation by nitrifiers is a competing pathway for phytoplankton assimilation of regenerated N (NH4+ and urea). Sharing the overlapping substrates may result in the competitive exclusion, thus, niche separation for the two assemblages. Both pathways are sensitive to light, but whether light intensity will intensify or alleviate such resource competition in the euphotic zone remains poorly explored in the field at community level. By using 15N labelling techniques, paired kinetic responses of uptake and oxidation were conducted in one single bottle under manipulated light intensities for both NH4+ and urea. In contrast, light effects were opposite for oxidation kinetics (Rm and ɑO). As irradiance increased, the rapid increase in ɑU and concomitant decrease in ɑO imply a distinctive competition advantage of photosynthetic organisms over oxidizers under substrate limited environments. The ratio of ɑU/ɑO for NH4+ ranged from 0.8 to 3089 (5.8−46788 for urea) showing a distinct increasing pattern as ambient light increases, demonstrating that phytoplankton overwhelm nitrifiers throughout the oligotrophic euphotic zone driving down concentrations and maintaining short turnover times of the two regenerated N. Moreover, phytoplankton relied equally on NH4+ and urea, yet, nitrifiers preferred NH4+ to urea. In the nitrate-depleted euphotic ocean, light acts as a crucial driver for utilization pathways of regenerated N and vertical niche separation. This field study in the open ocean showing that light can shape the specific affinity of assimilators and oxidizers toward NH4+ and urea. Moreover, an enhanced photosensitivity under very low substrate levels was observed, providing an insight into the joint control of light and substrate on the distribution of N recycling pathways. This information may contribute to N-based ocean biogeochemical models.

O-M5-07 Comparative genomics and evolutionary analyses of marine ammonia-oxidizing archaea

Wei Qin, University of Washington, School of Oceanography, Seattle, USA
Yue Zheng, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, China

Feng Zhao, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, China
David A. Stahl, University of Washington, Department of Civil and Environmental Engineering, Seattle, USA
Anitra E. Ingalls, University of Washington, School of Oceanography, Seattle, USA
Presenter Email: qinwei2010@gmail.com

Marine ammonia-oxidizing archaea (AOA) are a diverse group that forms a monophyletic clade within the Thaumarchaeota. They are essential and abundant microorganisms in the ocean due to their role in regulating the nitrogen cycle, contributing to the dark ocean carbon fixation, and supplying vitamin B12 to B12-dependent organisms. Although marine AOA provide the foundation for the function and stability of marine ecosystems, we still have very limited understanding about their incredible genetic diversity and associated high adaptive capacity. To test the extent to which genotypic differences translate to phenotypic variation among AOA, we compared the whole-genomes of 45 AOA species across diverse geographic locations. Comparative analysis revealed extensive gene content diversity among these genomes. The pan-genome analysis of Nitrosopumilus-like marine AOA indicated that the degree of openness of their pan-genome is comparable or even slightly higher than those of the other two globally widespread marine microorganisms, SAR11 and Prochlorococcus. In addition, since the isolation of N. maritimus SCM1 in 2005, this strain has been continuously transferred under optimum growth condition. We monitored the evolution process of N. maritimus along the ~3000 generations of continuous transferring, and identified the mutations underlying their adaptive growth. Following ~1200 generations of continuous culturing of N. maritimus under optimum growth condition in the lab, the glycine residue near the Cu binding site of nitrite reductase was mutated. This mutation is associated with an enhanced growth rate and different production rate of nitric oxide, a key intermediate in the ammonia oxidation pathway. Together, these findings highlight a significant genetic reservoir in marine AOA, which confers selective advantages for their niche-specific adaptations.

O-M5-08 Insights on Halocline Ventilation in the Western Arctic from Nitrate Isotope Ratios

Julie Granger, University of Connecticut
Presenter Email: julie.granger@uconn.edu

Nitrogen is a limiting nutrient for primary production in the western Arctic Ocean. Measurements of the nitrogen (15N/14N) and oxygen (18O/16O) isotope ratios of nitrate in the southeastern Beaufort Sea provide insight into biogeochemical cycling of nitrogen in the western Arctic Ocean. Nitrate O isotope ratios in the Pacific Halocline evidence a highly regenerated reservoir. Coincident peaks in nutrient concentrations and reduced dissolved oxygen concentrations suggest that nitrate accrues from organic matter remineralization in bottom waters of the Chukchi shelf and that these ventilate the basin predominantly in

summer, when isolated from the atmosphere. Pre-formed nitrate in the Halocline lacks a 18O/16O enrichment from nitrate assimilation, contrasting preformed nitrate in other ocean basins. A reactive N deficit and elevated nitrate N isotope ratios in the Pacific Halocline further indicate substantial N loss to coupled nitrification-denitrification in shelf sediments upstream. The observations reveal that shelf processes have a disproportionate influence on tracer properties of the Pacific Halocline.

O-M5-09 DON cycling in the South China Sea: insights from stable isotope

Run Zhang, Xiamen University
Xingchen Wang, California Institute of Technology
Presenter Email: zhangrun@xmu.edu.cn

Dissolved organic nitrogen (DON) is the most dominant species of total dissolved nitrogen (TDN) in the upper water column oligotrophic tropical and subtropical surface ocean, and is of great implications for understanding marine C and N biogeochemical cycles. Given the large pool size of DON in the surface ocean, its putative role in regulating production and biological pump should be non-negligible, as there is some evidence suggesting that a portion of DON may be bioavailable. The isotope composition of DON can provide unique insights into the pathways of DON cycling, and determining the stable isotope composition of DON is important for understanding biogeochemistry in the ocean. Here we first present a dataset of isotopic composition of DON in the upper water column of the tropical western South China Sea (wSCS). Concentration and d15N of DON fell in a relatively narrow range (eg., 4.6 uM and 4.3 per mil at 5 m) in the wSCS. Concentration of DON was positively correlated to cholorophyll a concentration in surface waters, suggesting a main photosynthetic origin of DON. An isotope effect during DON consumption in the upper 50 m is revealed. We find a high similarity in the d15N of upper water column DON and subsurface nitrate (4.5 vs 4.6 per mil, suggesting that the upwelled nitrate is the primary source of N for DON. DON may represent a missing N source and fuel production in the N-depleted surface layers of the South China Sea.

O-M5-10 Hydro-biological modulation of nitrate and its dual isotopes in the northwest Pacific Ocean

Xiuli Yan, Marine Science Institute, Shantou University, Shantou, China, 515063
Yanhua Wu, Shenzhen Marine Environment Monitoring Center Station, State Ocean Administration, Shenzhen, China, 518000
Jin-Yu Terence Yang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China, 361005
Min Nina Xu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China, 361005
Qiao Wu, State Key Laboratory of Marine Environmental Science, Xiamen University,

Xiamen, China, 361005
Huiwang Gao, Key Laboratory of Marine Environmental Science and Ecology, Ministry of Education, Ocean University of China, Qingdao, China, 266100
Shuh-Ji Kao, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China, 361005
Presenter Email: yanxl@stu.edu.cn
The influences of anthropogenic nitrogen (such as increases in seawater N:P ratios and sedimentary δ15N) has been found to extend far into the northwest Pacific Ocean (NWPO) associated with atmospheric N deposition (AND). However, remains no observational δ15N evidence was reported to witness the cumulative effect of AND on seawater nitrate (NO3-). Coupled with N biogeochemical processes associated with assimilation and recycling, hydrological influence may play important role in modulating the signal of N dynamics in horizontal and vertical scales. The mid-latitude NWPO is composed of multi water masses, such as the Kuroshio Water, Oyashio Water, North Pacific Intermediate Water (NPIW) and North Pacific Deep Water. Under the scenario of increasing anthropogenic N influences and complex physical-biological dynamics, we aimed to explore the NO3- dynamics in the NWPO, especially from the perspective of N isotope. Water samples were collected during the spring of 2015 to investigate the spatial distribution of NO3- and its dual isotopes (δ15NNO3 and δ18ONO3) versus N* (N*=Nobs-16Pobs+2.9). The signal of NPIW (the salinity minima near 26.5-27.0σ) was observed latitudinally in the upper 1000 m varying concomitantly with the depth of nitracline. In the upper layer, NO3- decreased significantly upward while dual isotopic compositions (especially for δ18ONO3) covary becoming heavier due to NO3- assimilation by phytoplankton. Intriguingly, at some stations in the euphotic zone, δ15NNO3 decreased firstly and then increased upward deviating from the upward variability in δ18ONO3. This was contributed to the influences of AND (include N2 fixation) and nitrification according to the judgement of Δ(15,18)<0 and N*>0. Below the water depth of >400 m, both NO3- concentration and its dual isotopic compositions remained relatively a uniform value near the averages of NO3- in global ocean (5.3‰ for δ15NNO3, 2.4‰ for δ18ONO3).

O-M5-11 The effect of nitrogen cycles in the Kuroshio on the marine environment of East China Sea

Wentao Wang, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences
Zhiming Yu, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences
Xiuxian Song, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences
Yongquan Yuan, CAS Key Laboratory of Marine Ecology and Environmental Sciences,

Institute of Oceanology, Chinese Academy of Sciences
Zaixing Wu, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: wtwang@qdio.ac.cn
In 2014, in the southern East China Sea (ECS) and east of Taiwan, nutrient and isotope samples were collected and analyzed. Also, dissolved oxygen (DO), chlorophyll-a, and physical parameters were determined. The Kuroshio subsurface water intruded into the ECS and separated into two branches on the continental shelf: the nearshore Kuroshio branch current (NKBC) and the offshore Kuroshio branch current (OKBC). The NKBC was able to extend to nearshore area in spring while it was hardly to be described in autumn. In spring, the variations of DO, nitrate and nitrogen isotopes in the bottom water showed that continuous nitrification occurred in the NKBC after intrusion into the ECS. This process might contribute to the hypoxia zone near the coast of Zhejiang Province, China. However, in autumn, the biogeochemical process was weak to lead the nutrients variations. Additionally, higher phosphorus (P) concentrations was transported onto the ECS continental shelf in autumn. Through the water columns analysis, we speculate that the distinctions among the seasonal variations of P-enriched water masses were attributable to the different intrusion positions of the Kuroshio. Moreover, according to the Rayleigh model, primary production in most of southern ECS was supported by the intrusion of the Kuroshio subsurface water, causing 5‰ isotope fractionation. In some of nearshore stations which located in the northern investigated area, the assimilated nitrate was contributed from both the NKBC and coastal currents originated from the Changjiang diluted water.

O-M5-12 Pathways of anthropogenic nitrogen in the coastal environment of Hong Kong

Naomi Geeraert, The University of Hong Kong, Swire Institute of Marine Science
Yvonne Yu Yau, The University of Hong Kong, Department of Earth Sciences
Benoit Thibodeau, The University of Hong Kong, Department of Earth Sciences and Swire Institute of Marine Science
David M Baker, The University of Hong Kong, School of Biological Sciences and Swire Institute of Marine Science
Presenter Email: geeraert@hku.hk
The nitrogen (N) dynamics in coastal environments has altered due to urbanisation and human activities in the connected catchments. Eutrophication due to excessive N discharge can lead to negative ecological impacts, such as harmful algal blooms and hypoxia. We wanted to identify the pathways of anthropogenic N upon reaching the coastal waters. Therefore, we measured d15N of nitrate and particulate matter in Hong Kong waters, which are under influence of the Pearl River and local sewage discharge. The samples were

collected in 42 sites at 2 or 3 depths during the OCEAN-HK summer cruise in 2017. The d15N showed a gradual transition from west to east and spanned a broad range from 7 to 23 permille in nitrate and -9 to 14 permille in particulate matter. The application of the steady state equation pointed toward strong N transformations at all depths. Assimilation of N in phytoplankton was the dominant process in the surface waters in the south of Hong Kong. Nitrification explained the patterns in the middle and bottom waters. The fractionation factors obtained from the steady state plots were subsequently applied into a model to estimate the magnitude of the different N transformation processes. Based on this dataset, we concluded that discharges of N, often caused by human activities, are significantly transformed in the coastal zone. The substantial assimilation of N in the surface waters which we observed on the south of Hong Kong can lead to algal blooms and associated environmental impacts.

O-M5-13 The influence of riverine nutrients in niche partitioning of phytoplankton communities - A contrast between the Amazon River plume and the Changjiang (Yangtze) River Diluted Water of the East China Sea

Helga Gomes, Lamont Doherty Earth Observatory at Columbia University, Palisades, NY, USA
Qian Xu, Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan
Joji Ishizaka, Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan
Joaquim Goes, Lamont Doherty Earth Observatory at Columbia University, Palisades, NY, USA
Presenter Email: helga@ldeo.columbia.edu

Riverine nutrients act in concert with local hydrographic conditions to create distinct ecological niches for phytoplankton communities across river-ocean continuums. Here we compare two of the world's largest river-ocean systems, the Amazon River Plume (ARP) which outflows into the Western Tropical North Atlantic and the Changjiang Diluted Water (CDW) which empties into the East China Sea to show how distinctly different N: P supply ratios of their source waters, shape phytoplankton communities along the river-ocean continuum. Sampling in the relatively unpolluted surface waters of the ARP during peak river discharge revealed that phytoplankton communities along the river-ocean continuum were strongly limited by Dissolved Inorganic Nitrogen (DIN, nitrate plus nitrite) which was low or beyond detectable, while Dissolved Inorganic Phosphorous (DIP, phosphate) and Silica were not limiting. The resulting low N:P supply ratio allowed diazotrophs to co-exist with the non-diazotrophs. Diatom-Diazotroph Associations (DDAs) such as Hemiaulus hauckii-Richelia proliferated, while in the oligotrophic oceanic waters, Trichodesmium spp. thrived. In contrast, in the CDW, anthropogenic nitrogen inputs from human pressures in

the Changjiang River system has led to a system where the changing supply rate of the single nutrient (DIP) is responsible for the interannual variability seen in the phytoplankton community structure of the CDW. During years of low discharge, DIP limitation can be ameliorated by on-shelf upwelling of DIP rich Kuroshio Intermediate Waters leading to domination of diatoms and dinoflagellates. Conversely, during years of heavy discharge, the westward flowing CDW plume was severely DIP limited, probably because water column stratification dampened upwelling of subsurface waters. The consequent DIP limitation led to the proliferation of small phytoplankton such as Chlorophytes and Cyanobacteria. The absence of diazotrophs in the CDW, leads us to hypothesize that river-ocean continuums, whose source waters are heavily impacted by anthropogenic activities and with high nitrate concentrations often substantially in excess of Redfield ratios, may not support diatoms on account of DIP limitation nor diazotrophy because of excess DIN.

O-M5-14 Atlantic Meridional Overturning Circulation during the abnormally long interglacial of marine isotope stage 11: What can we learn from surface nutrient utilization

Benoit Thibodeau, Department of Earth Sciences and Swire Institute of Marine Science, The University of Hong Kong, Hong Kong SAR
Presenter Email: bthib@hku.hk

The marine isotope stage 11 (MIS 11) is often used as a potential analogue for the Holocene because of its similarities regarding orbital and greenhouse gas forcing (e.g., Droxler et al., 2003). However, recent studies portrayed the surface subpolar North Atlantic to be fresher by about 6 salinity units compared to today (Kandiano et al., 2017). This added to the growing body of evidence that the subpolar North Atlantic was characterized by much fresher and cooler surface waters during MIS 11 peak interglacial conditions (MIS 11 sensu stricto (ss)) compared to the Holocene (Kandiano et al., 2016; Thibodeau et al., 2017). Interestingly, MIS 11ss is often characterized by a strong AMOC (e.g., Vazquez Riveiros et al., 2013; Dickson et al., 2009), which seems at odds with the notion of major fresh and cold water input at high latitudes (e.g., Rahmstorf et al., 2005). Here, I show that the fresh and cold surface layer in the Nordic Seas created a strong salinity gradient in the polar North Atlantic at the beginning of the interglacial concurrent with strong variation in the surface nutrient utilization. I further demonstrate, with the help of a simple box model, that the weakening of this gradient in the peak interglacial allowed for the onset of deep water formation in the Nordic Seas, which contributed to a global intensification of the AMOC. Finally, I highlight that this thermohaline-driven sharp intensification of the AMOC is concomitant with the observed general enrichment in North Atlantic benthic d13C (Lisiecki, 2010) and could help explain the abnormally long duration of MIS 11 (Dickson et al., 2009), underlining the importance of the North Atlantic freshwater budget in regulating AMOC.

O-OB-01 The evolution of optofluidic sensors for pH and pCO2

Mike DeGrandpre, University of Montana
Cory Beatty, University of Montana
James Beck, Sunburst Sensors
Reuben Darlington, Sunburst Sensors
Presenter Email: michael.degrandpre@umontana.edu

It has been more than 25 years since the first indicator-based autonomous $p\mathrm{CO_2}$ sensors were successfully developed and deployed on moorings. These sensors, an example of which is the Submersible Autonomous Moored Instrument (SAMI), utilize a pump and valve to refresh a pH indicator solution and run blanks. More of an in situ analyzer than a sensor, the additional complexity is necessary to achieve calibration-free performance, i.e. low or no drift for year-long deployments. Fiber optics are used to bring the light from the light source contained within a pressure housing to the optical flow cell that is at pressure. The design minimizes total flush volumes to reduce reagent consumption to 100 µl ($p\mathrm{CO_2}$) per measurement. The instruments have evolved from an optical design based on a white light source (tungsten lamp) with a spectrograph for detection to light-emitting-diode sources with bandpass filters and photodiodes. The nearly identical seawater pH instrument (SAMI-pH) utilizes 50 µl per measurement providing 10,000 measurements with a 500 ml reagent reservoir. Unlike the SAMI-$\mathrm{CO_2}$, which uses deionized water blanks for baseline correction, the SAMI-pH records a blank in seawater for each measurement. This presentation will focus on various technical aspects of the evolution of the sensors that should be of interest to other instrument developers. The various stages of development provide insights into the sacrifices that are made to minimize power and reagent consumption and maximize performance (precision, accuracy). The prospects for further advancements in autonomous optofluidic sensors will also be discussed.

O-OB-02 Microfluidic Biogeochemical sensors for global scale observation

Matthew Mowlem, National Oceanography Centre, European Way, Southampton, UK
Presenter Email: matm@noc.ac.uk

Microfluidic sensors (also known as lab on chip) enable adapted traditional reagent based analytical techniques for chemistry and biology to be performed in situ, e.g. submerged in the marine environment. Recently this has included use on landers and moorings, profiling floats (PROVOR, NKE, France), ocean gliders (Seaglider, Kongsberg, Norway) and AUVs (e.g. Autosub Long-Range, NERC, UK). This approach is advantageous as the metrology quality is assured by using high performance assays. In addition, standards and blanks can be carried allowing in situ calibration to improve accuracy and to address drift. Recent deployments (including >1 year in the Arctic) indicate that challenges from biofouling and reliability, particularly of moving components, have been adequately addressed. We present a family of microfluidic sensors that use a common component set with subtle design and more fundamental assay variations to provide high performance operational measurement of a number of parameters including nutrients (e.g. nitrate, nitrite, phosphate, silicate), micronutrients (e.g. Iron), and the ocean carbonate system (pH, TA, DIC). Assays and sensors for further parameters (e.g. RNA and DNA) are in development. The sensors use a network of microchannels formed in a polymer substrate to mix sample (sea) water (or standards or blanks) with reagents to produce a colour or conductivity change in response to changes in the parameter of interest. Physically they consist of a microfluidic manifold (chip) on which is mounted a high performance multi-barrel syringe pump and microvalves to enable fluid manipulation within the manifold and optical, electrical or temperature sensors for analytical determinations. Columns for extraction and concentration of analytes or conversion to reactive forms (e.g. from Nitrate to Nitrite, the latter reacting with the Greiss reagent for determination) can be attached to the manifold. The system is controlled with embedded microelectronics and interfaces with a wide range of communication systems and platforms. The systems are robust over a wide range of temperature (<-10 oC to >30 o C) and pressure (tested to 60 MPa) allowing for a wide range of deployments and applications in a variety of aquatic environments.

O-OB-03 The importance of in-situ measurements of turbidity currents: the limitations of grain-size and upscaling in flume experiments

Guilherme Bozetti, Visua-Log Geology Consulting, AB39 2PR, Stonehaven, United Kingdom; University of Aberdeen, Department of Geology & Petroleum Geology, AB24 3UE, Aberdeen, UK
Presenter Email: g.bozetti@visua-log.com

Submarine gravity flows, including turbidity currents, are the main sediment transport mechanism recognised on the Earth鈥檚 surface, responsible for redistributing more sediments than any other sediment flow process. Although turbidity currents play a major role shaping the bottom of our oceans and large lakes, direct measurements of their properties are extremely rare, and important properties such as sediment concentration and density stratification have never been directly acquired. In an attempt to diminish uncertainties regarding turbidity currents properties, flume experiments have been carried out extensively for the past 30 years, and their results upscaled to dimensions encountered in nature. However, making predictions of natural gravity-flow processes based on turbidity current behaviours produced in experiments in tanks that range from 5 to 25 metres, with very limited grain-size range, and extremely restricted duration is rather concerning, and some major issues should be addressed: i) there has never been reliable experiments on turbidity currents produced with grain-sizes greater than 0.5 mm, leaving a huge grey area when it comes to the behaviour of the flows transporting larger grain-sizes; ii) in such a short duration of the experiments, there is not enough time for a series of well-known phenomena such as water entrainment and flow rheology transformation to be observed; iii) the vast majority of the experiments are unimodal in terms of grain-sizes, not representing, even within the finer grain fraction, the effects of a series of grain-sizes within the same flow interacting one another. For a precise understanding of the sediment transport mechanisms, direct monitoring observations of gravity-driven flows, now available due to recent technological advances in monitoring sensors, moorings, and autonomous data recovery, should be combined with cores and seismic data to link flow and deposit character. Experimental and numerical models play a key role in understanding specific properties, but the better the knowledge of natural properties of these events, better models can be produced, generating results that are more reliable.

O-OB-04 Quantifying the capability of ocean observation system in representing ocean heat content changes using synthetic observation

Gongjie Wang, National University of Defense Technology
Lijing Cheng, Institute of Atmospheric Physics, Chinese Academy of Sciences
Presenter Email: wanggj_9015@sina.com

Ocean heat content (OHC), as the best measure of planetary energy imbalance, is a fundamental metric for climate change. OHC change is monitored by ocean in situ observation systems (OOS) with irregular and incomplete data coverage. The ability of past and current OOS for monitoring OHC and its variability is a question. Lack of information in data-sparse regions is the main difficulty in addressing this problem. Ocean reanalyses or model simulations could be regarded as one realizations of the "possible" past for evaluation purposes. Here we use an ocean reanalysis (CMCC Global Ocean Reanalysis System version 5: C-GLORSv5) as one realization of the past ocean, considered as "truth" for our purpose, for the 1980-2015 period. We then construct a synthetic ocean observation dataset by re-sampling the ocean from the reanalysis according to actual spatio-temporal locations of in situ ocean subsurface temperature data (extracted from the EN4 profile database). Based on these synthetic data, OHC for 0-2000m is calculated based on a gap-filling method. It is then compared with the "truth" to quantify the error. We show that the global OHC tendency (OHCT) in the upper 2000m can be reconstructed with a root-mean-squared error (RMSE) of 3.61W/m2, with 3.15 W/m2 in the upper 700m and 1.16 W/m2 for 700 to 2000-m in the 1980-2015 period. The error is more prominent on a quasi-annual scale (3.36W/m2) but much smaller on inter-annual (0.90 W/m2) and decadal scales (0.15 W/m2). Spatially, very large uncertainties appear in both west boundary currents and Antarctic Circumpolar Current (ACC) systems regions (RMSE >400W/m2). The RMSE decreases from 4.00 W/m2 (1980-2004) to 2.50 W/m2

(2005-2015) due mainly to the build-up of the Argo network. The impact of the two individual OOS components are quantified: removing XBT (Argo) data increases the RMSE in the OHCT estimate from 3.53 W/m2 (2.50 W/m2) to 5.05 W/m2 (4.87 W/m2) over the 1980-2004 (2005-2015) period in the upper 700m (2000m) layer. This study provides a basis for evaluating OOS in monitoring OHC change, for quantifying the uncertainty associated with OHCT estimates, and for improving the OOS in the future.

O-OB-06 Automated determinations of pH and carbonate ion concentrations in seawater

Jian Ma, Xiamen University
Qipei Shangguan, Xiamen University
Peicong Li, Xiamen University
Huilin Shu, Xiamen University
Kunning Lin, Xiamen University
Robert H. Byrne, University of South Florida
Quanlong Li, Xiamen University
Dongxing Yuan, Xiamen University
Presenter Email: shuilinm@sina.com

Ocean acidification, which is manifested by the long-term trend of decreasing pH and carbonate ion concentrations in seawater, has become a research hotspot in the field of ocean science. The changing inorganic carbon system equilibrium caused by this process can be characterized by four parameters, including partial pressure of carbon dioxide (pCO2), pH, dissolved inorganic carbon (DIC) and total alkalinity (TA). Carbonate ion concentrations ([CO32-]) can be calculated from any two of the four parameters. Except for pCO2, samples for other parameters are still collected discretely in most studies, and then analyzed either in shipboard or land-based laboratories. These techniques are labor and cost intensive. Furthermore, sample transferring and storage needs particular considered. Consequently, development of automated instruments for real-time monitoring of seawater carbonate systems will benefit greatly for ocean acidification and ocean carbon cycle research.

Until now, all of the carbonate system parameters can be measured spectrophotometrically with minor modifications. Spectrophotometry has the unique advantage of easiness to be automated. In order to improve instruments' diversity, reliability and cost effectiveness, this work focused on the development and application of automated instruments for determing pH and CO32-in seawater. The main results are summarized below:

(1) An automated instrument for pH measurement based on visible spectrophotometry was described. The instrument consisted of a syringe pump equipped with a multiport valve for liquid delivery, LEDs and charge-coupled device for absorbance measurement. Absorbance values of seawater and indicator (meta-Cresol Purple, mCP) mixture at specific

wavelengths allow direct measuremnt of pH. Laboratory test showed that the instrument has a precision of ~0.001. The instrument was used to on-line monitor pH variations continuously in a coral reef tank. During the 5-day field test, the pH automated measurement instrument operated properly, and the measurement error was -0.015±0.014 (n=38) compared to calculated values with TA-DIC pair.

(2) The automated CO32-measurement instrument was built with similar manifold of pH measurement instrument except ultraviolet detection components. Carbonate ion concentrations can be determined from ultraviolet spectra of Pb(II) and seawater mixture. Laboratory test showed that the instrument has a precision of 1.1% (n=13). During the coral reef tank field test, the measurement error was -2.4±15.7 μmol/kg (n=14). The instrument was tested at sea to perform underway measurements and discrete samples measurement from two vertical profiles. The measurement error in the first stage was -0.5±5.0 μmol/kg (n=31) and 2.1±5.7 μmol/kg (n=22), respectively.

O-OB-05 Automated Spectrophotometric Determination of Total Alkalinity in Surface Seawater along the East Coast of the USA

Qian Li, School of Marine Science and Policy, University of Delaware, Newark, DE 19716, USA
Quanlong Li, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China
Yongming Huang, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China
Qipei Shangguan, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China
Wei-Jun Cai, School of Marine Science and Policy, University of Delaware, Newark, DE 19716, USA
Presenter Email: qianlicn@udel.edu

The automated spectrophotometric total alkalinity (TA) analyzer is a fast, precise, and accurate measurements of underway total alkalinity in surface seawater, which is based on single-point titration and spectrophotometric pH detection. During leg-2 of the East Coast Ocean Acidification Cruise-2 (ECOA-2) in summer 2018, the analyzer was used to obtain a dataset of surface seawater TA in the Mid-Atlantic Bight (MAB) and the South Atlantic Bight (SAB) with high spatio-temporal resolution. The calibration against aged seawater with different TA values shows high accuracy (0.91 ± 3.60 μmol kg-1, n=32) and excellent stability over 11 days (drifted no more than 0.1%). In addition, the underway TA results agree well with the shipboard TA titration on discrete samples (0.96 ± 3.96 μmol kg-1, n=56). The results show that the distribution of surface seawater TA in summer 2018 (high to low from SAB to MAB) was similar to the pattern in summer 2007 (Gulf of Mexico and East Coast Carbon Cruise-1, GOMECC-1), summer 2012 (GOMECC-2) and summer

2015 (ECOA-1). However, the surface seawater TA in SAB in summer 2018 was about 5 - 10 μmol kg-1 higher than the value in summer 2007 and 2012. Here, we proposed that the different hydrological processes and/or other carbonate parameters changes lead to the mentioned difference. More mechanism interpretation will be carried out.

O-OB-07 Development of an integrated Syringe-pump-based Environmental-water Analyzer (iSEA)

Jian Ma, Xiamen University

Presenter Email: jma@xmu.edu.cn

Since the publication of the first flow-based techniques, various types of flow analysis techniques have been developed over the past several decades. Due to its simplicity, robustness and excellent analytical figures of merit, analytical flow techniques present an elegant way to apply wet-chemistry procedures in environmental monitoring applications. Among the unsegmented flow techniques, flow injection analysis (FIA) and sequential injection analysis (SIA) might be the most widely used methods for environmental analysis. However, FIA has the disadvantage of high reagent consumption, laborious optimization via manual manipulation of the manifold and flow rate drift, and both FIA and SIA are based on flow-through detection at non-equilibrium conditions, which result in decreased sensitivity compared to similar manual methods. Flow batch analysis (FBA) was developed in 1999, it combines the characteristics of both flow (continuous) and batch (discrete) systems through the use of programmed multi-commutation. FBA has the favorable advantages of both flow analysis (e.g. low sample and reagent consumption and high sampling rate) and batch analysis (e.g. high sensitivity and wide application range), which is suitable for field analysis. Herein, we describe a new automated system based on FBA, and our system is termed iSEA (integrated Syringe-pump-based Environmental-water Analyzer). The compact and portable system consisted a mini-syringe pump equipped with a selection valve and laboratory-programmed software written by LabVIEW. Based on spectrophotometric detection, the analyzer has been applied in the field determination of nutrients (More details can be found at Ma et al., Anal. Chem., 2018, 90, 6431-6435). When combined with a 2.5 m liquid waveguide capillary cell (LWCC), the iSEA is also a powerful tool for measuring trace analytes such as nanomolar level phosphate and Cr (VI). For the research of ocean acidification, the iSEA has an elegant performance in the measurement of carbonate system parameters (e.g. pH, carbonate ion and total alkalinity) when all components are thermostatted at 25° inside an air bath using a Peltier device and a PID controller. The iSEA has been successfully applied in several occasions: 1) continuous real-time monitoring of ammonium and carbonate ion variations for 14 days and 5 days respectively; 2) high resolution shipboard underway monitoring of macro nutrients and carbonate ion in seawater (including estuarine, coastal and open ocean waters); 3) the detection of Cr (VI) in industrial waste and mineral water. The successful applications in real samples demonstrated the robustness and reliability of iSEA for autonomous environmental monitoring under harsh conditions.

O-E1-01 Bioaccumulation and biomagnification of halogenated organic pollutants in marine biota from the Pearl River Estuary and South China Sea

Bixian Mai, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Presenter Email: nancymai@gig.ac.cn

Marine organisms (fish and invertebrates) were collected from the Pearl River Estuary and South China Sea to investigate bioaccumulation and trophic transfer of halogenated organic pollutants (HOPs). Dichlorodiphenyltrichloroethane and its metabolites (DDTs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), dechlorane Plus (DP), decabromodiphenyl ethane (DBDPE), 2,3,5,6-tetrabromo-p-xylene (pTBX) and pentabromotoluene (PBT) were detected in biota samples. The levels of DDTs, PCBs, and PBDEs showed sharp decreases, with more than 60% drops between 2005 and 2013. No clear temporal trends were found for the other HOPs. The concentration and contaminant pattern exhibited species-specific values in marine organisms. Habitat, feeding habit, and metabolic capability for xenobiotics can contribute to these species differences. The body burden of DDTs, PCBs and PBDEs was negatively correlated with the body length. Biota-sediment accumulation factors (BSAFs) for DDTs, PCBs, PBDEs, DP, DBDPE, pTBX, and PBT were 0.53-2.61, 0.79-10.31, 0.058-8.93, 0.031-0.043, 0.0018, 0.22, and 0.14. All the target compounds exhibited biomagnification, with biomagnification factors (BMFs) greater than 1 in the studied feeding relationships. The BMFs for PCBs increased with Kow at log Kow < 7.7, and subsequently decreased with a further increase of log Kow. However, a negative relationship was found for PBDEs. Food web magnification was found for PCBs, DDTs, PBDEs and DP, with trophic magnification factors (TMFs) of 2.76, 2.61, 2.20 and 2.31, respectively. Marine fish from Yongxing Island accumulated more POPs than those from Natuna Island, attributing to historical usage of POPs in the surrounding countries. Different POPs compositional profiles were found in marine fish from the South China Sea. The contribution of DDTs to POPs was higher than those of PBDEs and PCBs in marine fish from Yongxing Island, while PCBs was dominated in marine fish from Natuna Island. 31% of fish samples had values of (DDD+DDE)/DDTs lower than 0.5, suggested that fresh input of DDT exist in the environment of the South China Sea. Difference for POPs levels in Golden thread was observed among the sampling sites from the South China Sea. Levels of PBDEs and PCBs decreased gradually from eastern to western areas and from northern to southern areas; while no specific distribution for DDTs concentrations were found among the sampling sites. The hazard quotient values were lower than 1 for both PCBs and DDTs, suggested that consumption of marine fish in the South China Sea might not subject residents to significant health risk as far as PCBs and DDTs concerned. Keywords: Halogenated organic pollutants; Marine organisms; Bioaccumulation; South China Sea

O-E1-02 Marine Photosynthetic organisms under influence of ocean acidification

Kunshan Gao, Xiamen Univ
Presenter Email: ksgao@xmu.edu.cn

The oceans are taking up over one million tons of fossil fuel CO2 per hr, and consequently have been acidified by 30% since the industrial revolution, and will be further acidified by 150% (IPCC A1F1 scenario) by the end of this century. Typical chemical changes associated with the ocean acidification (OA) are increased concentrations of pCO2 + and HCO3- and decreased concentration of CO32- and CaCO3 saturation state, with different extents in different regions. When exposed to CO2 concentrations projected for the end of this century, natural phytoplankton assemblages in the upper surface layer of the South China Sea (SCS) responded with decreased photosynthetic carbon fixation and increased non-photochemical quenching (NPQ). The community composition of these experimental phytoplankton assemblages shifted away from diatoms, the dominant phytoplankton group encountered during our field campaigns. Meanwhile, when diatom species were grown at different CO2 concentrations under varying levels (5-100%) of solar radiation, above 22-36% of incident surface solar radiation, corresponding to 26-39 m depths in the SCS, growth rates in the high CO2-grown cells were inversely related to light levels, and exhibited reduced thresholds at which PAR becomes excessive, leading to higher NPQ. That is, elevated CO2 concentrations (lowered pH) impaired the specific growth rate of diatoms at high levels, but enhanced it at low to moderate levels of solar irradiances. These puzzling results are explained as follows: elevated CO2 concentrations down-regulate the uptake capacity (CO2 concentrating mechanisms) of the cells for dissolved inorganic carbon, so that energy, which is used for the active uptake mechanism, is saved and the diatoms growth at low irradiances is augmented; on the other hand, at high levels of solar radiation, the saved light energy could add to enhance photorespiration and photoinhibition, result in reduced growth rate and enhanced NPQ. Additionally, based on the data obtained from micro- and mesocosm experiments, OA increases contents of phenolic compounds in phytoplankton and in zooplankton assemblages fed with OA-grown phytoplankton cells. The observed accumulation of the toxic phenolic compounds in primary and secondary producers can have profound consequences for marine ecosystem and seafood quality, with a possibility that fisheries industries could be influenced due to progressive ocean changes. In terms of combined effects of OA with solar UV irradiances, we found that calcified keleton of calcifying micro- and macro-algae plays a protective role against harmful solar UV radiation. Under OA conditions, these algae calcify less and less under the acidic stress and lowered saturation state of CaCO3. When exposed to solar radiation, OA treatment acted with solar UV radiation synergistically to inhibit rates of calcification and photosynthesis. These results, also supported from shipboard experiments in the South China Sea, imply that calcifying algae suffer from more damages caused by

UVB with progressing ocean acidification.

O-E1-04 Bioaccumulation of Tetrabromobisphenol A and Hexabromocyclododecane in Mangrove Plants from the Pearl River Estuary

Huawei Li, 1 CAS Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China 2 University of Chinese Academy of Sciences, Beijing 100049, China
Weiwei Wang, 1 CAS Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China 2 University of Chinese Academy of Sciences, Beijing 100049, China
Yongxia Hu, 1 CAS Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
Yuxin Sun, 1 CAS Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
Xiangrong Xu, 1 CAS Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
Presenter Email: soledadlee1227@163.com

Tetrabromobisphenol A (TBBPA) and hexabromocyclododecane (HBCD) are two common brominated flame retardants widely used in construction, textile and electronics industries. Due to their characteristics as persistent organic pollutants, TBBPA and HBCD have attracted worldwide attention and have been frequently detected in various environmental matrices. However, field researches on the behavior of TBBPA and HBCD in plants are still limited. In the present study, root, stem and leaf samples of three mangrove plant species (Bruguiera sexangula, Kandelia candel and Avicennia marina) were collected from Futian Mangrove Nature Reserve in Shenzhen city of China to investigate the bioaccumulation and translocation of TBBPA and HBCD in plants. Concentrations of TBBPA and HBCD were in the range of root > leaf, while those in A. marina were of root > leaf > stem. y-HBCD was the major diastereoisomer in the root samples for all the three species, followed by a- and b-HBCD, with mean contributions of 65.6%, 29.2% and 5.2%, respectively. However, a-HBCD dominated in the stem and leaf samples, with average ratios of 68.9% and 56.9%, respectively. The predominance of a-HBCD in aboveground tissues may be a result of diastereoisomer-specific translocation, isomerization and/or metabolization within plants. A preferential enrichment of (-)-a-, (-)-b- and (+)-y-HBCD was found in all tissues of all species, which may be attributed to the enzymes in plants. Soil-root concentration factors (log RCFs) and stem-leaf translocation factors (log TFs) both showed no obvious correlation with log Kow. Root-stem translocation factors (log TFs) and log Kow were

significantly positively correlated ($p < 0.05$) for the HBCD diastereoisomers, indicating that HBCD may be transported from root to aboveground tissues by transpiration stream.

O-E1-05 Fast adaptation of tropical phytoplankton to increased warming

Peng Jin, College of Environmental Science and Engineering, Guangzhou University
Susana Agusti, King Abdullah University of Science and Technology (KAUST), Red Sea Research Center
Presenter Email: pengjin@gzhu.edu.cn

Ocean warming with climate change is forcing marine organisms to shift their distributions polewards and phenology. In warm tropical seas where no organism replacement is expected, evolutionary adaptation by local species to warming will be crucial to avoid predicted desertification and reduction in diversity. However, uncertainties in the capacity for organisms to adapt to warming prevail among scientists and policy makers. Across the global oceanic system, diatomic microalgae are the main primary producers in cold waters; they also contribute to tropical communities where they play a necessary role in the biological pump. Here we show that four species of diatoms isolated from the tropical Red Sea adapted to warming conditions (+ 4oC) by using various thermal strategies. Two of the species shifted their optimal growth temperature (Topt) above the ambient Topt. The other two diatoms shifted their maximum critical thermal limit. Our data show that tropical diatoms can adapt to increased warming, although trade offs from thermal adaptation could alter their competitive fitness. Our findings suggest that adaptive responses to warming among phytoplankton could help to arrest the sharp decline in diversity resulting from climate change that is predicted for tropical waters.

O-E1-06 A novel, highly efficient method for the separation of plastic particles in sediments of aquatic environments

Julian von Borries, Hydro-Bios Apparatebau GmbH, Altenholz, Germany
Hannes Imhof, University of Bayreuth, Animal Ecology I, Bayreuth, Germany
Johannes Schmid, Technical University of Munich, Institute of Hydrochemistry, Munich,Germany
Reinhard Niessner, Technical University of Munich, Institute of Hydrochemistry, Munich,Germany
Natalia Ivleva, Technical University of Munich, Institute of Hydrochemistry, Munich,Germany
Christian Laforsch, University of Bayreuth, Animal Ecology I, Bayreuth, Germany
Presenter Email: j.borries@hydrobios.de

Plastic debris is constantly accumulating in aquatic environments. A first important step to assess the consequences of plastic debris in aquatic ecosystems is the establishment of a reliable, verified, and standardized method to quantify the amount of plastic particles in

the environment.
We improved the density separation approach by the construction of the MicroPlastic Sediment Separator (MPSS). It enables a reliable separation of different ecologically relevant size classes of plastic particles from sediment samples. A high dense separation fluid allows for an extraction of plastic particles ranging from large fragments (L-MPP) to small microplastic particles (S-MPP). Identification and quantification of the particles with spatial resolution down to 1μm can be performed using Raman microspectroscopy.
Our study is the first providing validated recovery rates of 100% for large microplastic particles L-MPP and 95.5% for S-MPP. The recovery rate for S-MPP, using the MPSS, was significantly higher than the value obtained by application of classical density separation setup (39.8%). Moreover, our recovery rates were significantly higher than those based on froth flotation (55.0% for L-MPP) commonly used in recycling industries.
Hence, our improved method can be used for a reliable and time-efficient separation, identification and quantification of plastic fragments down to S-MPP.

O-E1-07 Accumulation of quaternary ammonium compounds as emerging contaminants in sediments collected from the Pearl River Estuary, China and Tokyo Bay, Japan

Xi Dai, State Key Laboratory of Marine Environmental Science, College of Oceanography & Earth Science, Xiamen University, Xiamen, China
Xiaolin Li, State Key Laboratory of Marine Environmental Science, College of Oceanography & Earth Science, Xiamen University, Xiamen, China
Cuicui Wang, State Key Laboratory of Marine Environmental Science, College of Oceanography & Earth Science, Xiamen University, Xiamen, China
James C.W. Lam, Department of Science and Environmental Studies, The Education University of Hong Kong, Hong Kong SAR, China.
Nobuyoshi Yamashita, National Institute of Advanced Industrial Science and Technology, 16-1 Onogawa, Tsukuba, Ibaraki 305-8569, Japan
Eriko Yamazaki, National Institute of Advanced Industrial Science and Technology, 16-1 Onogawa, Tsukuba, Ibaraki 305-8569, Japan
Yuichi Horii, Center for Environmental Science in Saitama, 914 Kamitanadare, Kazo, Saitama 347-0115, Japan
Weifang Chen, State Key Laboratory of Marine Environmental Science, College of Oceanography & Earth Science, Xiamen University, Xiamen, China
Presenter Email: daixi@xmu.edu.cn

Relatively high concentrations of BACs and DADMACs were detected on the surface of two sedimentary cores from China and Japan, suggesting a highly quaternary ammonium compounds (QACs)-polluted status of the two countries. A sediment core was collected from the Pearl River Estuary (PRE) using a standard box corer in November 2013, while a gravity corer equipped with an inner polycarbonate tube was used to sample a sediment core from Tokyo Bay (TB) in 2012. Quantification of QACs was performed by UPLC-MS-MS using an Agilent 1290 UPLC coupled with 6490 triple quadrupole mass spectrometer. Quantification of QACs was based on the response of pure standards of nine target compounds: DADMAC10:10, DADMAC12:12, DADMAC14:14, DADMAC16:16 and DADMAC18:18, and BAC12, BAC14, BAC16 and BAC18. The vertical distribution of in two sediment cores collected from the PRE and TB were investigated to understand the historical input of QACs and their diagenetic behavior in the urban estuarine environments. The vertical distribution of BACs was found to be similar to that of DADMACs in PRE, China. Their levels increased gradually from the 1950s, with two peaks appearing in the early 1960s and 1980s. The down-core variations of BAC and DADMAC concentrations in TB initially increased and then decreased achieving the maximum concentrations in the 1970s. The declining environmental concentrations of QACs suggest a compositional change of commodities and the effectiveness of emission controls. For the individual QAC homologues, BAC homologues dropped significantly over time, while DADMAC compositions were relatively stable. DADMAC18:18 represented an average level of 61% and 87% in PRE and TB, respectively. The high levels of BACs in sediments indicate extensive commercial usage during that period, and that of DADMACs mainly suggest their excellent adsorption efficiency and poor biodegradation. Therefore, the differences of concentration and composition profiles of BACs and DADMACs in sediment cores from the PRE and TB are due to the usage patterns of QACs. These findings are useful to identify sources, transport and differential fate on current and historical contamination in the PRE and TB and to reconstruct the pollution history of QACs in Asia.

O-E1-08 Occurrence and distribution of antibiotic resistance genes in coastal area: from wastewater treatment plants to bay

Donghui Wen, College of Environmental Sciences and Engineering, Peking University
Aolin Li, School of Environment, Tsinghua University
Zhiguo Su, College of Environmental Sciences and Engineering, Peking University
Jiayu Chen, College of Life and Environmental Sciences, Shanghai Normal University
Lujun Chen, School of Environment, Tsinghua University
Presenter Email: dhwen@pku.edu.cn

The abuse of antibiotics in human society promotes frequent occurrence and wide dispersion of antibiotic resistance genes (ARGs) in environment. In recent years, the environmental pollution of ARGs has aroused deep concerns, and wastewater treatment plants (WWTPs) are regarded as one of the most important sources. Nevertheless, few study tracks ARGs from WWTPs, through their effluent disposal area, to the natural waterbody. In this study, in the coastal area of Zhejiang Province we investigated the occurrence and distribution of a series of ARGs, class I integrase gene (intI1), and 16S rRNA in 1 pharmaceutical WWTP and 3 municipal WWTPs, 2 effluent disposal areas, and Hangzhou Bay. The concentrations of total ARGs in the influents of 4 WWTPs were at the level of 107~108 copies·mL-1. Among the 14 detected ARGs, sulII and ermB were the most abundant. Although the municipal WWTPs partly removed ARGs in the sewage, the total ARGs in all the effluents were still abundant. The correlation analysis showed that the concentration of ARGs in sewage were well correlated with 16S rRNA, intI1, and total phosphorus (TP). WWTP effluents contributed greatly to the ARGs pollution in the 2 effluent disposal areas, where the ARGs concentrations were much higher than those in the bay area. The correlation analysis showed that the concentrations of ARGs in Hangzhou bay were well correlated with intI1 and water indexes of NH3-N, NO2-N, TP, and COD. As Hangzhou Bay is one of the most seriously polluted bays in China, our study indicates the linkage between conventional pollutants and the emerging pollutants of ARGs.

O-E1-09 Conventional pollution factors and antibiotic resistance genes co-driven status of microbial community structures and their predicted functions in coastal sediments.

Zhiguo Su, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Jiayu Chen, College of Life and Environmental Sciences, Shanghai Normal University, Shanghai 200234, China
Yuhan Zheng, School of Water Resources and Environment, China University of Geosciences, Beijing 100083, China
Tianjiao Dai, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Bei Huang, Zhejiang Provincial Zhoushan Marine Ecological Environmental Monitoring Station, Zhoushan 316021, China
Qinglin Wen, Zhejiang Provincial Zhoushan Marine Ecological Environmental Monitoring Station, Zhoushan 316021, China
Donghui Wen, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Presenter Email: 15165123073@163.com

Abstract: In coastal sediments, microbial community structures and functions under human-induced disturbances are evidently affected by different pollution factors, especially the antibiotic resistance genes (ARGs), which are acquired by special pathogenic genera via horizontal gene transfer originated in environmental microbiome. In this study, we analyzed samples properties and 12 ARG subtypes (including class 1 integrase gene, intI 1) in Zhejiang coastal area, and explored the microbial ecology of sediments by using high-throughtput 16S rRNA sequencing, PICRUSt software, FAPTOTAX software, and multivariate statistical methods. The surface sediments were collected from 20 sites, covering the Hangzhou Bay (HZB), Taizhou Bay (TZB), and Xiangshan Bay (XSB) of the coastal area. The results showed Proteobacteria was widespread in all the three bays and overwhelming in TZB. Firmicutes distributed most abundantly in XSB, which indicated the impacts of anthropogenic activities. Predicted by PICRUSt analysis, HZB was significantly lower than TZB and XSB in the subcategory of Xenobiotics Biodegradation and Metabolism; and XSB more enriched all the stress response functions related to Diseases, Immune, and Repair. In addition to the strong influence of conventional pollution factors, salinity, ARGs, and intI 1 were also key factors to the change of microbial community structures. Co-occurrence network analysis implied that oil was important for nitrogen cycle related functional groups. Then sulfonamide resistance genes, tetracycline resistance genes and intI 1 drove significantly the composition of human pathogens and human disease related function. The disclosure of above complex impacts provides a new insight into the evolution rules of microbial community in coastal area. Keywords: microbial community structures; predicted functions; antibiotic resistance genes (ARGs); PICRUSt; FAPTOTAX; coastal sediments. Acknowledgements: The study was funded by the National Natural Science Foundation of China (No. 51678003 and 51678334).

O-E1-10 Antibiotics in the Coastal Environment of the East China Sea: Levels, Distribution and Impact Factors

Feifei Li, 1 School of Water Resources and Environment, China University of Geosciences, Beijing 100083 China; 2 School of Environment, TsingHua University, Beijing 100084, China;

Donghui Wen, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China;

Chuanping Feng, School of Water Resources and Environment, China University of Geosciences, Beijing 100083 China;

Lujun Chen, 1.School of Environment, TsingHua University, Beijing 100084, China; 2.Zhejiang Provincial Key Laboratory of Water Science and Technology, Zhejiang 314006, China;

Bei Huang, Zhejiang Provincial Zhoushan Marine Ecological Environmental Monitoring Station, Zhoushan 316021, China

Qinglin Mu, Zhejiang Provincial Zhoushan Marine Ecological Environmental Monitoring Station, Zhoushan 316021, China

Presenter Email: feifeili0901@163.com

The levels and distribution of 28 antibiotics from 3 categories in the coastal area of the East China Sea were investigated using solid-phase extraction coupled with ultra-performance liquid chromatography tandem mass spectrometry (UPLC-MS/MS). The seawater and surface sediment samples were collected from 20 sites, covering the Hangzhou Bay (HZB), Xiangshan Bay (XSB) and Taizhou Bay (TZB). The results showed that 17 antibiotics, including 10 sulfonamides (SAs), 5 macrolides (MLs), and 2 Lincomycins (LMs), were frequently detected in both seawater and sediment samples. The total concentration of these 17 widely presented antibiotics in the coastal areas ranged in 5.17 – 2173.04 ng/L in the seawater, and specifically the concentrations of SAs, MLs, and LMs ranged in 3.76 - 607.72 ng/L, 0.19 - 4.97 ng/L and 1.76 - 1563.13 ng/L, contributing 32.31%, 0.50%, and 67.19% to the total antibiotics burden, respectively. Sulfamonomethoxine, sulfaquinoxaline, clindamycin hydrochloride and lincomycin hydrochloride were the main antibiotic species in the seawater, which contributed 12.79%, 9.14%, 58.90% and 8.30% to the total antibiotic burden, respectively. The total concentrations of the presented antibiotics ranged in 11.42 - 108.78 ng/L, 5.71 - 32.59 ng/L, and 36.98 - 2173.04 ng/L in HZB, XSB and TZB, respectively. In addition, the main antibiotic category was SAs contributing 89.30% and 62.04% to the total antibiotic burden in HZB and XSB, respectively. However, LMs was the main antibiotic category contributing 74.52% to the total antibiotic burden in TZB. In sediment samples, the concentrations of MLs and LMs ranged in 0.08 - 1.32 ng/g and ND - 2.93 ng/g. Moreover, the relevance relationship between antibiotics and water quality and sediment properties was explored. The results showed that antibiotic concentration in seawater was significantly negatively correlated ($p<0.05$) with salinity, DO and pH, but positively correlated ($p<0.05$) with SS, PO43+, COD, NO3-, petroleum and As, and has no correlation with NO2-, Hg, Cu, Pb and Cd. Meanwhile, antibiotic concentration in sediments had the same relevance relationship with sediment properties as them in the seawater.

O-E1-11 METHYLMERCURY CYCLING IN THE BOHAI SEA, YELLOW SEA AND EAST CHINA SEA, CHINA: SOURCES/SINKS AND CONTROLLING FACTORS

Yanbin Li, Ocean University of China, QINGDAO, China
Lufeng Chen, Ocean University of China, QINGDAO, China
Chang Liu, Ocean University of China, QINGDAO, China
Presenter Email: liyanbin@ouc.edu.cn

Chinese marginal seas, important regions of the western Pacific Ocean, have been facing a variety of environmental problems, including mercury (Hg) pollution. Although methylmercury (MeHg) has been recognized as the most toxic Hg species in the environment, there is still a lack of knowledge on its cycling in Chinese marginal seas, limiting a sound understanding of Hg cycling in these important regions. To address these needs, we investigated the distribution and methylation/demethylation of Hg in the Yellow

Sea (YS), Bohai Sea (BS), and East China Sea (ECS). A decreasing trend from inshore to offshore was observed for total Hg (THg), suggesting the importance of terrestrial discharge; however, the distribution of MeHg was found to be complicated, with several "hot spots" located in both inshore and offshore areas, indicating the importance of in situ production and degradation processes. Methylation in the sediment and demethylation (both photo-mediated and biotic) in the water column were identified as the two most important processes controlling MeHg levels, while SO42-, THg, and dissolved organic matter were found to be the most influential environmental factors. By quantifying the in situ production/degradation, along with river input and exchange with nearby seas, sediment was found to be the most important source of MeHg; meanwhile, the water serves as the largest sink in the three investigated regions. In comparison with other marine systems, a relatively low ecosystem conversion efficiency of inorganic Hg to MeHg, i.e., low MeHg/THg ratios in the water, was observed in these Chinese coastal systems. This may result from the low efficiency of transporting THg from water to the sediment, slow Hg methylation in the sediment, and quick MeHg degradation in the water. The low conversion efficiency of inorganic Hg to MeHg may be one of the convincible reasons for the low Hg levels detected in marine organisms from China, in comparison to the high THg concentrations in the water.

O-E1-12 A biotic ligand model for simultaneously modeling the bioaccumulation and toxicity of Cd-Zn mixtures in the clam *Potamocorbula laevis*

Qiao-Guo Tan, College of the Environment & Ecology, Xiamen University
Shun-Hua Lu, College of the Environment & Ecology, Xiamen University
Presenter Email: tanqg@xmu.edu.cn

Metal contaminants usually occur as a mixture in aquatic environments. However, it is still a challenge to assess the ecological risks of metal mixtures. The biotic ligand model (BLM) is a useful tool for predicting the bioavailability of metals. It can be used for simulating the effects of water chemistry on either metal bioaccumulation or metal toxicity, although usually separately in different studies. Therefore, even for the same combination of metal and organism, two different sets of BLM parameters would be generated, sharing the same symbols (e.g., KCuBL, KCaBL) but having different values. It has not been tested whether it is possible to obtain universal parameter values for both scenarios. Moreover, there are ongoing efforts to extend BLM for simulating the bioaccumulation and toxicity of metal mixtures, which raise the same question again. In this study, we tested the feasibility of using a single set of BLM parameters to explain both the bioaccumulation and toxicity of mixtures of cadmium (Cd) and zinc (Zn) in an estuarine clam *Potamocorbula laevis*. The assumptions of our mixture BLM include: (1) Cd2+ and Zn2+ are internalized through the same biotic ligands (i.e., transport sites); (2) Cd2+ and Zn2+ compete with each other during internalization; (3) Internalized Cd and Zn exert toxicity independently. Metal bioaccumulation were quantified using a stable isotope tracer technique; toxicity tests of

the Cd-Zn mixtures were conducted in parallel. We found significant interactions between Cd and Zn in both the bioaccumulation experiments and the toxicity tests, consistent with the prediction of BLM. Analyzing the data under the framework of a toxicokinetic-toxicodynamic model using BLM as the toxicokinetic module, we obtained a set of parameter values that could well explain all of the bioaccumulation and toxicity data. The model can be further used to separately quantify the contribution of Cd and Zn to the overall toxicity of the mixture. Through this work, we demonstrated that a unified BLM could be developed to model the interaction between metals in their mixtures.

O-E1-13 Biokinetic modeling of Cd bioaccumulation from water, diet and sediment ina marine benthic goby: a triple stable isotope tracing technique

Zhiqiang Guo, Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences,Guangzhou 510301, China
Hengzhen Ye, State Key Laboratory of Marine Resource Utilization in South China Sea, College of Marine Science, Hainan University, Haikou 570228, China
Juan Xiao, College of Food Science and Technology, Hainan University, Haikou 570228, China.
ChristerHogstrand, Metals Metabolism Group, School of Life Course Sciences, King's College London, 150 Stamford Street, London SE1 9NH, UK
Li Zhang, Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences,Guangzhou 510301, China
Presenter Email: GUOZQ@SCSIO.AC.CN

Aquatic animals are often simultaneously exposed to metals through multiple routes in the natural environment. This study explored a triple stable isotope tracing method to quantify simultaneous cadmium(Cd) uptake biokinetics by yellowstripe gobyfromwater (traced by 110Cd), sediment (traced by 111Cd), and diet (traced by 113Cd) when the fish were exposed to Cd for 24 h. The simultaneous uptake of Cd from multiple routes during 4 weeks was then predictedby the modified biokinetic model. The results demonstrated that the uptake rate constant of waterborne 110Cd, sediment-associated 111Cd, and dietary 113Cdwas 3.1 L kg-1 d-1, 2.2x10-4g g-1 d-1 and 3.3x10-3 g g-1 d-1 in the fish. Sedimentary Cd was less bioavailable than the waterborne and dietary Cd, however, sediment could become the predominant Cd source of the total Cd bioaccumulation when the partition coefficient of Cd between sediment and seawater (Kd) is larger than 6x104 L kg-1. The simultaneous uptake of Cd from the three routes could be successfully predicted by the modified model. The model revealed that the Cd bioaccumulation generally increased with the increase of ambient Cd concentration inall the three routes.Overall, our findingsdemonstrated thatthe multiple stable isotopes tracingmethod and the modified biokinetic model have a wide generality and applicability for predicting Cd bioaccumulation under multiple routes of metal exposure scenario and may have application to other

metals.

O-E1-14 Biomagnification Potential of Arsenic in Marine Food Chains

Li Zhang, Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Sen Du, Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: zhangli@scsio.ac.cn

Arsenic (As) is one of the most hazardous environmental pollutants and widely exists in the coastal area. Marine organisms usually accumulate high level of arsenic which is mainly as organic species with low toxicity. Arsenic could be biomagnified along some marine food chains/webs, e.g. seagrass and mangrove ecosystems, resulting in the high bioaccumulation in higher trophic levels and potential harm to the organisms; in contrast, arsenic is commonly biodiminished in freshwater food chains/webs. Marine fish and shellfish could biotransform inorganic arsenic into arsenobetaine (AsB). Organic arsenic had higher trophic transfer ability than inorganic species which may cause fish accumulate more arsenic. Arsenic biomagnification is most probably related to the high content of organic arsenic species in marine organisms. The future research should pay more attention to the biomagnification potential of different arsenic speciation and identify by indoor experiments. It will be helpful for our better understanding of the ecotoxicology and biogeochemistry of arsenic, the assessment of the ecological risks of arsenic, and the safeguard of the marine ecological safety.

O-ED-01 Knowledge management across the environment-policy interface in China: what knowledge is exchanged, why, and how is this undertaken?

Ying Zheng, School of Geographical & Earth Sciences, University of Glasgow, UK
Larissa A. Naylor, School of Geographical and Earth Sciences, University of Glasgow, UK
Susan Waldron, School of Geographical and Earth Sciences, University of Glasgow, UK
David M. Oliver, Faculty of Natural Sciences, University of Stirling, UK
Presenter Email: Ying.Zheng@glasgow.ac.uk

Global to local environmental policy-making is increasingly evidenced-based. Knowledge exchange (KE) is increasingly used by environmental scientists and policymakers, to deliver evidence-based policy and practice. There is thus an urgent need to identify whether and how knowledge is exchanged between knowledge producers and users in environmental science fields. Frameworks to evaluate KE practice are emerging. Here we apply an assessment framework developed in social medicine to identify what forms of environmental knowledge are exchanged, and why and how they are exchanged. We focussed on China as international research to better manage Chinese ecosystem services is rapidly increasing, yet, how to best integrate this into political decision-making and the

public realm remains a challenge. How KE is practiced in China is unknown. We addressed this through: 1) a systematic analysis of published KE research in China compared to global trends; 2) evaluating KE for environmental policy and management in China; 3) quantitative surveys of Chinese (n = 72) and British (n = 16) scientists researching Chinese environmental problems. China's contribution to the global KE database was low (6-7%) across all disciplines. The systematic review of two databases identified two key findings. One, there were no papers in the environmental sector examining the science-policy-practice interface in China out of 291 potentially relevant papers. Two, only 13 of 423 potentially relevant KE paper explicitly examined KE for environmental topics, notably for agriculture and information exchange (i.e. What). Most papers reported a one-way interaction between scientists and users (i.e. How), used to change practice (i.e. Why). Our quantitative survey showed significantly less awareness and use of KE methods (i.e. How) by Chinese scientists. The paucity of documented KE research and limited evidence for two-way interaction show KE at the environmental science-policy-practice interface in China is limited. Promotion of KE practice may benefit environmental decision-making in China. More broadly, our study shows how KE frameworks from social medicine are effective in understanding KE practice at the environmental science-policy-practice interface.

O-ED-02 Scientists and educators cooperation: using mobile microscope observes plankton to initiate ocean stewardship

Chia-Dai (Ray) Yen, Assistant Professor, Graduate Institute of Education, National Taiwan Ocean University

Li-Shu Chen, Leader of Exhibition and Education Division, National Museum of Marine Science and Technology

Presenter Email: hamrater@msn.com

Marine microbes play a very important part in the ecosystem. They are the primary productivities, the first level consumers, create the most energy to cultivate most marine biology, and absorb most carbon dioxide in the air. Marine microbes also have a huge influence on the environment and the economic from the food web system. However, most of the marine microbes size are small than 1 mm and hard to observe directly by eyes. Furthermore, the general marine education courses (includes formal and informal education) lack of marine popular science topics talk about planktons. It cases most of students know few about marine microbes. In 2010, NMEA (2010) first published Ocean Literacy framework. UNESCO also declared ocean literacy as the core of marine education promotion in 2017. Especially, the fifth principle of ocean literacy about primary productivities is a very important concept. Based on the experiential learning theory, this research took students to uses mobile microscope to observe microbes in intertidal zone, and leading students to identify the importance of phytoplankton and zooplankton in the food web system. Through the instruction of marine educators educate the participants

understand the concept of primary productivity. There were 180 students from 6 schools joined the microscopic ocean activities in Keelung Chaojing park. The result shows the significantly influence from the engagement of the microscope observation to ocean stewardship. The education project integrates marine scientist and filed educators to promote marine education, and could be a benchmark of marine education discipline.

O-ED-03 Rebranding nuisance: using education and outreach to promote understanding, interest and participation in citizen science about jellyfish in Israel

Philip Nemoy, Department of Maritime Civilizations Leon Charney School of Marine Sciences University of Haifa, Israel
Dori Edelist, Department of Maritime Civilizations Leon Charney School of Marine Sciences University of Haifa, Israel
Dror Angel, Department of Maritime Civilizations Leon Charney School of Marine Sciences University of Haifa, Israel
Presenter Email: philip.nemoy@gmail.com

Jellyfish are generally perceived as a nuisance by beachgoers, fishermen and other marine stakeholders. In Israel, the recurrent blooms of the stinging scyphomedusa Rhopilema nomadica have caused a particularly bad public perception of all gelatinous marine organisms (jellyfish). Our work is aimed at countering the public fear of jellyfish, which is largely caused by ignorance, with educational tools which promote interest and understanding. We use programs for schoolchildren, an internet website and dedicated social networking to engage the public in monitoring, awareness and research of jellyfish along the Mediterranean coast of Israel. Main outcomes: (1) The dedicated website, www.meduzot.co.il, fed by public jellyfish reports, provides citizens and beach-goers with information on the presence of jellyfish on Israeli beaches. (2) Through the website and social networking, we may document swarms and draw time series for several jellyfish species, thereby improving our understanding of the ecology of these groups. (3) The jellyfish citizen science activities contribute to the collective scientific knowledge, creating a community where citizens learn online about jellyfish and answer each other's questions. (4) Schoolchildren, ages 8 - 11 with little or no marine literacy, took part in this project, learning about the role of jellyfish in the marine ecosystem, reporting on the presence of jellyfish in the sea and educating their families and friends about jellyfish. Conclusions and directions for the future: During recent years, our research and outreach activities have encouraged a shift in public perception toward jellyfish in Israel: from a nuisance to enigmatic and important groups of marine animals. We promote the concept that jellyfish are a key group in the marine ecosystem, and that it pays to recognize their roles, appreciate their contribution and take advantage of jellyfish as valuable marine resources.

O-ED-04 The Contribution of marine geology to the Ocean Literacy Process

Francesca Alvisi, ISMAR-CNR
Presenter Email: francesca.alvisi@bo.ismar.cnr.it

Shape and dimensions are among the most important features of marine basins since they determine their peculiar oceanographic as well as biogeochemical and in the end ecological characteristics. Since geological processes are responsible for such features, it is crucial to introduce basic principles since the beginning in the Ocean Literacy process. Some examples of best practices developed at the Italian Institute of Marine Science in the framework of different educational projects will be shown and discussed. They are mainly focused on the visualization of concepts and context by means of 3D reconstructions, games, quizzes and interactive lectures.

O-ED-05 Ocean outreach & socail media: From lab to public

Wencui Zeng, Xiamen University
Presenter Email: 410106141@qq.com

With the rapid development of marine science in China, how to effectively conduct outreach became one of the new and interesting aspects. Social media outreach is the process of using social networks to raise awareness for the content and build new relationships. It has been successfully applied in other areas, but few on ocean outreach in China recently. The shellfish research team in Xiamen University has cooperated with the Social media Giant "Weibo" to do the sustainability seafood outreach through a new brand Awesome Abalone since July 2018. By the articles and videos, we transform obscure laboratory knowledge into vivid and interesting popular science content, which is successfully accepted by the public. Through this activity, we believe that the social media could be one of the most important ocean outreach in future.

O-ED-06 Cool Science: Children educating adults through their art on buses

Robert F. Chen, School for the Environment, University of Massachusetts Boston
Jill Lohmeier, University of Massachusetts Lowell
Presenter Email: bob.chen@umb.edu

Cool Science is an outreach program that integrates science and art to promote children's learning about climate change, the products of which are then displayed on buses to promote adult learning. Cool Science revolves around a children's art contest that has been running for six-years and consistently yields positive learning outcomes in informal learning environments for both adults and children. Additionally, it was identified by the White House in 2015 as an exemplary community climate literacy program. To enter the contest, K-12 students create posters (18 x 56 cm) in response to contest organizer questions such as: What evidence can you find for climate change in your community? How are animals in Xiamen being affected by climate change? What inventions are people making to reduce the impacts of climate change? Children are engaged by these questions and possibly supported by their teachers or parents to conduct research to address these questions. 500-1000 student entrees are submitted each year. Artwork is judged for its scientific accuracy, its originality, the clear communication of her/his message, and its overall artistic composition. An annual Cool Science Award Ceremony for winners, runners up, and honorable mentions in elementary, middle school, and high school categories celebrates student learning and artistic expression with their friends, family, teachers, and scientists. The winning artwork is displayed for 1-6 months on the inside and outside (76 x 224 cm) of local buses. Adults (5000/day) view the posters on buses making approximately 1,000,000 impressions per year. Cool Science acts to increase climate literacy in children as well as the public, and as such promotes intergenerational learning. Using art in conjunction with science learning appears to be effective at engaging not just traditionally high achieving science students, but also those interested in the creative arts. Hearing winners' stories about how they created their artwork and what this contest meant to them supports the idea that Cool Science attracts a wide diversity of students. Parents discuss climate change with their children. Multiple press releases announcing the winners further promotes the awareness of climate change throughout school districts and their communities. Pre- and post-surveys of bus riders suggest that public viewers of winning artwork increase their awareness that climate change is happening, that climate change is human caused, and that they want to learn more. Using student artwork appears to be an effective way to communicate climate change issues to public audiences.

O-ED-07 Graphical abstracts: How to master the latest trend in publishing

Tullio Rossi, Animate Your Science

Presenter Email: tullio@animateyour.science

Most of us have been there. You spend months writing and revising your manuscript to perfection. You feel proud of it and you are certain that your target journal is going to welcome it on a red carpet. However, something unexpected happens. You cannot reach the end of the manuscript submission process because you don't have a graphical abstract? What on earth is this thing preventing me from submitting my amazing manuscript! Certainly, a useless waste of time! Calm down. Graphical abstracts have a place and a purpose in the publishing process. More and more journals are adopting them for a reason. In this talk, Dr. Tullio Rossi, Founder of Animate Your Science will explain what the purpose of graphical abstracts is, what they should look like and how you can easily create one.

XMAS-IV POSTER ABSTRACTS

P-P1-01-S Similarity and Difference in Interannual Sea-Level Variations Between the New York and Nova Scotia Coasts

Nan Chen, Xiamen University
Presenter Email: chennan@udel.edu
Previous studies have identified coherent interannual sea level variations (SLVs) along the coasts from New York to Nova Scotia and speculated possible large-scale forcing factors such as variations in the Gulf Stream strength and the alongshore winds. Here we combine in-situ measurements, satellite observations, as well as ocean and atmospheric reanalysis data to examine interannual SLVs on the New York coast and the Nova Scotia coast from 1993-2012 and to provide quantitative analyses of factors contributing to the interannual SLVs. The present study shows not only spatial correlation of the interannual SLVs under the two regimes during the study period, but also similarity and difference in their contributing factors. The interannual SLVs along both the Nova Scotia coast and the New York coast are mainly (50\% and 38\% respectively) contributed by the steric effect associated with the temperature and salinity changes, followed to a lesser degree (36\% and 29\% respectively) by the inverse barometer effect. However, the impact of the Gulf Stream strength is significant at the New York coast only; while the influence of the alongshore winds is significant at the Scotia coast only.

P-P1-02-S Dynamic and geomorphic process in a transition zone of salt marsh and mudflat

Dezhi Chen, School of Geography and Ocean Science, Nanjing, University,Nanjing
Wang Ya Ping, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Presenter Email: 479398086@qq.com The sediment transport process and mechanism in a transition zone of salt marsh and mudflat was discussed through the observation of sedimentary dynamic process. Combined the data of multiple tidal cycles with the analysis of the vegetation cover, the influence of the vegetation on the dynamic and sedimentary processes of the tidal flat is studied. The results of the preliminary analysis show that: (1)Plants in salt marsh can reduce the tidal current velocity by 20%-60% and absorb most of the wave energy. (2) The SSC was related with the wave height, when the wave height is higher, the SSC in mudflat is higher than the salt marsh site, and the average SSC is higher, but when the wave height is relatively low, it showed an opposite situation. (3)The sediments in the mudflat is much coarser compared with the salt marsh, it is difficult to form and preserve various physical sedimentary structures in the mudflat.

P-P1-03-S Riverine sediment transport from different outlets in the Pearl River Estuary

Guang Zhang, School of Marine Science, Sun Yat-sen University, Guangzhou, China, 510275
Weicong Cheng,
Heng Zhang,
Wenping Gong,
Presenter Email: zhangg28@mail2.sysu.edu.cn

Riverine sediment is important for the development of river delta as well as for carrying nutriment and contaminants into estuaries and coasts. Previous studies of sediment transport focused on single-source estuary and paid less attention to the multi-sources estuary. In this paper, we used the COAWST (Coupled Ocean Atmosphere Wave Sediment Transport) model to study the sediment transport in the Pearl River Estuary where there are four main outlets. During the flood season, most riverine sediment is transported downstream in spring tides and entrapped in the estuary during neap tides, and the distribution of different outlet sediment is quite independent. In upper estuary, sediment is transported by advection depending on river discharge, and in lower estuary, sediment flux is related to tide and runoff. During the dry season, riverine sediment is resuspended by currents and waves and then transported downstream in the lower estuary and upstream in the upper estuary. Tidal pumping is more important than advection, and the distribution of different outlet sediment has more overlapping area due to enhanced mixing. Changes in wind and river discharge are the main reasons for the alteration of sediment transport pathways into the sea. This study helps to better understand sediment transport in multi-sources estuary and has distinct implications for coastal environmental management.

P-P1-04-S Investigation into the spatial and temporal tide-river dynamics and the underlying controlled factors in the Yangtze estuary

Huang Jingzheng, Institute of Estuarine and Coastal Research, School of Marine Sciences ,Sun Yat-sen University
Cai Huayang, Institute of Estuarine and Coastal Research, School of Marine Sciences ,Sun Yat-sen University
Wu Zheng, College of Water Conservancy and Hydropower Engineering, Hohai University
Presenter Email: 956884377@qq.com

Abstract: As tidal waves propagate into the estuary, they are featured by significant longitudinal variation in seasonal scale due to the nonlinear interactions between tide and river discharge. In this study, the variations of tide-river dynamics in terms of tidal damping rate, wave celerity and residual water level slope were explored based on long-term time series of tidal water levels from 2002 to 2014 along the Yangtze estuary

(including the Tianshenggang, Jiangyin, Zhenjiang, Nanjing, Maanshan and Wuhu stations) in together with the monthly averaged river discharge observed at Datong hydrological stations. Subsequently, the underlying controlled factors that influence the tidal wave propagation were discussed. It was shown that the seasonal difference in tide-river dynamics was gradually reduced in the seaward direction. We identified a transitional zone located between the Tianshenggang and Jiangyin stations, where the seasonal differences in tidal range are +0.01 m and -0.04 m, respectively. Generally, upstream from Jiangyin station the dynamics character was river-dominated, while in the lower reaches it was mainly controlled by the tidal forcing. In addition, we show that there exists a threshold in river discharge in the upper reaches of the Yangtze estuary due to the increase of residual water level and hence water depth caused by the residual water level slope. This phenomenon was particularly true in the upstream reach between Maanshan to Wuhu, where the threshold of river discharge was approximately 33000 m3s-1. The results obtained from this study can enhance our understanding of tide-river interaction, and will, hopefully, provide guidelines for water resources management in the Yangtze estuary.

P-P1-05-S Variations in water and sediment discharge in rivers along the east coast of the Liaodong Peninsula over the last millennium

Hui Sheng, State Key Laboratory of estuarine and coastal research,East China Normal University
Jianhua Gao, Key Laboratory of coastal and island development, Nanjing University
Yaping Wang, State Key Laboratory of estuarine and coastal research,East China Normal University
Presenter Email: ShenghuiNJU@163.com

Under the increasing impact of rising sea levels, ground surface subsidence and anthropogenic sediment trapping the coastal wetland, large delta and coastal zone are drowning, living 60% of the world's population. The sediment delivered by the global river systems paly the key roles to prevent the situation. In order to identify the forcing factor and quantify isolated the impact of climate change and human activities on water and sediment to coastal ocean, the hydrologic data of five rivers along the east coast of the Liaodong Peninsula and Hydrotrend V.3.0 were applied. Simulation results indicate that the water discharge and sediment load of the five rivers during the past millennium reached 27.88 km3 yr-1 and 5.97 Mty-1, and Climate change was the most significant forcing factor altering the water discharge in the study area, with human activity having an insignificant effect on the accumulation of freshwater discharge. However, the variations in the sediment load were dominated by human activity. Quantify isolation demonstrated that the soil erosion of the five rivers induced by human activity amounted to 1.04 Mty-1 in the past millennium, and the total trap efficiency of the eastern Liaodong Peninsula was 71.7%. If no dams were constructed in the study area during 1941-2012, the total

sediment load of the five rivers would have reached 11.33 Mty-1. This reflects an increase of 92.6% relative to 1000-1850 (5.88 Mty-1) and was 3.5 times the actual sediment load during 1941-2012 (3.21 Mty-1). Consequently, when we investigated the geomorphic evolution, the sedimentary and ecosystem of estuaries and coastal zones, the long-term water and sediment discharge must be considered not just the measured data. The sediment load of five rivers (middle to high latitudes) is dominated by human activities, unlike the tropical zone dominated by combined of climate (tropical-cyclone) and human activities (Dams). Identify the rapid changing of sediment change in short period impact on the coastal system is a new challenge.

P-P1-06 Assimilating remote sensing and in situ observations into a coastal ocean model using ensemble optimal interpolation

Wenfeng Lai, Hong Kong University of Science and Technology
Ye Liu, Swedish Meteorological and Hydrological Institute
Jianping Gan, Hong Kong University of Science and Technology
Zhiqiang Liu, Hong Kong University of Science and Technology
Jiang Zhu, The Institute of Atmospheric Physics,Chinese Academy of Sciences
Presenter Email: laiwf@ust.hk

To improve the forecasting performance of the water around Hong Kong, a multivariable data assimilation (DA) system using the ensemble optimal interpolation (EnOI) method has been developed and adopted for a high-resolution estuary-shelf ocean model around Hong Kong. A data assimilation experiment was conducted by using the ROMS model during the cruise in July, 2015. The assimilated data include high-resolution sea surface temperature from the Operational SST and Sea Ice Analysis (OSTIA) and in-situ conductive-temperature-depth (CTD) observations. Based on analysis of spatiotemporal correlation among ocean parameters, optimal assimilation scheme was identified. By assimilating SST and in situ CTD hydrographic profiles, the root mean square errors (RMSEs) between the DA forecasts and observations for temperature and salinity have been reduced by 23.5% and 14.0% in the experiment period, respectively. We found that by adjusting localization radius according to a weight function of observations, by considering the intra-tidal variation of the observed data and by increasing observation samples and model states for error covariance, it improved significantly the DA skill and reduced the model error.

P-P1-07-S Differentiating the effects of advection and resuspension on suspended sediment concentrations in a turbid estuary

Yuan Li, Ministry of Education Key Laboratory for Coast and Island Development, Nanjing University
Jianjun Jia, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Qingguang Zhu, Department of Environmental Sciences, University of Virginia
Peng Cheng, State Key Laboratory of Marine Environment Science, College of Ocean and Earth Sciences, Xiamen University
Shu Gao, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Ya Ping Wang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Presenter Email: yuanlee@smail.nju.edu.cn

Suspended sediment concentration (SSC) has a significant impact on the estuarine environment and its morphological evolution. At any given location, variability in depth-averaged SSC is controlled by a combination of two processes: horizontal advection and local resuspension. In this study, we investigate the sediment dynamics at three anchored monitoring stations close to the maximum turbidity zone of the Changjiang Estuary, and developed a box model to differentiate the effects of advection and resuspension. Further, settling velocities were estimated using the ADV Reynolds flux method. We found that predicted changes in advection- and resuspension-induced SSCs were consistent with the bed shear stress and erosion/accretion observations. The combination of observed bed erosion/accretion changes and the predicted advection-induced SSCs indicates that the advective transport of suspended sediment is an important process in accelerating persistent erosion at the observation stations. Although SSC variations due to advection and resuspension are of similar magnitudes, our model results indicate that if resuspension dominates, then the resuspension-induced component can reach up to twice the magnitude of the advection-induced component. We conclude that the box model is a valuable tool for evaluating subaqueous delta erosion/accretion in response to sediment reduction caused by upstream dam construction and climate change in recent decades.

P-P1-08-S Intraseasonal and interannual variabilities of saltwater intrusion during dry seasons and the associated driving forcings in a partially mixed estuary

Zhongyuan Lin, a-School of Marine Science, SunYat-sen University, Guangzhou, China, 510275 b-Guangdong Provincial Key Laboratory of Marine Resources and Coastal Engineering, Guangzhou, China, 510275
Heng Zhang, a-School of Marine Science, SunYat-sen University, Guangzhou, China,

510275 b-Guangdong Provincial Key Laboratory of Marine Resources and Coastal Engineering, Guangzhou, China, 510275 c-Guangdong Provincial Key Laboratory for Climate Change and Natural Disaster Studies, Sun Yat-sen University, Guangzhou, China, 510275
Hongyang Lin, d-State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China, 361102
Wenping Gong*, a-School of Marine Science, SunYat-sen University, Guangzhou, China, 510275 b-Guangdong Provincial Key Laboratory of Marine Resources and Coastal Engineering, Guangzhou, China, 510275
Presenter Email: lzy900414@126.com
Saltwater intrusion is a major environmental problem in many estuaries worldwide, including Modaomen Estuary in China's Pearl River Delta. It varies in multiple time-scales and is regulated by many external forcings. Here we focus on its intraseasonal and interannual variabilities in dry seasons and their relationships with external forcings. Empirical orthogonal function analysis (EOF) and multiple linear regression analysis are used to investigate the effects of river discharge, tides, and winds on saltwater intrusion from 2004 to 2016 based on daily observation data. On the intraseasonal timescale, tidal range has the largest influence, followed by river discharge and winds, and the effect of the alongshore winds is greater than that of the cross-shore winds. On the interannual timescale, river discharge contributes 57% of the variance for the saltwater intrusion and plays the most important role, while tidal range has a negligible impact. The effect of winds contributes 13% of the variance, and the effect of the cross-shore winds is larger than that of the alongshore ones. A combination of river discharge, tidal range, and winds explains 71% of the saltwater intrusion variance. The interannual variability of saltwater intrusion is also found to be correlated with ENSO, with the correlation coefficient reaching as high as 0.48. In most El Niño/La Niña events there are more/less river discharge, stronger Easterly/Northeasterly winds, and less/more saltwater intrusion in Modaomen Estuary.

P-P1-09-S Impact of Human Activities on the Hydrodynamics Regime in the Pearl River Delta During the Flood Season

Liu Changjie, State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University
Yu Minghui, State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University
Cai Huayang, Institute of Estuarine and Coastal Research, School of Marine Sciences, Sun Yat-sen University, Guangzhou
Presenter Email: liuchangjie@whu.edu.cn
It is well-known that both human activities and river-tide dynamics are significant factors

affecting the hydrodynamic process in the estuarine and coastal regions. In particular, the riverbed down-cutting caused by human interventions (e.g., dam construction, sand excavation and dredging for navigation etc.) may exert dramatic changes in hydrodynamic characteristics of the Pearl River Delta (PRD). In this study, we examine the changes in rating curves of residual water level (RWL) versus residual water discharge (RWD) at the upstream stations of the PRD and the variations of RWL along the West, North and East Rivers in three different flood seasons (here termed as "986", "056", "086" respectively). The results show that the rating curves shift down dramatically (0.65-4.9 m) in "056" and "086", compared with the case in "986". Meanwhile, the RWL along the three tributaries falls significantly at the same RWD and the maximum reduction of RWL occurs in the East River. In addition, the RWL decreases more seriously at the upper reaches than that at the lower reaches, which reduces the RWL slope and enhances the tidal dynamic of the PRD. The main reason may be contributed to the uneven deepening of the river channels induced by uncontrolled and disorderly human activities. However, when compared with the case in "056", the rating curves in "086" shift up slightly (0.11-0.29 m) and the RWL increases at the upstream parts but decreases at the downstream parts. The underlying causes can be attributed to the impacts of river-tide dynamics, which is converse to the effect of the riverbed down-cutting. These obtained results will, hopefully, provide scientific guidelines for the general water managements, especially for the flood control in the PRD.

P-P1-10-S Adjustment of Changjiang River plume front during downwelling-favorable wind events

Runqing Lv, Xiamen University
Peng Cheng, Xiamen University
Presenter Email: 22320161151281@stu.xmu.edu.cn

River plume is an important phenomenon in the estuary region, which is affected by various factors, and plays vital role in near-shore sediment transport and bio-distribution. The front of river plume is a barrier to astrict the nutritional materials to the ocean and downwelling-favorable wind is supposed to be a mechanism to break out the barrier effect. An analysis with 3D numerical idealized model indicated that river plume front underwent destratification stage and restratification stage with downwelling-favorable wind. Meanwhile, symmetric instability developed in the frontal region due to the continuous along-shelf buoyancy flux. Based on the previous idealized model, a verification with a realistic model is necessary. In this post, we took an example of Changjiang river plume, which is always suffered from downwelling-favorable wind during winter time monsoon, to confirm the idealized result, using the Regional Ocean Modeling System (ROMS). The model was set with a realistic topography and a boundary condition from HYCOM. Both the tidal and atmospheric forcing were considered. The result exhibited that similar adjustment of plume front developed in the Changjiang river plume during a downwelling-favorable

wind event. Within a northwest wind case, the front firstly became well-mixed and then restratified. The parameter calculation for the plume front also showed the evolution of symmetric instability. Moreover, a series of sensitive experiments were applied with the realistic model, which confirmed that the along-shelf buoyancy flux and wind forcing were the major factors for the front adjustments.

P-P1-11-S the effect of high suspended sediment concentration on bed roughness and shear velocity

Tang Jieping, Nanjing University, School of Geography and Ocean Science
Wang Yaping,
Presenter Email: tjpsky@139.com

Suspended sediment concentration (SSC) and density stratification due to SSC will influence bed shear stress, μ*, which is an important parameter to estimate the start-moving of bed and diffusion of sediment. From 2015.12.20 to 2016.01.20, in-situ observation outside the abandoned Yellow River estuary recorded high suspended sediment concentration (HSSC) events of maximum SSC value reaching 8g/L. When HSSC events happening, the bed shear velocity calculated with LP and Reynolds methods had large different, where LP method was according to von Karman-Prandtl equation: $U(z) = (\mu^*/k)\ln(z/z_0)$, and Reynolds methods was calculated by $-\rho(u' w')$ with the turbulent fluctuation at 0.3 m above sea bed. It’s a good chance to research the effect of SSC on bed shear stress.

P-P1-12-S Numerical modelling of sub-mesoscale processes in a coupled estuary-shelf system off Hong Kong

Waipang Tsang, Department of Mathematics, Hong Kong University of Science and Technology
Jianping Gan, Department of Mathematics, Hong Kong University of Science and Technology
Presenter Email: wptsangaa@connect.ust.hk

We conduct a numerical simulation on an idealized estuary-shelf system to investigate sub-mesoscale processes under multiple forcing of winds, buoyancy from river runoff and tides. The system is analogue to physical settings of Pearl River Estuary (PRE) and adjacent shelf off Hong Kong. The model is based on Regional Ocean Modelling Systems (ROMS) of primitive equations with turbulent closure model. To resolve sub-mesoscale processes in the system, various combinations of physical forcing and numerical implementations were utilized to examine the response of estuarine and shelf circulation to the multiple forcing. In particular, we will examine the freshwater bulge, frontal instability and estuary-shelf exchange under the influence of active sub-mesoscale processes in the system.

P-P1-13-S The Response of Phytoplankton Mortality to Ocean Acidification in Subtropical Eutrophic Bay

Peixuan Wang, State Key Laboratory of Marine Environmental Science,Xiamen University
Xin Liu, State Key Laboratory of Marine Environmental Science,Xiamen University
Jixin Chen, State Key Laboratory of Marine Environmental Science,Xiamen University
Bangqin Huang, State Key Laboratory of Marine Environmental Science,Xiamen University
Presenter Email: pxWang_123@163.com

Phytoplankton are the most important primary producers of the ocean, and their death significantly affects the structure of marine ecosystem and biogeochemistry. However, the current acidification researches mainly focus on phytoplankton community structure, zooplankton grazing and other aspects, and there are few studies on phytoplankton mortality. This study relied on ocean acidification mesocosm facility (FOANIC-XMU), and aims to explore the influence of ocean acidification on phytoplankton mortality in subtropical eutrophic bay by flow cytometry combined with cell digestion assay. The experimental results showed that: 1. In day0-day6,the mortality rate under the high CO2 treatment was lower than that under the low CO2 treatment condition, the mortality rate under the high CO2 treatment was higher in day6-day9, and there was no significant difference between the two treatments in day9-day12, indicating that the impact mechanism of acidification on phytoplankton death was very complex;2. In the phosphate-adding culture experiment that lasted for 24 hours at day9, the mortality rate of phytoplankton in the phosphate group decreased significantly, while there was no significant difference between the acidifying and non-acidizing groups, indicating that phosphate had a more significant impact on phytoplankton death compared with acidizing group;3. According to the activity data of alkaline phosphatase, in the culture experiment, the activity of the bacterial state alkaline phosphatase was lower in the condition of acidification, no matter in the phosphate group or the blank group, indicating that the acidification condition may indirectly affect phytoplankton death by directly affecting the bacteria.

P-P1-14-S Quantifying the alteration of residual water level caused by the human interventions in the Modaomen estuary of the Pearl River, China

hao yang, Sun Yat-Sen University,school of marine engineering and technology
huayang cai, Sun Yat-Sen University,school of marine sciences
Presenter Email: yangh236@mail2.sysu.edu.cn

Residual water level (i.e. the tidally averaged water level) is mainly driven by the residual frictional effect and strongly related to the nonlinear tide-river interactions. Understanding its development and evolution is important with regard to sustainable water resources management in general, such as flood control and salt intrusion. In recent decades, due to

the intensive human interventions the patterns of tide-river dynamic and the corresponding residual water level in the Modaomen Estuary of the Pearl River have changed a lot. In this study, a nonstationary harmonic model (NS_TIDE) was used to reproduce the natural dynamics residual water level that would have occurred in absence of the large-scale human interventions (such as sand excavation) based on collected observed hydrological data from 5 stations in the Modaomen Estuary spanning the period 1958–2015. Model results show that, under the overall influence of human interventions, the amplitudes of the K_1 and M_2 constituents in 1994 and 2003 were increased significantly, with the maximum increase by 0.13 m and 0.09 m, respectively. It was shown that the residual water level along the Modaomen estuary was significantly decreased, with the maximum decrease by 1.39 m in Makou station. Moreover, we showed that the decline of residual water level during the flood season was much greater than that during the dry season, and the more upstream the location of the station, the more obvious of the change is. The underlying mechanism can be primarily attributed to reduction of the residual water level slope due to the deepening of the channels along the Modaomen estuary caused by human interventions.

P-P1-15 Characterization and expression profiling of trypsin in *Phaeodactylum tricornutum*

Yanchun You, Xiamen University
Senjie Lin, Xiamen University
Presenter Email: fjyhy@163.com

Trypsin (EC 3.4.21.4) is a serine protease that cleaves peptide chains mainly at the carboxyl side of the amino acids lysine or arginine, and can be found in many organisms. Trypsin is multifunctional enzyme and has been found involved in many important physiological processes in animal, such as food digestion, hemostasis, immune defense response and nerve response. In addition, it has been used widely in various biotechnological processes. However, the function of marine phytoplankton trypsin is still unknown. Interestingly, the diatom trypsin genes showed high expression in our previous metatranscriptome data of marine harmful algae. Hence, trypsin may play an important role in the growth of marine phytoplankton. In this study, the typical marine diatom *Phaeodactylum tricornutum* was selected as model species to explore the function of trypsin in marine phytoplankton. The public published P. tricornutum genome data provide an opportunity to investigate the structure, function, and evolution of trypsin on a genome-wide scale. Ten putative trypsin genes have been identified in P. tricornutum by searching the P. tricornutum genome, and named according to the order of position on the genome. Phylogenetic analyses on the trypsin amino acid sequences reveal that the ten trypsin could be divided into two main subclasses. Furthermore, expression of all the trypsin genes in different life stages and culture conditions was detected by qRT-PCR.

PtTrp1 showed no significant expression between different culture conditions. PtTrp2 and PtTrp6 showed high constitutive expression in various life stages. PtTrp2, PtTrp6, PtTrp9 and PtTrp6 exhibited higher expression in P-deficiency. The diversified features and expression patterns of the trypsin are inferred to be associated with the alga growth. Our findings provide a base for functional research on phytoplankton trypsin, a better understanding of the outbreak mechanism of harmful algal blooms, and strategies for monitoring harmful algal blooms.

P-P1-16-S Influences of sea-level rise on tides in the East China Seas

Yuanjie Chen, xiamen university
Presenter Email: 785070984@qq.com

Greenhouse Effect causing sea level rise has become a research hotspot. A numerical model has been developed to clarify the tidal response to sea-level rise in the east China seas. Five experiments were simulated, in which sea-level rises 0.2m in turn. Based on the above experimental analysis and research, this paper gives the changes of tidal characteristic in the following points, tidal currents, tidal energy fluxes, tidal energy dissipation and tidal residual currents.

P-P1-17-S Vegetation Competition Observed by High Resolution Remote Sensing Images Within an Estuarine Saltmarsh

Silong Huang, Second Institute of Oceanography, SOA, Hangzhou, China
Yining Chen, Second Institute of Oceanography, SOA, Hangzhou, China
Tinglu Cai, Second Institute of Oceanography, SOA, Hangzhou, China
Presenter Email: throne0824@hotmail.com

The tidal flat of the Andong Shoal is a typical mudflat expanding rapidly towards the sea. The upper part of this tidal flat is covered by a mature saltmarsh which has developed over the last decade after embankment. The evolution of the saltmarsh on the Andong Shoal is mainly determined by the competition and succession of the exotic species Spartina alterniflora and the native species Scirpus mariqueter. Therefore, in this study, we attempt to investigate the temporal and large-scale spatial variations of the exotic and native species under competition, over a period of rapid saltmarsh development. Three high resolution (<1m) remote sensing images were collected, during the period from 2016 to 2018, in order to investigate the spatial and temporal variations of Scirpus mariqueter and Spartina alterniflora within this area. Professional software packages, such as ENVI and ArcGIS, were used to analyze and further interpret the images, after the calibration using field survey data. The results showed that the total area of the studied saltmarsh increased from 2016 to 2018, at a mean rate of 161.5 m a-1. The upper marsh was mainly occupied by Spartina alterniflora and the vegetation area increased, at a rate of 1.585 km2 a-1. Scirpus mariqueter originally covered the middle to lower marsh in 2016. However, due to

the competitive stress of Spartina alterniflora, the area of Scirpus mariqueter decreased over this period, at a rate of 1.245 km2 a-1, although the seaward edge of Scirpus mariqueter was still expanding. Overall, the expansion rate of Spartina alterniflora is two times of that of Scirpus mariqueter and this resulted in the succession of the middle marsh, from Scirpus mariqueter to Spartina alterniflora. The observation of the spatial patterns over two-year period also indicated a bimodal pattern for Spartina alterniflora: this exotic species expand both at the upper marsh and the seaward edge of the saltmarsh. The upper marsh expansion of Spartina alterniflora is mainly caused by the lateral expansion of rhizome, whilst the expansion at the edge is associated with seed diffusion and settling driven by tidal hydrodynamics.

P-P1-18 Naturally restored coastline: definition and examples

Jianjun Jia, School of Marine Sciences, East China Normal University
Xiaoming Xia, Second Institute of Oceanography, SOA
Tinglu Cai, Second Institute of Oceanography, SOA
Xinkai Wang, Second Institute of Oceanography, SOA
Presenter Email: jjjia@sklec.ecnu.edu.cn

Coastline is an artificially delimited line that divides earth surface into two parts: land and ocean, which is usually defined as the high water mark of mean spring tides. Traditional classification for natural coastline could be described as a three-part system, in terms of sediment composition: rocky, sandy and muddy coastlines. Human activities, however, created a brand-new type of coastline, i.e., artificial coastline, including seawall, dyke, port and harbor and other buildings that take the place of natural coastlines. In China, artificial coastline occupies more than two thirds of the 18000 km-long mainland coasts in 2010, a sharp contrast to the number of one thirds in 1980's. It is by no means a pleasant scenery when people go to the coasts and find nothing but concrete constructions. Therefore, the ratio of natural coastline to total coastline in a coastal region or country is adopted as an important indicator of ecological health. We have one option only to improve this indicator: ecological restoration. However, we have two directions for this options: with dike excavation VS without dike excavation. In this presentation, we show some recent practices in Zhejiang Province with special references to inventory of Naturally Restored Coastline (NRC). Most NRC are coastline defined over muddy flat, located outside of artificial along-coast constructions, where elevation, slope, seabed materials and vegetation of restored coastline are identified with natural coasts. It is helpful for coastal zone protection and sustainable development to introduce the concept of NRC in that, considerable times are need during which the ecological function of intertidal zone would be restored after construction of artificial along-coast building.

P-P1-19 Coupled surface-subsurface modeling of fresh submarine groundwater discharge of an island in the Mediterranean Sea

Xuan Yu, School of Civil Engineering, Sun Yat-sen University, Guangzhou 510275, China
Zexuan Xu, Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA
Daniel Moraetis, College of Science, Earth Science Department, Sultan Qaboos University, P.O. Box 36, Muscat 123, Oman
Nikolaos P. Nikolaidis, Department of Environmental Engineering, Technical University of Crete, University Campus, 73100 Chania, Greece
Frank W. Schwartz, School of Earth Sciences, The Ohio State University, Columbus, OH 43210, USA
Lele Shu, Department of Land, Air and Water Resources, University of California, Davis, California 95616, USA
Bingjun Liu, School of Civil Engineering, Sun Yat-sen University, Guangzhou 510275, China
Christopher Duffy, Department of Civil and Environmental Engineering, The Pennsylvania State University, University Park, Pennsylvania 16802, USA
Presenter Email: yuxuan7@mail.sysu.edu.cn

Fresh submarine groundwater discharge (SGD) contributes to the physical and chemical conditions of coastal waters, but the role of coastal groundwater at regional scale is poorly described and quantified due complex surface and subsurface interactions of hydrologic processes. We used a coupled surface-subsurface hydrologic model to calculate the spatial and temporal dynamics of regional groundwater discharge at the coastlines of an island in the Mediterranean Sea. The model result suggested that 2.3x108 m3/yr of groundwater directly enters the Mediterranean Sea, amounting to 31% of river discharge. Spatially, fresh SGD varied from 1.5 m3/yr/m to 13.4x104 m3/yr/m, with a mean of 0.14x104 m3/yr/m. The local maximum was found close to river mouth with stronger hydraulic gradient and karst faults with higher permeability. Temporally, fresh SGD was impacted by episodic precipitation in a delayed and prolonged pattern depending on the topography. Overall, the results of fresh SGD demonstrated a strong dependence of local conditions and temporal hydrologic regimes, suggesting that results from large-scale estimation are problematic to apply to plot scale that typically exhibit spatial and temporal uncertain, scale-dependent properties.

Observed precipitation changes in Ecuadorian coast influenced by Interdecadal and Interannual Variability during the Period 1975-2014

Freddy Hernández, INOCAR
Leonor Vera, INOCAR
Susy Marín, INOCAR
Presenter Email: freddy.hernandez@inocar.mil.ec

Continental Ecuador, with a relatively short coast (750 Km), is subject to a coastal climate defined by two seasons: a rainy period between January and March, with a unimmodal distribution with maximum peaks in March and April, and a dry season between June and December. This seasonality is influenced by several factors, including global and regional atmospheric circulation, local air masses determined by the topography, oceanic currents (the equatorial front, the Humboldt current system, among others) and the Andean mountains. Nevertheless, the normal development of this seasonality is from time to time altered by the interannual variability of El Nino (La Nina), which is characterized by an anomalous warming (cooling) of the Central-Eastern Pacific Ocean. These alterations impact the ecosystem, modify the circulation patterns and bring social-economic consequences to the country with different levels of impact. As an example, Guayaquil, a city in low lands, registered a monthly precipitation increase about 1400%, in May71983, during the 1982-1983 El Nino and, several coastal locations, showed a decrease up to 100%, in February/1999, at the beginning of a La Nina period. Eleven ENSO events occurred between 1975 and 2014 were analyzed, indifferently to its origin (canonical, Modoki or central). The length of each one is variable; while El Nino had a durations between 5 and 19 months, La Nina last between 5 and 33 months. Additionally, two El Nino events categorized as extraordinary, occurred in 1982-1983 and 1997-1998. In the late 1990s a shift in global scale was detected in ocean-atmospheric conditions. Nowadays studies relate this shift to a change of phase in the Interdecadal Pacific Oscillation (IPO). In this context, the period concerning this work covers both phases of the IPO, a positive phase from 1975 to1999, in which 7 El Nino (including two El Nino extreme episodes) and 5 La Nina events were found; and a negative phase from 2000 to 2014, with 4 El Nino and 5 La Nina events. In the ongoing negative IPO period, more frequent events but with a shorter duration have occurred. El Nino, La Nina, and normal conditions scenarios were discriminated in both IPO phases, using a non-parametric test to determine differences between the precipitation ranges. The results suggest that precipitation at three locations in the Ecuadorian coast (Esmeraldas, Libertad and Guayaquil) is not influenced by the Interannual and Interdecadal variability. The implications of the differences and relations found are discussed in this work.

P-P2-01-S Ocean Salinity as a Predictor of Summer Rainfall over East Asian Monsoon Region

Biao CHEN, 1. State Key Laboratory of Tropical Oceanography (LTO), South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Science, Guangzhou
Huiling QIN, 3. School of Atmospheric Sciences, and Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, Sun Yat-sen University, Guangzhou
Guixing CHEN, 3. School of Atmospheric Sciences, and Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, Sun Yat-sen University,

Guangzhou
Huijie XUE, 1. State Key Laboratory of Tropical Oceanography (LTO), South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Science, Guangzhou
Presenter Email: chenbiao@scsio.ac.cn

The Sea Surface Salinity (SSS) can vary largely as a result of evaporation-precipitation difference, indicating the source or sink of regional/global water vapor. In this study, we identify a close relationship between the spring SSS in the Northwest Pacific and the summer rainfall of the East Asian Monsoon Region (EAMR) during 1980-2017. Analysis results suggest that the SSS-rainfall link may involve the coupled ocean-atmosphere-land processes with a two-stage evolution. In spring, evaporation and water vapor flux divergence were enhanced in some years over the Northwest Pacific where an anomalous atmospheric anticyclone was established and a high SSS was well observed. As a result, the convergence of water vapor flux and the soil moisture over the EAMR were strengthened. The change in spring soil moisture over the EAMR then modulated the subsequent large-scale atmospheric circulation and the regional water cycle, which contributed to the variation of summer rainfall. The high correlations among the above factors suggest that the signals of water cycle can be preserved for up to three months, implying a predictability of EAMR rainfall using SSS data. Using a random forest regression algorithm, we further evaluate the relative importance of SSS in predicting summer rainfall compared to other climate indices. As the SSS is now monitored routinely by satellite, it may serve as a good metrics for measuring the water cycle and predicting the EAMR rainfall.

P-P2-02-S Examining the pattern of salinity change at upper Pacific Ocean during the Argo Period

Guancheng Li, International Center for Climate and Environment Sciences, Institute of Atmospheric Physics, Chinese Academy of Sciences
Lijing Cheng, International Center for Climate and Environment Sciences, Institute of Atmospheric Physics, Chinese Academy of Sciences
Jiang Zhu, International Center for Climate and Environment Sciences, Institute of Atmospheric Physics, Chinese Academy of Sciences
Presenter Email: liguancheng15@mails.ucas.ac.cn

Observations and models show that global water cycle has been intensified due to global warming, which is evident by a clear ocean fingerprint of salinity change. After 2005, Argo network reached near-complete global coverage, providing the best observations than ever for the salinity changes. During this period, the Global and Pacific salinity experience an opposite change at vertical layers: the ocean saltier at the upper-200m and fresher within 200 to 600m, with distinctive regional signatures compared with long-term pattern. Our study aims to explore how the upper-200m salinity pattern forms by using observations

and reanalysis data.
An upper-200m salinity budget analysis, based on an ocean state estimate ECCO v4.3 (Estimating the Circulation and Climate of the Ocean version 4 release 3), was conducted to access the recent decadal trend reversal in Pacific (rising after 2005) and investigate the mechanisms controlling the increasing trends. The budget diagnostics in the major salinity increasing regions at the upper-200m indicate that the salinity increases since 2005 were contributed to the freshwater changes near the sea surface due to the precipitation forcing, together with the ocean advection mainly forced by the wind anomalies. Further analysis suggests the decadal changes of these patterns since 2005 are likely related to the Interdecadal Pacific oscillation (IPO). This study highlights a significant regulation of the ocean salinity change by natural decadal variability in the climate system.

P-P2-03-S The relationship between the East Asian summer rainfall and Ross Sea Ice Concentration(SIC)

Hui CAI, Department of Atmospheric Sciences, China University of Geosciences, Wuhan 430074, China
Shuanglin LI, Department of Atmospheric Sciences, China University of Geosciences, Wuhan 430074, China
Presenter Email: huicai@cug.edu.cn

The relationship between the East Asian summer rainfall (20-40N, 110-125E) and Antarctic Sea Ice Concentration (SIC) from 1980 to 2017 was analyzed by using GPCP global precipitation dataset, SIC obtained from Hadley Center and NCEP/NCAR Reanalysis . It was found that the East Asian summer precipitation anomalies show a significant positive correlation with the SIC anomalies during boreal spring over the Ross Sea (65-72S, 160E-165W). By using the regression analysis, we found that the sic growth acts to strengthen the Mascarene high (MH) and the Australia high (AH). MH and AH enhancement (weaken) further increases (decreases) precipitation in East Asia by enhancing (weakening) the cross-equatorial flow. And it seemed the Ross SIC can strengthen the south flow which brings water vapor from sea to land. The results suggest that the SIC over Ross Sea is another factor to affect the East Asian summer rainfall.

P-P2-04 Integrated Leakage Monitoring of Marine Carbon Storage

Dr. Jianghui Li, University of Southampton, UK
Prof. Fei Yuan, Xiamen University, China
Prof. En Cheng, Xiamen University, China
Presenter Email: J.Li@soton.ac.uk

Carbon dioxide (CO_2) Capture and Storage (CCS) has been identified as an important strategy to mitigate greenhouse gas emissions. To confirm that injected CO_2 stays in the reservoir as intended, reliable Marine Carbon Storage monitoring is critical, and that any

occurring leakage is promptly detected and corrected. Technologies for such leakage monitoring include acoustic (passive/active) and chemical (pH/concentration) methods. For such monitoring, integrated way of combining and optimizing multiple methods is emerging as a promising strategy. Develop such an integrated monitoring technology is the basic of this connection. Combination of acoustic and chemical methods will be considered. Direct detection of greenhouse gases as gas phase in the water column will be discussed with active and passive acoustic sensors. Indirect detection of gas leakage will be discussed with pH sensors as pH changes in the surrounding liquid against expected background levels established during baseline assessment. Wireless sensor networks will also be discussed in the baseline establishment and application. A baseline with natural fluctuations can be established over time, to interpret measurements of CO2, pH or temperature as indicating leakage. Many acoustic recorders consist of multiple acoustic sensors. Sensor array systems, including active and passive, will be considered to investigate the movement of bubbles and their spatial distribution. Array processing algorithms will be considered to process data received by distributed (e.g., horizontal or vertical) multiple acoustic sensors. This type of data analysis may contribute to extract more information from gas bubble stream and enables creating a more comprehensive monitoring system. Field work on acoustic experiments has been conducted in the natural greenhouse gas seeps offshore Panarea, Italy, along with the Southampton-join European Union project STEMM-CCS (Strategies for Environmental Monitoring of Marine Carbon Capture and Storage). We will focus on integration of various techniques and discuss the best integrated way for monitoring the flux of greenhouse gases through the seafloor into the ocean. The development of such monitoring technologies will be considered and discussed to monitor existing abandoned wells in the South China Sea and form an important component for future Marine Carbon Capture and Storage in China. Laboratory and field work can then be conducted. This topic is crucial for promoting confidence in global marine carbon storage as a viable technology for reducing greenhouse gas to the atmosphere.

P-P2-05 Subseasonal Change in the Seesaw Pattern of Precipitation between the Yangtze River Basin and the Tropical Western North Pacific during Summer

Xinyu Li, College of Oceanography, Hohai University
Riyu Lu, Institute of Atmospheric Physics, Chinese Academy of Sciences
Presenter Email: lixinyu@lasg.iap.ac.cn

There is a well-known seesaw pattern of precipitation between the tropical western North Pacific (WNP) and the Yangtze River basin (YRB) during summer. This study identified that this out-of-phase relationship experiences a subseasonal change; that is, the relationship is strong during early summer but much weaker during mid-summer. We investigated the large-scale circulation anomalies responsible for the YRB rainfall anomalies on the

subseasonal timescale. It was found that the YRB rainfall is mainly affected by the tropical circulation anomalies during early summer, i.e., the anticyclonic or cyclonic anomaly over the subtropical WNP associated with the precipitation anomalies over the tropical WNP. During mid-summer, the YRB rainfall is mainly affected by the extratropical circulation anomalies in both the lower and upper troposphere. In the lower troposphere, the northeasterly anomaly north of the YRB favors heavier rainfall over the YRB by intensifying the meridional
gradient of the equivalent potential temperature over the YRB. In the upper troposphere, the meridional displacement of the Asian westerly jet and the zonally oriented teleconnection pattern along the jet also affect the YRB rainfall. The subseasonal change in the WNP–YRB precipitation relationship illustrated by this study has important implications for the subseasonalto-seasonal forecasting of the YRB rainfall.

P-P2-06 Arctic sulfate aerosol and cloud sensitivity to changes in future surface seawater dimethylsulfide concentrations

Rashed Mahmood, School of Earth and Ocean Sciences, University of Victoria, Victoria, British Columbia, Canada
Knut von Salzen, Canadian Center for Climate Modelling and Analysis, Environment and Climate Change Canada, Victoria, British Columbia, Canada
Ann-Lise Norman, Department of Physics and Astronomy, University of Calgary, Calgary, Alberta, Canada
Martí Galí, Takuvik Joint International Laboratory & Québec-Océan, Université Laval, Québec, Québec, Canadabec, Canada
Maurice Levasseur, Takuvik Joint International Laboratory & Québec-Océan, Université Laval, Québec, Québec, Canada
Shuanglin Li, Department of Atmospheric Science,China University of Geosciences, Wuhan, China
Presenter Email: rmahmood@uvic.ca

Dimethylsulfide (DMS), outgassed from ocean waters, plays an important role in the climate system, as it oxidizes to methane sulfonic acid (MSA) and sulfur dioxide (SO_2), which can lead to the formation of sulfate aerosol. Newly formed sulfate aerosol resulting from DMS oxidation may grow by condensation of gases, in-cloud oxidation, and coagulation to sizes where they may act as cloud condensation nuclei (CCN) and influence cloud properties. Under future global warming conditions, sea-ice in the Arctic region is expected to decline significantly, which may lead to increased emissions of DMS from the open ocean and changes in cloud regimes. In this study we evaluate impacts of DMS on Arctic sulfate aerosol budget, changes in cloud droplet number concentration (CDNC), and cloud radiative forcing in the Arctic region under current (2000) and future (2050) sea ice conditions using an atmospheric general circulation model. Given that future DMS

concentrations are highly uncertain, several simulations with different surface seawater DMS concentrations and spatial distributions in the Arctic were performed in order to determine the sensitivity of sulfate aerosol budgets, CDNC, and cloud radiative forcing to Arctic surface seawater DMS concentrations. We found that the simulated aerosol nucleation rates are higher in future, which results in an overall increase in CDNC and substantially more negative cloud radiative forcing. Thus potential future reductions in sea ice extent may cause cloud albedos to increase, resulting in a negative climate feedback on radiative forcing in the Arctic associated with ocean DMS emissions.

P-P2-07-S A comparison of two cold events in 2008 and 2018 winter

Mingyue Qin, Shuanglin Li
Presenter Email: qinmingyue@mail.iap.ac.cn

A persistent cold event was identified in East Asia during late January – early February 2018, which exhibits a resemblance to that in the 2007/08 winter. Both events occured in late winter exceeding synoptic time scales, with reductions in sea ice and La Niña phases. A comparative study of the two events was conducted from phenomenon, large-scale circulation conditions and possible reasons. The following conclusions can be drawn. There is a difference in the spatial distribution and duration of the cold SAT anomaly. In the 2007/08 case, cold SAT anomalies occurred in northwestern China, then extended southward along the eastern slope of Tibetan Plateau and reached south China, but with warm SAT anomalies in northeastern China and Tibetan Plateau. In comparison, cold SAT anomalies occurred in most parts of China whereas warm anomalies were found over Tibetan Plateau. Intensified blocking activity and intensified Siberian High are found in both events. In the 2008 events, Rossby wave energy propagates along the subtropical jet, and leads to the formation of southern branch trough in South China and the northward expansion of the western Pacific subtropical high. In the 2018 event, Rossby wave energy originating from Atlantic ocean were splited into two wave trains with one propagating along 50°N and the other along 30°N. They together strengthed the East Asian trough, causing invasion of cold air.

P-P2-08-S A deep learning algorithm of neural network for the parameterization of typhoo-ocean feedback in typhoon forecast models

Guoqing Jiang, Peking University
Xiao-Chen Ren, Peking University
Si-Lin Zou, Peking University
Presenter Email: renxxc@pku.edu.cn

Two algorithms based on machine learning neural networks are proposed—the shallow learning (S-L) and deep learning (D-L) algorithms—that can potentially be used in

atmosphere-only typhoon forecast models to provide flow-dependent typhoon-induced sea surface temperature cooling (SSTC) for improving typhoon predictions. The major challenge of existing SSTC algorithms in forecast models is how to accurately predict SSTC induced by an upcoming typhoon, which requires information not only from historical data but more importantly also from the target typhoon itself. The S-L algorithm composes of a single layer of neurons with mixed atmospheric and oceanic factors. Such a structure is found to be unable to represent correctly the physical typhoon-ocean interaction. It tends to produce an unstable SSTC distribution, for which any perturbations may lead to changes in both SSTC pattern and strength. The D-L algorithm extends the neural network to a 4 × 5 neuron matrix with atmospheric and oceanic factors being separated in different layers of neurons, so that the machine learning can determine the roles of atmospheric and oceanic factors in shaping the SSTC. Therefore, it produces a stable crescent-shaped SSTC distribution, with its large-scale pattern determined mainly by atmospheric factors (e.g., winds) and small-scale features by oceanic factors (e.g., eddies). Sensitivity experiments reveal that the D-L algorithms improve maximum wind intensity errors by 60–70% for four case study simulations, compared to their atmosphere-only model runs.

P-P2-09 A possible mechanism for the impacts of the Madden-Julian Oscillation on the North Atlantic Oscillation

Xiaolu Shao, Hohai University
Jie Song, Institute of Atmospheric Physics
Shuanglin Li, Institute of Atmospheric Physics
Presenter Email: shaoxl06@163.com

After the onset of the MJO phase 3 (6), a wave train over the Pacific-North American (PNA) region with an anticyclone anomaly over the northeastern Pacific are formed and developed, then followed by a positive (negative) NAO-like pattern over the North Atlantic sector. The atmospheric responses to the initial-value perturbations aroused by tropical heating forcing of the MJO are simulated using the Geophysical Fluid Dynamics Laboratory (GFDL) dynamical core model. Compared with the control experiment, the initial-value perturbations over the Indian Ocean aroused by the tropical heating of the MJO phase 3 (6) can lead to faster (slower) eastward speed of synoptic eddies over the North Atlantic, driving the formation of the synoptic eddy vorticity forcing (EVF) associated with the positive (negative) NAO. In response to the initial-value perturbations over the Indian Ocean, the circumglobal teleconnection pattern is formed, while the Atlantic jet strengthens (weakens). The observational results show that after the strengthening (weakening) of the subtropical Asian jet associated with the MJO phase 3 (6), the synoptic eddies over the North Atlantic have faster (slower) eastward speed. Therefore, we provide a possible mechanism for the impacts of the MJO on the NAO. Firstly, circulation anomalies over the Indian Ocean are aroused by the anomalous heating of the MJO phase 3 (6).

Then, through the circumglobal teleconnection pattern, the Atlantic jet strengthens (weakens). Finally, the synoptic eddies have faster (slower) eastward speed, producing the anomalous EVF and thus driving the formation of the positive (negative) NAO.

P-P2-10 Weakening of Northwest Pacific anticyclone anomalies during post-El Nino summers under global warming

Jiang Wenping, Hohai University, College of oceanography.
Huang Gang, Institute of Atmospheric Physics, Chinese Academy of Sciences.
Huang Ping, Institute of Atmospheric Physics, Chinese Academy of Sciences.
Hu Kaiming, Institute of Atmospheric Physics, Chinese Academy of Sciences.
Presenter Email: jwp@mail.iap.ac.cn

The Northwest Pacific anticyclone (NWPAC) anomalies during post-El Niño summers are a key predictor of the summer climate in East Asia and the Northwest Pacific (NWP). Understanding how this will change under global warming is crucial to project the changes in the variability of the Northwest Pacific summer monsoon. Outputs from 18 selected coupled models from phase 5 of the Coupled Model Intercomparison Project show that the anomalous NWPAC response to El Niño will likely be weakened under global warming, which is attributed to the decreased zonal contrast between the tropical Indian Ocean (TIO) warming and the NWP cooling during post-El Niño summers. Under global warming, the NWPAC anomalies during the El Niño mature winter are weakened due to decreased atmospheric circulation in response to El Niño–Southern Oscillation (ENSO), which leads the weakening of local air–sea interaction and then decreases the cold NWP SST anomalies. Furthermore, the decreased surface heat flux anomalies, the weakened anticyclone anomalies over the southeast Indian Ocean, and the slackened anomalous easterlies over the north Indian Ocean, weaken the warm TIO SST anomalies. However, the strengthened tropospheric temperature anomalies could enhance the anomalous TIO warming. Although the changes in TIO SST anomalies are indistinctive, the weakening of the SST anomaly gradient between the TIO and the NWP is robust to weaken the NWPAC anomalies during post-El Niño summers. Moreover, the positive feedback between the TIO–NWP SST anomalies and the NWPAC anomalies will enhance the weakening of NWPAC under global warming.

P-P2-11 Roles of tropical SST patterns during two types of ENSO in modulating wintertime rainfall over southern China

Kang Xu, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Qing-Lan Huang, Jiangmen Meteorological Service, Jiangmen, China
Chi-Yung Tam, Earth System Science Programme, The Chinese University of Hong Kong, Hong Kong, China

Weiqiang Wang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Sheng Chen, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Congwen Zhu, State Key Laboratory of Severe Weather (LASW) and Institute of Climate System, Chinese Academy of Meteorological Sciences, Beijing, China
Presenter Email: xukang@scsio.ac.cn
The impacts of the eastern-Pacific (EP) and central-Pacific (CP) El Nino-Southern Oscillation (ENSO) on the southern China wintertime rainfall (SCWR) have been investigated. Results show that wintertime rainfall over most stations in southern China is enhanced (suppressed) during the EP (CP) El Nino, which are attributed to different atmospheric responses in the western North Pacific (WNP) and South China Sea (SCS) during two types of ENSO. When EP El Nino occurs, an anomalous low-level anticyclone is present over WNP/the Philippines region, resulting in stronger-than-normal southwesterlies over SCS. Such a wind branch acts to suppress East Asian winter monsoon (EAWM) and enhance moisture supply, implying surplus SCWR. During CP El Nino, however, anomalous sinking and low-level anticyclonic flow are found to cover a broad region in SCS. These circulation features are associated with moisture divergence over the northern part of SCS and suppressed SCWR. General circulation model experiments have also been conducted to study influence of various tropical sea surface temperature (SST) patterns on the EAWM atmospheric circulation. For EP El Nino, formation of anomalous low-level WNP anticyclone is jointly attributed to positive/negative SST anomalies (SSTA) over the central-to-eastern/western equatorial Pacific. However, both positive and negative CP Nino-related-SSTA, located respectively over the central Pacific and WNP/SCS, offset each other and contribute a weak but broad-scale anticyclone centered at SCS. These results suggest that, besides the vital role of SST warming, SST cooling over SCS/WNP during two types of El Nino should be considered carefully for understanding the El Nino-EAWM relationship.

P-P2-12 On the simulations of global oceanic latent heat flux in CMIP5 multi-model ensemble

Rongwang Zhang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Xin Wang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Chunzai Wang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: rwzhang@scsio.ac.cn
Simulations of the global oceanic latent heat flux (LHF) in CMIP5 multi-model ensemble (MME) were evaluated in comparison with 11 LHF products. The results show that the

mean state of LHF in MME coincides well with that in the observations, except for a slight overestimation in the tropical regions. The reproduction of the seasonal cycle of LHF in MME is in good agreement with that in the observations. However, biases are relatively obvious in the coastal regions. A prominent upward trend in global mean LHF is confirmed with all of the LHF products during the period of 1979 to 2005. Despite the consistent increase of LHF in CMIP5 models, the rates of increase are much weaker than those in the observations, with an average of approximate 1/9 of that in the observations. The findings show that the rate of increase of near-surface specific humidity (qa) in MME is nearly six times that in the observations, while the rate of increase of the near-surface wind speed (U) is less than 1/2 of that in the observations. The faster increase of qa and the slower increase of U could both suppress evaporation, and thus latent heat released by the ocean, which may be one of the reasons that the upward trend of LHF in MME is nearly one order lower than that in the observations.

It is worth noting that the very weak trend in LHF in all the models suggests that the LHF values are nearly conserved in the models. This discrepancy with respect to the observations may have an important impact on the energy budget in the models, and further studies are needed.

P-P3-01 Impacts of mesoscale currents on the critical latitude dependence of internal tides

Jiahi Dong, Nanjing University of Information Science and Technology
Robin Robertson, Xiamen University Malaysia
Changming Dong, Nanjing University of Information Science and Technology
Paul Scott Hartlipp, University of New South Wales
Presenter Email: jihai_dong@nuist.edu.cn

Critical latitudes are believed to be a significant factor for tidal dissipation. Studies have revealed that non-linear interactions of tides occur easily at the critical latitudes, but the influence of background currents on these non-linear interactions is not well known. The latitude effects of background currents from eddies or a boundary current on tides, the internal tidal fields, internal waves, and mixing were investigated using the Regional Ocean Modeling System (ROMS). This was accomplished by shifting a small domain including a seamount from 20.6o to 38.6oS and comparing simulations with and without background currents from an eddy. Compared to the results without background currents, the kinetic energy of diurnal frequencies was unchanged for most latitudes except decreased 1-4o poleward of the critical latitude, which had a slight decrease; however, the kinetic energy of semidiurnal frequencies and the high frequency harmonics (≥3 cpd) increased with the presence of the mesoscale currents, especially between the latitude range of O1 and K1 critical latitudes. Spectral and non-linear analyses indicated that the mesoscale currents broadened the critical latitude range and enhanced energy transfers from diurnal

frequencies to semidiurnal and high frequencies and from waves with low modes to high modes. Correspondingly, local diffusivities also increased dramatically, roughly a factor of 20, when mesoscale currents were present. The impacts of mesoscale currents on the broadening of the critical latitude range and enhancement of non-linear interactions were attributed to the additional relative vorticity and near-inertial internal waves generated by mesoscale currents.

P-P3-02-S Fourier power spectrum of ocean data missing or irregular sampling

Yang Gao, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University
Yongxiang Huang,
Jianyu Hu,
Presenter Email: yanggao@stu.xmu.edu.cn

Fourier power spectrum plays an important role in the dynamical analysis, which associates the energy with different frequencies/scales. Due to a large range of scale interaction in the ocean, power-law behavior of the Fourier power spectrum is emerged spontaneously. This behavior is a signature of the turbulence cascade. However, the collected data, such as ocean current and temperature, are either with missing data or with irregular sampling, which violates the application of the Fast Fourier Transform (FFT). In this work, with the help of the bootstrap procedure and Wiener-Khichine theorem, we propose a systematical way to estimate the Fourier power spectrum without bias from the data missing or irregular sampling. We first validate the new method via a numerical experiment with fractal Brownian motion. It is then applied to ocean current velocity data which was collected form ADCP in the South China Sea to show the efficiency of the new algorithm. It is indicated that the measured scaling exponents for the South China Sea to be -3 and -5/3, respectively for scale below 200 km and scale above 200 km fluctuations, coincidently agreeing with the theoretical prediction of the Kraichnan's 2D turbulence.

P-P3-03 Striations in Marginal Seas and the Mediterranean Sea

Yuping Guang, South China Sea Institute of Oceanology, CAS,China
Yu Zhang, South China Sea Institute of Oceanology, CAS, China
Zhiyu Liu, Xiamen University,China
Rui Xin Huang, WHOI, USA
Presenter Email: guan@scsio.ac.cn

Striations are ubiquitous in the world oceans, in particular the open ocean; however, it was unclear whether striations exist in the marginal seas and semi-closed seas. Our analysis reveals exist of striations in several marginal seas, such as South China Sea (SCS), Japan Sea (JS), Gulf of Mexico (GM), and the Mediterranean Sea (MS). Comparing to the open ocean, striations in marginal or semi-enclosed sea are characterized by narrower

bandwidth, more non-zonal orientations, and stronger baroclinic structure and deep intensification. Through power spectral analysis, the typical bandwidth of striations is about 60km in marginal seas and 100km in the Mediterranean Sea. The orientations of striations are highly correlated with the potential vorticity contours on isentropic surfaces. In vertical direction, striations often extend from the surface to a certain depth; but within SCS and MS they are baroclinic in up 1000m layer and intensified at more than 3000m depth. The different characters of striations in the open oceans and marginal seas are mainly due to the difference in the background flow. In particular, the coherent mesoscale features are strongly affected by background flow in these smaller basins.

P-P3-05-S Direct numerical simulation of chemical reactions in homogeneous isotropic turbulence

Wenwei Wu, UM-SJTU Joint Institute, Shanghai JiaoTong University/ Univ. Lille, Unite de Mecanique de Lille/ CNRS, Univ. Lille, ULCO, Laboratory of Oceanology and Geosciences
Lipo Wang, UM-SJTU Joint Institute, Shanghai JiaoTong University
Enrico Calzavarini, Univ. Lille, Unite de Mecanique de Lille
Francois G. Schmitt, CNRS, Univ. Lille, ULCO, Laboratory of Oceanology and Geosciences
Michael Gauding, Univ Rouen, CORIA, CNRS
Presenter Email: wenwei_wu@sjtu.edu.cn

Reactive tracers are of interest for turbulent studies in the engineering domain, in the atmospheric and the oceanic research. These tracers can be chemically or biologically active. The knowledge on the statistical properties, including scaling behaviour, of high order reactions in homogeneous and isotropic turbulence is still very sparse. In this study we consider first order, 1.5 order and second order reactions, using direct numerical simulations of turbulent flows at Taylor based Reynolds number of 220. The spatial and temporal spectra are computed in order to investigate the scaling law of the different reactive scalar fields. Besides, we considered the scaling exponents of structure functions in the different configurations, and analyzed and compared their intermittency properties.

P-P3-06-S Modification of parametric subharmonic instability in the presence of background geostrophic currents

Wei Yang, Ocean University of China
Toshiyuki Hibiya, The University of Tokyo
Yuki Tanaka, The University of Tokyo
Liang Zhao, Tianjin University of Science and Technology
Hao Wei, Tianjin University
Presenter Email: yangwouc@163.com

The parametric subharmonic instability (PSI), a kind of triad wave resonant interaction, is capable of rapidly cascading the energy of internal tides to smaller-scale waves of half the

tidal frequency. Regarding with the simulation of internal tide energy cascade through PSI, most studies studied the internal tides propagating through a quiescent ocean, hence ignoring the presence of background relative vorticity. Here, we showed for the first time that the presence of background relative vorticity can significantly modify the behavior of PSI through changing the local effective Coriolis frequency. A series of idealized experiments at 25.4°N show that the PSI efficiency increases several times above the background value where positive vorticity have shifted the effective Coriolis frequency approaching the critical frequency. Also, with the negative relative vorticity low enough, significant energy transfer associated with PSI can occur at 31°N (poleward of the critical latitude for M2) which is never expected before. The presented results provide important implications on understanding the spatial distribution of diapycnal mixing in the ocean where geostrophic currents prevail.

P-P3-07 Numerical Study of Atmospheric Turbulence over Ocean Waves

Zixuan Yang, St. Anthony Falls Laboratory & Department of Mechanical Engineering, University of Minnesota, USA State Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Science, China
Tao Cao, St. Anthony Falls Laboratory & Department of Mechanical Engineering, University of Minnesota, USA
Xuanting Hao, St. Anthony Falls Laboratory & Department of Mechanical Engineering, University of Minnesota, USA
Lian Shen, St. Anthony Falls Laboratory & Department of Mechanical Engineering, University of Minnesota, USA
Presenter Email: yangzx@imech.ac.cn

The dynamics of marine atmospheric turbulence is significantly influenced by surface gravity waves. In this study, we investigate the wave effect on wind turbulence in the marine atmospheric boundary layer. In the problem setup, we simulate turbulent air flows over both broadband and monochromatic waves. For the broadband wave fields, we have identified distinct wave signatures in the space-time correlation of wind turbulence by examining the full frequency-wavenumber spectrum; for a monochromatic wave prorogating opposing wind direction, we have observed that the wave coherent structure is characterized by large in-phase wave-induced pressure, which is nearly symmetric with respect to the surface wave crest. It is further found that this in-phase pressure wave fluctuation agrees with the inviscid theory well, indicating a self-similar behavior in the outer region. We also study the wind turbulence over breaking waves. We focus on the effects of wave breaking on the turbulence statistics and structures. We report a high pressure ahead of the wave crest during wave breaking. This finding provides an explanation to why the air flow is not able to see the wave trough during wave breaking, which was believed to be an important factor contributing to the saturation of drag

coefficient at high wind speeds, such as in hurricanes. Through the comparison of turbulence statistics at different stages of wave breaking, we discover a magnitude increase of kinetic energy of velocity fluctuations during wave plunging at small and large wave ages, which is attributed to the enhancement of turbulence motion and wave-coherent motion, respectively. However, at an intermediate wave age, such a transient growth of kinetic energy is not observed, which is explained as the absence of significant enhancement of either turbulence motion or wave-coherent motion. This discovery indicates that the wave age needs to be considered in the parametrization of marine atmospheric boundary layer flow with breaking waves.

P-P3-08-S The Turbulent Vertical Kinetic Energy under Tropical Cyclone

Zhihua Zheng, School of Oceanography, University of Washington, Seattle, Washington, USA; Applied Physics Laboratory, University of Washington, Seattle, Washington, USA.
Ramsey Harcourt, Applied Physics Laboratory, University of Washington, Seattle, Washington, USA
Eric D’Asaro, School of Oceanography, University of Washington, Seattle, Washington, USA; Applied Physics Laboratory, University of Washington, Seattle, Washington,USA
Presenter Email: zhihua@uw.edu

The turbulent vertical kinetic energy in the Ocean Surface Boundary Layer (OSBL) is an important property of the turbulence, indicating the vertical mixing strength in the upper ocean. With the growing effort in field observation using Lagrangian float, we have made some progress in understanding its strength and dynamical evolution, while the prediction of it in boundary layer models is still not quite satisfactory. One significant issue in these models is the ability to accurately represent the surface wave effect, which includes both surface wave breaking and Craik-Leibovich interaction. Here we examine the behavior of turbulent vertical kinetic energy in an improved Second-Moment Closure (SMC) model, against observational data collected during Hurricane Frances (2004). This model has explicitly included surface wave effect and is forced by NOAA hindcast wind data, incorporating recent progress in refining drag coefficient parameterization. The wave field for this simulation is derived from WaveWatch III output, forced by the same surface forcing. The comparison of turbulent vertical kinetic energy between model prediction and observation shows the improved SMC model is good at capturing the overall enhanced turbulent kinetic energy induced by Craik-Leibovich interaction, but apparent discrepancy still occurs around the surface and the base of the mixed layer, implying lack of consideration for surface wave breaking and misrepresentation of dynamics in entrainment. As informed by this result, we will further explore the path to modify the model through more comparisons with Large Eddy Simulation (LES) solutions.

P-P4-01-S Generation and propagation of M2 internal tides modulated by the Kuroshio northeast of Taiwan

Hang Chang, Institute of Oceanology, Chinese Academy of Sciences
Zhenhua Xu, Institute of Oceanology, Chinese Academy of Sciences
Yang Wang, Institute of Oceanology, Chinese Academy of Sciences
Baoshu Yin, Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: xuzhenhua@qdio.ac.cn

The variability and energetics of M2 internal tides during their generation and propagation through the Kuroshio background field northeast of Taiwan are investigated using a high-resolution numerical model. The corrugated continental slopes, particularly the I-Lan Ridge and Mien-Hua Canyon, are first identified as the energetic sources of M2 internal tides. The domain-integrated M2 barotropic-to-baroclinic conversion rate under the Kuroshio influence is ~2.35 GW, ~0.9 GW of which is generated at the I-Lan Ridge, ~0.93 GW at the Mien-Hua Canyon and ~0.52 GW at the north shelf. The M2 internal tide generation is influenced by horizontally varying, zonally tilting stratification associated with the Kuroshio, and compared with the ideal simulation initiated with horizontal homogeneous stratification, the conversion rate decreased by ~30% at the I-Lan Ridge but increased within ~10 % at the Mien-Hua Canyon and north shelf. Internal tides from multiple sources interfere to form a three-dimensional baroclinic field. The interference by the internal tides from the Mien-Hua Canyon and north shelf is refracted by the Kuroshio and exhibits a mesoscale gyre pattern, which can explain the frequent occurrence of internal solitary waves. An energetic along-slope tidal beam from the I-Lan Ridge radiates southward against the northward Kuroshio flows with strong vertical displacement in the intermediate layer, which favourably compares with recently reported field measurements. The M2 internal tide energy dissipates primarily near the source sites, and the remaining energy radiates outward over limited distances. Various topographic features and background currents enhance the internal tide dissipation, which induces strong, inhomogeneous vertical mixing.

P-P4-02-S SST front anchored mesoscale feature of surface wind in the southern Indian Ocean

Xia Huang, College of Oceanography, Hohai University, Nanjing, China
Xuhua Cheng, College of Oceanography, Hohai University, Nanjing, China
Yiquan Qi, College of Oceanography, Hohai University, Nanjing, China
Presenter Email: h_xiaia12@163.com

Using 28-yr satellite-borne Special Sensor Microwave Imager (SSM/I) observations, features of high-wind frequency (HWF) over the southern Indian Ocean are investigated. Climatology maps show that high winds occur frequently during austral winter, located in the open ocean south of Polar Front in subpolar region, warm flank of the Subantarctic

Front between 55°E-75°E, and south of Cape Agulhas, where westerly wind prevails. The strong instability of marine atmospheric boundary layer (MABL) accompanied by increased sensible and latent heat fluxes on the warmer flank acts to enhance the vertical momentum mixing, thus accelerate the surface winds. Effects of sea surface temperature (SST) front can even reach the entire troposphere by deep convection. HWF also shows distinct interannual variability, which is associated with the Southern Annual Mode (SAM). During positive phase of the SAM, HWF has positive anomalies over the open ocean south of Polar Front, while has negative anomalies north of the SST front. A phase shift of HWF happened around 2001, which is likely related to the reduction of storm tracks and poleward shift of westerly winds in the Southern Hemisphere.

P-P4-03-S Wind-driven SST fronts and its seasonal variability in the southeast Brazil

Huanhuan chen, Yuntao Wang
Presenter Email: chenhh@hhu.edu.cn

Fourteen years (Sep. 2002-Aug. 2016) satellite observations of sea surface temperature (SST) data are used to describe the frontal pattern and frontogenesis in the southeast continental shelf of Brazil. The SST frontal probabilities are obtained from SST observations by using an edge-detection algorithm. High SST frontal probabilities mainly distribute along the coast, decrease with distance from coastline. Results from empirical orthogonal function (EOF) decompositions reveal strong seasonal variability of SST frontal probabilities, with maximum (minimum) in astral summer (winter). Wind plays an important role in driving the SST fronts, high SST frontal probability is accompanied with strong alongshore wind stress and wind stress curl. This is particularly true for summer when the total transport induced by alongshore component of upwelling-favorable winds and wind stress curl reaches annual maximum. The fronts are influenced by multiple factors other than wind forcing, e.g. the orientation of coastline, bottom topography and mender of Brazil Current. As a result, there is slight difference between the seasonality of SST fronts and wind. Large coupling coefficients are found between the crosswind (downwind) SST gradients and wind stress curl (divergence), which indicates the difference of SST at both sides of front can significantly modify the wind pattern. Thus, the analysis between SST fronts and wind leads to a better understanding of the front and frontogenesis off Brazil, and the results can be used to instruct the development of air-sea coupled model at regional level.

P-P4-04 Eddy-induced cross-slope exchange in the northwestern Black Sea

Mengyao Ma, 1st affiliation
Feng zhou,
Presenter Email: mmy@sio.org.cn

Mesoscale eddies are frequently observed ocean processes at the shelf edge of the Black Sea. Remotely sensed high-resolution chlorophyll *a* and altimetry data have been used to investigate the development and migration of the mesoscale eddies in the northwestern Black Sea, along with a 3D circulation model output in this study. More than 15,000 eddies of different signs were identified in 2002–2010, with 53% of them appearing from March to July. During these periods, eddy-induced exchange accounts for 16%–31% of the total cross-slope volume transport at the upper layers shallower than 20 m. About   volume of northwestern-shelf water was renewed by a single mesoscale eddy over the period 5 May to 20 July 2005, which is equivalent to 30.9% of the overall volume of shelf water

P-P4-05-S Dipole eddies in the Mozambique Strait and Ecological implications

Ting Huang, 1
Presenter Email: 1193540879@qq.com

Previous studies on anticyclones in the Mozambique channel have been carried out, but there are few studies on cyclones and dipole eddies.This paper mainly takes the dipole eddies found in the joint voyage between China and Mozambique in 2016 as the research object.In this study, ARMOR3 reanalysis data were used to analyze the characteristics of temperature ,salinity and density of the dipole eddies, and it was found that the anticyclone carried the water with high temperature and low density on the north side of the channel in the process of moving along the east coast of the African continent to the southwest, while the northward flow between dipole eddies would transfer the low-temperature and high-density water from the south side of the channel to the north side.In addition, we also used AVISO's Mesoscale Eddy Trajectory Atlas Product to calculate the occurrence frequency of the dipole eddies in the Mozambique channel, and found that there are about three or four dipole eddies generated in the channel every year, which is basically consistent with the occurrence frequency of the anticyclones.In addition, the southern side of the anticyclone often has a filament of chlorophyll hundreds of kilometers from the shore to the middle of the channel.

P-P4-06-S High-resolution cross-frontal observations in the Taiwan Strait

Zhu Wenjun, Xiamen University, China
Lin Hongyang, Xiamen University, China
Liu Zhiyu, Xiamen University, China
Hu Jianyu, Xiamen University, China
Presenter Email: wjzhu@stu.xmu.edu.cn

Fronts are a prominent feature in the Taiwan Strait. In cold seasons (winter and spring), a sea surface temperature (SST) front is formed as the southward-flowing, cold and fresh China Coastal Current interfaces with the northward-flowing, warm and saline South China Sea Warm Current extension. The hydrography and dynamic processes in this frontal region are explored based on high-resolution in situ measurements (with horizontal resolution of 1~4 km) from two spring cruises (May 2017 and April 2018) and the MODIS satellite SST data. The main results are summarized as follows. Both the satellite SST and in situ salinity data indicate that the China Coastal Current reaches around 25°N in late spring where it sets the southern boundary for this along-strait front. Comparisons of the satellite and in situ data suggest that the MODIS SST data, although sometimes underestimate the observed frontal intensity, are generally able to capture the location of the front. Temperature and salinity gradients appear to have compensating effects on density gradients at both sides of the frontal region, whereas density gradients in the frontal region are strengthened by both temperature and salinity variations. The observed turbulent kinetic energy dissipation rate indicates enhanced turbulence in the surface and bottom boundary layers, but the calculated Richardson number (Ri) tends to suggest that flows were prone to shear instability (Ri < 0.25) east of the front. A comparison of the observed horizontal density gradient and the vertical shear of the horizontal velocity suggests that the thermal wind relation does not hold for the observed flow. Ekman dynamics seemed to be the dominant process in this shallow coastal region, where the surface and the bottom Ekman layers were likely overlapped.

P-P4-07 Impact of Mesoscale Eddies on Chlorophyll Variability off the Coast of Chile

Yuntao Wang, Second Institute of Oceanography
Hao-Ran Zhang, Second Institute of Oceanography
Fei Chai, Second Institute of Oceanography
Yeping Yuan, Ocean College, Zhejiang University
Presenter Email: yuntao.wang@sio.org.cn

The mesoscale eddies off the coast of Chile significantly impact the distribution of local chlorophyll and the development of marine ecosystem. Multiple processes, including eddy trapping, pumping, advection, Ekman-pumping, and submesoscale dynamics, exert their impacts simultaneously on transport of water masses at different distances with respect to the eddy center. The cyclonic (anticyclonic) eddies are generally characterized by upwelling (downwelling) within the eddy, which elevates (depresses) chlorophyll inside the eddy. Outside the eddy periphery, multiple processes are involved simultaneously, but their corresponding influences on chlorophyll are not well identified. In this study, the amplitudes of cyclonic and anticyclonic eddies are distinguished as positive and negative values, respectively. A linear regression method is applied to seek the connection between eddy's amplitude and chlorophyll distribution at different locations w.r.t. the eddy center. The regression slope between eddy amplitude and chlorophyll anomaly is found to be negative in the eddy interior and along the periphery, which gradually changes to positive away from the periphery. The location where the response of chlorophyll to an eddy switches its sign is defined as the transition zone. The location of the transition zone varies with offshore distance and is impacted by topography, such as the presence of islands, which can change the dynamics of eddies. Thus, the distance from eddy center and offshore distance from coast should be taken into consideration when investigating their influences on nutrient transport and chlorophyll distribution.

P-P4-08 Seasonal response of river plume to freshwater discharge in river-dominated ocean margins: a multi-salinity products analysis and inter-regional comparison

Yang Feng, Southern University of Science and Technology NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA
Dimitris Menemenlis, 2. NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA
Huijie Xue, 1. State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Peng Xiu, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Presenter Email: yfeng.ocean.1982@outlook.com

River plume dynamics generated considerable research interests for the past decade due to the important role in coastal ecology, biogeochemistry, shoreline morphology and climate. Remote sensing and numerical models yield synoptic data to understand river plume variability, which are unattainable from cruise observations or moorings. Previous investigators have utilized satellite ocean color or configured regional models in studying the dispersal of river plumes, with focusing on a certain continental shelf. In this study, we used high-resolution satellite sea surface salinity (SSS) observations and a global configured 18-km resolution, eddy permitting model with the river source improvement to investigate seasonal variability of river plumes at three continental shelves, including the Northern Brazilian (NB) Shelf; the Northern Angola (NA) Basin; the Texas-Louisiana (TL) Shelf. A comparison with world ocean data (WOD) base has shown that SMAP SSSA field had smallest RMSE, followed by SMOS and ECCO2. Typical river plume dispersal patterns are all well identified from the three products, including: (1) the eastward transport of the Amazon River Plume in July - November; (2) the southward dispersal of the Congo River plume in February-March; (3) the July - September reversal of the Mississippi River plume. We found that the plume area responded to freshwater discharge differently for these three regions. The response time is about 2-mo for the NB shelf, 1-mo for the NA Basin

and 4-mo for the TL shelf. About 70 -80% variability can be explained by freshwater discharge at the NB shelf and the NA Basin. In contrast, only about 40 - 50% can be explained at the TL shelf. The delay time reflected the lag between maximum river discharge and external forcing, primarily wind and ambient currents. Lower explained variance at TL shelf is because the shelf is wider and located at the mid-latitude, resulting the more bottom advected river plume rather than the surface advected. Our ensemble analysis provided strong support for river plume dynamic theories from idealized and realistic models.

P-P5-01 Interannual Modulations of the 50-day Oscillations in the Celebes Sea: Dynamics and Impact

Xiao Chen, Hohai University
Presenter Email: chenxiao1231@hhu.edu.cn

Abstract Intense 50-day oscillations have been previously observed at the entrance of Celebes Sea and their formation has been suggested to be a result of Rossby wave resonance where the frequency of cyclonic eddy shedding by the intruding Mindanao Current matches that of the gravest Rossby mode of the semi-enclosed Celebes Sea basin. Using the ocean state estimate of 1993-2016 from the Estimating the Circulation and Climate of the Ocean, Phase II (ECCO2), we detected strong interannual modulations in the shedding of cyclonic eddies at the Celebes Sea entrance. Active eddy sheddings occurred during 1993, 2002-03, 2006-10, and 2013-2015. Southward shifting of the wind-driven North Pacific tropical gyre and the concurrent strengthening of the Mindanao Current in these years are found to be inducive for the generation of cyclonic eddies intruding into the Celebes Sea. Modulated by the activity of eddy sheddings, the upper ocean water mass properties in both the Celebes Sea and Makassar Strait exhibit noticeable interannual changes with less saline waters appearing in the 75-175m layer during the active eddy shedding years.

P-P5-02-S Asymmetry of the predictability limit of the warm ENSO phase

Zhaolu Hou, State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 10029, China
Jianping Li, State Key Laboratory of Earth Surface Processes and Resource Ecology, and College of Global Change and Earth System Science, Beijing Normal University, Beijing 100875, China
Ruiqiang Ding, State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 10029, China
Christina Karamperidou, Department of Atmospheric Sciences, University of Hawaii at

Manoa, 2525 Correa Rd, Honolulu, HI 96822, USA
Wansuo Duan, State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 10029, China
Ting Liu, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Hangzhou, China
Jie Feng, School of Meteorology, University of Oklahoma, Norman, Oklahoma, USA
Presenter Email: hzl@lasg.iap.ac.cn

A nonlinear local Lyapunov exponent (NLLE) method based on monthly sea surface temperature data is employed to explore the predictability limit of warm ENSO events. Results using observational data show an asymmetry of the predictability limit between the developing and decaying stages of the warm ENSO phase. To wit, predictability of the developing stage of warm ENSO events is found to approach a limit of 10 months, less than that of the mature and decaying stages. This asymmetrical predictability limit is also found in a long climate model simulation and may explain the asymmetry in operational forecast skill of warm ENSO events. Through exploring the error growth rate as represented by NLLE and the instantaneous error growth rate, it is shown that error growth, especially during the first eight-month lead forecasts, is the primary contributor to the asymmetry of the predictability limit of warm ENSO events.

P-P5-03 Atmospheric fall-out of microplastics: comparison of remote island and coastal urban area

Seung-Kyu Kim, Incheon National University
Su-Hyun Kim, Incheon National University
Presenter Email: skkim@inu.ac.kr

Microplastic pollution is a global environmental issue. Most MP studies have focused on aquatic systems and a few studies have confirmed the presence of MPs in indoor and outdoor air. Although atmospheric transport and fall-out can be important mechanism in the global distribution of MPs, there exists little information on their occurrence and transport in air. We investigated the occurrence and seasonal change of MPs in air. For that, we collected atmospheric fall-out samples (including dry and wet deposition) periodically every two weeks (or one month) throughout one year from April 2017 to May 2018 at two stations. Sampling stations consist of Daecheong Island and Incheon city, representing a remote area and coastal urban area, respectively. Our preliminary results showed the occurrence of various MPs including fiberous, fragmented and spherical MPs. In the present study, we compare atmospheric deposition flux of MPs between two stations, and confirm the atmospheric transport of MPs.

P-P5-04-S Atmospheric trace elements over China Seas: distribution and sources

Junyi Liu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Yayong Liu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Yue Liu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Xiaoshuang Guo, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Caiqing Yan, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Mei Zheng, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Presenter Email: 1701111788@pku.edu.cn

Atmospheric trace elements from offshore China are vulnerable to the continental anthropogenic emissions and transport of Asian Dust. To investigate the characteristics and sources of trace elements (TEs) over the China Sea, we summarized the results from previous studies in recent years. The level, spatial variation, seasonal variation and sources of the atmospheric TEs of Al, Fe, Cu, Zn, Pb, Mn, V, Ni, Cd were characterized over the Bohai Sea (BS), Yellow Sea (YS), East China Sea (ECS) and South China Sea (SCS). EFs were also recalculated based on Al concentration to compare the influence of anthropogenic sources with a unified standard.

Overall, the elemental concentrations were highest over the BS due to the rapid expansion of industrialization in the North China Plain, especially for Zn, Pb and Mn. The SCS showed lowest level of TEs, which was mainly attributed to industrial transformation. Compared with other seasons, low concentrations of TEs were found over all the regions in summer due to the frequently precipitation. In all studied TEs, Cd exhibited the highest EFs among TEs in China Seas, especially in BS. Our results showed that BS is mainly impacted by industrialized sources, while the YS and ECS are more susceptible to ship emissions with higher ratios of V/Ni. This study suggested that the industrial sources around the BS and ship emissions from ECS need to be better controlled.

P-P5-05-S Spatial distribution and impact factors of atmospheric trace elements over the Yellow Sea, East China Sea and Northern Pacific during spring

Yayong Liu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Junyi Liu, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Xiaoshuang Guo, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Caiqing Yan, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Mei Zheng, State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, China
Presenter Email: craes_sp@163.com

High resolution ship-borne measurements of atmospheric trace elements (K, Ca, Fe, Mn, Cu, Zn, Ba, Pb, As, Se, V and Ni) were conducted over the Yellow Sea (YS), East China Sea (ECS) and Northern Pacific (NP) using Xact during spring, 2015. The aim of our work was to investigate the elemental spatial distribution and its impact factors. Overall, the YS region showed higher elemental concentrations compared to ECS and NP. The cruise over the YS were selected to further analyze using dust modeling and air mass back-trajectory calculation. Based on air mass source region and Principal Component Analysis (PCA), the cruise track could be divided into four sections. The Shandong Peninsula transect showed the highest elemental concentrations due to Asian dust transport and local combustion sources. Higher concentrations and fractions of Zn and Mn were investigated from Northwestern China transect, which were mainly impacted by numerous industrialized provinces such as Liaoning, Hebei, Tianjin and Beijing. Higher V/Ni ratios were found from southern China transect, which is mainly attributed to ship emissions along the Yangze River Delta coast. Our results showed that high latitude of YS are particularly impacted by continental pollution while low latitude of YS are more vulnerable to ship emissions. The patterns of elemental concentrations found in this study also provide support for further research of elemental deposition and productivity impact.

P-P5-06-S Contrasting impacts of two types of El Nino on the yield of early rice in Southern China

Runnan Sun, Beijing Normal University
Jianping Li, Beijing Normal University
Juan Feng, Beijing Normal University
Zhaolu Hou, University of Chinese Academy of Sciences
Presenter Email: heavenjazz@163.com

Rice production in Southern China (SC), which amounts to almost one-third of China's total production, has been shown to be closely associated with climate change. This study examines the contrasting effects of the Eastern Pacific (EP) El Niño and the Central Pacific (CP) El Niño on early rice yields in SC during boreal early summer (May–June–July) using composite and correlation analysis, and grid cell early rice yield data covering the period 1982–2006. During EP El Niño events, the early rice yields reduce in southeastern SC but increase in northwestern SC, whereas during CP El Niño events the early rice yields show a moderate increase across the entire SC region. Over nearly half of SC, the impacts of EP and CP El Niño events on early rice yields show significant differences in terms of harvested areas. The potential mechanism leading to the significantly different effects of the two types of El Niño on early rice yield in SC is investigated here. During boreal early summer, CP El Niño significantly decreases rainfall across SC, which favors early rice yields. In contrast, EP El Niño significantly increases rainfall in eastern SC, resulting in unfavorable growing condition for early rice production. Moreover, although temperature does affect early rice yields in SC, the differences in yield between the two types of El Niño events are related mainly to differences in rainfall. Our finding highlights the importance of investigating the impacts of two types of El Niño on crop yields separately with the increase occurring frequency of CP El Niño under the circumstance of global change. Therefore, our study deepens the current understanding of the relationship between global change and food security.

P-P5-07-S Contrasting ocean circulation features associated with two types of La Nina during the seasonal evolution

Wang Yaqi, Beijing Normal University
Feng Juan, Beijing Normal University
Feng Licheng, National marine enviromental forecating center
Li Jianping, Beijing Normal University
Presenter Email: 301029987@qq.com

The ocean circulation features are investigated associated with Eastern Pacific（EP）La Niña and Central Pacific（CP）La Niña during seasonal evolution,by using the monthly sea surface temperature from HadISST，reanalysis data from NCEP/NCAR,and the factor of ocean circulation from SODA during period 1951-2011.For EP La Niña，the max centre of

negative sea surface temperature anomalie（SSTA）occur over the eastern equatorial Pacific ,for CP La Niña,the negative SSTA centre covers the central equatorial pacific and it’s symmetric about the equator,the different of SSTA between eastern and western Pacific is large. Because of SSTA distribution pattern,the CP La Niña are more intensive and persist longer compared to the EP La Niña. The combined effect of equatorial undercurrent and upwelling leads to the upwelling of cold SST,rising of thermocline and change of salt.These make the thermocline shallower, the sea level lower, and the subsurface SST have stronger cold anomaly during CP La Niña.

P-P5-08-S South-Atlantic-forced multidecadal teleconnection to the mid-latitude South Indian Ocean

Jiaqing Xue, Institute of Atmospheric Physics, Chinese Academy of Sciences
Cheng Sun, College of Earth Science, University of Chinese Academy of Sciences
Jianping Li, College of Earth Science, University of Chinese Academy of Sciences
Jiangyu Mao, Institute of Atmospheric Physics, Chinese Academy of Sciences
Presenter Email: 1506425793@qq.com

Sea surface temperature (SST) in the mid-latitude South Indian Ocean (MSIO) exhibits prominent multidecadal fluctuations that have profound climate impacts for regions around the Indian Ocean. Observational analysis suggests these multidecadal fluctuations can be explained by remote forcing from South Atlantic multidecadal variability (SAMV). A suite of Atlantic Pacemaker experiments performs well in reproducing the observed MSIO SST multidecadal variation and its association with the South Atlantic. This trans-basin covariability can be described by an atmospheric bridge mechanism, in which SAMV-related SST warming weakens regional meridional circulation over the South Atlantic, suppressing convection over tropical Africa. The reduced diabatic heating then drives cold atmospheric Kelvin wave that penetrates into the tropical Indian Ocean, leading to an anomalous cyclonic circulation there that weakens the westerlies over the MSIO and subsequently triggers the warming of MSIO. This initial warming is further amplified by local SST-water vapor positive feedback over the MSIO.

P-P5-09-S Impact of the South China Sea Summer Monsoon on the Indian Ocean Dipole

Yazhou Zhang, Beijing Normal University
Jianping Li, Beijing Normal University
Jiaqing Xue, State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG)
Juan Feng, Beijing Normal University
Qiuyun Wang, Beijing Normal University
Yidan Xu, Beijing Normal University

Yuehong Wang, Beijing Normal University
Fei Zheng, State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG)
Presenter Email: 201531490008@mail.bnu.edu.cn

This paper investigates the impact of the South China Sea summer monsoon (SCSSM) on the Indian Ocean Dipole (IOD). The results show that the SCSSM has a significant relationship with the IOD over the boreal summer (June-August, JJA) and fall (September-November, SON). When the SCSSM is strong, more and less precipitation falls over the western North Pacific and Maritime Continent, respectively, and this corresponds with enhanced South China Sea monsoon Hadley circulation (SCSMHC). The precipitation dipole over the western North Pacific and Maritime Continent, as well as the enhanced SCSMHC, lead to intensification of the southeasterly anomalies off Sumatra and Java, which then contribute to the negative sea surface temperature (SST) anomalies in the tropical southeastern Indian Ocean through the positive wind-evaporation-SST and wind-thermocline-SST (Bjerknes) feedbacks. Consequently, a positive IOD develops due to the increased zonal gradient of the tropical Indian Ocean SST anomalies, and vice versa. The SCSSM has a peak correlation with the IOD when the former leads the latter by three months. This implies that a positive IOD can persist from JJA to SON and reach its mature phase within the frame of the positive Bjerknes feedback in SON. In addition, the El Nino-Southern Oscillation (ENSO) has a slight influence on the relationship between the SCSSM and the IOD.

P-P5-10-S Spatial and temporal distribution of global atmospheric energy and its variation trend analysis

Kaiqi Chen, State Key Laboratory of Earth Surface Processes and Resource Ecology, and College of Global Change and Earth System Science, Beijing Normal University, Beijing 100875, China
Jianping Li, State Key Laboratory of Earth Surface Processes and Resource Ecology, and College of Global Change and Earth System Science, Beijing Normal University, Beijing 100875, China
Presenter Email: kyle1023@163.com

Based on the data of NECP reanalysis from 1948 to 2016, this paper makes a statistical analysis of the global atmospheric energy distribution and changes, reveals the fact that climate change affects the spatial and temporal distribution of atmospheric energy, and makes a preliminary discussion on the cause of the spatial and temporal characteristics of energy.It was found that the total energy of the atmosphere was gradually decreasing from the equator to the poles.The distribution and variation of internal energy and potential energy are similar to that of total energy, while latent heat and kinetic energy are different.The total energy shows a significant growth characteristic of jump on the

interannual scale. Volcanic eruption will make the total energy of the atmosphere develop towards a negative trend, and the significant areas of energy change are different.At the same time, it is pointed out that the atmospheric energy in the northern and southern hemispheres is converging, and the energy gap between the ocean and the land is widening.In addition, changes in atmospheric energy are likely to be the result of a combination of external compulsion and internal variability, among which the annular mode (NAM/SAM) in the northern and southern hemispheres has a greater influence on energy distribution, and the large-scale mutation of climate modalities in the late 1970s May also be closely related to changes in atmospheric energy.

P-P5-11-S In Search of … Wind

Paul Hartlipp, University of New South Wales
Dr. Angela Maharaj, University of New South Wales
Presenter Email: paul.hartlipp@unsw.edu.au

In Search of cheap, reliable energy sources. This talk will concentrate on searching for potential locations where wind power can be found in the satellite record over the Maritime Continent during the satellite program’s operational lifetime. The investigation will focus on along shore locations and will identify how close to shore the measurements can be trusted. Obviously, it is intended for engineers and policy makers so they can identify regions of high wind energy productivity. It is hoped this information can guide government and business efforts to produce cheap, clean, reliable green energy sources while reducing investment risk.
The talk will continue with the description of a satellite altimetry data-processing system. It will outline issues involved in processing satellite altimetry and how this software system addresses those issues. I will concentrate on the Maritime Continent and discuss special considerations encountered in processing and interpreting results derived from that regional data.
While you may not be interested in the specific topic of energy, the speaker intends for you to get a better appreciation of how satellite altimetry works. From this understanding it is hoped potential new satellite data users can find more applications and more importantly consider its limitations in their roles as decision-makers.

P-C1-01-S Export of terrigenous organic matter from rivers during extreme rain events: fluxes and influencing factors

Jing Qiao, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University
Hongyan Bao, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University
Dekun Huang, Third Institute Of Oceanography,State Oceanic Administration

Dawei Li, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University
Shuh-Ji Kao,
Presenter Email: 651125495@qq.com

The riverine transport of terrestrial particulate organic carbon (POC) is the major link between terrestrial and marine systems, which affects the global carbon cycle. It is predicted that extreme rain events will increase in the future, therefore, understanding the responses of riverine export of terrestrial POC, especially factors controlling the response of river systems to extreme rain event, is essential for projecting the future carbon cycle. Here we quantified the POC sources in a mid-scale river during base flow and extreme rain event by combing bulk properties (elemental composition and stable carbon isotope) and lignin phenols. We found that riverine suspended matter mainly comes from aquatic organism during base flow. During flood, POC in river is mainly from surface soil and C3 plants. The source of riverine suspended matter significantly changes during the transition from the base flow period to the flood period. However, it remains stable with continuous increase in water discharge during the flood period. We further estimated that during the ten - days event the export of POC and particulate lignin was 21% and 31% of their annual flux, respectively. During a period of time (approximately 20 days) after flood, the POC is still dominated by soil sources, and due to the hysteresis effect of flushing, peaks of soil sources occur only after the discharge peak.

P-C1-02-S The distribution of labile organic matter in Pearl River estuary as indicated by amino acid carbon isotopes

Peihong kang, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, 361102, China School of Ocean and Earth Sciences, Xiamen University, Xiamen, Fujian, 361102, China
Han Zhang, Key Laboratory of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen 361021, China;
Yifan Zhu, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, 361102, China School of Ocean and Earth Sciences, Xiamen University, Xiamen, Fujian, 361102, China
Jie Liu, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, 361102, China School of Ocean and Earth Sciences, Xiamen University, Xiamen, Fujian, 361102, China
Biyan He, School of Bioengineering, Jimei University, Xiamen 361021, China;
Qing Li, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, 361102, China School of Ocean and Earth Sciences, Xiamen University, Xiamen, Fujian, 361102, China
Tiantian Tang*, State Key Laboratory of Marine Environmental Science (Xiamen

University), Xiamen, Fujian, 361102, China School of Ocean and Earth Sciences, Xiamen University, Xiamen, Fujian, 361102, China
Presenter Email: kangpeihong@stu.xmu.edu.cn

The production, transportation and decomposition of particulate organic matter (POM) has a profound influence on estuarine carbon cycling. To better understand the behavior of estuarine labile organic matter, stable carbon isotope patterns of amino acids(δ13CAA) were investigated in particles from surface water collected along a salinity transect in the Pearl River Estuary in the winter of 2016. A varied isotopic difference between amino acids and bulk organic carbon is speculated to result from the changing relative contributions of refractory terrestrial input and algal derived organic matter. During a degradation incubation of Cyanobacterium *Synechococcus* sp. CCMP1334, individual amino acids altered their isotopic signatures in the 30-day decomposition, while the bulk remains little change. This indicates that degradation may be a major cause of the change in δ13CAA of algal derived amino acid , which may partially explain the observed δ13CAA pattern in the estuary.

P-C1-03 Effects of algal bloom on dynamics of dissolved organic matter in the Yangtze Estuary

Penghui Li, Department of Ocean Science and Engineering, Southern University of Science and Technology
Qinghui Huang, School of Environmental Science and Engineering, Tongji University
Ling Chen, School of Environmental Science and Engineering, Tongji University
Chuanlun Zhang, Department of Ocean Science and Engineering, Southern University of Science and Technology
Presenter Email: lipenghui1987@126.com

To investigate the effects of algal bloom on dissolved organic matter (DOM), surface water samples were collected during algal-bloom and non-bloom periods in the Yangtze Estuary and characterized using UV-Vis spectroscopy and fluorescence spectroscopy. The DOC addition were identified during algal-bloom period while there was no apparent increase of chromphoric DOM (CDOM) and fluorescent DOM (FDOM). This indicates that primary production was an important source for DOC, resulting high DOC concentration during algal bloom, and could not contribute significantly to CDOM and FDOM pools in a short period. To further assess the effects of algal-bloom on the dynamics of DOM in the Yangtze Estuary, microbial incubation was conducted for DOM sample collected from algal-bloom and non-bloom periods. The results showed that both CDOM and humic-like FDOM increased after 40-d incubation for algal-bloom samples while CDOM and humic-like FDOM showed decrease or little variation for non-bloom samples. This indicated that there is a time lag between algal bloom and CDOM/FDOM could be produced microbially from DOM released during algal bloom. Collectively, our results showed that algal bloom could

contribute to increase of DOC instantly but CDOM/FDOM over a medium period of time.

P-C1-04-S Spatial changes in phytoplankton community structure in the Taiwan Strait

Weisen Liao, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Jianfang Hu, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Ping'an Peng, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Presenter Email: wilson-no-1@163.com

Biomarkers have been widely used to reconstruct phytoplankton productivity based on the assumption that biomarker concentrations could reflect phytoplankton productivity in the surface seawater. In this study, the concentrations of diols and sterols in the surface sediments of Taiwan Strait were analyzed. Since brassicasterol, dinostanol and C_{30} 1,15-alkyl diol are indicators of diatom, dinoflagellate and eustigmatophyte, respectively, they can be used to reconstruct phytoplankton community structure. The results show high productivity of diatom, dinoflagellate and eustigmatophyte in the upwelling region. The spatial patterns of these biomarkers indicated that diatoms are the dominant phytoplankton inside the upwelling region (Fig. 1). High diatom/dinoflagellate ratios also occur in the central of Taiwan Strait and off the Jiulong River mouth, which suggest that terrestrial source provide nutrient for the growth of diatoms. These results are consistent with previous studies using phytoplankton cell and pigments, which provides support for the use of biomarker to reconstruct phytoplankton productivities and community structure in the Taiwan Strait.

P-C1-05-S Impact of typhoon Matmo (2014) on the distribution and sources of sedimentary organic matter in the Quanzhou Bay

Yunpeng Lin, Laboratory for Ocean & Coast Geology, Third Institute of Oceanography, State Oceanic Administration, Xiamen
Yunhai Li, Laboratory for Ocean & Coast Geology, Third Institute of Oceanography, State Oceanic Administration, Xiamen
Presenter Email: linyunpeng@tio.org.cn

Estuaries and coastal areas are direct channels of material transport between land and sea, and are one of the areas with the highest primary productivity of the ocean, where large amounts of terrestrial and marine organic matter settle down. Organic matter is susceptible to a series of complex physical, chemical, and biological processes, including hydrodynamic disturbances, remineralization, decomposition and absorption by organisms during transport, deposition, and burial in these areas. These processes will change the storage and distribution state of organic matter in sediments. The typhoon process, which represents one of the most influential weather-scale atmosphere-sea interactions in marine environments, has a significant influence on the water environment and sedimentary organic matter. Therefore, it is of great significance to explore the impact of typhoon on the distribution and sources of sedimentary organic matter in estuary and coast areas. Based on the grain-size and TOC, TN, δ13C and δ15N data of surface sediment samples collected in Quanzhou Bay under normal and post-typhoon Matmo conditions, we studied the distribution characteristics of sedimentary organic matter (SOM) in Quanzhou Bay, analyzed the sources of SOM, compared the differences between the content and distribution of SOM under both normal and post-typhoon conditions, and determined the influence mode of typhoon Matmo on the distribution and source of SOM. The results showed that the content of TOC and TN in the sediments of Quanzhou Bay decreased from the estuary to the outer bay. Combined with the value of TOC/TN and δ13C, these data indicated that sedimentary organic carbon of Quanzhou Bay had mixed sources of marine and terrestrial material, and was mainly marine sources for whole bay, while terrestrial organic matter mainly distributed in the inner bay. What's more, the outer bay has stronger microbial remineralization than inner bay. The impact of typhoon on SOM in Quanzhou Bay was mainly reflected in the increase of organic matter flux of terrestrial and sea sources, which indicated that the distribution of SOM in Quanzhou Bay was mainly controlled by the organic matter input. Furthermore, the typhoon process may inhibit the biological activities in water and sediment environments, resulting in the weakening remineralization of SOM. This study was significance to understand the source and distribution of SOM in Quanzhou Bay, and provided effective references for comprehensively exploring the impact of typhoon on estuary environment. Keywords: Sedimentary organic matter, Stable isotope, C/N ratio, Typhoon Matmo, Quanzhou Bay

P-C1-06-S Comparison of seasonal biogeochemical characteristics of suspended particulate matter in the continental shelf of the southern East China Sea

Qianqian Liu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, PR China

Lin Wang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, PR China

Huawei Wang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, PR China

Baozhi Lin, State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, PR China

Aiguo Gao, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China

Chen-Tung Arthur Chen, Department of Oceanography, National Sun Yat-sen University, Kaohsiung 80424, Taiwan, R. O. C.

Selvaraj Kandasamy, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, PR China

Presenter Email: liuqq@stu.xmu.edu.cn

The compositions of suspended particulate matter (SPM) in marginal seas often vary with seasons due to hydrographic conditions and other localized processes, such as fresh water input, primary productivity and resuspension. As one of the largest river-dominated marginal seas in the western Pacific region, the East China Sea (ECS) receives large quantities of terrestrial material mainly from the Changjiang, which is seasonally varied. However, the coupling between seasonal hydrographic dynamics and the response of the isotopic composition of particulate organic carbon and nitrogen (δ13C and δ15N) in the ECS are less understood. In this study, we compared the organic carbon and nitrogen (POC and PN) and δ13C and δ15N values of SPM investigated from the continental shelf of the southern ECS in summer and autumn 2013 to characterize their seasonal biogeochemical characteristics and to understand the controlling factors of their spatial distribution. The hydrographic parameters of summer SPM revealed that the ECS shelf water was stratified with a distinct deep chlorophyll maximum layer, and the shelf was weakly influenced by fresh water derived from the Changjiang; while in autumn the ECS shelf water was well-mixed and Taiwan warm current water was much weaker. Investigation on organic compositions indicated the dominance of marine-sourced organic matter in both seasons with molar C/N ratios similar to the Redfield ratio (6.63). In contrast to particulate organic matter (POM) in summer that was dominantly sourced from in situ marine productivity, autumn POM was regulated by the cross-shelf mixing and lateral transportation of particles. To summarize, though the marine-sourced POM dominated in summer and autumn 2013, seasonal hydrodynamic forcing plays an essential role in the spatial distribution of elemental and isotopic values of POM in the southern ECS.

P-C1-07 Spatial and temporal variation of transparent exopolymer particles in a semi-enclosed bay: the Jiaozhou Bay, North China

Shujin Guo, Jiaozhou Bay National Marine Ecosystem Research Station, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, PR China
Xiaoxia Sun, Jiaozhou Bay National Marine Ecosystem Research Station, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, PR China
Mingliang Zhu, Jiaozhou Bay National Marine Ecosystem Research Station, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, PR China
Junhua Liang, Jiaozhou Bay National Marine Ecosystem Research Station, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, PR China
Presenter Email: shujin135@qdio.ac.cn

Transparent exopolymer particles (TEP) contribute to carbon export and can represent a significant part of the carbon pool, most notably in eutrophic systems. This study investigates, for the first time, TEP spatial distribution, seasonal variability and contribution to the carbon pool in a highly productive semi-enclosed bay—the Jiaozhou

Bay, North China. TEP concentrations ranged from 75.24 to 552.60 μg xanthum gum equivalent (Xeq.) L-1 in the Jiaozhou Bay, which was within the range of values reported in other coastal seas around the world. Spatially, high levels of TEP were always observed in the northeastern and northwestern part of the bay during all four seasons, which was consistent with the distribution pattern of nutrients and Chl a concentrations. Significant positive correlations were observed between TEP and Chl a during spring, summer and fall, suggesting that phytoplankton was the primary source of TEP during these three seasons in the Jiaozhou Bay. N/P values were found to have a significant positive correlation with TEP concentrations in spring and summer, indicating that a P limitation would probably accelerate production and/or formation of TEP in these two seasons. TEP concentrations were highest in summer (mean = 275.05 ± 141.74 μg Xeq. L-1), followed by winter (mean = 209.41 ± 54.81 μg Xeq. L-1) and fall (mean = 179.54 ± 49.37 μg Xeq. L-1), and lowest in spring (mean = 141.55 ± 43.31 μg Xeq. L-1). Resuspension of exopolysaccharide-rich particles from sediments contributed to the relatively high TEP levels in winter. TEP carbon (TEP-C) ranged from 56.43 to 414.45 μg C L-1 in this study, constituting for 26.05 ± 7.68 % of the particulate organic carbon (POC) in the Jiaozhou Bay. This study highlights the fact that TEP-C could represent a significant fraction of the POC pool in the Jiaozhou Bay, and will help to make predictions about biogeochemical and economical effects of TEP in this area.

P-C1-08-S Organic carbon transfer across the open and closed estuary systems: a case study of Geum and Seomjin River systems, South Korea

Sujin Kang, Hanyang university
Jung-Hyun Kim, Korea Polar Research Institute (KOPRI)
Daun Kim, Hanyang university
Hyeongseok Song, Korea Basic Science Institute
Jong-Sik Ryu, Korea Basic Science Institute
Kyung-Hoon Shin, Hanyang university
Presenter Email: su1423@hanyang.ac.kr

To understand river damming impact on the transport of riverine carbon, we investigated spatial and temporal variations in organic carbon (OC) concentration and their stable and radio carbon isotope. The surface water samples were collected in two contrasting Korean river systems (Geum and Seomjin) across the river-sea interfaces along a salinity gradient in August and December 2016 to analyse OC concentrations and carbon isotopes. The Geum River flows into the Yellow Sea which has a dam at the river mouth while the Seomjin River flowing into the South Sea of Korea has an open estuary. The riverine total organic carbon (TOC, dissolved OC (DOC) and particulate OC (POC)) fluxes were much larger (4236.9 and 963.1 g/s in August and December, respectively) in the Geum River than those (51.5 and 38.5 g/s in August and December, respectively) in the Seomjin

River. The DOC concentrations in the Geum River showed similar range between August (2.0-3.8 mg/l) and December (1.3-5.3 mg/l), while the POC concentrations in August (0.2-12.7 mg/l) showed much large variation than in December (0.3-2.6 mg/l). In the Seomjin River, the DOC and POC concentrations were 1.9-2.4 mg/l and 0.8-1.0 mg/l for August and 1.1-1.5 mg/l and 0.3-0.5 mg/l for December, respectively. The DOC and POC concentrations showed decreasing trends from river to sea in the Geum River. In the Geum River, the δ13CPOC values were -21.1+/-2.5 ? before the dam and -22.4+/-1.5 ? after the dam in August, while they were -30.61+/-2.7? before the dam and -27.17+/-2.4 ? after the dam in December. We observed a large algal bloom before the dam during the sampling in August, which resulted in heavier δ13CPOC values in the Geum River. In the Seomjin River, the δ13 CPOC values were -29.1 to -21.1 ?in August and -29.0 to -26.6? in December, showing a decreasing contribution of terrestrial organic matter from river to sea. The D14CPOC values in the Geum River were -51.1 ?before the dam and -98.2 ?after the dam in August and -87.0 ?before the dam and -221.8 ?after the dam in December. In the Seomjin River, the D14CPOC values were much lower with -186.7+/-2.2 ? in August and -214.2+/-38 ? in December. Accordingly, our results show that the two contrasting river and sea interface systems differently influence OC sources and transport from river to sea.

P-C1-09-S Carbon isotope behavior of amino acids in sediment

Zixiang Yang, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, China
Peihong Kang, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, China
Jie Liu, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, China
Biyan He, School of Bioengineering, Jimei University, Xiamen, China
Qing Li, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, China
Tiantian Tang, State Key Laboratory of Marine Environmental Science (Xiamen University), Xiamen, Fujian, China
Presenter Email: zixiangyang@stu.xmu.edu.cn

Marine sediment is an important sink of organic carbon in marine biogeochemical cycles. As a novel but powerful tool, compound-specific isotopic analysis of amino acids (CSIA-AA) was applied to trace the origin and fate of organic matter. Stable carbon isotopic values (δ13C) of individual amino acids and bulk organic carbon were analyzed in surface sediments collected along the Pearl River Estuary in the winter of 2016. Primary result shows that the δ13C values of sediment amino acids gradually increased along the studied salinity gradient, implying an origin of sediment amino acids from in situ production of

phytoplankton. Our result indicaets that δ13C values of amino acids is a good tracer to distinguish the origins of labile organic matter in sediments. Moreover, we found that sediment amino acids are more enriched in δ13C than those of bulk sediment organic carbon, but both of them have similar pattern of distribution along the salinity transect. This indicates that organic carbon in the water column may experience a non-selective deposition during the early diagenetic process.

P-C1-10 Spatial variations of extracellular enzyme activity in the East China Sea and the Yellow Sea

Juan Yu, Ocean University of China
Presenter Email: yuetian@ouc.edu.cn

The degradation of organic matter along the water column is mediated by enzymes released into the environment by planktonic organisms. Variations in extracellular enzymes activity reflect the trophic status (quality and quantity of organic matter) of the environment. Horizontal and vertical distribution of nine kinds of extracellular enzyme activities in seawater of 42 stations, one transects C (three stations located in the SYS Cold Water Mass), and one day and/or night continuous observing station MT1 in the Yellow Sea (YS) and the East China Sea (ECS) on the cruises from 12nd July to 1st August in 2013 were investigated to evaluate the distribution and the degradation of organic matter. The mean extracellular enzymes activity in the surface water differed, the ranking of them with largest to smallest: alkaline phosphatase (APA), aminopeptidase (AMP), lipase (LIP), cellulase (CEL), chitinase (CHI), d-D-glucosidase (AGLU), d-D-glucosidase (BGLU), d-D-galactosidase (BGAL), xylosidase (XYL). The vertical activity profiles of transact C showed that APA, AMP, LIP, BGLU and AGLU reached the highest values in 10-20 m water, whereas CEL and XYL showed higher activities in surface water than the bottom water. Significant differences in enzyme activity between different parts of the studied area were demonstrated, with higher values in the seawater zone and lower values in the freshwater zone, which were influenced by Yangtze Diluted Water. These results were helpful to understand the biogeochemical cycle of organic carbon and the trophic status of the East China Sea and the Yellow Sea.

P-C1-11 Origin and dynamics of dissolved organic matter in a mariculture area suffering from summertime hypoxia and acidification

Yong ZHANG, Institute of Marine Science and Technology, Shandong University
Xuelu GAO, Yantai Institute of Coastal Zone Research, CAS
Weidong GUO, Xiamen University
Jianmin ZHAO, Yantai Institute of Coastal Zone Research, CAS
Yanfang LI, Yantai Institute of Coastal Zone Research,CAS
Presenter Email: zhangyong6111@163.com

Based on six cruises from March to September in 2016, we investigated monthly distributions of dissolved organic matter (DOM) and ancillary water chemistry parameters in a mariculture area in the Northern Yellow Sea, where summertime hypoxia and seawater acidification were observed. The most severe oxygen depletion (hypoxia covered approximately one third of the aquaculture area) and the largest pH decrease (8.07 +/- 0.05 in surface layer vs. 7.66 +/- 0.07 in bottom layer) were revealed in August. Concentration of dissolved organic carbon (DOC) and the absorption properties of chromophoric DOM (CDOM) were used to characterize DOM. Results showed that DOM was mainly originated from marine in situ processes. In March, a DOM pool with the lowest DOC concentration of 211 +/- 23 umol L-1 and nearly uniform optical characteristics were presented in the well-mixed water column. In August, however, DOC increased to 361 +/- 29 umol L-1 in the surface layer and 342 +/- 25 umol L-1 in the bottom layer. Two nonlinear relationships between the absorption coefficient at 355 nm (aCDOM(355)) and the absorption spectral slope over 275-295nm (S275-295) were revealed. According to modelling results, the nonlinear relationships were mostly caused by the conservative mixing of a refractory CDOM pool with a freshly-produced CDOM pool. Apparent oxygen utilization in August was positively related to DOC but not to aCDOM(355) and S275-295, presumably due to multiple sources of CDOM in bottom waters. Both aCDOM(355) and S275-295 respond largely to decreasing pH, however, they would be less affected by ocean acidification since this process leads to a limited pH decline.

P-C1-12-S Study on GDGTs in Sediments of Jiulong River Estuary

Zhangyu Cheng, State Key Laboratory of Marine Environmental Science(Xiamen University)
Fengling Yu, State Key Laboratory of Marine Environmental Science(Xiamen University)
Xiaoyan Ruan, State Key Laboratory of Biogeology and Environmental Geology(China University of Geosciences)
Presenter Email: zy3896966@126.com

Estuary as a confluence of the land and ocean, river systems has transported large amount terrigenous organic matter into the estuary, joining the global carbon cycle system. At the meantime, due to the obvious salinity gradient and complex hydrodynamic conditions, estuary has become the hot spot of global carbon circulation research. Despite the terrigenous organic matter, the sources of organic matter in estuarine sediments include marine aquatic organisms, higher plants,bacteria, fungi and other microorganisms, as well as modern human activities. It is important to understand the compositions of the different-originated organic matter in the estuarine sediments and before estimating the carbon burial/flux of the estuary system. Nowadays,GDGTs has been widely used in tracing the sources of organic matters due to its stability and high sensitivity. Recently, there have been some studies on GDGTs'behavior in the estuary and coastal areas and its environmental impact,but because of the complexity of the estuarine environment,there are still many problems remain to be solved, such as: 1) Sources of different types of GDGTs are still rarely discussed, while this issue is crucial for determining the provenance of organic matter; 2) How does the complexity of estuarine environment affect the preservation of GDGTs? To sum up, the question is: what is the main controlling mechanism of GDGTs distribution and behavior in estuary sediments? Jiulong River as an important freshwater river in southern Fujian, scientists have already researched on its physical and chemical characteristics from river basin to the estuary for many years. Such researches provide a rich environmental background information for understanding the system, which will help understand the characteristics of the GDGTs in the system. To combine the scientific problems with the feature of Jiulong River estuary area, the research goal of this study is taking Jiulong River estuary as an example to analyse the behavior of GDGTs, and to explore its main mechanism in the estuarine system. In addition to the GDGTs, sedimentary n-alkanes have also been analyzed for comparison. The results of this study will be of great scientific significance for better applying GDGTs to the studies on sources of estuarine organic matter.

P-C2-01 Exploring impact of seasonal nutrient influx on sedimentary organic carbon and its relationship with a benthic foraminifera genus in a shallow tropical coastal lagoon

Punyasloke Bhadury, Department of Biological Sciences and Centre for Climate and Environmental Studies, Indian Institute of Science Education and Research Kolkata, Mohanpur-741246, Nadia, West Bengal, India.
Areen Sen, Department of Biological Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur-741246, Nadia, West Bengal, India.
Presenter Email: pbhadury@gmail.com

Nutrient loading from land masses can affect coastal lagoons located at the land-ocean boundary. This type of ecosystem is particularly vulnerable to nutrient enrichment and associated changes in environmental condition due to its limited marine connection and longer water residence time. Benthic foraminifera are widely used as proxy for tracking nutrient enrichment as organic carbon produced in the water column is sequestered through sediment compartment. In the present study, seasonal nutrient loading in a shallow tropical coastal lagoon and its contribution to the generation of sedimentary organic carbon (Corg) was investigated. Moreover, the relationship between Corg and dominant benthic foraminiferal genus Ammonia has been also investigated. Concentrations of dissolved nutrients were measured from water in Chilika, Asia's largest coastal lagoon along with sedimentary organic carbon which was characterized by estimating ratio between stable isotopes of carbon ($\delta 13C$) across twelve months. Ammonia population was also enumerated from the surface of sediment column. The investigation revealed that

concentration of dissolved nitrate was extremely high along with increased values of sedimentary organic carbon. The δ13C measurement from sedimentary carbon revealed it to largely autochthonous in nature and thus supported the idea of nutrient driven increased primary production. Moreover, assemblages of Ammonia spp. also displayed significant correlation with sedimentary organic carbon.

P-C2-02-S Nutrient biogeochemistry in the Cross River estuary system and adjacent Gulf of Guinea, South East Nigeria (West Africa)

Solomon Felix Dan, Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 26610, China
Su-Mei Liu, Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 26610, China
Enobong Charles Udoh, State Key Laboratory of Marine Geology, College of Ocean and Earth Science, Tongji University, Shanghai 200092, China
Shuai Ding, Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 26610, China
Presenter Email: solomon.dan86@yahoo.com

The Cross River, Calabar River, and Great Kwa River together form a network of an estuary system otherwise known as the Cross River estuary system. Studies of nutrients and water mass dynamics was conducted in February 2017. Nutrients measured included NO3-, NO2-, NH4+, dissolved inorganic phosphate (DIP), total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), dissolved organic nitrogen (DON), dissolved organic phosphorus (DOP) and dissolved silicate (DSi). The rivers were enriched with DSi and depleted in DIP. Dissolved nutrients were elevated in the Great Kwa River than Cross River and Calabar River. The levels of DSi and DIN were less than average global concentration and that of eutrophic tropical systems. DON represented 68% and 84% of TDN in the Calabar River, and Cross River, respectively. DOP also accounted for ~75% and 67% of TDP in the Calabar River and Cross River, respectively. DIN and DIP occupied 76% of TDN and 56% of TDP in the Great Kwa River. Based on nutrient molar ratios, primary production was strongly limited by DIP, while DIN was potentially limiting. Nutrients in the Cross River estuary system behaved both conservatively and nonconservatively and were affected by biogeochemical and physical processes. Preliminary estimate of nutrient budgets using the LOICZ steady-state box model demonstrated that riverine input was the primary source of nutrients to the estuary system. Nutrient input from atmospheric deposition was very limited. The total residence time of water in the estuary system was ~25 day and may have affected biotic processes and nutrient transport to the adjacent shelf. Nonconservative fluxes of dissolved nutrients resulted in the transport of DIP, DOP, DIN, DON, and DSi to the adjacent shelf. The ecosystem metabolism indicated that the Cross River estuary system is heterotrophic and slowly fixing nitrogen more than it is

denitrifying during the study period

P-C2-03 Missing Carbon from mangroves

Manab Kumar Dutta, Postdoctoral Fellow, State Key Laboratory of Marine Environmental Science, Xiamen university, Xiang'an campus, China
Minhan Dai, Professor, State Key Laboratory of Marine Environmental Science, Xiamen university, Xiang'an campus, China
Presenter Email: manab@xmu.edu.cn

Mangroves, a prominent feature of many tropical and subtropical estuaries play potentially significant role in the carbon budget of the tropical coastal zone. It is the most productive ecosystem (storage ~15 Pg C as live biomass and in soil) after tropical peatland (storage ~ 88.6 Pg C) having faster carbon sequestration rate (174 g C m-2 yr-1) compared to other coastal habitats. Although via litter fall significant influx of mangrove derived carbon to intertidal mangrove sediment is well documented but its subsequent fate is still a matter of debate. Sediment carbon accumulation rate coupled with mineralization and its subsequent CO2 efflux across sediment-atmosphere interface are not sufficient to balance total mangrove derived carbon influx, confirming researchers about some alternative pathway for carbon sink from the ecosystem. The alternative pathway is carbon export from mangroves to adjoining aquatic system. Although very recently scientists are paying large attention on this topic, but to our knowledge best no reports are available from any Chinese mangrove system and more specifically anthropogenically influenced mangrove system. To accomplish the gap, we have selected Zhangjiang mangrove system, Fujian province, China as our study point. Presence of natural mangroves coupled with anthropogenic inputs through aquaculture and domestic sewage make the ecosystem highly complicated compared to other natural mangrove systems worldwide. Combining published reports by several researchers on the given system, primary signal for carbon export from this anthropogenically influenced mangrove system is also evident based on low sediment carbon concentration and low CO2 emission from sediment-atmosphere interface, despite of having similar carbon content of mangrove leaf compared to other tropical mangroves. Some baseline data from the above mentioned Chinese mangrove system will also be presented in the seminar.

P-C2-04-S Distribution and Behaviour of Nutrients in Kelantan River Estuary during Different Monsoon Seasons

Md Nasir, Fatin Adlina, Institute of Oceanography and Environment, Universiti Malaysia Terengganu
Suratman, Suhaimi, Institute of Oceanography and Environment, Universiti Malaysia Terengganu
Dung Le Quang, Institute of Oceanography and Environment, Universiti Malaysia

Terengganu
Presenter Email: eyna_nasir@yahoo.com

Nutrients input to estuarine has increased significantly globally in tandem with anthropogenic activities, which correspond to the rising of human populations and leads to eutrophication. Eutrophication is major water pollution, which can alter food webs and causes loss of submerged aquatic vegetation. Thus, this study was designed to determine the distributions and behaviour of nutrients in Kelantan River Estuary area (southern water of South China Sea) during different monsoon seasons. Surface and bottom water samples were collected using "Van Dorn Sampler" along the salinity gradient and the nutrients concentration analysed colorimetrically. Nutrient such as nitrate, nitrite, ammonia, and phosphate are determined to be critical indicator of water quality in this estuary. This study shows all nutrients behaved in a non-conservative manner in the study area during all monsoon seasons. Highest concentration of inorganic nutrients was observed during monsoon seasons. This may happened, due to the input from strong seasonal land runoff. In addition, there were also strong water turbulence, which resulted in resuspension of nutrients in bottom sediment and lead to the increase of nutrients in the surface water. The results from this study highlighted the importance in understanding the nutrient compounds behaviour for future protection of the estuary. Keywords: Nutrients, distribution, behaviour, Kelantan River Estuary

P-C2-05-S The impact of bioturbating crabs on salt marshes carbon flux.

Laura Elisabeth Agusto, The Swire institute of Marine Science, The University of Hong Kong/ School of Biological Sciences, The University of Hong Kong
Benoit Thibodeau, The Swire institute of Marine Science, The University of Hong Kong/ Department of Earth Sciences, The University of Hong Kong
Jianwu Tang, The Ecosystems Center, Marine Biological Laboratory, The University of Chicago
Faming Wang, The Ecosystems Center, Marine Biological Laboratory, The University of Chicago
Stefano Cannicci, The Swire institute of Marine Science, The University of Hong Kong/ School of Biological Sciences, The University of Hong Kong
Presenter Email: cannicci@hku.hk

The effects of bioturbating crabs and related microbial activities within salt marshes, makes it complex to understand the carbon processes and measure the gas fluxes in these coastal ecosystems Gas flux measurements in intertidal salt marshes are generally taken on an undisturbed patch of sediment, void of any animal activity. However, this sampling methodology does not take into account the potential contribution of burrowing crabs, which can reach high densities and proved to be a critical ecosystem component of coastal wetlands. Each burrow is connected to the surface and increases the sediment-air

interface, adding another dimension to that hidden world underneath the vegetated areas. An additional and reactive interface area which mediates gas exchange and may complicate measurements. Intertidal marshes store significant amounts of coastal 'blue carbon' through carbon sequestration thus playing a crucial role in mitigating global climate change. It is therefore imperative to take crab burrows into account to accurately assess carbon fluxes within wetlands, thus to avoid overlooking the potential flux linked to their faunal component. Here, we present preliminary data collected in a natural salt marsh located at the outlet of the Herring River in Wellfleet, Cape Cod, Massachusetts, US during the summer of 2018. We used an LGR (LGR Corp, CA, USA) ultraportable CO2, CH4 and H2O Analyzer to measure out flux of greenhouse gases from the salt marsh with and without presence of crab burrows. We discuss the importance of crab burrows as an untended factor within carbon stock calculations. We thus propose a new conceptual approach to assess carbon fluxes within intertidal marshes, not overlooking important bioturbators.

P-C2-06-S Benthic respiration exacerbates hypoxia in coastal seas: New insights derived from 224Ra-228Th disequilibrium

Xiangming Shi, Xiamen University
Presenter Email: kidsxm@stu.xmu.edu.cn

Hypoxia in coastal seas is a worldwide environmental issue and oxygen consumption through sediment organic degradation or microbial remineralization was proposed to be one of the drivers. In this study, benthic oxygen exchange across the sediment-water interface was investigated in two China hypoxia areas, the Pearl River Estuary and the inner shelf of the East China Sea adjacent to the Yangtze River Estuary, by utilization of 224Ra-228Th disequilibrium in sediments. The benthic dissolved oxygen consumption rates are 1~2 orders of magnitude higher than the values computed based on the traditional molecular diffusion method. In the Pearl River estuary, benthic oxygen flux ranged from 240 to 1400 mmol m-2 d-1, and exhibited a seaward decreasing trend. In comparison, the inner shelf of the East China Sea had a lower rate of 8 ~ 30 mmol m-2 d-1. In combination with the DO mass balance in the bottom water and the residence time estimated from 224Ra, benthic respiration could account for up to 30% of the total loss of O2. Moreover, the extension of residence time induced by the change of physical circumstances, e.g. seasonal intense stratification, would highlight the benthic impact, and further aggravate the oxygen consumption of bottom water.

P-C2-07-S Using 224Ra/228Th disequilibrium to illuminate the seasonal and tidal variations of solute transfer across mangrove sediment-water interface and internal cycles

Xueying Shi, Xiamen University, China
Pinghe Cai, Xiamen University, China
Presenter Email: shixueying@stu.xmu.edu.cn

Mangroves are gradually being regard as an important player in coastal biogeochemical and hydrological cycles with their complex belowground structures (i.e., crab burrows) and various biota species in sediments. The former facilitate pore water exchange and submarine groundwater discharge, meanwhile the latter make biochemical properties of mangrove sediments different from other coasts. Spatial and seasonal variability of sedimentary salinity, DIC, nutrients and trace metals concentration were investigated in a tidal cross section of mangrove sediments with four seasons. Exchange and circulation of solute transfer across the sediment-water interface has been recognized as a significant process, the 224Ra/228Th disequilibrium was recently observed in coastal muddy sediments which has been proven to be an excellent proxy for tracing the benthic processes that regulate these solute and calculating their fluxes when they transfer across the interface. Fluxes of dissolved inorganic carbon (DIC) gradually increase from autumn(1.58±162.81 mmol/m2/d), winter(328.77±774.46 mmol/m2/d) to spring(1707.68±773.70 mmol/m2/d) and then decrease in summer(85.14±263.88 mmol/m2/d). But if upscale to the whole area of the Zhangjiangkou mangrove in a whole year, mangrove sediments still provide DIC to surroundings(4.57x109±2.45x109 mol/y)as a source. Irrigation is a major process that controls solute transfer across the sediment-water interface as we have known, whereas bioturbation is also a significant factor while solute cross the interface in mangrove sediments. However, we not only observe the deficit of 224Ra from 228Th, but also discover the balance even excess between 224Ra and 228Th in this study and these phenomena vary with season and tide that illustrate there is an internal exchange and circulation in mangrove sediments. Our data indicate an obvious water cycle that exits in a tidal cross section of sediments with a two or three layers' loop mode.

P-C2-08 Interaction between photochemical and microbial degradation of dissolved organic matter in the Pearl River Estuary

Guisheng Song, School of Marine Science and Technology, Tianjin University
Fangming Yang, School of Marine Science and Technology, Tianjin University
Presenter Email: guisheng.song@tju.edu.cn

The migration and fate of dissolve organic matter (DOM) in estuarine ecosystems have gained more attention, due to the important role of the estuary as the bridge of the land and ocean. Photochemical and microbial processes have long been considered as the key

routes for the transformation and mineralization of DOM in the aquatic ecosystems. However, how the above processes influencing each other is still poorly understood. In this study, the interaction between photo- and bio-degradation of DOM was investigated in surface water in the Pearl River Estuary in south China. Microbial, photochemical and microbial + photochemical experiments were carried out and monitored by direct measurements of dissolve organic carbon (DOC) and the adsorption spectra of chromophoric dissolved organic matter (CDOM). The results demonstrated both the fraction of microbial degradation of DOM and the rate of this pathway in the dark were higher in the mid estuary than those in the upper and lower estuaries. The microbial degradation of CDOM under natural light along the estuary was promoted, whereas that of DOC was inhibited. After one-month microbial consumption in the dark, the photobleaching rate of CDOM was slightly enhanced along the estuary. Differently from CDOM photobleaching, the photodegradation rate of DOC was promoted in the upper estuary, but inhibited in the lower estuary. Furthermore, two broadband shoulders at 300-310 nm and 350-360 nm, respectively, were found for the absorption spectrum of CDOM after microbial and then photochemical degradation in the upper estuary, which meant the formation of carbonyl and aromatic heterocyclic compounds. The shoulders were smaller(absent) for the mid(lower) estuarine sample. This study provides direct evidence that microbial and photochemical degradation of DOM can significantly impact on each other in the estuarine ecosystem. Further studies are needed to explore the mechanisms between the two processes in large scale areas.

P-C2-09-S Estimation of submarine groundwater discharge and associated heavy metal and nutrient fluxes into Bohai bay, China

Qianqian Wang, 1MOE key Laboratory of Groundwater Circulation and Environment Evolution and School of Water Resources and Environment, China University of Geosciences-Beijing, Beijing, China 2State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences-Beijing, Beijing, China 3School of Environmental Science and Engineering and Shenzhen Key Laboratory of Soil and Groundwater Pollution Control, Southern University of Science and Technology, Shenzhen, China

Hailong Li, 2State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences-Beijing, Beijing, China 3School of Environmental Science and Engineering and Shenzhen Key Laboratory of Soil and Groundwater Pollution Control, Southern University of Science and Technology, Shenzhen, China

Yan Zhang, 1MOE key Laboratory of Groundwater Circulation and Environment Evolution and School of Water Resources and Environment, China University of Geosciences-Beijing, Beijing, China 2State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences-Beijing, Beijing, China

Xuejing Wang, 3School of Environmental Science and Engineering and Shenzhen Key Laboratory of Soil and Groundwater Pollution Control, Southern University of Science and Technology, Shenzhen, China
Kai Xiao, 3School of Environmental Science and Engineering and Shenzhen Key Laboratory of Soil and Groundwater Pollution Control, Southern University of Science and Technology, Shenzhen, China
Wenjing Qu, 4Department of Earth Sciences, The University of Hong Kong, Hong Kong, China
Xiaolang Zhang, 4Department of Earth Sciences, The University of Hong Kong, Hong Kong, China 5School of Water Resources and Environment, Hebei GEO University, Shijiazhuang, China
Presenter Email: qqwang@cugb.edu.cn

Bohai Bay, one of the three major bays of the Bohai Sea, is subjected to serious environmental problems. However, submarine groundwater discharge (SGD) and associated nutrient and metal fluxes of the bay are seldom reported. In this study, we presented a mass balance models of the radium isotopes 223Ra and 228Ra considering the radium losses caused by recirculated seawater to estimate the flushing time and SGD in Bohai Bay, in May 2017. Submarine fresh groundwater discharge (SFGD) was estimated based on water and salt mass balance models. The estimated fluxes of nutrients (DIN, DIP and DSi) and heavy metals (Fe, Mn, Zn, Pb, Li, Cr and Cd) from SGD were comparable to or even more than those supplied by the local riverine sources. This results indicate that SGD can act as a significant source of nutrients and metals, and may pose great impacts on marine biogeochemical cycles in Bohai Bay.

Keywords: Submarine groundwater discharge; 223Ra; 228Ra; Nutrient loadings; Metal loadings; Bohai Bay

P-C2-10-S The chemical speciation of particulate manganese in the Arctic ocean and potential implications on scavenging of other trace elements

Yang Xiang, University of California, Santa Cruz
Phoebe J. Lam, University of California, Santa Cruz
Presenter Email: yaxiang@ucsc.edu

The Arctic Ocean is characterized by extremely broad continental shelves, consisting of 53% of its overall area (Jakobsson et al., 2003). Shelf sediments have long been recognized as a source of manganese (Mn) to the ocean (Johnson et al., 1992). We find that the Arctic Ocean has relatively high observed concentrations and fractions of Mn oxides compared to other ocean basins, and this is because of the importance of the broad continental shelves. Particle-reactive trace metals have a very high affinity for Mn oxides, therefore, information about the chemical speciation of different types of Mn oxides, which varies in the adsorption capability, may help understand the total scavenging of particle-

reactive trace elements and their isotopes (TEIs). Here, we present the chemical speciation of particulate manganese derived from synchrotron-based X-ray absorption spectroscopy (XAS) in the upper 250 m from the U.S. GEOTRACES Arctic cruise (GN01) in 2015. An evident basin and shelf difference in the oxidation state of pMn reflects two different pools in the total Mn reservoir: pMn on the Arctic shelf is mostly Mn (II), and XAS spectra indicate that this is predominantly lithogenic material; in contrast, pMn in the basin at halocline depths (~100 - 250 m) is significantly more oxidized, consistent with authigenic Mn (III/IV) oxides. XAS analyses of pMn from both Pacific- and Atlantic-derived halocline waters in the Amerasian Basin show that pMn appears to be biogenic hexagonal birnessite, a highly reactive layer-structure Mn (IV) oxide with hexagonal symmetry. Furthermore, there also seems to be inter-basin variability of pMn speciation in the Arctic Ocean. A higher fraction of reduced Mn, possibly as sorbed Mn (II), is found in the upper water column of the North Pole in the Eurasian Basin when compared to Amerasian Basin stations, suggesting a possible difference in sorption capacity by Mn oxides in the two sub-basins. Further study is necessary to disentangle the Mn cycling in the Arctic Ocean with such intense shelf-basin interactions and quantify scavenging of other TEIs by different types of Mn oxides. We hope to understand the baseline cycling of Mn before climate change fully affects the Arctic.

P-C2-11-S Methane emission from mangrove wetland soils is marginal but can be stimulated significantly by anthropogenic activities

Xiawan Zheng, Department of Earth System Science, Tsinghua University
Jiemin Guo, Department of Botany, University of Wyoming
Weimin Song, Yantai Institute of Coastal Zone Research, Chinese Academy of Science
Jianxiang Feng, School of Life Sciences, Sun Yat-sen University
Guanghui Lin, Department of Earth System Science, Tsinghua University
Presenter Email: zhengxw16@mails.tsinghua.edu.cn

Mangrove wetland soils have been considered as important sources for atmospheric CH4, but the magnitude of CH4 efflux in mangrove wetlands and its relative contribution to climate warming compared to CO2 efflux remains controversial. Our aims were to clarify the magnitude of CH4 efflux in mangroves wetlands, and to evaluate the relative contribution of CH4 efflux over CO2 efflux from mangrove wetland soils to climate warming. In this study, we measured both CH4 and CO2 effluxes from mangrove soils during low or no tide periods at three tidal zones of two mangrove ecosystems in Southeastern China and collected CH4 efflux data from literature for 24 sites of mangrove wetlands worldwide. The CH4 efflux was highly variable among our field sites due to the heterogeneity of mangrove soil environments. On average, undisturbed mangrove sites have very low CH4 efflux rates (ranged from 0.65 to 14.18 μmol m-2 h-1; median 2.57 μmol m-2 h-1), often less than 10% of the global warming potentials (GWP) caused by the

soil CO_2 efflux from the same sites (ranged from 0.94 to 9.50 mmol m-2 h-1; median 3.67 mmol m-2 h-1) even after considering that CH_4 has 28 times more GWP over CO_2. Plant species, study site, tidal position, sampling time, and soil characteristics all had no significant effect on mangrove soil CH_4 efflux. Combining our field measurement results and literature data, we demonstrated that the CH_4 efflux from undisturbed mangrove soils was marginal in comparison with the CO_2 efflux in most cases, but nutrient inputs from anthropogenic activities including nutrient run-off and aquaculture activities significantly increased CH_4 efflux from mangrove soils. Therefore, CH_4 efflux from mangrove wetlands are strongly influenced by anthropogenic activities and future inventories of CH_4 efflux from mangrove wetlands on regional or global scale should consider this phenomenon.

P-C2-12 Chloride Dependency of Cu Transformation in the Presence of Natural Organic Matter at Alkaline pH

Guowei Xing, School of Civil and Environmental Engineering, The University of New South Wales
Christopher J. Miller, School of Civil and Environmental Engineering, The University of New South Wales
A. Ninh Pham, School of Civil and Environmental Engineering, The University of New South Wales
T. David Waite, School of Civil and Environmental Engineering, The University of New South Wales
Presenter Email: xgw0829@hotmail.com; z3214434@unsw.edu.au

In coastal waters, natural organic matter (NOM) and chloride (Cl^-) can significantly influence Cu transformations as a result of the effect of these entities on Cu speciation and associated redox interactions. In this study, the impact of chloride and the well-characterized Suwannee River Fulvic Acid (SRFA) on Cu-transformations was investigated. High chloride concentrations lead to highly-reactive Cu(II) complexes ($CuCl_x^{2-x}$) but more stable Cu(I) complexes ($CuCl_x^{1-x}$) with respect to reaction with all reductants/oxidants in the system. In the absence of O_2, SRFA acted like a hydroquinone in the reduction of Cu(II); in the presence of O_2 additional reactions mediated by superoxide that consumed the SRFA reductant needed to be considered, as well as complexation of Cu(I) by an oxidized SRFA moiety. The presence of chloride promoted H_2O_2 generation by maintaining a higher $[Cu(I)]_{ss}$ in a dynamic steady-state in air-saturated conditions with the $O_2^{\bullet -}$-driven Cu(I) oxidation accounting for the generation of H_2O_2. A conceptual kinetic model was developed which described all the data obtained. The results of this study assist in understanding the transformations of Cu species that are likely to occur under natural water conditions.

P-C2-13-S Sediment nitrogen cycling and removal in tidal freshwater zones of two rivers in south Texas, USA

Xin Xu, The University of Texas Marine Science Institute, USA
Hengchen Wei, The University of Texas Marine Science Institute, USA
Kevan Moffett, Washington State University at Vancouver, USA
James McClelland, The University of Texas Marine Science Institute, USA
Amber Hardison, The University of Texas Marine Science Institute, USA
Presenter Email: xinxu@utexas.edu

Nitrogen is the major limiting nutrient in marine ecosystems, and river-borne sources provide 20-30% of nitrogen input to global oceans. Tidal freshwater zones (TFZs) in the lower reaches of rivers may substantially alter the amount and composition of nitrogen transported from watersheds to estuaries due to longer water residence times (compared to non-tidal river reaches) and associated build-up of organic-rich sediments. We conducted flow-through sediment core incubations from TFZs and upstream riverine sites in the Aransas and Mission rivers in south Texas during multiple seasons and years. We measured net fluxes of different constituents (O2, N2, DIC, NH4+, NO3-) across the sediment-water interface to quantify organic matter decomposition and major nitrogen cycling processes. Our results showed higher respiration and denitrification rates in TFZ sediments than in non-tidal riverine sediments. Average O2 fluxes were -771 +/- 35 umol m-2 hr-1 and -797 +/- 69 umol m-2 hr-1 in summer in the Aransas River TFZ (AR) and the Mission River TFZ (MR), respectively; and -363 +/- 38 umol m-2 hr-1 and -484 +/- 70 umol m-2 hr-1 in winter, with negative values indicating net O2 consumption. Average N2 fluxes were 53 +/- 8 umol m-2 hr-1 (AR) and 22 +/- 5 umol m-2 hr-1 (MR) in summer and 36 +/- 8 umol m-2 hr-1 (AR) and 30 +/- 6 umol m-2 hr-1 (MR) in winter, with positive values indicating net denitrification. Average dissolved inorganic nitrogen (DIN) fluxes were 49 +/- 9 umol m-2 hr-1 (AR) and 106 +/- 9 umol m-2 hr-1 (MR) in summer, and -12 +/- 11 umol m-2 hr-1 (AR) and 22 +/- 6 umol m-2 hr-1 (MR) in winter, with negative values indicating net DIN removal. Within the TFZs, rates of biogeochemical processes varied as a function of sediment physical properties, nutrient loading, and seasonal temperature changes.

P-C2-14 Sanya Bay is a Weak Source of Atmospheric CO2

Junxiao Zhang, South China Sea Marine Survey and Technology Center, SOA
Hui Huang, South China Sea Institue of Oceanography
Presenter Email: 88186497@qq.com

Coral reefs are one of the most complex habitats in the marine environment and support an impressive array of biodiversity. Understanding the mechanisms of Ocean acidification (OA) direct and indirect impact on coral reefs ecosystem is vital to protect them. We conducted a curise in sanya and found, sea surface partial pressures of CO2 (pCO2) range

from 303μatm to 459μatm with the average of 388μatm. The diural variation of pCO2 range from 377μatm to 459μatm with the average of 418μatm. The diurnal variations are mainly controlled by biological activities, especially by the processes of photosynthesis and respiration in the reef ecosystem. Further analyses indicate that the surface seawater in Sanya is a weak source of atmospheric CO2.

P-C2-15 Impacts of watershed hydrologic modification on freshwater drainage and productivity in small estuaries: Example from three small sub-tropical estuaries, SW Florida, USA

Eliot Atekwana, Department of Geological Sciences, 101 Penny Hall, University of Delaware, Newark, DE 19716, USA
Lenore P. Tedesco, The Wetlands Institute, 1075 Stone Harbor Boulevard, Stone Harbor, NJ 08247-1424, USA
Presenter Email: eatekwan@udel.edu

Small estuaries are sensitive to anthropogenic hydrologic alterations of their watersheds, yet such alterations on hydrologic mixing, productivity and carbon cycling are not often assessed. We measured axial variations in physical, chemical and stable oxygen and carbon isotopes of water from three small sub-tropical estuaries in southwest Florida, USA, to assess the effects of variable anthropogenic watershed modification on freshwater drainage, hydrologic mixing and productivity. The Blackwater River estuary is pristine and receives freshwater drainage as sheet flow and groundwater. Anthropogenic alteration of Faka Union's watershed included extensively canalling with focus freshwater discharge to the estuary via a weir. Anthropogenic alteration of the Henderson Creek watershed is from residential and agricultural activities and water is drained by a canalled system and with water from the watershed periodically released into the estuary via a weir. The watershed alterations are such that water the head of Faka Union was severely freshened and that of Henderson Creek was saline compared to head of Blackwater River estuary. The stable oxygen isotope-salinity relationship indicates a two component mixing with identical stable oxygen isotope freshwater endmember for all three estuaries. The dissolved inorganic carbon (DIC) concentrations which were ~50% higher in the head of Faka Union and Henderson Creek than Blackwater River and the DIC concentrations decreased with increase in the stable carbon isotopes of DIC to the estuary mouths. Higher DIC concentrations were concomitant with higher dissolved oxygen (DO) concentrations in the Faka Union indicating photosynthetic driven productivity, while in Henderson Creek, higher DIC concentrations with lower DO concentrations is driven by water column respiration. We conclude that anthropogenic alteration of freshwater drainage pathways into small estuaries result in markedly different salinity regimes, productivity and carbon cycling.

P-C3-01 Recent progress of GEOTRACES activities in the Xiamen University, China

Yihua Cai, State Key Laboratory of Marine Environmental Science, Xiamen University
Kuanbo Zhou, State Key Laboratory of Marine Environmental Science, Xiamen University
Liping Ye, State Key Laboratory of Marine Environmental Science, Xiamen University
Yongming Huang, State Key Laboratory of Marine Environmental Science, Xiamen University
Zhimian Cao, State Key Laboratory of Marine Environmental Science, Xiamen University
Gregory A. Cutter, Department of Ocean, Earth, and Atmospheric Sciences, Old Dominion University
Haili Wang, State Key Laboratory of Marine Environmental Science, Xiamen University
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: yihua_cai@xmu.edu.cn

Trace elements and their isotopes (TEIs) play an important role in regulating the marine ecosystem, global carbon cycle and climate change, and to serve as useful proxies of various oceanographic processes. An ongoing international program on the study of marine biogeochemical cycles of trace elements and their isotopes (GEOTRACES) is implemented to accelerate the scientific research of marine biogeochemistry of TEIs and to generate abundant datasets of TEIs distribution at a global scale for a precise and comprehensive understanding of TEIs behaviors in the ocean. However, the ocean sections in the Western Pacific Ocean and Chinese marginal seas planned by GEOTRACES still remain largely unexploited until now. To be capable of conducting the Western Pacific Ocean GEOTRACES cruises and to contribute to the GEOTRACES program, the scientific team in State Key Laboratory of marine environmental science of Xiamen University works closely with international TEIs geochemists to build the GEOTRACES sampling facility, carry out test cruises, and perform laboratory intercarlibration. We will give an overview on the recent progress of these activities in this talk and also introduce the future plan on the Chinese GEOTRACES cruise.

P-C3-02-S Functions of three predicted genes associated with biosilicification in the diatom *Thalassiosira pseudonana*

Peng-Yu Ji, School of Life Sciences, Xiamen University, Xiamen 361102, China
Shan-Shan Zhuang, School of Life Sciences, Xiamen University, Xiamen 361102, China
Lu Huang, School of Life Sciences, Xiamen University, Xiamen 361102, China
Chang-Ping Chen, School of Life Sciences, Xiamen University, Xiamen 361102, China Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen University, Xiamen 361102, China
Ya-Hui Gao, School of Life Sciences, Xiamen University, Xiamen 361102, China State Key Laboratory of Marine Environment Science, Xiamen University, Xiamen 361102, China
Jun-Rong Liang*, School of Life Sciences, Xiamen University, Xiamen 361102, China Key

Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen University, Xiamen 361102, China Corresponding author: sunljr@xmu.edu.cn
Presenter Email: j1yue1993@gmai.com

Marine diatoms are one of the most successful groups of algae and their photosynthesis in the oceans is known to be an extremely important component of global element cycles. Despite their significant roles in global marine carbon fixation, diatoms are also a major group of siliceous organisms, contributing to the global silicon cycle. Up to now, several proteins or component associated with silica cell wall formation, such as silaffin, cingulin, have been discovered. But the function of a number of proteins associated with silicon metabolism still remains unknown. In the present study, 19 candidate genes without function annotation (named as predicted genes 1-19) were detected to potentially associated with cell wall synthesis based on their genes expressions patterns in transcriptomics and structural characteristics (KXXK domain, RXL domain, signal peptide). Real-time PCR results have verified that genes expression models of these predicted genes 1-19 have a significant relationship with silicon metabolism during synchronization process. Transgenic vectors of P3, P13, P19 were made to verify the roles of these genes in the formation of siliceous cell walls. This study improves our understanding of the biosilicification process and silicon metabolism and provides a brand new view of the peculiarity of diatoms in marine ecosystem. This work was supported by the National Natural Science Foundation of China (Grant No. 41576138 and 41276130). keywords: diatom, *Thalassiosira pseudonana*, biosilicification, Si-related genes

P-C3-03 Effects of iron enrichment on nitrogen cycle near the subsurface chlorophyll maximun in the subtropical North Pacific

Shigenobu Takeda, Graduate School of Fisheries and Environmental Sciences, Nagasaki University
Yuya Fujita, Graduate School of Fisheries and Environmental Sciences, Nagasaki University
Presenter Email: s-takeda@nagasaki-u.ac.jp

Mechanisms sustaining a peak in nitrite concentrations at the base of the euphotic zone (primary nitrite maximum, PNM) have remained uncertain, with available data supporting either bacterial nitrification or nitrite release by phytoplankton. Based on the field observations and on board incubation experiments conducted in the subtropical North Pacific, we tested a hypothesis that iron limitation stimulates nitrite release from phytoplankton cells to the surrounding water near the subsurface chlorophyll maximum (SCM) due to inhibition of nitrite metabolic pathway.
Intensive vertical samplings around the SCM along an east-west transect at 23-24°N in the North Pacific showed that the PNMs were 5–25 m deeper than the nitracline and SCM. The incubation experiments confirmed that the phytoplankton assemblage in the SCM were under iron-limitation. At a station where the PNM was observed near the SCM, the iron

enrichment resulted in an increase in nitrate consumption and a decrease in nitrite accumulation in the incubation bottles. The bottles incubated under a stronger light intensity than that at the SCM layer also showed similar trend in the nutrient dynamics. These results suggest that the excretion of nitrite by phytoplankton under both iron and light limitation is playing an important role for PNM formation. On the other hand, at a station where the SCM was much shallower than the PNM and the nitracline, the observed nitrite excretion by phytoplankton assemblage in the bottles was not significant probably due to the severe nitrogen limitation at the SCM.

P-C3-04-S Dust as a source of Phosphorus for natural and cultured *Trichodesmium*

Siyuan Wang, 1. Interuniversity Institute for Marine Science - Eilat, POB 469, Eilat 88103, Israel 2. The Freddy and Nadine Herman Institute of Earth Sciences, Edmond J Safra Campus, Givat Ram, Hebrew University of Jerusalem, Jerusalem, Israel
Subhajit Basu, 1. Interuniversity Institute for Marine Science - Eilat, POB 469, Eilat 88103, Israel 2. The Freddy and Nadine Herman Institute of Earth Sciences, Edmond J Safra Campus, Givat Ram, Hebrew University of Jerusalem, Jerusalem, Israel
Yeala Shaked, 1. Interuniversity Institute for Marine Science - Eilat, POB 469, Eilat 88103, Israel 2. The Freddy and Nadine Herman Institute of Earth Sciences, Edmond J Safra Campus, Givat Ram, Hebrew University of Jerusalem, Jerusalem, Israel
Presenter Email: 834711819@qq.com

Trichodesmium, a globally important N2-fixing phytoplankton, establishes large blooms in subtropical/tropical ocean waters and sustains other marine microbes by releasing fixed nitrogen and carbon. Phosphorus (P), an essential plant nutrient, is found in short supply in many oceanic ecosystems. Large fluxes of aeolian dust provide the ocean surface with large quantities of P, but the low solubility of dust-P, turns aeolian dust to a rather poor source of bioavailable P. Our study explores the ability of *Trichodesmium* colonies from the Gulf of Aqaba, Red Sea, to utilize dust as a source of P. In response to P-stress, many microorganisms activate the extracellular enzyme Alkaline Phosphatase (AP), which is commonly used as a reporter of the cell's P-nutrition. In this study, we measured AP Activity (APA) of natural and cultured *Trichodesmium* prior to and following dust addition. P-limited *Trichodesmium* IMS101 cultures expressed high APA, which dropped shortly (5hrs) after phosphate addition, indicating that APA is a good probe for the cell's P-stress. Natural colonies from the Gulf of Aqaba were found to be P-limited based on high APA detected in single fresh colony. Desert dust added at a range of concentrations to P-limited cultures or individual natural colony resulted in a drop of APA, suggesting that dust supplied enough P to meet the cell's P-requirements. These data are part of an extensive research examining the adaptations enabling natural *Trichodesmium* colonies to utilize dust as a source of P including sensing, selection, collection and processing of dust and P-

rich particles. Our preliminary findings of efficient utilization of dust-P by *Trichodesmium* may have significant implications on the marine biogeochemical cycles of P, N, and C.

P-C3-05-S Effects of CO2 and light on the diatom *Phaeodactylum tricornutum* under iron-limited conditions

Youting Ye, State Key Laboratory of Marine Environmental Science, Xiamen university, Xiamen, China
Dalin Shi, State Key Laboratory of Marine Environmental Science, Xiamen university, Xiamen, China
Haizheng Hong, State Key Laboratory of Marine Environmental Science, Xiamen university, Xiamen, China
Presenter Email: yyt@stu.xmu.edu.cn

In the contemporary ocean, diatoms are responsible for about 40% of the global oceanic primary production. However, in the high nutrient low chlorophyll (HNLC) regions, the growth of diatoms is often limited by iron (Fe) and/or light that both play an important role in photosynthesis. Previous studies have shown that Fe availability can be affected by light intensity and seawater pH, and also CO2 concentration and light intensity can affect the Fe requirement of diatoms. Hence, the ongoing seawater acidification, as anthropogenic CO2 dissolves into the ocean, coupled with the increasing light intensity, as warming augments water column stratification, will likely lead to significant effects on Fe-limited diatoms in the high altitude regions. In this study, we used *Phaeodactylum tricornutum* as a model organism to examine how Fe-limited diatoms respond to ocean acidification under different light intensities by analyzing transcription and expression of key genes and proteins involved in Fe acquisition, storage and photosynthesis. The preliminary results showed that under low light conditions, high CO2 significantly improved Fe use efficiency, as reflected by the increased ratios of growth rate to Fe quota, and enhanced photosynthesis (e.g., Chla content, Fv/Fm, and PsaC, PsbA and RbcL expression) of P. tricornutum especially under Fe limitation. Further study is in progress to evaluate the effects of acidification on Fe and C uptake rates and key gene transcription under different light and Fe conditions. Overall, our study would provide an insight into the response of diatoms to ocean acidification in light and Fe co-limited environments.

P-C3-06-S Transcriptome analyses of silicon metabolism in the resting cells of marine diatom *Thalassiosira pseudonana*

Shan-Shan Zhuang, School of Life Sciences, Xiamen University, Xiamen 361102, China
Qian-Qian Huang, School of Life Sciences, Xiamen University, Xiamen 361102, China
Peng-Yu Ji, School of Life Sciences, Xiamen University, Xiamen 361102, China
Chang-Ping Chen, School of Life Sciences, Xiamen University, Xiamen 361102, China Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen

University, Xiamen 361102, China
Lin Sun, State Key Laboratory of Marine Environment Science, Xiamen University, Xiamen 361102, China
Ya-Hui Gao, School of Life Sciences, Xiamen University, Xiamen 361102, China State Key Laboratory of Marine Environment Science, Xiamen University, Xiamen 361102, China
Jun-Rong Liang*, School of Life Sciences, Xiamen University, Xiamen 361102, China Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen University, Xiamen 361102, China Corresponding author: sunljr@xmu.edu.cn
Presenter Email: zss133@foxmail.com

Diatom resting stage (including resting cell and resting spore) must be considered as an effective strategy for maintaining diatom populations in marine ecosystems under adverse conditions. One of outstanding characteristics of resting stage cells is producing more heavily silicified frustules, which increasing the sinking rates of the cells to improve the export of the carbon and silicon into the deeper ocean as biological pump. However, the mechanism of biosilicification during resting stage cell formation in diatoms is still unknown. Here, the resting cells of the modern diatom *Thalassiosira pseudonana* were induced under dark and 4 degree centigrade for three months. Cellular response and genes involved in biosilicification during resting cells formation were investigated using transcriptome analysis. A total of 11882 unique genes were identified in six time points (weeks 0, 4, 6, 8, 10, 12) and 4840genes with significant expression levels were selected for further analysis. Especially, the genes related to girdle band (Cingulin W2) and valve formation (Silaffin 4) kept up-regulation in the process of resting cells formation, indicating their roles in heavy silicification. The function analysis in the genes that co-varying in expression with Cingulin W2 and sillafin 4 has revealed the cellular responses associated with silicon metabolism and identified some new specific proteins containing a unique domain. Our findings have provided a new insight into silicon metabolism associated with resting cells formation, which will enhance our understanding of the role of diatom resting cells in biogeochemical cycles of silicon and carbon. This work was supported by the National Natural Science Foundation of China (Grant No. 41576138 and 41276130).
Keywords: diatom, *Thalassiosira pseudonana*, resting cells, biosilicification, silica-forming genes, biogeochemical cycles of silicon and carbon

P-C3-07 Effects of aluminum on the ocean carbon cycle and climate change: the Iron-Aluminum Hypothesis

Linbin Zhou, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Yehui Tan, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Liangmin Huang, South China Sea Institute of Oceanology, Chinese Academy of Sciences,

Guangzhou, China
Claude Fortin, Institut national de la recherche scientifique, Centre Eau Terre Environnement, Quebec, Canada
Peter G.C. Campbell, Institut national de la recherche scientifique, Centre Eau Terre Environnement, Quebec, Canada
Presenter Email: zhoulb@scsio.ac.cn/zhoulinbin2004@163.com
In contrast to substantial studies and established knowledge of aluminum (Al) effects (mainly toxicity) on freshwater organisms and terrestrial plants, and even on human health, only a few studies of Al effects on marine organisms have been reported, and our understanding of the role of Al in marine biogeochemistry is limited. Here we will present our understanding of the effects of Al on marine organisms, especially the beneficial effects of Al on marine phytoplankton growth, and we discuss possible links of Al to the biological pump and the global carbon cycle. We propose a revised Iron (Fe) Hypothesis, i.e., the Fe–Al Hypothesis that introduces the idea that Al as well as Fe play an important role in the glacial-interglacial change in atmospheric CO_2 concentrations and climate change. We propose that Al could not only facilitate Fe utilization, dissolved organic phosphorus utilization and nitrogen fixation by marine phytoplankton, enhancing phytoplankton biomass and carbon fixation in the upper oceans, but also reduce the decomposition and decay of biogenic matter. As a result, Al allows potentially more carbon to be exported and sequestered in the ocean depths through the biological pump. We also propose that Al binds to superoxide to form an Al-superoxide complex, which could catalyze the reduction of Fe(III) to Fe(II) and thus facilitate Fe utilization by marine phytoplankton and other microbes. Further ocean fertilization experiments with Fe and Al are suggested, to clarify the role of Al in the stimulation of phytoplankton growth and carbon sequestration in the ocean depths.

P-C4-01 Seasonal and spatial variations of chloroform, trichloroethylene, tetrachloroethylene, chlorodibromomethane, and bromoform in the Northern Yellow Sea and Bohai Sea

Zhen He, Ocean University of China
Ying Wei, Ocean University of China
Gui-Peng Yang, Ocean University of China
Presenter Email: weiying@stu.ouc.edu.cn
Concentrations of five volatile halocarbons (VHCs), such as chloroform ($CHCl_3$), trichloroethylene (C_2HCl_3), tetrachloroethylene (C_2Cl_4), chlorodibromomethane ($CHBr_2Cl$) and bromoform ($CHBr_3$), in the Northern Yellow Sea (NYS) and Bohai Sea (BS) were determined during spring and autumn 2012. Strong seasonality in VHCs concentrations (except for $CHCl_3$) were observed. $CHCl_3$ concentrations were markedly higher (1.5 fold) to coincide with the higher Chl-*a* concentrations during the spring. While

the elevated concentrations of C_2HCl_3, C_2Cl_4, $CHBr_2Cl$, and $CHBr_3$ were found matching higher inputs of land runoff during autumn. The VHCs distributions evidently decreased along the freshwater plume from the river mouth (such as Yellow and Yalu rivers) to the open sea, indicating that distributions of these gases were significantly influenced by terrestrial input and biological activity. Correlation analyses were conducted to investigate possible controls on the concentrations of these gases. In particular, significant correlation was observed only between $CHBr_2Cl$ and chlorophyll *a* concentrations in the surface seawater during spring, with the tentative conclusion that phytoplankton biomass might not be the main limiting factor of sources of VHCs in the surface sea waters. The sea-to-air fluxes indicated that NYS and BS acted as sources of the gases in the atmosphere during summer and winter.

P-C4-02 Communities, sources and cross-oceanic transport of terrestrial bioaerosols

Xiongfeng Huang, Shuh-ji Gao, Xiamen University
Presenter Email: fhuang@xmu.edu.cn

Bioaerosols are usually defined as airborne particles or large molecules that are either alive, carry living organisms or are released from living organisms, presented in the form of pollen, fungal spores, bacteria, viruses, and so on. Bioaerosls account for large proportions of atmospheric particles, and may potentially influence the hydrological cycle and global climate as ice nuclei and cloud condensation nuclei. The behavior of bioaerosls in various environment is affected by the community, size, shape, and chemical components of atmospheric particles, and meteorological factors. Recently bioaerosols have attracted more and more interest, but large uncertainties exist in identifying communities and sources of a broad coverage of bioaerosols based on traditional cultivation and chemical techniques.

In this study, we will investigate and characterize the budgets, residence time, diversity and sources of cultivable and uncultivable bioaerosls in multiple continental and marine environment by molecular genetic and individual particle techniques on attempts at elucidating their possible effects on climate change.

P-C4-03-S Development of Measurement System for Marine and Atmospheric Isoprene and Dimethyl Sulfide using Curie-Point Pyrolyzer (CPP)

Jianlong Li, Ocean University of China
Sohiko Kameyama, Hokkaido University
Presenter Email: namelongli@126.com

A new analytical method using curie-point pyrolyzer (CPP) and a gas chromatograph-flame ionization detector (GC-FID) system was developed. A suitable adsorbent (Carbopack X) has been applied for the first time on seawater and air samples to analyze biogenic

isoprene and dimethyl sulfide (DMS). Target compounds from seawater samples (isoprene: 630 mL; DMS: 20 mL) and air samples (1 L) are adsorbed into a funnel-shaped glass adsorption tube at room temperature and then desorbed thermally (385 oC) using portable curie-point injector into gas chromatography-flame ionization detector (GC-FID). Good reproducibility (< 3%; < 1%), linearity (r2=0.999; r2=0.997) and low detection limits (0.5 pmol L-1; 0.07 nmol L-1) were obtained for seawater isoprene and DMS, respectively. In addition, this method can also be used for atmospheric isoprene quantitation, and is easier than the previous extraction technique. The CPP method was also applied for in situ seawater analysis in the coast of Zenibako in Hokkaido and Alaska. The results suggest that the CPP method can be used successfully at room temperature in place of the traditionally used cryo-trapping techniques in marine environments to determine dissolved trace isoprene and DMS in seawater.

P-C4-04-S Effect of the multi-phase reaction between organic acids and chloride on ice nucleation of sea spray aerosols

Jing Li, Xiamen University
Jiao Xue, Xiamen University
Bingbing Wang, Xiamen University
Presenter Email: 22320171150781@stu.xmu.edu.cn

Aerosol particles can act as cloud condensation nuclei (CCN) and ice nuclei (IN). It can affect the global radiative budget and lead to the formation of new clouds and modification of the radiative properties of existing clouds. The particles from ocean is the second largest source of worldwide aerosol. Chloride from ocean can react with atmospheric organic acids. For example, aqueous sodium chloride reacts with citric acid to produce sodium citrate and hydrogen chloride. After these reactions, the chemical composition and physical properties of particles will be changed and their ice nucleation efficiency may be affected. Here, we present potential effects of these acid displacements on heterogeneous ice nucleation of inorganic particles reacted with organic acids. Heterogeneous ice nucleation including deposition mode nucleation and immersion freezing on reacted particles will be investigated.

P-C4-06 Nitric oxide (NO) in the Yellow Sea and the Bohai Sea

Chun-Ying Liu, Key Laboratory of Marine Chemistry Theory and Technology, Ocean University of China, Ministry of Education, Qingdao, 266100, China
Ye Tian, College of Chemistry and Chemical Engineering, Ocean University of China, Qingdao, 266100, China
Chao Xue, College of Chemistry and Chemical Engineering, Ocean University of China, Qingdao, 266100, China
Gui-Peng Yang, Key Laboratory of Marine Chemistry Theory and Technology, Ocean

University of China, Ministry of Education, Qingdao, 266100, China
Pei-Feng Li, College of Chemistry and Chemical Engineering, Ocean University of China, Qingdao, 266100, China
Wei-Hua Feng, Key Laboratory of Engineering Oceanography, Second Institute of Oceanography, SOA, Hangzhou, 310012, China
Hermann W. Bange, GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, 24105, Germany
Presenter Email: roseliu@ouc.edu.cn

The distributions and photoproduction of NO were investigated in the Yellow Sea (YS) and the Bohai Sea (BS) in June 2011. NO concentrations ranged from below detection limit to 616 pmol L^{-1} in the surface water and below detection limit to 482 pmol L^{-1} in the bottom, with average values of 186 ± 108 and 174 ± 123 pmol L^{-1} respectively. The horizontal distribution of NO showed higher concentrations in the inshore waters and lower values in the offshore. The vertical distribution presented higher values in the surface and bottom waters. Dissolved nitrite and O_2 concentrations had significant influence on spatial distributions of NO. The diurnal variation of NO was similar to those of light intensity and chlorophyll a. The average sea-to-air flux of NO was 4.5 $\pm 3.6 \times 10^{-16}$ mol cm^{-2} s^{-1} in the study area. The mean photoproduction rates of NO in the YS and the BS were 1.15×10^{-11} and 1.06×10^{-11} mol L^{-1} s^{-1}, respectively. Based on a box model for the NO fluxes of the BS and YS in the mixed layer, the bulk of photoproduced NO was consumed in the box besides the loss of NO by air-sea exchange.

P-C4-07 New Insights into Carbon Export from Sea Ice

Lisa A. Miller, Centre for Ocean Climate Chemistry, Institute of Ocean Sciences, Fisheries and Oceans Canada
Daniela Konig, Department of Environmental Systems Science, ETH Zurich
Patrick Duke, Department of Geography, University of Calgary
Brent G.T. Else, Department of Geography, University of Calgary
Akash Sastry, Ocean Networks Canada
Kyle G. Simpson, Centre for Ocean Climate Chemistry, Institute of Ocean Sciences, Fisheries and Oceans Canada
Svein Vagle, Centre for Ocean Climate Chemistry, Institute of Ocean Sciences, Fisheries and Oceans Canada
Presenter Email: lisa.miller@dfo-mpo.gc.ca

Whereas brine rejection during sea-ice formation is known to contribute to global deepwater formation, evidence for CO_2 sequestration in association with that process has been elusive. A number of field expeditions in the Arctic over the last 15 years, including high temporal resolution observations at a cabled observatory in the Canadian Arctic Archipelago, have provided circumstantial evidence that sea-ice brine export injects CO_2

into the underlying water. Laboratory studies have confirmed this CO_2 export, including more carbon rejection when the ice forms slowly at relatively high temperatures. Our laboratory experiments indicated a potential for brine injection deeper into the water column, when ice is formed more quickly at lower temperatures, but the question remains as to how effective sea-ice brine export is in sequestering CO_2 in deep waters and over what time scales.

P-C4-08 Micro-spectroscopic characterization of particles generated from mesocosm and collected over South China Sea

Bingbing Wang, Xiamen University
Peter A. Alpert, Paul Scherrer Institute
Jiao Xue, Xiamen University
Peihong Kang, Xiamen University
Pablo Corral Arroyo, Paul Scherrer Institute
Jing Dou, ETH
Ulrich K. Krieger, ETH
Swarup China, Pacific Northwest National Laboratory
Markus Ammann, Paul Scherrer Institute
Kunshan Gao, Xiamen University
Presenter Email: Bingbing.Wang@xmu.edu.cn

Aerosol particles are often not a single compound residing the atmosphere, but rather a mixture of e.g. soot, organic and inorganic materials. The marine environment is one major source of atmospheric particles due to the direct emission of sea salts and biogenic/organic matter. A wealth of research in the recent years has been investigated the capability of these mixed organic/inorganic particles to act as cloud condensation and ice nuclei with implications for cloud formation and precipitation. During transport of airborne particles in the atmosphere, chemical and physical aging can alter their physicochemical properties. In turn, freshly emitted and aged particles may pose different environmental and climatic impacts. Here we present micro-spectroscopic characterization of particles collected during cruises over the South China Sea or generated by bubble busting during a mesocosm experiment. Two single particle techniques, scanning transmission X-ray microscopy coupled with near-edge X-ray absorption fine structure spectroscopy (STXM/NEXAFS) and computer-controlled scanning electron microscopy coupled to energy dispersive X-ray analysis (CCSEM/EDX), were applied to hundreds of individual particles to obtain information on the particle elemental composition and spatially resolved mixing state at statistically significant level. The mixing state is a quantitative measure which is the number of particles having a single component or a combination of the components which are soot, organic and inorganic matter. These results will be discussed on cloud formation ability with a particular focus on the ice

nucleation potential of these field and laboratory generated particles.

P-C4-09-S Temporal variations and chemical characteristics of atmospheric aerosol over the South Yellow Sea and the East China Sea

Hui Wang, Ocean University of China
Presenter Email: huiwangll@163.com

The chemical compositions and characteristics of atmospheric aerosol over the South Yellow Sea and the East China Sea were investigated during spring (18 March to 9 April) and autumn (17 October to 5 November) in 2011. The water-soluble constituents (SO42-, NO3-, Cl-, Na+, Mg2+, K+, Ca2+, NH4+ and methanesulfonic acid, MSA) and metal elements (Al, Fe, Pb, Mn, Cu and Zn) were determined in total suspended particulate (TSP) aerosol samples from marine boundary layer. The TSP abundances ranged from 13.3 to 55.3 μg m-3 (average: 24.0 ± 10.3 μg m-3) and from 26.5 to 55.0 μg m-3 (average: 38.0 ± 8.2 μg m-3) during spring and autumn cruises, respectively. Secondary aerosol ions dominated the TSP aerosol composition, contributing 70.9% and 73.3% to the major water-soluble species collected during the two cruises, respectively. Principle component analysis presented the existence of four major sources (anthropogenic, crustal, sea salt and biomass burning) for aerosol species measured over the study oceanic regions. The average concentrations of MSA were 0.052 ± 7.7 and 0.041 ± 0.027 μg m-3 during spring and autumn, respectively, and the relative biogenic sulfur contributed to be 14.1% and 5.1% to the total non-sea-salt sulfate (nss-SO42-), suggesting the major contribution of anthropogenic source to sulfur budget over the study area. The acidic property was discovered in the aerosol samples. The averages of Cl- deficit were 31.1 ± 11.9% and 26.4 ± 11.3% in spring and autumn cruises, respectively, which might be caused by the reactions of sea-salt with acidic species like SO42- and NO3-. In addition, the total concentrations of determined metal species averaged 4.15 ± 1.09 and 4.79 ± 1.27 μg m-3 during the two cruises, respectively, accounting for 17.3% and 12.6% to the total TSP concentrations. In atmospheric aerosols, there was a clear seasonal variation in the dry deposition flux of the chemical components. Among them, the secondary inorganic ions deposition fluxes of NO3-, NH4+ and nss-SO42- were very large, accounting for 74.6% and 81.8% of the total deposition fluxes.

P-C4-10-S Distribution and Biogeochemical Cycling of Dimethylsulfide in the Yellow Sea and the Bohai Sea During Spring

Feng XU, Ocean University of China
Xiao-Yan CAO, Ocean University of China
Presenter Email: xufeng00@foxmail.com

Marine dimethylsulfide (DMS) is the prevailing volatile sulfur compound of the biological sulfur cycle in the ocean, which can indirectly impact Earth's radiation balance by their major oxidation products in the atmosphere, scattering solar radiation, ultimately, inducing the global climate change. In this research, the spatial distributions of three biogenic sulfur compounds, including DMS, dimethylsulfoniopropionate (DMSP) and dimethylsulfoxide (DMSO) were determined in the Yellow Sea (YS) and the Bohai Sea (BS) during April-May 2014. Besides, in situ incubation experiments were emphatically simulated on board at 12 selected stations, to study the production, migration and transformation processes of DMS. The concentrations of chlorophyll a (Chl-a) and DMS were ranged from 0.20 to 5.83 μg L-1 and from 1.08 to 16.45 nmol L-1, with mean values of 1.57 μg L^{-1} and 5.95 nmol L^{-1} respectively. The average concentrations (min-max) of particulate DMSP (DMSPp), dissolved DMSP (DMSPd), particulate DMSO (DMSOp) and dissolved DMSO (DMSOd) were 21.34 (5.06-37.39), 6.03 (1.62-19.81), 14.70 (1.90-47.06) and 17.08 (4.50-44.87) nmol L^{-1}, respectively. The concentrations of DMS and DMSP were significantly correlated with the stocks of Chl-a even under complex hydrographic conditions, presenting a downward trend from the inshore to the offshore. In situ incubation experiments manifested that the average rates (min-max) of DMS gross production and DMSPd degradation were calculated to be 11.67 (7.05-16.27) and 19.62 (13.33-28.23) nmol L^{-1} d^{-1}, which suggested that only approximately half of degraded DMSPd were translated to DMS. The mean rates (min-max) of DMS microbial consumption and photochemical oxidation were 6.15 (2.35-9.36) and 7.15 (2.30-16.93) nmol L^{-1} d^{-1}. The biological production was too insufficient to maintain the internal sink of DMS. Vertical transport input from the underlying water may be another source of DMS in surface seawater. The turnover times of microbial consumption, photochemical oxidation and sea-to-air exchange were determined to be 1.53, 1.16 and 1.42 d^{-1}, respectively, which contributed 31.4%, 31.7% and 36.9% of total DMS removal. Simultaneously, the radiation experiments stated that the photolysis under UVB, UVA and visible light accounted for 23.9%, 71.8% and 4.3% of the total photolysis, respectively. Additionally, the sea-to-air fluxes of DMS were estimated to from 0.24 to 34.11 μmol m^{-2} d^{-1}, with a mean of 8.84 μmol m^{-2} d^{-1} and preliminary calculation of average annual release of DMS from the study area to atmosphere reached 0.0472 Tg S a^{-1}, which indicated that the DMS emission from the YS and the BS to the atmosphere was not negligible given the investigation area proportion of the global ocean area.

P-C4-11-S Heterogeneous ice nucleation and micro-spectroscopic characterization of particles generated from mesocosm

Jiao Xue, Xiamen University, Xiamen, China
Peter Alpert, Paul Scherrer Institute, Villigen, Switzerland
Swarup China, Pacific Northwest National Laboratory, Richland, USA
Peihong Kang, Xiamen University, Xiamen, China
Jing Li, Xiamen University, Xiamen, China
Xin Lin, Xiamen University, Xiamen, China

Xin Liu, Xiamen University, Xiamen, China
Kunshan Gao, Xiamen University, Xiamen, China
Tiantian Tang, Xiamen University, Xiamen, China
Bingbing Wang, Xiamen University, Xiamen, China
Presenter Email: jiaoxue@stu.xmu.edu.cn

Sea spray aerosol (SSA), which is a mixture of organic and inorganic materials such as sea salts and phytoplankton cell exudates, is one of the major contributors to atmospheric particles. These aerosol particles emitted to atmosphere and undergoing atmospheric aging may affect the formation, precipitation and lifetime of clouds. Here, we present heterogeneous ice nucleation and micro-spectroscopic characterization for particles generated by bubble busting during a mesocosm experiment. In this mesocosm experiment, chlorophyll-a (Chl a) concentration during phytoplankton bloom is similar to natural conditions. We observed heterogeneous ice nucleation including deposition mode and immersion freezing on particles using optical microscopy coupled with ice nucleation setup. Ice nucleating particles (INPs) were identified. Two micro-spectroscopic techniques, scanning transmission X-ray microscopy coupled with near-edge X-ray absorption fine structure spectroscopy (STXM/NEXAFS) and computer-controlled scanning electron microscopy coupled to energy dispersive X-ray analysis (CCSEM/EDX), were applied to individual particles to obtain information on the particle elemental composition and spatially resolved mixing state at statistically significant level. We find that SSAs collected from this mesocosm experiment, nucleate ice effectively. These results suggest that SSAs associated with sea salts and organics have the potential to affect the formation of ice crystals in the atmosphere.

P-C4-12-S Water activity and ice nucleation of aqueous droplets consisting marine related compounds

Yao Yao, Xiamen University, Xiamen, China
Bingbing Wang, Xiamen University, Xiamen, China
Presenter Email: oceanyaoyao@stu.xmu.edu.cn

Marine aerosols such as sea spray aerosol emitted from oceans constitute the most globally abundant aerosol type by mass and can serve as ice nuclei. Ice formation can proceed via heterogeneous nucleation and homogeneous nucleation at different atmospheric conditions. Ice nucleation, which has been observed to be a dominant process in deep convective clouds or cirrus, remains a challenge in the atmosphere. Homogeneous nucleation of ice from aqueous droplets depend only on the water activity (aw) of the solution. However, data on aw for supercooled aqueous solutions are scarce. Here, we measure the melting temperature and homogenous ice nucleation for marine related aqueous droplets including methanesulfonic acid, methanesulfonte salt, and other organics. The aw of these aerosol systems will be measured or derived at temperature down to homogeneous ice nucleation limit. Possible heterogeneous ice nucleation of these aerosol systems will also discussed for better understanding on the role of these marine related particles in cloud formation

P-C4-13-S Methane production in the oxygenated water in the marginal seas of China and the potential contribution to the atmosphere

Wang-Wang Ye, Ocean University of China
Gui-Ling Zhang, Ocean University of China
Xiao-Lei Wang, Ocean University of China
Xiao-Hua Zhang, Ocean University of China
Presenter Email: yezikasuo@126.com

Methane (CH4) is an important greenhouse gas and contributes substantially to global warming. Over-saturation of methane with respect to atmospheric equilibrium is ubiquitous in the surface oceans. This is commonly termed Oceanic Methane Paradox because oceanic surface waters are well oxygenated and methanogenic archaea are assumed to be strictly anaerobic. Thus, traditional pathways of methane production are challenged and the basis for this paradox is still controversially discussed. However, the most popular explanation in recent studies is that methane can be formed as the by-product by decomposition of methyl-rich organic matter (such as MPn and DMSP). To better understand the mechanism of surface methane accumulation in the marginal seas of China, we conducted a series of laboratory and onboard experiments to preliminarily explore the paradox. Through DOM-amended incubations, we measured the methane production rates in the coastal waters (Yellow Sea) and open ocean waters (South China Sea). The methane concentration increased 2-3 orders of magnitude when the coastal water was amended with MPn. The results from the 16S rRNA sequencing suggest that vibrionales were the most abundant microbes in the MPn treatments. The vibrionales may play important roles in hydrolyzing phosphonates as a source of phosphorus, but preliminary results show a preference for inorganic phosphorus. In the open ocean, nitrogen-fixing cyanobacteria *Trichodesmium* is predicted to be capable of cleaving the C-P bond. Our onboard incubations confirmed that methane was significantly released by the degradation of MPn when a *Trichodesmium* bloom occurred. Taken together, our study in the marginal seas of China demonstrates a mechanism of aerobic methane production, by which it may be directly linked to global methane fluxes, contributing to the surface ocean methane oversaturation.

P-C4-14-S Coastal Observation of Non-methane Hydrocarbons in the Yellow Sea and East China Sea during Spring: Spatial Variability, Controlling Factors and Environmental Effect

Ying-Cui Wu, Ocean university of China
Hong-Hai Zhang, Ocean university of China

Presenter Email: honghaizhang@ouc.edu.cn

To clearly understand the spatial distribution and sea-to-air flux of non-methane hydrocarbons (NMHCs) and their environmental effects in the coastal seas of China, the concentrations of NMHCs (ethane, ethylene, propane, propylene, i-butane, n-butane, isoprene) were determined in the Yellow Sea and the East China Sea during March-April in 2017. Mean concentrations of oceanic NMHCs were 18.07 (ethane), 67.14 (ethylene), 15.35 (propane), 20.53 (propylene), 6.80 (i-butane), 6.41 (n-butane), and 17.00 pmol L^{-1} (isoprene), respectively. The concentrations of oceanic NMHCs decreased with carbon numbers and the alkenes were generally present in higher concentrations than their saturated homologues. Except isoprene, no clear associations between Chl-*a* and other dissolved NMHCs were found in this cruise. Average atmospheric mixing ratios of individual NMHCs were 4.36 (ethane), 0.92 (ethylene), 3.45 (propane), 0.17 (propylene), 0.21 (i-butane), 0.94 (n-butane), and 0.53 ppbv (isoprene), respectively. Contrary to the seawater NMHCs, the concentrations of alkanes in the atmosphere were higher than those of unsaturated alkenes. Besides, atmospheric concentration of alkenes were higher in daytime than in nighttime, whereas alkanes displayed an opposite trend in the diurnal variation. Emission from ocean′s surface into the atmosphere is considered to be the major loss of NMHCs. Based on the simultaneously measured atmospheric and seawater concentration, the sea-to-air fluxes of NMHCs were estimated to be 34.96 (ethane), 32.65 (propane), 262.54 (ethylene), 74.98 (propylene), 20.41 (i-butane), 17.41 (n-butane) and 54.95 nmol m^{-2} d^{-1} (isoprene), indicating that the coastal and shelf seas of China may be important sources of NMHCs to the atmosphere. For the first effort to estimate the contributions of the individual NMHCs to secondary organic aerosol (SOA) and ozone formation over the study area via SOAP (toluene weighted mass contributions) method and propylene-equivalent (Prop-Equiv) concentration, maximum incremental activity (MIR), respectively. The SOA concentrations formed from ethane, ethylene, propylene, n-butane, and isoprene were 3.2×10^{-4}, 8.1×10^{-4}, 2.8×10^{-4}, 4.0×10^{-4} and 14.7×10^{-4} μg m^{-3}, respectively. The ozone formation potential (OFP) of individual NMHCs was 1.64 (ethane), 10.37 (ethylene), 3.33 (propane), 3.72 (propylene), 0.67 (i-butane), 2.80 (n-butane) and 17.10 (isoprene) μg m^{-3}, respectively. The contributions of alkanes to SOA and OFP were lower than alkenes although alkanes concentrations were higher, with the highest contributor to SOA and ozone formation of isoprene. The results of this study have demonstrated that the control of NMHCs, especially alkenes such as isoprene, should be a focus of future regulatory measures in order to reduce air pollution over the study area.

P-C4-15 Distribution of concentration and stable isotopic composition of N2O in the shelf and slope of the northern South China Sea: Implications for production and emission

Gui-Ling Zhang, Ocean University of China
Su-Mei Liu, Ocean University of China
Karen L. Casciotti, Stanford University
Matthew Forbes, Stanford University
Yan-Yan Ren, Ocean University of China
Wen-Jing Zheng, Ocean University of China
Xue-Ji Gu, Ocean University of China
Presenter Email: guilingzhang@ouc.edu.cn

Oceans are the second most important natural source of the greenhouse gas nitrous oxide (N_2O). The isotopomer signature of N_2O provides a useful tool to differentiate the production and consumption processes of N_2O in the oceans. Here we present the distribution of concentration and stable isotopic composition of dissolved N_2O in the water column of the continental shelf and slope region of the northern South China Sea (SCS) in June 2015. Dissolved N_2O concentrations in surface waters ranged from 6.85 to 9.07 nM with an average of 7.72±0.58 nM (136±10% saturation). Higher N_2O was found at the region influenced by coastal water entrained by eddies. Vertical profiles of dissolved N_2O showed a general increase with depth below the mixed layer and reached a broad peak (23-29 nM) at around 700m coinciding with the nitrate maximum and oxygen minimum. The SP values measured for N_2O ranged between 10.18‰and 18.76‰ (14.17±2.53‰, suggesting that dissolved N_2O in the water column can be produced from both nitrification (ammonium oxidation) and nitrifier denitrification (nitrite reduction). Nitrification dominants in the intermediate water while nitrifier denitrification dominants in the euphotic zone. The measured $\delta^{15}N$-N_2O values (6.28‰-10.29‰, 7.85±1.03‰ indicate that AOA might contribute significantly to the formation of N_2O in the studied region. N_2O yields from nitrification were estimated to be 0.03% and comparable to those observed at the northwestern Pacific. The sea-to-air fluxes of N_2O were estimated to be 7.04±6.10 and 6.94±6.49 μmol m^2 d^{-1} by N2000 and W2014 relationships. N_2O emission from continental shelf and slope region of the northern SCS were estimated to be 0.25 Tg N_2O yr^{-1}, suggesting this area is an active area to produce and emit N_2O to the atmosphere.

P-B1-01-S Marine benthic dinoflagellates Prorocentrum (Dinophyceae) from Rawa Island, Terengganu, Malaysia, with a description of *Prorocentrum malayense* sp. nov.

Zhen Fei Lim, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia
Zhaohe Luo, Third Institute of Oceanography, SOA, Xiamen 361005, China

Li Keat Lee, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia
Kieng Soon Hii, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia
Sing Tung Teng, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia
Leo Lai Chan, State Key Laboratory in Marine Pollution, Department of Biomedical Sciences, City University of Hong Kong, Hong Kong, 999077, China
Bernd Krock, Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany
Haifeng Gu, Third Institute of Oceanography, SOA, Xiamen 361005, China
Chui Pin Leaw, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia
Po Teen Lim, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia
Presenter Email: limzfrc@hotmail.com

Prorocentrum is a genus of harmful microalgal species that exists as both planktic and benthic dinoflagellates. Species of Prorocentrum were distinguished by morphological characteristics including cell shape, pore ornamentation, presence of apical spine, periflagellar ornamentation and platelet arrangement. Some species of Prorocentrum were known to produce okadaic acid (OA) and responsible for diarrhetic shellfish poisoning. In this study, clonal cultures of Prorocentrum were established from Rawa Island, Terengganu, Malaysia. Individual strains were identified through light microscopy, scanning electron microscopy and molecular phylogeny. Cultures identified included P. lima, P. concavum, P. caipirignum, P. cf. emarginatum, P. mexicanum and a new morphotype. The morphotype resembled P. leve in general, but differed by having larger pore size, and a more deeply excavated periflagellar area. Platelet 2 is the most excavated platelet on the left plate and platelet 6 is divided into platelet 6a and 6b. The phylogenetic trees of the nuclear large subunit ribosomal RNA gene and the second internal transcribed spacer (ITS2) depicted the monophyly of the new morphotype and supported the lineage delineation. Pairwise comparison of the ITS2 transcript between the morphotype and P. leve showed the presence of compensatory base changes (CBCs) and hemi-CBCs. As such, the morphotype was considered to represent a new species, and the name, P. malayense sp. nov., was proposed. Furthermore, OA was detected in P. caipirignum (3 pg cell-1) and P. lima (1.6 pg cell-1)and this is the first report of toxigenic P. caipirignum and P. lima from Malaysia. Other Prorocentrum species, however, showed no detectable OA. This study aimed to characterize Prorocentrum species morphologically and molecularly as well as to determine the production of DSP toxins from all the species found.

P-B1-02-S Study on algicidal functional microbes against Prorocentrum donghaiense blooms

Fuxing Zhang, School of Life Sciences, Xiamen University
Qian Ye, School of Life Sciences, Xiamen University
Danyang Zhang, School of Life Sciences, Xiamen University
Xueping Shao, School of Life Sciences, Xiamen University
Yongxiang Fan, School of Life Sciences, Xiamen University
Jiali Gui, School of Life Sciences, Xiamen University
Sisi Zheng, School of Life Sciences, Xiamen University
Yun Tian, School of Life Sciences, Xiamen University
Tianling Zheng, School of Life Sciences, Xiamen University
Hong Xu, School of Life Sciences, Xiamen University
Presenter Email: zhangfx_xmu@163.com

Prorocentrum donghaiense has caused most frequent large-scale blooms at the Yangtze River Estuary and the adjacent East China Sea in recent years, bringing tremendous economic losses and local environments serious impacts. Therefore, it is urgent to search for potent and ecofriendly methods to control Prorocentrum donghaiense blooms. Compared with physical and chemical methods, biological-control is an effective and specific method to control red tide. Decades of studies have reported that algicidal bacteria exert algicidal activity by direct or indirect mode. To find the potential algicidal bacteria and apply them to eliminate the harmful blooms of Prorocentrum donghaiense, in this study, strain SCM-1T, which exhibited high algicidal activity against P. donghaiense, was isolated from coastal surface sediment and identified as the bacterium Sulfitobacter, the algicidal efficiency achieved to 95% after 72 h. To investigate the algicidal mechanism of strain SCM-1T, the different fractions of the SCM-1T cultures, including bacterial cells and cell-free supernatant, were added to the algal cultures at a concentration of 5% (v/v) to assess their algicidal activities. The result showed that the strain SCM-1T was indirectly attacked by secreting algicidal compounds to the supernatant, and the algicidal activity of the SCM-1T supernatant was stable under different temperatures, light intensities and wide pH range (pH 3-12). In addition to showing algicidal activity against P. donghaiense, the supernatant of SCM-1T showed strong algicidal activity against Alexandrium minutum and Scrippsiella trochoidea. To explore the algicidal mechanism of the action of the SCM-1T supernatant, the morphological alteration, chlorophyll a content, photosynthetic activity, and reactive oxygen species (ROS) content of P. donghaiense were investigated. The scanning and transmission electron microscopy showed that the SCM-1T supernatant destroyed the cell membrane structure and the inclusion of algal cell leaked out. The decrease of photosynthetic pigments, photosynthetic efficiency (Fv/Fm) and electron transport rate (rETR) demonstrated the SCM-1T supernatant could inhibit the activity of the photosystem of P. donghaiense. The dichloro-dihydro-fluorescein diacetate (DCFH-DA)

assay showed that the ROS levels in algae treated with the SCM-1T supernatant were 1.33-fold higher than those in control after 2 h treatment. These results indicated that the SCM-1T supernatant induced the production of excessive ROS, damaged cell membrane and destroyed photosynthesis system which caused algal cell death. This research reports the potential of strain SCM-1T to control P. donghaiense blooms.

P-B1-03 Sympatric occurrence of two Azadinium poporum ribotypes in the Eastern Mediterranean Sea

Haifeng Gu, Third Institute of Oceanography, State Oceanic Administration
Zhaohe Luo, Third Institute of Oceanography, State Oceanic Administration
Amalia Venetsanopoulou, Hellenic Center for Marine Research, Institute of Oceanography
Bernd Krock, Alfred Wegener Institute for Polar and Marine Research
Urban Tillmann, Alfred Wegener Institute for Polar and Marine Research
Presenter Email: 952533946@qq.com

The marine dinoflagellate Azadinium poporum produce azaspiracids (AZA) and has been recorded widely in the world. However, information on its biogeography is still limited, especially in view of the fact that A. poporum comprises several genetically differentiated groups. A total of 18 strains of A. poporum were obtained from the Eastern Mediterranean area by incubating surface sediment collected from Ionian Sea of Greece. The morphology of these strains was examined with light microscopy and scanning electron microscopy. Small subunit ribosomal DNA (SSU rDNA), large subunit ribosomal DNA (LSU rDNA) and internal transcribed spacer (ITS) sequences were obtained from all cultured strains. Molecular phylogeny based on concatenated SSU, LSU and ITS sequences confirmed three ribotypes within A. poporum and revealed two subclades within ribotypes A and C. Greek strains of A. poporum ribotype A were nested within ribotype A2 together with strains from Western Mediterranean Sea and French Atlantic, and Greek strains of A. poporum ribotype C were nested within ribotype C2 together with a strain from the Gulf of Mexico. Growth experiments on four selected strains revealed that ribotypes A and C from Greece differed in their growth rates in response to temperature, indicating that they are physiologically differentiated. Azaspiracid profiles were analyzed for 15 cultured A. poporum strains using LC-MS/MS and demonstrate that the A. poporum ribotype A from Greece produce low level or no AZA and A. poporum ribotype C from Greece produces predominantly AZA-40 (9.6-30.2 fg cell-1) followed by AZA-2 (2.1-2.6 fg cell-1). The first record of AZA-40 producing A. poporum from the Mediterranean suggests that this species is a potential source for azaspiracid contaminations in shellfish from the Eastern Mediterranean Sea.

P-B1-04 Metagenomics assessment on the distribution and relative abundance of Alexandrium species along the eastern coast of Peninsular Malaysia

Kieng Soon Hii, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, Malaysia
Ing Kuo Law, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, Malaysia
Winnie Lik Sing Lau, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, Malaysia
Mohd Fadzil bin Mohd Akhir, Institute of Oceanography and Environment, Universiti Malaysia Terengganu, Malaysian
Zhaohe Luo, Third Institute of Oceanography China, Xiamen, China
Haifeng Gu, Third Institute of Oceanography China, Xiamen, China
Chui Pin Leaw, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, Malaysia
Po Teen Lim, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, Malaysia
Presenter Email: hiiks@um.edu.my

Paralytic shellfish poisoning (PSP) is one of the predominant shellfish poisoning threats in the Southeast Asian region that caused by the marine dinoflagellates Pyrodinium bahamense and some species in the genus Alexandrium. In Malaysia, other than P. bahamense, A. tamiyavanichii and A. minutum are the main PSP causative species that caused PSP incidents. Other non-toxic species, A. affine, A. tamutum, A. ostenfeldii, A. cf. tameranse, A. andersonii, A. leei and A. insuetum have also been documented in Malaysia. However, the spatial distribution and relative abundance of Alexandrium along the east coast of Peninsular Malaysia is not known. Nonetheless, identification and enumeration of Alexandrium species is challenging based on minute thecated morphological differences. Therefore, this study employed the metagenomics approach on samples collected from 30 stations on the east coast of Peninsular Malaysia during a scientific cruise expedition on RV discovery in August 2016. Plankton samples collected were preserved in modified saline ethanol buffer and the environmental DNA extracted were used to amplify the 18S ribosomal RNA gene (V9 domain) and analyzed by Illumina MiSeq platform. A total of 11 OTU taxa of Alexandrium species were recovered. The toxic A. tamiyavanichii was found to be widely distributed in the region; the highest abundance was recorded in the northeastern coast of Peninsular Malaysia. Surprisingly, A. minutum was not detected in the dataset. We thus postulated that this species is mainly occurred in semi-enclosed coastal waters. Alexandrium tameranse, A. affine, A. andersonii, A. fraterculus, A. leei, A. margalefii, A. monilatum, A. ostefeldii, A. pohangense and A. insuetum were found but with low relative abundances. The finding of this study could serve as a baseline data in the monitoring and studies of harmful algal blooms.

P-B1-05-S Metatranscriptome analysis reveals environmental and diel regulation of a *Heterosigma akashiwo* (Raphidophyceae) bloom

Nanjing Ji, State Key Laboratory of Marine Environmental Science, Xiamen University
Lingxiao Lin, State Key Laboratory of Marine Environmental Science, Xiamen University
Ling Li, State Key Laboratory of Marine Environmental Science, Xiamen University
Liying Yu, State Key Laboratory of Marine Environmental Science, Xiamen University
Yaqun Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University
Hao Luo, State Key Laboratory of Marine Environmental Science, Xiamen University
Meizhen Li, State Key Laboratory of Marine Environmental Science, Xiamen University
Xinguo Shi, State Key Laboratory of Marine Environmental Science, Xiamen University
Da-Zhi Wang, State Key Laboratory of Marine Environmental Science, Xiamen University
Senjie Lin, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: jinanjing@126.com

Despite numerous laboratory studies on physiologies of harmful algal bloom (HAB) species, physiologies of these algae during a natural bloom are understudied. Here, we investigated a bloom of the raphidophyte *Heterosigma akashiwo* in the East China Sea in 2014 using metabarcode (18S rDNA) and metatranscriptome sequencing. Based on 18S rDNA analyses, the phytoplankton community shifted from high diversity in the pre-bloom stage to H. akashiwo predominance during the bloom. A sharp decrease in ambient dissolved inorganic phosphate and strong up-regulation of phosphate and dissolved organic phosphorus (DOP) uptake genes, including the rarely documented (ppGpp)ase, in H. akashiwo from pre-bloom to bloom was indicative of rapid phosphorus uptake and efficient utilization of DOP that might be a driver of the H. akashiwo bloom. Furthermore, observed up-regulated expression of mixotrophy-related genes suggests potential contribution of mixotrophy to the bloom. Accelerating photosynthetic carbon fixation was also implied by the up-regulation of carbonic anhydrase genes during the bloom. Notably, we also observed a strong morning-to-afternoon shift in the expression of many genes. Our findings provide insights into metabolic processes likely important for H. akashiwo bloom formation, and suggest the need to consider timing of sampling in field studies on this alga.

P-B1-06 The physiological, biochemical characteristics and mechanism of the diatoms *Chaetoceros muelleri* resting spores formation

Jun-Rong Liang, School of Life Sciences, Xiamen University, Xiamen 361102, China Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen University, Xiamen 361102, China
Qian-Qian Huang, School of Life Sciences, Xiamen University, Xiamen 361102, China
Peng-Yu Ji, School of Life Sciences, Xiamen University, Xiamen 361102, China
Shan-Shan Zhuang, School of Life Sciences, Xiamen University, Xiamen 361102, China

Qin Liu, School of Life Sciences, Xiamen University, Xiamen 361102, China
Fang Han, School of Life Sciences, Xiamen University, Xiamen 361102, China
Chang-Ping Chen, School of Life Sciences, Xiamen University, Xiamen 361102, China Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen University, Xiamen 361102, China
Ya-Hui Gao, School of Life Sciences, Xiamen University, Xiamen 361102, China State Key Laboratory of Marine Environment Science, Xiamen University, Xiamen 361102, China
Corresponding author: gaoyh@xmu.edu.cn
Presenter Email: sunljr@163.com

Except the major contribution to marine carbon fixation, diatoms also account for big proportion of annual POC export fluxes due to diatom resting spore export as a carbon vector out of the mixed layer. The diatom resting spore is a special life stage of some bloom-forming species in response to the collapse of the bloom or environmental stresses, which playing a key role inthe persistence of the diatom's own population. However, little is known about the physiological and biochemical characteristics of diatoms during their resting spores formation. In the present study, the physiological and biochemical characteristics and changes in the resting spores formation of the bloom-forming diatom *Chaetoceros muelleri* were investigated, including cell morphology, photosynthetic characteristics, cell viability, absorption of nutrients, biological macromolecule content, etc. The comparative analysis of proteins in cell wall and organelle between resting stage cells and vegetative cells of the diatoms provided strong molecular biological evidence for changes in physiological and biochemical characteristics of the resting spores. The RNA-seq technology was also used to investigate the strategy of the diatom self-protection. The findings improved our understanding of the resting spores formation mechanism and their important roles in bloom succession.

P-B1-07-S Benthic harmful dinoflagellate assemblages of Perhentian Islands (South China Sea): the relationships between benthic substratum characteristics, depth and monsoonal shift

Li Keat Lee, Institute of Ocean and Earth Science, University Malaya
Zhen Fei Lim, Institute of Ocean and Earth Science, University Malaya
Hwa Lin Yong, Institute of Ocean and Earth Science, University Malaya
Nurin Izzati Mustapa, Institute of Ocean and Earth Science, University Malaya
Leo Lai Chan, State Key Laboratory in Marine Pollution, Department of Biomedical Sciences, City University of Hong Kong
Haifeng Gu, Third Institute of Oceanography, Xiamen
Chui Pin Leaw, Institute of Ocean and Earth Science, University Malaya
Po Teen Lim, Institute of Ocean and Earth Science, University Malaya
Presenter Email: likeat92@gmail.com

Ciguatera fish poisoning (CFP) is a foodborne disease associated with ciguatoxins (CTXs) contamination in seafood through multiple trophic transfers.The toxins are produced by the benthic dinoflagellates *Gambierdiscus* species, thus, the clue lies in the epiphythic nature of the benthic dinoflagellates which closely associated with the benthic biotic substrata that served as a feeding ground for the reef inhabitants.In this study, we investigated the dynamics of benthic harmful dinoflagellates assemblages in three components: benthic biotic substrate characteristics, depths and monsoonal shift. A total of 243 artificial substrate samples were deployed and collected from Perhentian Islands, Terengganu, Malaysia, between April 2016 and May 2017. Five benthic harmful dinoflagellates, *Gambierdiscus*, Ostreopsis, Coolia, Amphidinium, and *Prorocentrum* were enumerated. *Prorocentrum* and Ostreopsis were found to be the dominant groups in the assemblages. Blooms of these species were detected occasionally throughout the studied period. This study demonstrated the concomitant of benthic dinoflagellates with various benthic substrates,each demonstrated a different degree of preference towards the benthic substratum examined. *Gambierdiscus*, Ostreopsis, and Amphidinium were associated with turf algae assemblages than fleshy macrophytes, while Coolia and *Prorocentrum* occupied a broader range of microhabitats. In term of depth distribution, Coolia and *Prorocentrum* were more adaptive to varying depth range while *Gambierdiscus*, Amphidinium, and Ostreopsis were much confined to shallow waters. The results suggested the distribution and abundances of benthic harmful dinoflagellates are strongly driven by the variability of benthic microhabitats in the coral reef ecosystems, and the benthic substratum will likely affect the groups differently. This study highlights the role of benthic substratum in understanding the linkage between benthic dinoflagellates assemblages and the flux of ciguatoxins or other biotoxins in the marine food webs.

P-B1-08 Responses of phytoplankton community to eutrophication in Semerak lagoon, Malaysia

Po Teen LIM, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia

Huey hui ER, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia

Li Keat LEE, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia

Zhen Fei LIM, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia

Kieng Soon HII, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia

Sing Tung TENG, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.

Chui Pin LEAW, Bachok Marine Research Station, Institute of Ocean and Earth Sciences, University of Malaya, 16310 Bachok, Kelantan, Malaysia
Presenter Email: ptlim@um.edu.my

Drastic decline in the water quality and increased incidence of harmful algal blooms (HABs) have been frequently reported in Malaysia, partly owing to the intensifying anthropogenic activities such as aquaculture in the coastal embayment. In this study, the effects of aquaculture activities on the environmental parameters and phytoplankton community structure were investigated in a semi-enclosed lagoon located at Semerak River, Malaysia, between September 2015 and March 2016 . In Semerak River, cage aquacultures have been operated since 2000, with approximately 1120 fish cages situated along the river. Throughout the survey, elevated concentrations of phosphate and ammonia were observed at the aquaculture area and the inner lagoon. Relatively low dissolved oxygen, high total Chlorophyll a and high phytoplankton abundances but low species richness was recorded. Chaetoceros, Pseudo-nitzschia brasiliana, Blixaea quinquecornis, and Skeletonema blooms were observed, some were associated with anoxia condition. Eutrophication level assessed by UNTRIX suggests that the water quality in the lagoon is deteriorated. Dissolved inorganic phosphorus and nitrogen at the impacted area were 15 and 12 times higher than the reference sites, respectively. Such trophic status indices could provide a useful guideline for optimal aquaculture management plan to reduce the environmental impact caused by aquaculture.

P-B1-09-S Effect of a diatom on colony formation in the harmful bloom-forming species *Phaeocystis globosa*

Qi Liu, School of Life Sciences, Xiamen University, Xiamen 361102, China
Fang Han, School of Life Sciences, Xiamen University, Xiamen 361102, China
Lu Huang, School of Life Sciences, Xiamen University, Xiamen 361102, China
Chang-Ping Chen, School of Life Sciences, Xiamen University, Xiamen 361102, China Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen University, Xiamen 361102, China
Lin Sun, State Key Laboratory of Marine Environment Science, Xiamen University, Xiamen 361102, China
Ya-Hui Gao, School of Life Sciences, Xiamen University, Xiamen 361102, China State Key Laboratory of Marine Environment Science, Xiamen University, Xiamen 361102, China Corresponding author:gaoyh@xmu.edu.cn
Jun-Rong Liang, School of Life Sciences, Xiamen University, Xiamen 361102, China Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, Xiamen University, Xiamen 361102, China Corresponding author: sunljr@xmu.edu.cn
Presenter Email: 897043466@qq.com

The prymnesiophyte *Phaeocystis globosa*, a dimethylsulfide (DMS) producer, often forms a

large area harmful algal bloom, playing an important role in global sulphur and carbon cycle. P. globosa has a unique polymorphic life cycle that can alternate between single and colonial stage, and cooccurrence of diatoms with P. globosa in the latter is a common phenomenon in the ocean. Despite the significant contribution of colony formation to the bloom formation and development, the roles of diatoms that may interact with colony formation of P. globose still suffer from a sketchy knowledge. In the present study, a diatom species Ditylum brightwellii was co-grown with P. globosa in the cultures with different cell density ratio (P. globosa: D. brightwellii =1:1, 10:1, 50:1, or 100:1) in order to investigate the effects of the diatom on colony formation of P. globosa. The proportion of P. globosa colonial cells, average colony size, and number of colonies were enumerated. The results showed that diatom D. brightwellii could promote colony formation and increase colony size at early stage of colony formation when P. globosa was in a relative low initial cell density of 103 cells mL-1. Colony number and the diameter of P. globosa colony were improved by the diatom in early and late growth stages when the density ratio of the P. globosa to D. brightwellii was at least 10:1. When the density ratio of P. globosa to D.brightwellii was 100:1, the mean colony size increased up to 25% relative to the controls. The mean colony number of P. globosa was also increased up to 50% when the density ratio of P. globosa to D.brightwellii was 50:1.The findings suggested that diatom could play a role in colony formation of P. globose.

P-B1-10 Morphology and molecular phylogeny of bloom-forming planktonic *Prorocentrum* (Dinophyceae) species from China

Zhaohe Luo, Third Institute of Oceanography, State Oceanic Administration, Xiamen 361005, China
Yue Gao, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, China
Haifeng Gu, Third Institute of Oceanography, State Oceanic Administration, Xiamen 361005, China
Presenter Email: luozhaohe@tio.org.cn

The genus *Prorocentrum* includes many species responsible for Harmful algal blooms (HABs) around the world. Some of them, e.g., P. donghaiense and P. triestinum, has formed extensive blooms frequently in Chinese coastal waters, and caused serious economic impact on the marine fisheries. However, the diversity of planktonic *Prorocentrum* along the coast of China was not fully examined. A total of 19 strains of bloom-forming *Prorocentrum* were morphologically identified to six species including P. donghaiense, P. gracile, P. koreanum, P. minimum, P. micans and P. triestinum. The morphology of the periflagellar area appears to be a very useful character to distinguish planktonic *Prorocentrum*, and the periflagellar area platelet pattern of P. donghaiense and P. gracile were revealed for the first time. The taxonomic relationship among P.

donghaiense, P. shikokuense and P. dentatum will not be clarified until the platelet pattern of P. shikokuense and P. dentatum are examined in detail later. In combination with periflagellar area platelet pattern, cell shape and trichocyst pores pattern, the morphologically similar species P. micans, P. koreanum, P. gracile and P. texanum can be easily distinguished. Partial large subunit ribosomal DNA (LSU rDNA) and/or internal transcribed spacer region (ITS rDNA) sequences showing that there is a low genetic variability among the strains of planktonic *Prorocentrum* at intraspecific level. Both LSU rDNA and ITS rDNA based phylogeny revealed three groups within planktonic *Prorocentrum* referred as P. micans-like group, P. minimum-like group and P. triestinum-like group, which correspond to their morphological features.

P-B1-11 Pseudocryptic speciation in *Protoceratium reticulatum* (Dinophyceae) and its relationship with biogeography and physiology

Na Wang, Third Institute of Oceanography, SOA, Xiamen 361005, China
Bernd Krock, Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany
Kenneth Neil Mertens, Ifremer, LER BO, Station de Biologie Marine, Place de la Croix, BP40537, F-29185 Concarneau CEDEX, France
Zhaohe Luo, Third Institute of Oceanography, SOA, Xiamen 361005, China
Urban Tillmann, Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany
Haifeng Gu, Third Institute of Oceanography, SOA, Xiamen 361005, China
Presenter Email: wangna@tio.org.cn

Protoceratium reticulatum is a marine toxic dinoflagellate widely distributed around the world. However, its growth and toxin-producing characteristics differ markedly among different origin of strains. In this study, a total of 38 strains and 12 cysts of P. reticulatum were obtained from several climatic zones including British Columbia, Mediterranean Sea, New Zealand, Chile, Chukchi Sea, Greenland, Norway, Yellow Sea, East China Sea and South China Sea. The morphology of some strains was examined with light microscopy and scanning electron microscopy. Large subunit ribosomal DNA (LSU rDNA) and internal transcribed spacer (ITS)sequences of all the strains and cysts were obtained. Molecular phylogeny based on ITS rDNA sequences identified three distinct ribotypes (referred as ribotypes A, B and C) within P. reticulatum. Ribotype A was only found in cold waters and ribotype B was found in warm waters. Sympatric occurrence of ribotypes A and B was observed in Yellow Sea. Growth experiments were carried out on one stain of ribotype A and one strain of ribotype B from Yellow Sea; P. reticulatum ribotype B exhibited the highest growth rate at 20 degrees Celsius and 25 degrees Celsius (0.52 and 0.50 divisions/day), but the highest growth rate of P. reticulatum ribotype A occurred at 20 degrees Celsius and 15 degrees Celsius (0.26 and 0.25 divisions/day); P. reticulatum

ribotype A could not survive at 25 degrees Celsius. Yessotoxins(YTXs) profiles of 13 cultured P. reticulatum were analyzed using LC-MS/MS. These results demonstrated that all P. reticulatum ribotypes could produce high level YTXs . Our results support that pseudocryptic speciation occurred in P. reticulatum which is related with their ecophysiological differentiation.

P-B1-12 Allocation Costs Associated with Induced Defense in *Phaeocystis globosa* (Prymnesiophyceae): the Effects of Nutrient Availability

Xiaodong Wang, Jinan University
Yan Wang, Jinan Univeristy
Presenter Email: pouchetii@gmail.com

Colony enlargement in *Phaeocystis globosa* has been considered as an induced defense strategy that reduces its susceptibility to grazers, but allocation costs inflicted by this plastic morphological defense are poorly understood. We conducted experiments in which P. globosa cultures were exposed to chemical cues from copepods, ciliates and heterotrophic dinoflagellates, respectively, under nutrient sufficient and deficient conditions to evaluate allocation costs associated with induced defense. *Phaeocystis globosa* responded to chemical cues from grazers by increasing colony diameter irrespective of nutrient conditions. We did not find trade-offs between induced defense and growth rate under nutrient sufficient conditions. Instead, induced defensive P. globosa had higher growth rates than non-induced P. globosa. When nutrient became limited, P. globosa exposed to grazing cues from copepods and dinoflagellates had significantly decreased growth rates when compared with non-induced P. globosa. We suggested that the decreased growth revealed allocation costs associated with induced defense that may influence on the trophic interactions between Phaeocystis and consumers

P-B1-13 Rare Bacteria in Seawater Are Dominant of Bloom-forming Dinoflagellate *Noctiluca Scintillans* Associated Bacterial Assemblage

Xiaomin Xia, South China Sea Institute of Oceanology, CAS
Suki Leung, The Hong Kong University of Science and Technology
Hongbin Liu, The Hong Kong University of Science and Technology
Presenter Email: xxia@connect.ust.hk

Noctiluca scintillans, a bloom-forming dinoflagellate, is widely distributed in the global ocean. Endocytic bacteria of zooplanktons have been widely reported and proved to be essential for survival and growth of zooplanktons. However, few study investigated diversity of endocytic bacteria of *Noctiluca scintillans*. In this study, we applied 454 pyrosequencing and metagenomic sequencing to investigate the diversity,characteristics and function of endocytic bacteria in Noctiluca. Endocytic bacteria were discovered in both field and lab Noctiluca cells, with higher stability community composition in the lab

Noctiluca cells while greater variation in the field Noctiluca cells collected at different times. Bacterial communities of lab Noctiluca cells were mainly dominated by Rhodobacterales, while dominant species varied with sampling times in the field Noctiluca samples. Most of the endocytic bacteria were found in the environment where Noctiluca cells lived in, with low relative abundance. Cultivating the field Noctiluca cells with mono-specific food source shifted the bacterial communities in Noctiluca cells. Ampicillin caused death of Noctiluca cells, suggesting a critical role of endocytic bacteria to survival of Noctiluca. Metagenomic analysis shows that prop and ABCB-BAC were the two most abundant genes involved in the membrane transport.Our data suggested that bacteria widely distribute in Noctiluca cells, and endocytic bacterial community composition is related to the environmental condition that Noctiluca cells live in and is important to the survival of Noctiluca.

P-B1-14-S Phytoplankton Community in Xiamen Harbor and Its Relationship to Environmental Factors

Xiaojie Chai, Key Laboratory of Algal Biology, Institute of Hydrobiology, Chinese Academy of Sciences/University of Chinese Academy of Sciences
Qi Zhang, Key Laboratory of Algal Biology, Institute of Hydrobiology, Chinese Academy of Sciences
Zhe Lu, Key Laboratory of Algal Biology, Institute of Hydrobiology, Chinese Academy of Sciences/University of Chinese Academy of Sciences
Lirong Song, Key Laboratory of Algal Biology, Institute of Hydrobiology, Chinese Academy of Sciences
Presenter Email: lrsong@ihb.ac.cn

During January to October in 2018, We investigated the monthly variation of phytoplankton composition and abundance in Tongan Bay, Haicang Bridge and Jiulong River Estuary of Xiamen Harbor. This was aiming to find out the correlation between dynamics of phytoplankton and environmental factors, and the saxitoxin-producing algae as well. The results indicated that the average densities of phytoplankton were 2.59×106, 6.7×105 and 4.7×105 cells/L in the three stations, and the average concentrations of chlorophyll a were 6.2, 2.6 and 4.0 μg/L, respectively. The diatoms such as Chaetocero spp. and Skeletonema spp. were dominated in all three stations. The average concentrations of TN were 4.0, 3.6 and 3.5 mg/L , TP were 0.11, 0.11 and 0.14 mg/L, and N/P were 43, 33 and 30, respectively. The principal component analysis (PCA) of the environmental factors showed that the temperature, salinity, dissolved oxygen, oxidation-reduction potential, transparency, pH, total phosphorus, total nitrogen and N/P explained 59.4%, 59.4% and 60.7% in the three stations, respectively. Temperature, dissolved oxygen, transparency and oxidation-reduction potential correlated positively with the first component and negatively with salinity, pH, total phosphorus, total nitrogen and N/P in

Tongan Bay and Haicang Bridge. Transparency, salinity, oxidation-reduction potential and N/P correlated positively with the first component and negatively with dissolved oxygen, temperature, total nitrogen, total phosphorus and pH in Jiulong River Estuary. Additionally, we performed sxtA-based qPCR to identify saxitoxin-producing harmful algae, which structured the standard working curve of qPCR detection with mixed DNA from Alexandrium tamarense, A. catenella and A. minitum. The saxitoxin-producing algae by qPCR detection were at concentrations of 4.9×103, 1.0×103 and 1.2×103 cells/L by average in Tongan Bay , Haicang Bridge and Jiulong River Estuary. The quantifications of potential saxitoxin producers by microscope were at concentrations of 9.5×103, 4.8×103 and 6.9×103 cells/L by average in the three stations, which dominated by Gymnodinium spp., Alexandrium spp. and their cysts. The quantifications of potential saxitoxin producers by microscope were comparable with qPCR detection in the three stations (R2=0.84). Our result suggested that there was a high risk of paralytic shellfish poisoning in Xiamen Harbor.

P-B1-15 The emerging threat of toxic microalgae Coolia spp. in Hong Kong waters

Meng Yan, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China; Research Centre for the Oceans and Human Health, City University of Hong Kong Shenzhen Research Institute, Shenzhen, China
Priscilla T.Y. Leung, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China; Research Centre for the Oceans and Human Health, City University of Hong Kong Shenzhen Research Institute, Shenzhen, China
Jiarui Gu, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China; Department of Chemistry, City University of Hong Kong, Hong Kong, China
Xin Li, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China; Department of Chemistry, City University of Hong Kong, Hong Kong, China
Veronica T.T. Lam, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China
Tak-Cheung Wai, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China; Research Centre for the Oceans and Human Health, City University of Hong Kong Shenzhen Research Institute, Shenzhen, China
Sam K.F. Yiu, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China
Paul K.S. Lam, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong, China;Research Centre for the Oceans and Human Health, City University of Hong Kong Shenzhen Research Institute, Shenzhen, China; Department of Chemistry, City University of Hong Kong, Hong Kong, China
Presenter Email: mengyan@cityu.edu.hk

The emerging threat of benthic and epiphytic toxic algae (BETA) to marine ecosystems has

attracted worldwide attention. Seawater temperature is one of the major factors influencing the growth and distribution of BETA. Coolia are one of the cosmopolitan group of BETA, and are potentially toxic. There are four species of Coolia reported in Hong Kong waters, i.e., C. malayensis, C. canariensis, C. tropicalis, and C. palmyrensis. This study have examined the potential toxicities of these four species of Coolia, with particular focus on the toxic effect of algal extracts on the lethality of *Artemia* larvae and hemolysis rate on erythrocytes of local reef fishes. Our results showed that the lipid-soluble fraction of the extracts were lethal to *Artemia* larvae, with C. malayensis causing the highest mortality rate among the four. The water-soluble extracts from all the four Coolia spp. have induced significant hemolysis in ten species of reef fish. In-depth comparative study on physiological and molecular responses, toxicity, and toxin production under treatment of different seawater temperatures were performed for two selected species, i.e., C. malayensis (a tropical species) and C. canariensis (a temperate species). Coolia monocultures were exposed to seven temperatures i.e., 16, 18, 20, 22, 24, 26 and 28 degree C before sampled for determinations of growth curves, photosynthesis efficiency, amount of phaeo-pigments, toxicity, toxin levels, plus elucidation with transcriptional responses. Coolia malayensis showed the best growth under 24 degree C while its photosynthesis was steady across the range of temperatures. The growth rate of C. canariensis was peaked at 20 degreeC. Lower temperatures, i.e., 16 and 18 degree C inhabited its growth and photosynthesis. The amount of phaeo-pigments reached the highest at 26 degree C for both C. malayensis (3.06 ug/ml) and C. canariensis (15.61 ug/ml), but the level reached the lowest at 20 degree C for C. malayensis (0.90 ug/ml) and at 16 degree C for C. canariensis (2.76 ug/ml). The 48h LC50 values of C. malayensis on lethality of *Artemia* larvae decreased as temperature increased, indicating the algae being more toxic under higher temperatures. The okadiac acid (OA) analogue was detected in the lipid-soluble extracts of C. malayensis using LC-MS/MS analysis, and the relative amounts detected were significantly correlated to their toxicities. With more upcoming results on toxin analysis and transcriptome profiles, we could gain further insight on possible mechanisms that associated with algal growth and toxin production with respect to the temperature effect.

P-B1-16-S Are changes in N:P ratios in coastal waters the key to harmful algal species occurence?

Anqiang Yang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University

Richard bellerby, 1.State Key Laboratory of Estuarine and Coastal Research, East China Normal University 2. Norwegian Institute for Water Research, Bergen N-5006, Norway

Quanxing Liu, State Key Laboratory of Estuarine and Coastal Research, East China Normal University

Xiaoshuang Li, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Jing Li, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Presenter Email: 51173904027@stu.ecnu.edu.cn
There is a growing amount of evidence for an increase in nutrient concentrations in coastal waters from anthropogenic sources. Meanwhile, the frequency, diversity and intensity of harmful algal blooms (HABs) are increasing. Although there are many factors that control the growth and persistence of HABs, recent studies suggested the nutrient ratios (such as N:P and Si:P) are important regulators. However, it is still not possible to conclude the extent to which the N:P ratios in coastal waters can be attributed to the change in HABs species. In May 2017, we surveyed the East China Sea and identified that the dinoflagellate (Proprocentrum donghaiense) was blooming (3-21 *105cells L-1) in higher N:P ratios waters, while diatom (Skeletonema costatum) was dominant (1-6 *106 cells L-1) in lower N:P ratios waters. This result supports, to some extent, that change HABs species coincide with high N:P ratios. We discuss this finding and how other environment factors, such as light, temperatures or CO2 may also play an important role. This field study is guiding new perturbation studies on the competition between diatoms and dinoflagellates under changing multiple ecosystem drivers.

P-B1-17-S Okadaic acid exposure inhibits the development of neural crest cells through the EMT proces

Yu-hu Jiao, Key Laboratory of Aquatic Eutrophication and Control of Harmful Algal Blooms of Guangdong Higher Education Institute, College of Life Science and Technology, Jinan University, Guangzhou 510632, China
Guang Wang, Division of Histology and Embryology, Key Laboratory for Regenerative Medicine of the Ministry of Education, Medical College, Jinan University, Guangzhou 510632, China
Hong-ye Li, Key Laboratory of Aquatic Eutrophication and Control of Harmful Algal Blooms of Guangdong Higher Education Institute, College of Life Science and Technology, Jinan University, Guangzhou 510632, China
Jie-sheng Liu, Key Laboratory of Aquatic Eutrophication and Control of Harmful Algal Blooms of Guangdong Higher Education Institute, College of Life Science and Technology, Jinan University, Guangzhou 510632, China
Xuesong Yang, Division of Histology and Embryology, Key Laboratory for Regenerative Medicine of the Ministry of Education, Medical College, Jinan University, Guangzhou 510632, China
Wei-dong Yang, Key Laboratory of Aquatic Eutrophication and Control of Harmful Algal Blooms of Guangdong Higher Education Institute, College of Life Science and Technology,

Jinan University, Guangzhou 510632, China
Presenter Email: 739933791@qq.com

Okadaic acid (OA), the main component of diarrheic shellfish poisoning (DSP), is a potent phosphatase specific inhibitor and neurotoxin. However, it is still unclear how OA exposure could affect neural crest cells (NCCs) generation in early embryo development. In this study, using a chick embryo model, we investigated effects of OA exposure on neural crest cells during embryonic development. We found that OA exposure could lead to craniofacial bone defects in the developing chick embryo, and delay the development of gastrulating chick embryos. Immunofluorescence staining of HNK-1, PAX7, and Ap-2α indicated that cranial NCCs generation was inhibited after OA exposure. Double immunofluorescent staining (Ap-2α and PHIS3 or PAX7 and c-Caspase3) suggested that OA exposure inhibited both NCCs proliferation and apoptosis. Furthermore, Msx1 and BMP4 expression were down-regulated in the developing neural tube. It revealed that production of NCCs was inhibited. We also determined that expression of EMT-related adhesion molecules, Cad6B and E-Cadherin, for example, and found that they were altered. In all, OA exposure could affect the development of neural crest cells, which in turn causes defective cranial bone development.

P-B1-18 Factors influence the successive blooms induced by *Noctiluca scintillans* and *Mesodinium rubrum*

Shuwen Zhang, College of Life Science, South China Normal University, Guangzhou 510631, PR China
Xiaomin Xia, Laboratory of Marine Bio-resource Sustainable Utilization, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, 510301, PR China
Ying Ke, Division of Life Science, The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong SAR, China
Shuqun Song, Key Lab of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China
Zhuo Shen, Microbial Ecology and Matter Cycle Group, School of Marine Sciences, Sun Yat-sen University, Zhuhai 519082, China
Shunyan Cheung, Division of Life Science, The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong SAR, China
Hongbin Liu, Division of Life Science, The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong SAR, China
Presenter Email: szhangaf@connecu.ust.hk

Noctiluca scintillans (Noctiluca) and *Mesodinium rubrum* bloomed concomitantly or successively from November to December 2014 in Port Shelter, a semi-enclosed bay in Hong Kong. Microscopic observation of microzooplankton and phytoplankton, as well as rRNA gene analysis of picoeukaryotes communities, together with environmental data

collected before, during and following the bloom events are used to examine the factors that may have triggered such blooms. Our results showed that the onset of Noctiluca and M. rubrum blooms appeared to be driven initially by physical conditions, but stronger relationships were seen among communities afterwards, indicating that internal feedback mechanisms, including reciprocity, competition, preferential feeding and other predator-prey interactions, strongly influence the progression and demise of Noctiluca and M. rubrum blooms, as well as the structure of the phytoplankton community during and after bloom initiation. Our findings have great implications in coastal zones worldwide that are affected by these two ubiquitous red tide forming species.

P-B1-19-S The effective algicidal bacterium *Microbulbifer maritimus* TF-17 triggered *Phaeocystis globosa* autophagy dominated by membrane destruction

Zhu Xiaoying, School of life sciences, Xiamen University
Presenter Email: zxynwsuaf@126.com

*Phaeocystis globosa*is one of the disruptive harmful algal blooms (HABs) algae strains in South China. It can form capsules to block fish and can cause hemolytic toxins to pollute the environment. We have isolated a bacteria strain from the mangrove wetland in Zhangzhou, Fujian Province, which can kill 90% of algae cells in 72 hours. The effective algicidal bacterium was identified as *Microbulbifer maritimus* TF-17 by 16S rDNA sequence blasting. The results of GC-MS indicated that the active substance of *Microbulbifer maritimus* TF-17 is cyclic dipeptide, with temperature and acid-base stability. In order to utilize the algicide material efficiently, we conducted a preliminary study on the mechanism of algae killing. It was found that the content of malondialdehyde (MDA) in P. globosa cells increased after adding bacterial sterile supernatant for only 6 hours, while the levels of NO and H2O2 in algae cells increased significantly in 12 hours treatment. At the same time, the activities of enzymes related to oxygen free radical scavenging (POD, CAT, etc.) are enhanced. This indicates that membrane peroxidation occurs first and the inner membrane of the cell is initially attacked. At the same time, the morphological changes of algal cells were also significant. The flagella of algal cells break off, and the cells deform, producing round bubbles. Compared with healthy cells, algal cell organelles (chloroplasts, mitochondria) are sparse in structure, without obvious membranes, and eventually disappear. Algae cell nuclear membrane disappeared, chromatin marginalized, nucleoli gradually disappeared. A large number of autophagosome structures are produced invivo, and eventually the cells become vacuolated to death. In addition, we also found that although the TEM results showed severe nuclear damage, no obvious DNA Ladder was formed, possibly because the algal nuclei were affected but did not break into small fragments. It was concluded that triggered by *Microbulbifer maritimus* TF-17, the cytoplasmic membrane of globular brown cystis was first damaged, a large amount of NO and H2O2 was produced in the cell, and the antioxidant system was also activated, but still could not prevent cell death. This form of death begins with the destruction of internal organelles by autophagy. Our study suggested that under the stress of *Microbulbifer maritimus* TF-17, P. globosa cell death is autophagy as similar as in plant which was starting with membrane damaged.

P-B1-20-S Comparison of photosynthetic pigments and phytoplankton assemblages in two types of coastal regions in Southeast Asia-Indonesian Throughflow and river estuary

Lina An, Third Institute of Oceanography,State Oceanic Administration
Lei Wang,
Hao Huang*,
Haifeng Gu,
Presenter Email: anlina@tio.org.cn

Water samples were collected in order to study the spatial variation of photosynthetic pigments and phytoplankton community composition in the Lembeh Strait (Indonesia) and the Kelantan river estuary (Malaysia) during July and August 2016, respectively. Phytoplankton photosynthetic pigments were detected using high performance liquid chromatography combining with the CHEMTAX software to confirm the Chl a biomass and community composition. The Chl a concentration was low at surface in Lembeh Strait, which it was 0.580~0.682 ug L-1, with the average 0.620-0.039 ug L-1. Nevertheless, the Chl a concentration fluctuated violently at surface in the Kelantan river estuary, in which the biomass was 0.299~3.988 ug L-1, with the average 0.922-0.992 ug L-1. The biomass at bottom water was higher than at surface in the Kelantan river estuary, in which the Chl a concentration was 0.704~2.352 ug L-1, with the average 1.493-0.571 ug L-1. Chl b, zeaxanthin and fucoxanthin were three most abundant pigments in Lembeh Strait, but fucoxanthin monopolized in the Kelantan river estuary. As a consequence, phytoplankton community composition was different in the two study areas. In the Lembeh Strait, prasinophytes (26.48-0.83%) and *Synechococcus* (25.73-4.13%) occupied ~50% of the Chl a biomass, followed by diatoms (20.49-2.34%) and haptophytes T8 (15.13-2.42%). At surface water in the Kelantan river estuary, diatoms (58.53-18.44%) dominated more than half of the phytoplankton biomass, followed by *Synechococcus* (27.27-14.84%) and prasinophytes (7.00-4.39%). And it showed the similar status at the bottom water in the Kelantan river estuary, where diatoms, *Synechococcus* and prasinophytes contributed 64.89-15.29%, 16.23-9.98% and 8.91-2.62%, respectively. The different phytoplankton community composition between the two regions implied that the bottom up control affected the phytoplankton biomass in the Lembeh Strait where the oligotrophic water derived from the Western Pacific. The terrigenous nutrients supplied the diatoms growing, and pico-phytoplankton was grazed through top down control in the Kelantan river estuary.

P-B1-21-S An assessment on the intrapopulational and intraindividual genetic diversity in LSU rDNA in the harmful algal bloom-forming dinoflagellate *Margalefidinium* (= Cochlodinium) *fulvescens* based on clonal cultures and bloom samples from Jiaozhou Bay, China

Siheng Lin, Institute of Oceanology Chinese Academy of Sciences
Zhangxi Hu, Institute of Oceanology Chinese Academy of Sciences
Ying Zhong Tang, Institute of Oceanology Chinese Academy of Sciences
Presenter Email: linsiheng@qq.com

Large subunit ribosomal DNA (LSU rDNA) sequences have been increasingly used to infer the phylogeny and species identity of organisms including microalgae because LSU rDNA are considered to be more suitable for discriminating closely related species or identifying intraspecific genetic variability. Previous studies have observed high intraspecific and even intraindividual variability in LSU rDNA in a number of dinoflagellates due to large copy numbers of LSU rDNA in dinoflagellates. Since the number of copies in LSU rDNA varies tremendously among different species of dinoflagellates, the intraspecific and intraindividual diversity for a species of particular interest thus needs to be investigated individually. As a toxic and rapidly expanding harmful algal blooms (HABs)-forming dinoflagellate, *Margalefidinium* (= Cochlodinium) *fulvescens* has been observed to reach blooming density in Jiaozhou Bay, China since 2015 after numerous blooms of the species have been reported from many other countries. In trying to identify the source of this newly observed HABs-forming species in China by sequencing the LSU rDNA for both field samples and clonal cultures, we noticed and thus further investigated high intrapopulational and intraindividual genetic diversities of the dinoflagellate. The D1-D6 region of the LSU rDNA (1435bp) were amplified using universal primers from 7 field samples (assemblages of many cells of M. fulvesens picked up and pooled under microscope from bloom water) and 11 clonal cultures, cloned, sequenced, and further analyzed using DnaSP v5 for 2304 sequences obtained. We found high intrapopulational and intraindividual genetic diversity in M. *fulvescens* as reflected in pairwise differences between sequences and the mean nucleotide differences in the clone library for different field samples and clonal cultures. Based on that the mean and overall intrapopulational genetic diversity (based on the 7 field samples) was almost equal to the mean and overall intraindividual variability (based on the 11 clonal cultures) in all indices of genetic diversity, together with the result of AMOVA analysis, it was inferred that the sequence variability within individual cells (i.e. variability among polymorphic copies of LSU rDNA) caused both the observed intraindividual and intrapopulational genetic diversities of the Jiaozhou Bay population of M. fulvescens. It was thus assumed that a higher interpopulational diversity would be observed when different geographic populations (e.g. the west coast of Canada and USA, that from Spain, Japan and Korea, and Indonesia) are

compared. We believe the results as presented will provide an insightful basis for this comprehensive survey.

P-B1-22-S Proofs for production of sexual resting cyst by the toxic dinoflagellate *Karenia mikimotoi* from clonal cultures and marine sediments

Yuyang Liu, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences;University of Chinese Academy of Sciences
Zhangxi Hu, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences;Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology
Yunyan Deng, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences;Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology
Yingzhong Tang, CAS Key Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences;Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology
Presenter Email: lyy9303130@163.com

The toxic dinoflagellate *Karenia mikimotoi* is known to form large-scale and dense harmful algal blooms (HABs) in coastal waters worldwide and cause serious economic loss in aquaculture and fisheries and other adverse effects on marine ecosystems. Therefore, understanding the ecology of this species is extremely urgent, especially in the mechanisms of overwintering, bloom initiation, and geographic expansion. Resting cyst, as an important survival strategy in life cycle of dinoflagellates, has been proven to play vital roles in the initiation and termination of blooms and geographical expansion in many HABs-forming dinoflagellates. Whether or not K. mikimotoi forms resting cyst, however, has been a puzzling issue to the research community of HABs. Here, we provide visual and molecular confirmations of the production of sexual, thin-walled resting cysts by K. mikimotoi based on observations of laboratory cultures and detections in marine sediments. Evidences from the light and scanning electron microscopic observations in laboratory cultures include cell pairs in sexual mating, cells in fusion, planozygotes (two longitudinal flagella), thin-walled resting cysts and their germination processes (e.g. new germling with two longitudinal flagella), which together confirmed that K. mikimotoi produces sexual resting cysts homothallically. Evidences from marine sediments collected from locations where K. mikimotoi bloomed frequently include positive PCR detection using species-specific primers, positive detection with fluorescence in situ hybridization (FISH) using species-specific oligonucleotide probe which targets the LSU rDNA D2 domain of K. mikimotoi and was labeled with either FITC or Cys3, light microscopic observation of cysts labeled with FISH probe, and identity confirmation with single-cell PCR sequencing for cysts labeled with FISH probe. The confirmation of sexual resting cyst production by K.

mikimotoi in laboratory cultures and field sediment samples provides a possible mechanism accounting for the recurrences of annual blooms at certain regions and the global expansion of K. mikimotoi blooms during the past decades. Although a postulated population initiation based on the cyst abundance in sediments reflected in our FISH detection may lead to a bloom (e.g. 107 cells L-1) in about a month for a shallow water, the extremely low abundance of cysts, however, necessitates more extensive surveys on temporal and spatial distribution of cysts in the field in order to reveal the exact roles played by resting cysts in the population dynamics of K. mikimotoi, which is ongoing now.

P-B1-23 Correlation between phytoplankton bloom and hypoxia zone formation at the Pearl River Estuary

Pengbin Wang, Key Laboratory of Marine Ecosystem and Biogeochemistry, The Second Institute of Oceanography, State Oceanic Administration (SOA), Hangzhou, 310012, China
Douding Lu, Key Laboratory of Marine Ecosystem and Biogeochemistry, The Second Institute of Oceanography, State Oceanic Administration (SOA), Hangzhou, 310012, China
Leo Lai Chan, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong Special Administrative Region
Xinfeng Dai, Key Laboratory of Marine Ecosystem and Biogeochemistry, The Second Institute of Oceanography, State Oceanic Administration (SOA), Hangzhou, 310012, China
Jiajun Wu, State Key Laboratory in Marine Pollution, City University of Hong Kong, Hong Kong Special Administrative Region
Presenter Email: algae@sio.org.cn

Observations of harmful algal blooms (HABs) are increasing around the world's coastal ocean, with a growing number of reports indicating anthropogenic influences. These phenomena are caused by blooms of microscopic algae. Excessive microalgae growth in response to nutrient increases and/or shifts in nutrient ratios can result in a HABs of a single or several species that has negative ecosystem impacts. As HABs occur and result in the depletion of oxygen (hypoxia) in the water, fishery disasters were reported by many countries. To study the relationship of HABs and hypoxia, we conducted a study on 34 sites via cruise at the Pearl River Estuary from July 10-21, 2017. The temperature and salinity of surface water ranged from 27.9-30.8 degree C and 5.4-33.9 psu, respectively. The dissolved oxygen (DO) of surface water was from 6.1 to 11.7, while the DO of bottom water was lowest reach to 1.3 and the highest DO were just 7.4, an obvious hypoxia and low oxygen zone were detected. At the same time a wide range of phytoplankton bloom in surface water were observed over 10 study sites over 5000cells/ml and with maximum 45560 cells/ml at site F201. After the principal component analysis, there showed a positive correlation between phytoplankton abundance of surface water and DO of surface water, and a negative correlation were shown between phytoplankton abundance of surface water and DO at bottom layer. Further, with the analysis of Next Generation

Sequencing on bacteria composition of sediment, we have detected several typical bacteria may related HABs and hypoxia, such as family Saprospiraceae and class Clostridia, which give some evidence on HABs and its coupled benthic microbial community may trigger and accelerate hypoxia zone formation at the Pearl River Estuary.

P-B2-01-S Study of subcellular localization of dinoflagellate rhodopsin by transformation and expression in mammalian cells

Minglei Ma, State Key Laboratory of Marine Environmental Science(Xiamen University)
Xinguo Shi, State Key Laboratory of Marine Environmental Science(Xiamen University)
Kaidian Zhang, State Key Laboratory of Marine Environmental Science(Xiamen University)
Senjie Lin, State Key Laboratory of Marine Environmental Science(Xiamen University)
Presenter Email: 18850583965@163.com

Rhodopsins are now found in all domains of life. Based on amino acid sequences, rhodopsin proteins are classified into two large groups: type I, found in animal and type II found in microbes including Bacteria, Archaea, and Eukarya. The latter type of rhodopsin has been reported to convert light into ATP directly through light-driven proton pump in the ocean. Rhodopsin genes similar to that encoding proton-pumping rhodopsin in bacteria have been found in dinoflagellates. However, the Subcellular localization and the function of dinoflagellate rhodopsin are still poorly understood. In order to address the gap of knowledge, we constructed expression plasmid for *Prorocentrum* donghaisense and Alexandrium fundyence rhodopsin genes to transfect 293HEK cells. Total RNA was extracted from the stable transformed cells and RT-PCR performed. Results indicate that both of the P. donghaiense and A. fundyense rhodopsin genes have been incorporated into 293T successfully. The results of Western Blot show that the rhodopsin has been expressed in 293T cells successfully. The results of Subcellular localization shows that the rhodopsin is targeted to membrane. We will focus on studying functions of the rhodopsin gene which is to examine intracellular pH under illumination.

P-B2-02-S Measurements of particulate optical properties and their implications in biogeochemical variables in the open South China Sea

Guoqiang Qiu, Xiamen University, Xiamen, China
Xiaogang Xing, Second Institute of Oceanography, Hangzhou, China
Xiao-Hai Yan, University of Delaware, US
Rui Ren, Xiamen University, Xiamen, China
Haili Wang, Xiamen University, Xiamen, China
Presenter Email: guoq,qiu@xmu.edu.cn

Understanding and predicting the physical forcing and biogeochemical responses require multidisciplinary observation synchronously. Bio-optical measurements performed from in-situ and remote sensing platforms provide effective tools for retrieving the biogeochemical

properties in the ocean. Recently, new generations of miniature, low-power consumption bio-optical sensors have been developed. Integrated on in-water profiling floats, moorings, drifters, gliders and autonomous underwater vehicles, they allow significant extension of in-situ observation across multiple spatial and temporal scales. In the future, more autonomous platforms will be deployed in the open South China Sea (SCS). However, the previous bio-optical measurements were mainly carried out in the coastal or northern part of the SCS, while the in-situ observations in the open SCS are very limited. The concentration, composition, and size distribution of the particles vary largely in different regions, and undoubtedly the performance of the empirical relationships between biogeochemical and bio-optical variables can be better if they are established and applied in a specific region. The main aim of this study is to establish such relationships in the open SCS based on data acquired during a summer cruise. The results can be applied to such autonomous platforms in the SCS, which will expand the observation capability.

P-B2-03-S Unifying the concept of euphotic zone depth

Jinghui Wu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China.
Zhongping Lee, School of the Environment, University of Massachusetts, Boston, USA.
Shaoling Shang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China.
Yuyuan Xie, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China.
Gong Lin, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China.
Presenter Email: wujinghui199444@126.com

Traditionally the euphotic zone is defined as a layer from surface to a depth (ZeuPAR) the photosynthetically available radiation (PAR) is 1% of its value at the surface; while the euphotic zone in biological term is defined as a layer from surface to a depth (ZeuNPP) there is no net production. As a result, ZeuPAR can be very different from ZeuNPP, and there has been debate for decades which one should be used to represent "euphotic zone". In this study, based on measured profiles of radiation and primary production in the South China Sea, the compensation irradiance (Ic) corresponding to ZeuNPP is compared with PAR value at depth, as well as the value of usable solar radiation (Lee et al. 2014). It is found that the ratio IcPAR/PAR(0) is generally ~0.52% (± 0.13%), while the ratio IcUSR/USR(0) is generally ~0.98% (± 0.08%), which indicates ZeuPAR could be too shallow to represent the "euphotic zone", at least for these subtropical waters. On the other hand, the depth of 1% surface USR (ZeuUSR) appears closely matching ZeuNPP. Furthermore, the positions of all subsurface chlorophyll maximum are found slightly above ZeuUSR, but can be much deeper than ZeuPAR. These results suggest that ZeuUSR could

be a good candidate to unify the concept and determination of the "euphotic zone", at least for such subtropical waters.

P-B2-04 The diel vertical migration of zooplankton in the hypoxia area observed by Video Plankton Recorder

Pan Jun, Institute of Oceanology, Chinese Academy of Sciences
Cheng Fangping, Institute of Oceanology, Chinese Academy of Sciences
Yu Fei, Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: panjun@qdio.ac.cn

Temperature, salinity, fluorescence, and dissolved oxygen were investigated together with the vertical distribution of four taxa to discuss the reason for diel vertical migration (DVM). Copepods and chaetognatha performed typical DVM, but only a small part of the population appeared under 40 m. Gelatinous zooplanktons aggregated at the surface water layer shallower than 30 m. DVM of euphausiacea remained uncertain because of the small number of individuals investigated in the study. Our study confirmed that VPR could be used as a valuable tool to study zooplankton DVM. DVM of most zooplankton living in the coastal area of the East China Sea might be affected by multiple environmental elements, such as feeding activities, predator presenting, stratification of water column, and energy utilization.

P-B2-05-S High-frequency observation of floating algae from AHI on Himawari-8

Xinrong Chen, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Shaoling Shang, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Zhongping Lee, School for the Environment, University of Massachusetts Boston, Boston, MA 02125
Lin Qi, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Jing Yan, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Yonghong Li, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Presenter Email: 1191088508@qq.com

Himawari-8 (H8) is a geostationary meteorology satellite launched and operated by Japan Meteorological Agency (JMA) and takes measurements at a temporal resolution of 10 minutes for its full disk view. Although designed as a meteorological satellite, the Advanced Himawari Imager (AHI) on board H8 has three visible (460, 510, and 640 nm), one near infrared (860 nm) and two shortwave infrared bands (1610 and 2257 nm) to

observe the Earth system. In this study, the Floating Algae Index (FAI) developed for ocean color satellites (Hu, 2009) is adapted to process AHI data for the first time and applied for waters of Taihu Lake, China. The distribution of floating algae derived from AHI FAI was compared with that derived from concurrent GOCI AFAI (alternative FAI) and MODIS FAI. For a total of 18 near-cloud-free images, a correlation coefficient of 0.92 between the algae area derived from AHI FAI and MODIS FAI was found, with the mean percentage difference of ~5% in algae coverage. More concurrent images (n = 80) were collected for a comparison of FAI between AHI and GOCI as GOCI is also a geostationary satellite, resulting in a correlation coefficient of 0.91 and percentage deviation of ~8% in observed algae coverage. These results indicate that H8/AHI can obtain reliable observations of floating algae at ultrahigh temporal resolutions (10 minutes). In particular, such high-frequency measurements show that part of the Taihu Lake (e.g., the Meiliang Bay, Gong Bay) experienced more frequent cover of floating algae (mostly > 60%) than that observed by GOCI (generally < 40%). High-frequency measurements are thus important not only for efficient environmental monitoring, but also for scientific understanding of algae dynamics.

P-B2-06 A darkfield optical flow imaging system for high-throughput analysis of marine zooplankton

Tao Chen, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences
Jianping Li, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences
Presenter Email: tao.chen@siat.ac.cn

Zooplankton plays important role in matter and energy cycling in marine ecological system. High spatio-temporal frequency observation of zooplankton to quantify their abundance, taxonomy and size composition is one of the fundamental tasks for oceanographic research. However, compared to phytoplankton, fishes, sea birds, and sea mammals, zooplankton observation still represents a major bottleneck in the design of truly ecosystemic studies of marine systems. Optical imaging is promising for quantitative zooplankton sensing due to its non-contact, rapid characteristics and good resolution for morphological analysis. However, the sample volume and imaging resolution do not always enable quantitative estimates of key zooplankton variables. In-situ static imaging instruments (e.g. CPICS and SPC) are good in imaging quality and hence resulted in good taxonomic resolution for zooplankton observation at fixed site underwater. However, their imaging volume is too small for efficient sensing of sparsely distributed zooplankton in natural seawater environment. On the contrary, towed imaging technologies (e.g. VPR and ISIIS) have much larger imaging volume and water sampling throughput, but the increase in silhouette imaging efficiency is payed off by sacrificing morphological details, and hence resulting in taxonomy weakness. Net sampling enrichment followed by imaging (e.g. ZooScan) is another strategy proved highly efficient in zooplankton analysis. Particularly,

besides terrestrial lab examination of chemically fixed samples shipped back by cruise, there is an increasing need to have concentrated live samples being analyzed on board. Unfortunately, flat-scanning technology has poor imaging resolution and slow speed, and requires unilaminar distribution of samples in static. These limitations have disabled its application for live swimming zooplankton imaging and severely degraded their performance on a jerky research vessel. In this light, we aimed to develop a new flow imaging system that is capable of high-throughput imaging net-condensed live or fixed zooplankton particles with good imaging quality and enhanced efficiency. The system features in equipment of 360-degee darkfield illumination with matched illumination volume to depth-of-field, and in-line arrangement between imaging axis and flowing direction. With up to 27.2mmx21.7mm field-of-view and 20 micron resolution, the system can acquire high quality images of zooplankton in size range from 400 micron to 10mm at a volume flow rate of 1.5L/min. With dedicated image analysis software, the system is expected to produce zooplankton abundance, taxonomy and sizing information with greatly increased accuracy and efficiency. We will report the hardware and software development of this imaging system and present preliminary results in this conference.

P-B3-01-S Controls on seasonal variability in pelagic plankton productivity in the East China sea: a 1-D modelling perspective

Jianzhong Chen, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China.
Richard Bellerby, 1State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China;2Norwegian Institute for Water Research, Bergen N-5006, Norway.
Jianzhong Ge, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China.
Presenter Email: chenjianzhong1003@outlook.com

The East China Sea (ESC) is a highly productive continental shelf sea, however, the important ecosystem services it provides are under pressure from environmental and climate change. A better understanding of the interplay between ecosystems and ecosystem stressors will enable more efficient management of ecosystem services. Our approach is to develop new modelling tools that will deliver an improved understanding of the interactions among the components of the pelagic ecosystem. We developed simulations through a 1D physical-biogeochemical coupled model: GOTM-FABM-ERSEM that considered phytoplankton, zooplankton, bacteria, particulate matter and nutrients as state variables. Model results indicate that phytoplankton characteristics are driven by temperature, light, feeding pressure and nutrient availability, with two clear productive periods in spring and autumn. The maximum chlorophyll-a occurs in summer with a peak of 5.3 mg C m-3 along with high temperature and stable stratification of water column. In

addition, phytoplankton show cyclic variability influenced by season, light and tides. The timing of zooplankton and bacteria is similar to that of phytoplankton, though with a 3-day lag in spring, related to the trophic level in the ecosystem; respective biomasses reach highest values of 150 mg C m-3 and 39 mg C m-3 in the spring. Zooplankton also exhibits two productivity peaks through a year where as bacteria are present year round.

P-B3-02 A modeling study on the spatio-temporal variability of primary production in the East/Japan Sea

Rubao Ji, Department of Biology, Woods Hole Oceanographic Institution, Woods Hole, MA, USA
Meibing Jin, International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA
Yun Li, College of Marine Science, University of South Florida, St. Petersburg, FL, USA
Yun-Ho Kang, School of Earth Sciences & Environmental Engineering, Gwangju Institute of Science and Technology, Gwangju, Republic of Korea
Chang-Keun Kang, School of Earth Sciences & Environmental Engineering, Gwangju Institute of Science and Technology, Gwangju, Republic of Korea
Presenter Email: rji@whoi.edu

The primary productivity of the East/Japan Sea (EJS) displays strong spatio-temporal variability, largely driven by the oceanographic forcings that vary across the different regions of the sea. Consequently, the ecosystem responses to climate variability could be region-dependent. The model-based analysis from this study synthesized the complex biological-physical interactions across the EJS, and suggested an intricate role of water column stability in driving the observed seasonal and basin-scale variability. Compared to the northern EJS (e.g. the Japan Basin), the southern EJS (e.g. the Ulleung and Yamato Basins) has a more favorable mixing regime for higher productivity in both winter and summer, balancing the need for phytoplankton growth in terms of nutrient and light availability. In addition, the current- and wind- induced upwelling along the east coast of Korea further enhances the productivity in the southwestern EJS. The general south-north 'see-saw' pattern of mixing regime, combined with upwelling-downwelling switching, could be the key driver for the observed production patterns in the EJS.

P-B3-03-S Variability of hypoxia in coastal transition zone off Pearl River Estuary: observational and modelling studies

Dou Li, Department of Ocean Science, Hong Kong University of Science and Technology
Jianping Gan, Department of Ocean Science, Hong Kong University of Science and Technology
Presenter Email: dliar@connect.ust.hk

The deterioration of hypoxia (dissolved oxygen or DO<2 mg l^{-1}) condition in the Pearl River

estuary and adjacent coastal waters has attracted more and more attentions recently. In this study, data from two summer cruises in 2017 and 2018 are used to examine spatial and temporal variability of hypoxia in the Pearl River Estuary (PRE) and adjacent coastal waters around Hong Kong. Observations showed that there existed hypoxia occurred the coastal transition zone (CTZ) off PRE featured with two strong hypoxic centers in western and eastern part of the CTZ. We observed high variability of the hypoxia, as reflected by the location, area, thickness and volume of hypoxic waters from field measurements under variable wind, and river runoff and tidal forcing. A three-dimensional (3-D) coupled physical-biogeochemical model was applied to interpret the observed variability and explore the underlying mechanisms for the formation, sustenance and dissipation of hypoxia. Based on the variable physical and biogeochemical forcing conditions during the surveys, we conduct direct simulation on the observed biophysical responses under different forcing conditions. We conducted a series of analyses to determine the intrinsic coupled physical-biogeochemical response to the extrinsic forcing of winds, tides, river discharge of both buoyancy and nutrient loading, and the associated estuarine-shelf circulation in the CTZ.

P-B3-04-S Extending our understanding of the marine carbonate system in the Changjiang Estuary and adjacent East China Sea shelf using Artificial Neural Networks

Xiaoshuang Li, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062
Richard Bellerby, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062; Norwegian Institute for Water Research, Bergen, Norway N-5006
Yawen Wei, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062
Anqiang Yang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062
Jing Liu, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062
Presenter Email: 52173904019@stu.ecnu.edu.cn

We developed relationship between the marine carbonate system in the Changjiang Estuary and adjacent East China Sea shelf and both nutrient biogeochemistry and hydrography using canonical correspondence analysis (CCA), and estimated water column total alkalinity and pH through artificial neural networks (ANN). The CCA showed that carbonate parameters were strongly related to temperature (T), salinity (S), and dissolved oxygen (DO), which indicated both physical and biological processes had significant influence on the carbonate system. Accordingly, an artificial neural network was informed

using matrices from measured parameters (pressure (Pre), T, S, DO, nitrate (N), phosphate (P), and silicate (Si)) during a shelf study in May 2017, which was applied to estimate water column pH and total alkalinity. Overall, the ANN model retrieved the variables with high accuracies (RMSE): 7.514 μmol/kg for alkalinity and 0.022 for pH. This was confirmed for the independent test set not include in the training process. The ANN model was also applied to produce high resolution total alkalinity and pH data using temperature, salinity and dissolved oxygen from July 2016 cruise. It is thus a promising method to derive distributions of key biogeochemical variables. Whilst our model is not presently informed to analyze ocean acidification, it will be used to inform on the seasonal and inter-annual variability of the carbonate system using historical ocean data where no carbonate measurements are available.

P-B3-05 Modeling the Dissolved Oxygen in the Northern South China Sea in the Summer Driven by the Physical and Biogeochemical Processes

Qicheng Meng, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Feng Zhou, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Presenter Email: q.meng@sio.org.cn

The dissolved oxygen (DO) is essential for the vast aquatic species, and it is therefore significant for the whole marine ecosystem. The DO is not a conservative tracer. It is not only driven by the convection and diffusion processes, but also modulated by the air-sea interaction, photosynthesis, respiration, decomposition, etc. There are inadequate process-oriented observational data of the DO in the water column especially at the shelf seas. In the first decade of the 21st century, the State Oceanic Administration together with other authorities conducted a large-scale multi-disciplinary survey in the coastal waters of China. It provides the valuable data of the seasonal DO distribution in the northern South China Sea (NoSCS). It is found that the low DO water at the bottom on the shelf forms a pincerlike encirclement from two pathways which are off the eastern coastline of the Hainan Island and off the eastern coastline of the Guangdong province, respectively. Those two pathways seem to coincide with the two upwelling systems that are mainly induced by the prevailing summer monsoon. This research aims to use the state-of-the-art coupled physical-biogeochemical model, ROMS+CoSiNE, to reproduce the dissolved oxygen in the NoSCS in the summer. The ROMS+CoSiNE model covers the whole SCS with the 1/12° resolution. The circulation model is forced by the climatological monthly-averaged wind stress, heat flux and fresh water flux. The open boundary conditions are restored to those given by the global circulation model. It considers both the tidal forcing and the riverine runoffs. The initial and boundary conditions of the biogeochemical state variables are provided by the well-validated CoSiNE-Pacific model. The circulation model is validated by

the available observational data including the climatological dataset SCSPOD14 based on the WOD dataset, the ARGO profiles and the surveys by the South China Sea Institute of Oceanology, Chinese Academy of Sciences. The performance of the biogeochemical model is evaluated by the surface chlorophyll data provided by the SeaWiFS satellite. The distribution of the low DO bottom water in the NoSCS in the summer that resembles a pair of pincers can be seen from the model result and it agrees well with the observational data. With the process-oriented model, it is expected to reveal the coupled physical and biogeochemical mechanisms that govern the DO concentration in the bottom water of the NoSCS, which may facilitate the further study of the impact of the climate change on the ecosystem inhabiting there.

P-B3-06-S A one-dimensional physical-biogeochemical model applied to time-series Station Papa

Haoran Zhang, Second Institute of Oceanography Hohai University
Yuntao Wang, Second Institute of Oceanography
Fei Chai, Second Institute of Oceanography
Yi Yu, Second Institute of Oceanography
Presenter Email: zhanghaoran22@163.com

A coupled one-dimensional model was applied to Station Papa (50°N, 215°E), which is High Nitrate, Low Chlorophyll (HNLC) region. The physical model was based on the Regional Ocean Model System (ROMS), and the biogeochemical model used here was based on the Carbon, Silicate, and Nitrogen Ecosystem (CoSiNE) model. Observed seasonal cycles of ecosystem dynamics at Station Papa, such as maximum (minimum) chlorophyll-a concentration in summer (winter) in the upper ocean, were successfully reproduced by the model. Model simulations demonstrated that the temperature played an important role on the phytoplankton grow at high latitudes of the North Pacific. After taking into account the temperature effect on phytoplankton grow, the maximum concentration of chlorophyll appeared in July, which was consistent with the observation results. Therefore, the 1D model could successfully simulate the basic physical and ecological parameters of Station Papa. Based on this, a series of sensitivity analyses of iron-limitation were conducted in the model by reducing the potential maximum specific small phytoplankton and diatom growth rate. Within the iron-limitation experiments for small phytoplankton (diatom), the diatom population increased (decreased) and the small phytoplankton decreased (increased). In addition, total phytoplankton populations were mostly driven by the changes of small phytoplankton. Thus, the 1D physical-biogeochemical model could help to further investigate the ecosystem cycle in HNLC region and in the future, the iron cycle will be consisted in the 1D model. It is important to understand the major iron sources to the upper ocean, distributions and characters of different iron forms, the response of iron cycle to the change of ocean and atmospheric

conditions in future in HNLC region.

P-G1-01-S Possible geological evidence for historical storm events from Dongshan Bay, southern China

Chengcheng Gao, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Fengling Yu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Tian Xia, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Hui Zhang, Lanzhou University, Lanzhou, China
Liangrong Zou, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Zhangyu Cheng, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: 1512998201@qq.com

Every year, typhoon storm surges cause huge casualties and property losses in China. The prospective and accuracy of existing storm surge warning and forecasting methods is not enough to meet the requirements of disaster prevention. The occurrence law of ancient storm surges can be retrieved by geological records, which provides a scientific basis for the prevention and treatment of storm surges at a larger time and space scale. This study aims to reconstruct palaeo-typhoon/storm events using geological records from Dongshan Bay, Fujian Province, southern China. In 2018, a total of 12 surface sediments from the inner bay (near Zhangjiang Estuary) to the outer bay mouth, and one gravity core, 55cm in length, were collected. All samples were analyzed for particle size through Malvern Mastersizer 3000, and the core was scanned by XRF core scanner for elemental composition in Xiamen University. Results of the surface samples show that sediments from the inner bay are well-sorted clay and silt, with the maximum grain size of 500 microns, mostly 7 microns. Sediments become coarser from the inner bay to the outer bay. At the bay mouth region near the Gulei Penisula, the coarse particles increased significantly, and the gravel composition could account for 21.87% of the surface sediments. These coarse gravel components are most likely transported during recent storms from the Gulei Peninsula and/or Dongshan Island. The results of the particle size of the core show that core sediments are dominantly silt, between 10-50 microns, deposited under a low-energy condition. Results also show that the 55 cm core contains multiple coarse-grained interlayers (0-8cm,22-23cm,40-41cm and 51-55cm) with maximum particle sizes exceeding 3 mm, indicating at least two strong-energy events, such as typhoon-induced storm. Furthermore, the results of the elemental analysis show that these coarse layers contains higher contents of Cu, Zn, Ga, Br and Rb than the rest part of the

core. The above preliminary results show that the grain size and element analysis of surface sediments and core samples in Dongshan Bay, will provide a reliable geological basis for the reconstruction of palaeo-storm events and for the estimation of their reoccurrence period. More analyses on geochemistry and chronology are under process.

P-G1-02-S Identification of diverse particle types in the water column on the Gaoping shelf, SW Taiwan

Peter Z. Jue, Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan
James T. Liu, Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan
Presenter Email: legendstory0129@gmail.com

With the progress of science and technology, LISST-Holo can provide us particle images, which is a laser camera, whose advantage is to generate holograms of in-situ particles. We can use the programs released by the manufacturer Sequoia to reconstruct images and get statistics on particle data. With reconstructed images, we can classify particles into biogenic and floc categories and measure particle sizes easily. The strength of incorporating this brand-new instrument into particle research is Holo can avoid breaking fragile flocs into pieces during water sample collection and the ensuing filtering procedure. This study was conducted on board R/V Ocean Researcher III on the OR3-2039 cruise on November 11th, 2017. The field work was to observe particles in the water column off Gaoping area. In our field experiment, LISST-Holo was placed on the CTD Rossette and stopped at five depths (5, 20, 50, 100, 160 m) for at least two minutes each time to collect the enough samples due to the low sample frequency (0.2 Hz). In order to fit the limit on the moving speed of LISST Holo, we kept the CTD at the casting rate of 0.5 m/s. In addition to hologram data, we also collected water samples to analyze suspended sediment concentration (SSC) and chlorophyll-a. We used these data to examine the distribution of particles and their types at the study site. Until now, our findings from holograms show there were more zooplankton and phytoplankton in surface water than bottom water because of enough sunlight. The number of biogenic particles in the bottom was almost zero. The biogenic particles we found were diatoms, radiolarians, dinoflagellates, etc. On the other hand, flocs were present both in surface and bottom waters, but there were more flocs in the bottom. We also measured SSC corresponding to chlorophyll-a shallower than 45 m. The percentages of biogenic particles at each depth LISST-Holo measured were 89% (at 5 m) and 55% (at 20 m). The trend of SSC and chlorophyll-a were opposite in depths deeper than 45 m. With the increasing depth, chlorophyll-a concentration decreased, and SSC increased. The percentages of flocs were 74% (at 50 m), 97% (at 100 m), and 100% (at 160 m). As a result, we suggest the change of SSC shallower than the 45 m depth was dominated by biogenic particles, and

the change deeper than 45 m was dominated by flocs.

P-G1-03-S Hydrodynamics and Suspended Sediment transport in the South Passage of Changjiang Estuary after Typhoon Maria

Lan Tingfei, School of Geography and Ocean Science, Nanjing University
Yaping Wang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Presenter Email: qaz404250625@163.com

The sediment transport and hydrodynamics in Changjiang estuary are always popular topics. But researches focus on suspended sediment in south passage after a typhoon remain to further investigate. Data comes from the measurement in July 2018, just after the typhoon Maria went away. Vertical and tidal variability of velocity, sediment size, suspended sediment concentration and its relationship with halocline are analyzed using time series from one week long experiments. Evidence of flocculation are also found using in situ laser particle size analyzer. Mean particle size of particles in suspension is one order of magnitude larger than the primary size of the sediment. The contribution amount of typhoon Maria to this phenomenon is studied. Besides, SSC and sediment transport flux changes after typhoon are calculated to explain the influence mechanism. This research only studied for a week after typhoon, further study needs to be done.

P-G1-04 Using δ13C and C/N to Indicate the Source and Transport Process of Particulate Organic Matter in Jiulong River Estuary, Southeast China

Liangrong Zou, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Fengling Yu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Peng Cheng, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Nengwang Cheng, College of Ecology and Evironmental Science, Xiamen University, Xiamen, China
Tian Xia, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
James T. Liu, Department of Oceanography, National Sun Yat-sen University
Presenter Email: fengling.yu@xmu.edu.cn

This study chooses Jiulong River Estuary (JRE), a typical small macro-tidal estuary located at southeast of China, as a case to explore the source and transport process of POC by the indication of δ13C values and C/N ratios. The results show that there are three major pools of organic matter can be recognized in JRE: terrestrial, riverine and marine organic materials. POC is a conservative mixture riverine and marine POC in JRE. The filter effect

of ETM traps large amount of POC and deposits it. While terrestrial organic matter becomes an important origin of SOM in JRE. δ13C and C/N can indicate the influence of tide to the transport of POC in JRE, and sediment resuspension is the dominated source to settling organic matter in ETM of JRE.

P-G1-05-S The evolution of hypoxia off the Changjiang Estuary in the last ~3,000 years: evidence from the benthic foraminiferal assemblages

Fahui Ren, State Key Laboratory of Marine Geology, Tongji University
Daidu Fan, State Key Laboratory of Marine Geology, Tongji University
Quanhong Zhao, State Key Laboratory of Marine Geology, Tongji University
Yijing Wu, State Key Laboratory of Marine Geology, Tongji University
Jianfeng Su, State Key Laboratory of Marine Geology, Tongji University
Presenter Email: fahui1229@126.com

Coastal hypoxia exerts increasing impacts on the ecological system and fishery production, consequently attracting increased concern in the past decades. A lot of efforts have been made to better understand hypoxia trigger mechanism and future development tendency under the global change and increasing human disturbances. The hypoxia off the Changjiang Estuary occurs seasonally with a relatively stable core area. A continuous long core of YD0902 has been retrieved from the hypoxia core area in 2009. The core strata have been studied in detail and the stratal chronology has been established by the AMS14C dating result. In this study, hypoxia conditions will be reconstructed using benthic foraminifera assemblages, including the A-P index (A% + P%) and LOFA index (Bolivina spp.% + Bulimina marginata% +Epistominella naraensis%), together with sedimentary elemental ratios Mn/Ti and Cd/Al. The results show that, the benthic dissolved oxygen (DO) should be high during 3.00~2.56 cal. ka BP, and then it decreased rapidly to produce hypoxia. The former was inferred to link with the rapid cold climate event in the northern hemisphere during 3.50~2.50 cal. ka BP (Mayewski, 2004). Alternations of mild and severe hypoxia were identified over centennial scales with severe stages: 1.98~1.84, 0.80~0.76 and 0.48~0.42 cal. ka BP, versus mild stages: 2.36~2.26, 2.20~2.14, 1.84~1.60, 1.42~1.28 and 0.30~0.16 cal. ka BP. The sea level was considered to be relatively stable in the last ~3000 years, so we assume that the alternations of severe and mild hypoxia events were mainly linked to the enhanced East Asia Summer Monsoon (EASM) and cold climate events, respectively. The enhanced EASM could increase precipitation in the Changjiang drainage basin and river discharge into the sea, resulting in water stratification and eutrophication off the estuary to enhance the hypoxia. The cold climate events in the late Holocene, such as the Little Ice Age (LIA) of Ming and Qing dynasty (AD 1550~1851), could make the EASM weaken and precipitation decrease, so hypoxia would become weaker. Recently, the impact of anthropogenic activities on hypoxia has been observed to grow significantly.

P-G1-06-S The influence of seabed microrelief on hydrodynamic evolutions in the south branch of Yangtze River estuary

Hao Wu, School of Geography and Ocean Science,NANJING UNIVERSITY
Presenter Email: haowu.esx@foxmail.com

Submarine geomorphology and sedimentary dynamics of near-bottom boundary layer in the south branch of the Yangtze River estuary, July 13-19, 2018. 3d topographic, current velocity and Suspended Particulate Matter (SPM) concentration were obtained from 3D Sand Ripple Profiling (3D sonar), Acoustic Doppler Velocimetry (ADV), Optical Backscatter Sensor (OBS). The difference methods were utilized to extract the bedform information from observed sonar data. The relationship was established between the bedform evolution and hydrodynamic/suspended sediment concentration. The erosion and siltation of bottom bed in the study area were analyzed quantitatively and qualitatively. The change rule of roughness height is calculated and the change of hydrodynamic evolution is further analyzed. The results of bottom morphology data show that the morphology change of bed is obvious in tidal period. In addition, by analyzing the data of sedimentary dynamics, it is found that there is a positive correlation between the undulation degree of bed shape and current velocity. The relationship between the fluctuation degree and current velocity of the bed in the east-west direction and north-south direction shows that the current direction has an important influence on the fluctuation degree of the bed.

P-G1-07-S Sedimentological study of sediment cores offshore Jiulongjiang River: Preliminary results from 210Pbex

Jimmy J. Xu, Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan
James T, Liu, Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan
Steven C. Chien, Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan
Chih-Chien Su, Institute of Oceanography, National Taiwan University, Taipei, Taiwan
Presenter Email: qaz4778706@gmail.com

The Jiulongjiang River (JLJ) is located in Fujian, China and flows eastward into the Taiwan Strait. It is one of the major rivers in Fujian and the sediment supply is not negligible. The source-to-sink process of sediment dispersal process from JLJ is affected by many factors such as the river hydrology, China's coastal currents, and typhoons, etc. In this research, the 210Pbex activity in the cores collected offshore the mouth of JLJ was used to examine deposition pattern and to calculate the deposition rate to investigate the sedimentation process. In 2015, on R/V Ocean Research III (OR3) cruise 1850, our team collected 4 cores, KM4, KM6, KM7 and MK1. KM4-KM7 were located along a seaward transect between the JLJ mouth and the Taiwan Strait. MK1 was located near the south shore of Qinmen.

The 210Pbex activity indicates signals of fresh terrigenous sediments and can be used to calculate the deposition rate of surface sediments. Based on the 210Pbex activity profile of each core, the 210Pbex activity decreases from KM4 to KM7. The deposition rates of KM4 and KM7 are similar. KM6 was disturbed and has a slower deposition rate. These findings indicate that as the JLJ sediments were transported into the Taiwan Strait, there was sediment supplied from other sources. Also physical processes disturb the surface sediments, resulting in a decreasing 210Pbex activity. In the future, the Empirical Orthogonal Function (EOF) will be used to analyze the correlations among core composition, color reflection, physical properties from MSCL and radioisotope analysis (7Be activity) to investigate the sedimentation process and sediment composition of the JJL source-to-sink dispersal system.

P-G1-09-S Using 210Pb to constrain sediment focusing in Taiwan Strait

Xiao Zhang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University
Fang Zhang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University
Weifeng Yang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University
Min Chen, College of Ocean and Earth Sciences, Xiamen University
Yusheng Qiu, College of Ocean and Earth Sciences, Xiamen University
Presenter Email: xiaozhang@stu.xmu.edu.cn

210Pb has been proposed to be an effective tracer of constraining sediment redistribution in shelf regions. Here, the inventories of 210Pb in sediment cores were examined to test its application to identify sediment focusing in western Taiwan Strait. The focusing factor varied from 0.07 to 2.11, indicating sediment focusing at some stations. Spatially, stations with focusing were located in the sedimentary areas identified by other methods, validating the application of 210Pb to constrain sediment focusing in Taiwan Strait. A preliminary budget suggested that the focusing flux of 210Pb ranged from 0.42 Bq m-2 yr-1 to 2.13 Bq m-2 yr-1 with an average of 0.97 Bq m-2 yr-1, accounting for 31% of the burial flux of 210Pb in focusing areas on average. In addition to river runoff and interior focusing in Taiwan Strait, boundary scavenging (BS) via Kuroshio branch is also an important 210Pb source given the focused 210Pb, which contributes about 14% of the total 210Pb input into Taiwan Strait. Thus, Taiwan Strait is a site for intercepting BS-derived 210Pb.

P-G1-10 Long-term in situ observations on typhoon-triggered turbidity currents in the deep sea

Yanwei Zhang, Tongji University

Zhifei Liu, Tongji University
Yulong Zhao, Tongji University
Christophe Colin, University de Paris-Sud
Xiaodong Zhang, Tongji University
Meng Wang, Tongji University
Shaohua Zhao, Tongji University
Benjamin Kneller, University of Aberdeen
Presenter Email: ywzhang@tongji.edu.cn

Turbidity currents regulate the transport of terrigenous sediment, abundant in carbon and nutrients, from the shelf to the deep sea. However, triggers of deep-sea turbidity currents are diverse and remain debatable in individual cases due to few direct measurements and unpredictable occurrence. Here we present long-term monitoring of turbidity currents at a water depth of 2104 m on the margin of the Gaoping Submarine Canyon off Taiwan, which has the world's highest erosion rates and wettest typhoons. The unique 3.5 year record of in situ observations demonstrates the frequent occurrence of deep-sea turbidity currents (an average of six times per year from May 2013 to October 2016), most of which show enhanced sediment flux, raised temperature, and lowered salinity. They are attributed to elevated discharge of the Gaoping River due to typhoons traversing Taiwan. The total duration of these prolonged turbidity currents amounts to 30% of the entire monitoring period, contributing to ~72% of total sediment transport in the lower canyon. Our study demonstrates for the first time that typhoons are the most important triggers, in the long term, of frequent turbidity currents and enhanced sediment delivery into the deep sea in the typhoon-river-canyon-environment.

P-G1-11-S Abundance and burial flux of soot black carbon in sediments on the northern South China Sea Shelf

Junfei Zhou, College of Ocean and Earth Sciences, Xiamen University
Weifeng Yang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University
Ziming Fang, College of Ocean and Earth Sciences, Xiamen University
Fang Zhang, College of Ocean and Earth Sciences, Xiamen University
Xiao Zhang, College of Ocean and Earth Sciences, Xiamen University
Yusheng Qiu, College of Ocean and Earth Sciences, Xiamen University
Presenter Email: 22320171150797@stu.xmu.edu.cn

Black carbon (BC) represents one of the most refractory carbon pools in the ocean. Here, the abundance and burial flux of soot black carbon (soot-BC) were examined in five sediment cores collected on the northern South China Sea Shelf. From coast to offshore stations, soot-BC contents averaged 0.035% (mg-BC per mg-dry sediment), 0.050%, 0.041%, 0.016% and 0.027% at five stations respectively. Spatially, stations close to

slope showed lower BC values than nearshore stations. Soot-BC accounted for 2.5% to 18.2% of the total organic carbon with the lowest values in offshore stations, indicating a weakened influence of soot-BC on carbon pool in slope and basin regions. Combining the sedimentation rates constrained by 210Pb-chronology, the burial fluxes of soot-BC were estimated to average 0.062 mg cm-2 yr-1, 0.111 mg cm-2 yr-1, 0.042 mg cm-2 yr-1, 0.014 mg cm-2 yr-1 and 0.015 mg cm-2 yr-1 from nearshore to offshore stations. Prior to 1950s, soot-BC burial fluxes showed a little variability. From 1950s to 1980s, a slowly increase was observed at three nearshore stations. After 1980s, soot-BC burial had an evident elevation. However, such trends were not obvious at offshore stations. These results indicated that anthropogenic activities play an important role in affecting the abundance and burial flux of soot-BC in the northern South China Sea Shelf regions. Re-construction of the temporal variability in soot-BC would provide insights into the influence of human on the environmental changes in the South China Sea. Acknowledgments This work was supported by the NSFC(41476061).

P-G2-02 Regional paleoenvironment record of dinocycts in the Beibu Gulf: evidence from sedimentary core SO31

Chao Li, Xiamen University
Jinpeng Zhang, Guangzhou Marine Geological Survey, China Geological Survey, Guangzhou 510760, China
Yilin Cai, Xiamen University
Tingting Weng, Xiamen University
Xiulin Feng, Xiamen University
Zhichao Zhao, Xiamen University
Jianfei Mao, Xiamen University
Guangshan Liu, Xiamen University
Pengfei Zhan, Xiamen University
Presenter Email: lichao@xmu.edu.cn

Dinoflagellates are eukaryotic, single-celled plankton, important primary productivities in the sea, and some species could produce resting cysts during their life cycle. Dinocysts indicator related to productivity, temperature and the eutrophication situation of seawater etc. In order to understand paleoenvrionment in the Holocene and Last Deglaciation in the Beibu Gulf, NW of the South China Sea, a sedimentary core SO31 (716 cm length, since ca. 13 cal. kyr. BP) from the middle of Beibu Gulf was processed and focused on the dinoflagellate cysts. 14 genus 37 species of dinocycts are identified from 178 samples, including the dominated species, Gonyaulax scrippsae, Gonyaulax spinifera, Gonyaulax sp., Lingulodinium polyedra, Posoniella tricarinelloide, *Protoceratium reticulatum*, Protoperidinium sp. and Scrippsiella trochoidea. According to dinocysts abundance and species assemblages, four dinocyst assemblage zones could be divided in this core. The

first dinocyst assemblage zone, in the 0 - 285 cm interval (ca. 2700 cal. yr. BP to present), was characterized by not continuous disappearance of dinocysts, with poor abundance in general. These reflected dinoflagellates productivity was lower level under low nutrients condition. The dinocysts lack intervals, in term of unfavorable preservation conditions probably was influenced by strong hydrodynamics. More high average percentage of warm water species (e.g. G. scrippsae, G. spinifera, P. sp. Scippsiella trochoidea). indicated a warm seawater environment. The second dinocyst assemblage zone, in 285-485 cm interval (ca.2 700 - 7 500 cal. yr. BP) is characterized by higher abundances in general, with higher percentage of G. scrippsae, S. trohoides, L. polyedra. In addition, P. tricarinelloides and P. reticulatum with peak percentage were 30.5% and 76.5% respectively. These indicated relative stable hydrodynamic status with higher nutrients condition. The third zone, in 485-615 cm interval, (ca.7 500 - 11 700 cal. yr. BP) is characterized by dinocycts abundance changes greatly, with higher percentage of G. scrippsae, G. sp., L. polyedra and S. trohoides, the extreme abundance in this core occurred at ca.9 300-?9 500 cal. yr. BP, that means algal blooms might had outbroken with terrigenous nutrients input increased during the early Holocene. The forth dinocyst assemblage zone, in 615 - 715cm interval (ca. 11700 - ca. 13 000 cal. yr. BP), was characterized by lower abundances with less taxa, and just Gonyaulax spp., Protoperidinium sp. had relatively high percentage. This zone was set in the rising sea level process with relative strong hydrodynamic environment after the last Glacial Maximum. The autotrophic type a little more than heterotrophic type with means of the mix water happened. Key words: dinocycts, paleoenvironment record, Beibu Gulf

P-G2-03-S Characteristic and forcing mechanism of the North Equatorial Undercurrent: a numerical modeling study

Junlu LI, Division of Environment, The Hong Kong University of Science and Technology
Jianping GAN, Division of Environment, The Hong Kong University of Science and Technology
Presenter Email: jliaw@connect.ust.hk

The North Equatorial Current-Kuroshio-Mindanao Current (NKM) circulation system in the Western Pacific Ocean (WPO) governs the water/energy exchange in the warm pool and greatly influences the conditions in China Seas. Beneath each component of the NKM, there exist the eastward North Equatorial Undercurrent (NEUC), southward Luzon Undercurrent (LUC) and northward Mindanao Undercurrent (MUC), respectively. Although this undercurrent system (NKMU) has been observed in the past decades, its physical characteristics and underlying dynamics remain largely unclear. The NEUC transports intermediate water eastward and links dynamically with the NKM, while the LUC and MUC may fuel the NEUC. We know little about the connections among the undercurrents in the NKMU as well as the linkage between the NKMU and NKM. Based on physics-oriented

modeling studies, we find that the NEUC extends from the bottom of the NEC at ~600 m to deeper than 1500 m. It is characterized with the northern and southern branches, each with width of ~400 km. The net eastward transport of the NEUC reaches its peak intensity in the second half of a year but is replaced by a net westward transport in the first half of a year. Different dynamics origins lead to different seasonal variations in the northern and southern branches, which peaks in August and November, respectively. By decomposing the velocity of the NEUC into large-scale (>400 km) and meso-scale (<400 km) components according to the intrinsic width of each branch, we find that the large-scale variability has a stronger seasonality, which is significantly associated with the combined effect of the meridional barotropic pressure gradient force (PGF_BT) and the baroclinic PGF (PGF_BC). The meso-scale variability is spatiotemporally independent, which is attributed to the westward propagating meso-scale eddies. The NEUC is mainly fueled by the inflows of the adjacent LUC and MUC, and the variation and magnitude of the northern and southern branch of the NEUC is highly correlated with the LUC and MUC, respectively. The NEUC is largely offset by Sverdrup transport induced by wind stress curl, yet the atmospheric forcing contributes ~60% to the seasonal variation of the NEUC.

P-G2-04 Multi-decadal to centennial-scale variability in Australia n-Indonesian monsoon intensity over the past two millennia

Stephan Steinke, Department of Geological Oceanography and State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China

Mahyar Mohtadi, MARUM - Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany

Jeroen Groeneveld, Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany

Presenter Email: ssteinke@xmu.edu.cn

The Australian-Indonesian monsoon (AIM) system is an important determinant of the climate system in the tropical Indo-Pacific region. The factors controlling past variability of the AIM are, however, less well understood. Here, we present 2000 years high-resolution records of Australian-Indonesian winter monsoon (AIWM) winds and summer monsoon (AISM) rainfall from the same sedimentary archive retrieved offshore southern Indonesia. AIWM winds were generally strong during the Little Ice Age (LIA) and weak during the Medieval Warm Period (MWP) and the Roman Warm Period (RWP). We find that rainfall was generally stronger during the LIA and weaker during the MWP and RWP. Based on modern instrumental records, we suggest that changes in the background state of the tropical Pacific so-called El Niño-like or La Niña-like conditions may have substantially contributed to the multi-decadal and centennial-scale upwelling variations and hence changes in austral winter monsoon winds over the past 2000 years. However, the prevalence of El Niño-like conditions during the LIA and La Niña-like conditions during the

MWP and RWP conflicts with our AISM rainfall reconstructions. It is expected from modern observations that periods of more frequent and/or intense El Niño events, such as during the LIA have resulted in reduced rainfall and subsequent drought in the AISM region and, consequently, less riverine terrestrial supply to our site. This disagreement might suggest that either the centennial-scale variations of the AISM and AIWM during the past 2000 years are unrelated to ENSO dynamics and other factors, such as variations in the strength of the Walker circulation need to be invoked to explain austral summer and winter monsoon variability, or that El Niño events co-vary with La Niña events on that time scales, which typically would result in increased rainfall over central and southern Indonesia and northern Australia.

P-G2-05-S Carbon and Nitrogen Isotopic Records of Sedimentary Organic Matter from the Min-Zhe Mud Deposit on the East China Sea Continental Shelf: Implications for Paleoenvironmental Changes from the Late Glacial

Huawei Wang, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen China

Can Yang, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen China

Qianqian Liu, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen China

Shengfa Liu, Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography, State Oceanic Administration, Qingdao, China Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

Xuefa Shi, Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography, State Oceanic Administration, Qingdao, China Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

Huaiyan Lei, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen China

Selvaraj Kandasamy, Department of Geological Oceanography, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen China Laboratory for Marine Geology, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

Presenter Email: hwwang@stu.xmu.edu.cn

Millennial scale carbon cycling and glacial-interglacial environmental changes are profoundly dependent on organic carbon (OC) burial in the marine realm, wherein the continental margins alone account for approximately 85% of total OC burial. Mud deposits formed in the inner shelf of the marginal seas during the Holocene contain both land-derived and marine-sourced organic matter (OM), but the proportion of these sources and key mechanisms controlling their burial are less constrained. In this study, a 35.3 m-long core (MZ02) recovered from the Min-Zhe mud deposit in the East China Sea was measured for the contents of organic carbon (OC), total nitrogen (TN) and their stable isotopes (δ13C, δ15N), as well as grain size, to investigate the provenance of OM and reconstruct paleoenvironmental evolution for the last around 13000 yr BP. Results show relatively higher molar C/N ratios (7.3-10.5, mean: 8.7) and lower δ13C values (-24.0‰ to -22.2‰ mean: -23.0‰ indicating higher contribution of land-derived OM due to low sea level between 13000 and ~10000 yr BP. Very low OC and TN accumulated in sand dominated sediments with low δ15N values during Early Holocene (10000-8900 yr BP), reflecting a strong sea level control in OM preservation in the mud deposit. Based on δ13C and molar N/C three end-member (Changjiang, Taiwan river and Marine) mixing model, we noted an increased OM contribution from Taiwan Island, especially during 4600-2400 yr BP, corresponding to the strengthened East Asian Summer Monsoon (EASM) and intensified Taiwan Warm Current (TWC) during this interval. The mixing model calculation indicated that the marine-sourced OC was dominated (~55%) in most periods from the Late Glacial, followed by Changjiang (29%) and Taiwan (16%) river-derived OC. In addition, the Changjiang-derived OC slightly increased from 2400 yr BP to present, though the Changjiang freshwater discharge declined due to insolation-driven reduced EASM, suggesting increased OC production in the Changjiang drainage basin perhaps related to human activities.

P-G2-06-S Effect of changes in the Indian/African monsoon on the circulation, oxygen content and P cycling of Sapropel Intermediate Water (500-1800m) in Eastern Mediterranean

Eleen Zirks, University of Haifa
Michael D. Krom, University of Haifa
Dongdong Zhu, University of Haifa
Beverly N. Goodman-Tchernov, University of Haifa
Gerhard Schmiedl, University of Haifa
Presenter Email: zdd2dd@163.com

Sapropels are the sedimentological record of recurring anoxic events in the Eastern Mediterranean Sea (EMS) caused by global changes in the Indian/African monsoon pattern. The most recent of those events, S1, occurred in the early Holocene (~6-10.4 ka BP) and the 8.2 ka BP global cooling event can be identified within the sediment records.

Recent modelling and field studies have suggested that natural climate change during S1 caused the water column to be divided into 4 layers. Below the surface thermohaline circulation there was a Sapropel Intermediate Water mass (SIW; 500-1800m) and a deeper fully stagnant water mass. This SIW acted as an OMZ with anoxia first in the upper layers and progressively occurring in deeper water. In this study, we examined S1 from a sediment core collected from 1250m offshore from Israel. The extent of sapropel was defined by Ba/Al and TOC and the oxygen status of the overlying water determined from benthic foraminifera abundance and species distribution and V/Al as a redox sensitive trace metal. Our results show that the beginning of S1a was gradual over 400-500 years. The system became anoxic for ~1400 years. The 8.2 ka BP event was visible as an interruption in the sapropel in Ba/Al and TOC. As in other locations across the EMS, S1b was suboxic i.e. somewhat less intense than S1a. The P speciation in the sediment as determined by SEDEX measurements showed that changes in P content were controlled both by the redox state of the overlying water and the input from the nearby major river, the Nile. Our results show the effects of natural climate change on the oxygen status of deeper waters of the EMS. It is important to understand past hypoxic/anoxic events since oxygen minimum zones are spreading in the oceans nowadays which may cause major environmental problems.

P-G3-01-S Biogeography of coral endosymbionts in the genus *Symbiodinium* in the South China Sea and its adaptive potential to climate change

Chen Biao, 1.Coral Reef Research Center of China, Guangxi University, Nanning 530004, China 2.Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China 3.School of Marine Sciences, Guangxi University, Nanning 530004, China
Yu Kefu, 1.Coral Reef Research Center of China, Guangxi University, Nanning 530004, China 2.Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China 3.School of Marine Sciences, Guangxi University, Nanning 530004, ChinaSecond author and corresponding author
Liang jiayuan, 1.Coral Reef Research Center of China, Guangxi University, Nanning 530004, China 2.Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China 3.School of Marine Sciences, Guangxi University, Nanning 530004, China
Presenter Email: 475496334@qq.com

Coral reef ecosystem is under serious threat due to global climate change, so both the potential adaptability of coral-algal symbiosis and its impact factors need to be evaluated in more regions. The development of next-generation sequencing (NGS) technology provides us with an effective way to study the combined characteristics and ecological functions of symbionts in corals. Therefore, NGS was used to analyze the *Symbiodinium* rRNA internal transcribed spacer 2 (ITS2) marker genes from 88 reef-building coral

samples (five genera) in four biogeography coral habitats across ~15 ° of latitudes from the South China Sea (SCS), which located on the northern edge of the "coral triangle" The results showed that a symbiosis between abundant types of Symbiodinium (8 clades and 216 subclades) and scleractinian was found, in which clade C and D are dominant types of symbiont. Thus, the high diversity of *Symbiodinium* provides more options for coral-algal symbiosis to respond to climate change. PERMANOVA analysis suggested that there are significant differences among the *Symbiodinium* community composition in four latitude areas, due to the influence of environmental factors, especially the temperature. The major components of whole *Symbiodinium* communites are subclade C1 in high latitude areas, subclade Cspc, C50 and D1 in intermediate latitude area, and C3u in low latitude areas. It indicated that a variety of combinations of symbionts at different latitude sites will result in functional diversity in the *Symbiodinium* community, which has a positive effect on coral-algal in response to climate change. Phylogenetic analysis showed that the symbionts of clade C have closer phylogenetic relationships so that they have similar environmental adaptability, but it is not stable because it is affected by different evolution flora, ancestors and potential recent invasion of symbionts. The invasion is probably the result of human transportation activities The analysis of rare symbionts (relative abundance less than 5%) revealed that their ability to establish symbiosis with different coral genus, their adaptability to a wide range of changing environment, and their widespread distribution in the SCS have increased the flexibility of coral-algal symbiosis to respond to climate change. In addition, the discovery of new symbiosis, clade H and clade I, which had symbiosis with scleractinian, has raised our awareness of the flexibility of coral-algal symbiosis.

P-G3-02-S Unraveling nutrient assimilation into the coral skeletal organic matrix has implications for historical interpretations

Jonathan D Cybulski, Ph.D Candiate, main author
Inga Conti-Jerpe, colleague, Ph.D. candidate
David M. baker, Supervisor
Presenter Email: cybulski.j@gmail.com

The skeletal organic matrix (SOM) (the organic portion of the skeleton comprised of proteins, lipids, and polysaccharides) of scleractinian corals is significant for both biogeochemical and paleoceanographic research because it records elements over geologic timescales. The nitrogen bound inside the SOM reflects the nutrient sources of the coral-algal holobiont at the time of carbonate nucleation. However, research to date has yet to identify the leading source of nutrients corals preferentially assimilate, undermining accurate interpretation of stable isotope records preserved in their skeleton. We still do not know what the delta values from the SOM are actually telling us. Furthermore, the low nitrogen content of SOM, a limiting nutrient in coral ecosystems, has made it difficult to

measure and understand nitrogen fluxes during calcification. To fill this gap, we aimed to answer the question: What form of nitrogen is incorporated in the skeletal secretion process of calcifying corals? We first tested a new skeleton cleaning methodology that ensures no coral tissue or other organic contamination was included in analysis, and that we were only measuring the SOM signal. Preliminary experiments demonstrated that the use of enriched stable isotope tracer allowed for the detection of nitrogen signals on an isotope ratio mass spectrometer. We therefore exposed coral nubbins to 3 different forms of nutrients: 1) inorganics nutrients (nitrate) that can be assimilated by algal symbionts, 2) organic nutrients (urea) accessible by the entire holobiont, and 3) phytoplankton (Isochrysis galbana) or zooplankton (*Artemia* salina) for host heterotrophic feeding. In each treatment, one food source was enriched in nitrogen allowing us to identify which was preferentially ingested, and subsequently which are used for calcification. Our results demonstrate that Porites sp. does not feed on Isochrysis sp. but does assimilate nutrients from all other sources. The important implications of our results extend beyond simply identifying a corals preferred food, but can give insights into potential nitrogen assimilation changes with anthropogenic impacts to the nitrogen cycle. Most immediately, this study's implications extend to fossil coral in the paleo record, which can only be interpreted correctly by knowing the source of the incorporated nitrogen at that time.

P-G3-03-S Responses of coral-associated bacterial communities to thermal Stress

Kangkai Li, State Key Laboratory of Marine Environmental Science (Xiamen university)
Presenter Email: kangkaili@stu.xmu.edu.cn

Diazotrophs are an important symbiotic partner of corals and they can supplement the coral holobiont nitrogen budget by generating biologically usable form of nitrogen. In this study, we investigated the diversity of diazotrophic bacterial communities associated with coral *Pocillopora damicornis* in conditions of increased temperature seawater by profiling the conserved subunit of the nifH gene, which encodes the dinitrogenase iron protein. The diazotrophic bacterial communities are significantly different related to environmental conditions and coral health status.This study provides broad insight into the improvement of the fitness of corals during thermal stress.

P-G3-04 Monthly-resolved coral barium isotopic records in the South China Sea and its paleoceanographic implication

Xiaohua Li, Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
Zhen Zeng, CAS Key Laboratory of Crust-Mantle Material and Environment, School of Earth and Space Science, University of Science and Technology of China, Hefei, China
Yi Liu, Institute of Surface-Earth System Science, Tianjin University, Tianjin, China
Huimin Yu, CAS Key Laboratory of Crust-Mantle Material and Environment, School of Earth

and Space Science, University of Science and Technology of China, Hefei, China
Fang Huang, CAS Key Laboratory of Crust-Mantle Material and Environment, School of Earth and Space Science, University of Science and Technology of China, Hefei, China
Chuan-Chou Shen, High-Precision Mass Spectrometry and Environment Change Laboratory (HISPEC), Department of Geosciences, National Taiwan University, Taipei, Taiwan
Presenter Email: lxh1990@mail.ustc.edu.cn

Marine barium (Ba) is an important proxy for the nutrient cycle, productivity and the mixing of water masses. However, the factors affected Ba cycle are complicated and not fully understood. Coral-based Ba/Ca proxy have been used to reconstruct the timing and variability of seawater Ba concentration. However, the variation of Ba/Ca in aragonitic coral skeletons remains difficult to be interpreted as environmental proxy. This is mainly due to the disturbance by internal (biomineralization) and multiple external (environmental) processes on Ba incorporation into coral skeletons, and these processes are hard to be constrained with Ba/Ca alone. Ba stable isotope measurements may improve the use of coral Ba as a tracer and better constrain the cycling of Ba. Here we use Multicollector-Inductively Coupled Plasma-Mass Spectrometry (MC-ICP-MS) with double spike correction to obtain the first records of the monthly resolution Ba isotopic composition (δ137/134Ba) in shallow-water corals (Porites) collected alive in the Nanwan (NW), supplemented by the analysis of monthly Ba/Ca ratios. Monthly NW δ137/134Ba records express a seasonal cycle from 0.30‰ in dry season to 0.24‰ in rainy season, negative correlating with coral Ba concentration ($R = -0.53$, $p < 0.05$). The most striking feature of NW coral record is the significant increase in the Ba/Ca baseline that occurred from 1987 to 1996. The baseline ratios increase from 2.39 mmol/mol to 3.34 mmol/mol, an increase of about 40%, which are attributed to the terrestrial derived Ba input induced by human activities. However, with the increase of NW Ba/Ca, there is only a small decrease in Ba-isotopic compositions (~0.06‰ our 2SD long term measurement precision is 0.03‰. The relatively lighter Ba from terrestrial input preferentially absorb on the suspended sediment before incorporation into the coral skeleton and these may be the the main cause. In addition, NW Ba/Ca ratios exhibit a double-peak phenomenon, with the first large peak in spring and second smaller peak in summer/fall. Terrestrial derived Ba input by the large precipitation in summer/fall is the main reason for the second peak. Other possible causes, such as SST, upwelling, phytoplankton bloom and coral spawn are also discussed, but none provide satisfactory explanations for the first peak, further study is needed. Clearly, Ba isotopes in shallow-water corals combined with Ba/Ca show great potential as a proxy for land-sea interactions and water mass mixing.

P-G3-05-S Sea-level changes and reef development of the Paracel Islands (South China Sea) since 7900 y BP

Qin Yeman, 1. Coral Reef Research Center of China, Guangxi University, Nanning 530004, China 2. Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China 3. School of Marine Sciences, Guangxi University, Nanning 530004, China
Yu Kefu, 1. Coral Reef Research Center of China, Guangxi University, Nanning 530004, China 2. Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China 3. School of Marine Sciences, Guangxi University, Nanning 530004, China
Wang Rui, 1. Coral Reef Research Center of China, Guangxi University, Nanning 530004, China 2. Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China 3. School of Marine Sciences, Guangxi University, Nanning 530004, China
Wang Yinghui, 1. Coral Reef Research Center of China, Guangxi University, Nanning 530004, China 2. Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China 3. School of Marine Sciences, Guangxi University, Nanning 530004, China
Presenter Email: qinyemanman@163.com

The sedimentological and chronological study of Holocene reef sequence recovered in the drill core of Chenhang Island, Paracel Islands, South China Sea allows the reconstruction of reef growth patterns and sea level changes during Holocene. High-precision thermal ionization mass spectrometric 230Th ages for 22 in situ coral samples were obtained from the upper section of well Chenke-2(bottom:-878.21m; average recovery:60%), which provides extensive data due to complete core recovery and a success of basement drilling. And sedimentary facies analysis was made based on grain size data and organic components of 21 debris samples. Holocene growth began around 7900y BP at 16.7m, which is consistent with the time of reef initiation among most of the Indo-Western Pacific, Central Pacific and Caribbean reefs. The whole Holocene part is a reef flat deposit and consists of three sections, which are composed of principally coral and coralline algae clasts accounting for 68.95% and 17.88% respectively. Vertical accretion rates averaged 3.48 m kyr-1 , and to be more specific, the reef grew upward at about 6.44 m kyr-1 from 7900 to 6100 y BP, and then there is a broad inflection during 6100 to 4000 y BP with the vertical accretion rate slowing down to 0.87 m kyr-1. And different from other studies in this region, the lateral expansion of the reef took the position completely around 4000y BP, which is to some extent earlier than reefs in Spratly Islands. The reconstructed sea level curve, representing detailed Holocene curve based on U-Th dated corals within Paracel Islands, is characterized by a rapid rise between 7900 and 6500y BP, followed by a slight inflection around 6500y BP, and then stabilization to its present level around 5500y BP. Finally sea level peaked at approximately 1.5m above present mean sea level around 4000y BP.

P-G3-06-S The gut bacterial community composition of sea urchins and potential linkages to host's feeding behavior in coral reefs

Qiucui Yao, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China; Key Lab of Beibu Gulf Environm Change and Resources Use Minist of Education, Guangxi Teachers Education University, Nanning 530001, China
Jiayuan Liang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Kefu Yu, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Yinghui Wang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Baoqing Hu, Key Lab of Beibu Gulf Environm Change and Resources Use Minist of Education, Guangxi Teachers Education University, Nanning 530001, China
Presenter Email: 380928778@qq.com

Sea urchins play an important role in maintaining the health and stability of coral reef ecosystem, but some species tend to ingest corals and erode their skeleton. At past decades, sea urchins, as corallivore and bioeroder, had led many coral reefs to degrade. Gut bacteria closely linked to host's feeding behavior, but their composition and influence on the corallivorous behavior of sea urchins had not been studied well in coral reefs. Here, 20 scrapers from four sea urchin species Stomopneustes variolaris, Diadema setosum, Echinothrix calamaris and Diadema antillarum and 20 browsers from one sea urchin species Tripneustes gratilla were collected from Luhuitou fringing reef, Sanya, China, to investigate their gut bacterial composition by High-throughput pyrosequencing. Diversity analysis showed that the gut bacterial diversity of sea urchin was significantly higher in browsers than scrapers. Propionigenium, Prolixibacter and Photobacterium were the dominant bacterial genera in all five studied sea urchin species. However, their total abundance was higher in scraper than browser, accounting for 69.69% and 43.54%, respectively. PCoA (the principal co-ordinates analysis) and ANOSIM (the analysis of similarity) showed that gut bacterial community composition was analogous between the scrapers but significantly different between scrapers and browsers, suggesting that host's feeding strategies was one of the main factors to shape the gut bacterial community of sea urchins. In addition, the functional composition of these bacteria predicted by PICRUSt showed that the mean relative abundances of lipid metabolism and amino acid metabolism were higher in browsers, while the carbohydrate and nucleotide metabolism were higher in

scrapers. The evidence suggested that different between scrapers and browsers might be associated with the digestion of animal-based diet, suggested that the bacterial composition of sea urchins influenced on host's food degradation and food choice. Our study displayed a clear distinction of gut bacterial community and functional composition between scrapers and browsers. It highlighted that those distinction may interact with the feeding behaviors of sea urchins in coral reef, which in turn strongly impacted on the reef ecology.

P-G3-07 Nitrogen fixation and transfer of diazotroph derived nitrogen (DDN) in coral reef system

Hua-Xia Sheng, State Key Laboratory of Marine Environmental Science, Xiamen University
Xianhui Sean Wan, State Key Laboratory of Marine Environmental Science, Xiamen University
Chichi Liu, State Key Laboratory of Marine Environmental Science, Xiamen University
Bobo Zou, State Key Laboratory of Marine Environmental Science, Xiamen University
Hui Huang, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Shuh-Ji Kao, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: hxsheng@xmu.edu.cn

Coral reefs are essential ecosystems in tropical oceans, providing extensive ecosystem goods and services to around 500 million people. It is one of the most productive ecosystems but living in oligotrophic ocean. This has given rise to the ecosystem conundrum which is called as the "Darwin's paradox". A major hypothesis was that biological nitrogen fixation by cyanobacteria and heterotrophic bacteria provides the "new" N for the oligotrophic coral reef ecosystem and thus plays an important role in flourishing productivity. However, quantitative information on the contribution of N fixation to primary production remains sparse in field. Furthermore, transfer of the diazotrogh derived nitrogen (DDN) from diazotroph to non-diazotroph is poorly understood. Here we measured N fixation rate and its subsequent transfer in a typical tropical coral ecosystem by using 15N-N2 tracer methods. The result shows that, the symbiotic N fixation microbes in crustose coralline algae (CCA) and *Pocillopora damicornis* both contributed to the N fixation in coral system, and N fixation rate of CCA is significantly higher than coral halobiont. The DDN in coral holobiont can be transferred to *symbiodinium*s (zooxanthellae) and coral host cells, implying the redistribution and reuse of "new" N in coral holobiont.

P-G3-08-S Effects of elevated temperature and eutrophication on Acropora samoensis

Adam Wang, Chinese International School
Inga Elizabeth Conti-Jerpe, The University of Hong Kong
Johnny Lyons Richards, The University of Hong Kong
Phil Thompson, The University of Hong Kong
David Micheal Baker, The University of Hong Kong
Presenter Email: adamw5954@gmail.com

In the Anthropocene, corals face multiple stressors from different human activities including coastal development and climate change. Eutrophication from runoff negatively affects corals by slowing calcification rates and fueling algal growth that can smother corals. More recently, global climate change has warmed the oceans, resulting in a disruption in coral-algal symbiosis where zooxanthellae algae are expelled from the coral host's a phenomenon known as coral bleaching. Previous studies have identified that some genes are upregulated in response to stressors, including the 70 Kilodalton Heat Shock Protein (HSP70), a chaperone protein involved in refolding proteins during heat and heavy metal stress. While a large amount of research has been conducted on the effects of eutrophication and increased temperatures on different aspects of coral physiology, these two factors are predominantly studied independently, even though they act in tandem in the field. Here we present preliminary results from an experiment investigating the effect of high temperature combined with eutrophic conditions on the expression of HSP70 in a hermatypic coral. Four genotypes of the branching coral Acropora samoensis were subjected to four different treatments for five days: ambient conditions (28 ˚C, 2mM NO_3, 0.01 mM PO_4), high temperature (32 ˚C, 2mM NO_3, 0.01 mM PO_4), high nutrients (28 ˚C, 8mM NO_3, 0.3 mM PO_4), and high nutrients and temperature together (32 ˚C, 8mM NO_3, 0.3 mM PO_4). In the final three days of the experiment, we measured physiological changes in the coral symbiont with Pulse Amplitude Modulated (PAM) Fluorometry to quantify photosystem stress (photoinhibition). At the end of the experiment, treatments with only elevated temperature or nutrients were not significantly different from the control, however the combined high nutrient and high heat treatment had significantly lower Quantum Yield. Total RNA from the corals was immediately extracted and reverse transcribed. Gene expression for HSP70 was quantified using Real Time Quantitative Polymerase Chain Reaction (RT-qPCR). While there were slight differences in gene expression across treatments, they were not significant. These data suggest that magnitude and duration of heat stress was not enough to cause physiological changes in the host, but was enough to impact the photosystems in the symbionts. We plan to explore this hypothesis by investigating the relative expression of genes associated with oxidative stress (Catalase, Ferritin) and apoptosis (Survivin) that results from photoinhibition. Furthermore, we will also target a gene involved in calcification (Galaxin)

that may be down-regulated in the presence of excess nutrients.

P-G3-09-S Effects of Elevated Temperature on the Stony Coral *Pocillopora damicornis*

Chenying Wang, Xiamen university
Presenter Email: wangchenying0808@163.com

Collectively called zooxanthellae, photosynthetic dinoflagellates in the genus *Symbiodinium* are essential coral symbionts encompassing nine phylogenetic clades (A-I). The diversity and composition of zooxanthellae can fundamentally mediate coral responses to environmental change. For example, *Symbiodinium* in clade D is believed to be more thermally tolerant than its counterpart in clade C, and hence has the potential to convey thermal tolerance to the host coral. Yet, the physiological and molecular dynamics of symbiont changes underlying distinct coral responses upon environmental cues, remain largely unknown. In order to better understand the basal coral-zooxanthellae symbiotic responses to environmental perturbations, we conducted laboratory manipulative thermal stress experiments using freshly collected wild coral *Pocillopora damicornis* maintained in aquaria at ambient (26 °C) or elevated (32 °C) temperature, respectively. Based on our analysis of zooxanthellae density and genotypes, and the measurements of photosynthesis and calcification rates, we demonstrated that P. damicornis with dominant clade D *Symbiodinium* is much more robust to thermal stress relative to P. damicornis with dominant clade C *Symbiodinium*. This finding sheds new light on how symbiont shuffling could act as a defensive mechanism for increased coral resilience.

P-G3-10-S Zinc isotopic fractionation during natural inorganic carbonate precipitation

ZHONGWEI WANG, State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China University of Chinese Academy of Sciences, Beijing 100049, China
JIUBIN CHEN, State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China Institute of Surface-Earth System Science, Tianjin University, Tianjin 300072, China
Presenter Email: jbchen@tju.edu.cn

The usefulness of metal isotopes in surface carbonate achieves to trace the paleoenvironment and paleoclimate has not been well constrained. Surface carbonate precipitation is sensitive to a number of environmental conditions including light, temperature, salinity, pH and turbidity (Saenger and Erez, 2016). These condition changes could trigger or impact metal isotope fractionation. Therefore, physical and geochemical variations of trace elements and their isotopes in surface carbonates could be eventually used as proxies for reconstructing past environmental variability. Previous studies have shown that parameters such as pH, precipitation rate and Rayleigh fractionation may explain much (or part) of the variability in coral stable isotopes. Determining the controllers of the stable isotopes variation in surface environments will require considerable additional research using abiogenic precipitation experiments, biologic culturing, micro-analytical techniques and geochemical models(Ferrier-Pages et al., 2018; Saenger and Erez, 2016). In this study, Zn isotope compositions from both the inorganic carbonates and its provenance solution of an endogenic travertine-depositing stream in Baishuitai (Yunnan, SW China) was carefully examined. The Zn isotope fractionation between calcite and aqueous solution (δ66/64Zncalcite-solution) shows a large variation ranging between -0.63 and +0.73‰.The possible impacts of temperature, alkalinity, pH of the solution and the carbonate precipitation rate were carefully investigated and the main controllers were identified. This work provides new insight into the use of Zn isotopic signatures in carbonates for reconstructing paleo-environments and tested the possibility of metal isotopes as proxy of paleoclimate. References Ferrier-Pages, C., Sauzeat, L., Balter, V., 2018. Coral bleaching is linked to the capacity of the animal host to supply essential metals to the symbionts. Glob Chang Biol, 24(7): 3145-3157. Saenger, C., Erez, J., 2016. A Non-traditional Stable Isotope Perspective on Coral Calcification. 181-205.

P-G3-11-S Transcriptomic responses to thermal stress and varied phosphorus conditions in *Symbiodinium kawagutii*

Liying Yu, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: yly20070567@126.com

Symbiodinium species are essential symbionts of tropical reef-building corals and the disruption of their symbiosis with corals as a consequence of seawater warming and other stress conditions leads to the globally widespread coral bleaching. As coral reefs live in the oligotrophic environment, Symbiodinium photosynthesis can also face nutrient stress. How metabolic pathways in Symbiodinium respond to thermal stress and phosphate depletion is poorly understood and underexplored for many species. Here we conducted RNA-seq analysis to investigate transcriptomic responses to thermal stress, phosphate deprivation and glycerol-3-phosphate (Gro3P) replacement in S. kawagutii. RNA-seq and bioinformatic analysis were conducted for the above-mentioned three treatments and a control. We identified 221 (2.04%) genes showing no significant differential expression among all conditions, and defined them as “core” genes of S. kawagutii, which mostly were in the Gene Ontology terms of catalytic activity and binding. Using algorithms edgeR and NOIseq in combination, we identified a set of differentially expressed genes (DEGs) for each treatment relative to the control. Under heat stress 357 (4.42%) DEGs were found, with predicted roles in active molecular (protein-protein/RNA/DNA) interaction, cell wall modulation and transport (including nutrients, iron, and oxygen). About as many DEGs (396, 4.73%) were identified under P deprivation while nearly double of that (671, 8.05%)

were detected under Gro3P utilization; in both cases most of the DEGs were up-regulated and predicted to function in photosystem and defensome. Further KEGG pathway comparison revealed different molecular responses between phosphate deprivation and Gro3P utilization. Catalytic activity and binding seem to be two important core functions in S. kawagutii. The most significant transcriptional response in S. kawagutii to heat stress was regulation of molecular interaction, cell wall modulation, and transport of iron, oxygen, and major nutrients, suggesting that this species uses a unique mechanism to cope with heat stress, possibly conferring thermal tolerance. The greatest transcriptomic impact of phosphate deprivation and Gro3P replacement were the up-regulation of photosystem and defense. This study provides new clues about molecular mechanisms underpinning responses in Symbiodinium to temperature and nutrient stresses, which will generate new hypotheses and set a new framework for future investigations.

P-G3-12-S Altered immune landscape and disrupted coral-Symbiodinium symbiosis in the scleractinian coral *Pocillopora damicornis* by *Vibrio coralliilyticus* challenge

Zhi Zhou, hainan university
Shuimiao Zhao, hainan university
Jia Tang, hainan university
Zhaoqun Liu, hainan university
Yibo Wu, hainan university
Yan Wang, hainan university
Senjie Lin, hainan university
Presenter Email: zhaoshuimiao010@163.com

Vibrio coralliilyticus is known to cause coral diseases, especially under environmental perturbation, but its impact on coral physiology and underpinning mechanism is poorly understood. In the present study, we investigated cytological, immunological, and metatranscriptomic responses of the scleractinian coral *Pocillopora damicornis* to V. coralliilyticus infection. The density and chlorophyll content of symbiotic zooxanthellae decreased significantly at 12 and 24 h after Vibrio challenge. The activities of antioxidant enzymes such as superoxide dismutase and catalase, nitric oxide synthase, phenoloxidase, and the activation level of caspase3 all rose significantly in P. damicornis after Vibrio challenge. In the metatranscriptomic analysis, we found 10 significantly upregulated genes in the symbionts at 24 h after the challenge, which were mostly involved in the metabolism of nucleic acid and polysaccharide, and 133 significantly down-regulated symbiont genes, which were mainly related to amino acid catabolism and transport. Meanwhile, 1432 significantly upregulated coral genes were revealed, highly overrepresented in GO terms that are mostly related to the regulation of immune response, the regulation of cytokine production and innate immune response. Meanwhile,

at 24 h after Vibrio challenge, 890 coral genes were significantly downregulated, highly overrepresented in 4 GO terms implicated in defense response. These results in concert suggest that V. coralliilyticus infection triggered the innate immune response including the redox, PO and apoptosis systems, but repressed the response of the complement system in the scleractinian coral P. damicornis, accompanied by symbiont density decrease and symbiosis collapse through disordering the metabolism of the symbionts. These findings shed light on the molecular regulatory processes underlying bleaching and degradation of P. damicornis resulting from the infection of V. coralliilyticus.

P-G3-13-S Diversity of coral-associated Symbiodinium in 15 reef coral species and its potential adaptive strategy to thermal stress in the tropical South China Sea

Zhenjun Qin, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Kefu Yu*, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Yinghui Wang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Biao Chen, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Jiayuan Liang, Coral Reef Research Center of China, Guangxi University, Nanning 530004, China; Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 530004, China; School of Marine Sciences, Guangxi University, Nanning 530004, China
Presenter Email: qzj_gxu@163.com

It is well known that different coral species have different tolerances to thermal stress and coral-associated Symbiodinium play an important role in the coral-algal holobiont. However, the relationship between coral-associated Symbiodinium subclade and its density, and coral adaptive strategy to thermal stress are currently not well understood. In this study, we had characterized the Symbiodinium of 15 species of scleractinian corals at Xinyi Reef in the South China Sea, using amplicon sequencing and analysis of internal transcribed spacer 2 (ITS2) for Symbiodinium subclade and using hemocytometer for Symbiodinium denisty. A total of 1,816,596 high-quality sequence reads representing 188 distinct ITS2 sequences were generated and analyzed. 27 ITS2 sequences were present at ≥ 5% abundance in at least one sample, demonstrating the disparity between the total number of ITS2 sequences recovered and their relative proportion. The results showed

that all the Symbiodinium denisties of corals were generally in a relatively low density level in this tropical area, but were still followed the regular that massive corals > plating corals > branching corals. High SST resulted in lower levels of Symbiodinium density for all corals. Moreover, the results of Symbiodinium subclade indicated that the composition of the Symbiodinium subclade was mainly determined by the coral host. Carefully analyzing, we found that *Porites lutea* and Montipora efflorescens associated with the dominated Symbiodinium subclade C15 and Pocillopora verrucosa associated with the dominated Symbiodinium of clade D1 and D1a. They were more resilient to thermal stress than other coral species. This may be well explained that why Porites and Pocillopora are dominated corals in the tropical area of the South China Sea. In contrast, Acropora humilis, Merulina ampliata and the Faviidae (contained five species) associated with the dominated Symbiodinium of C3u and Cspc, which were more conducive to photosynthesis but were sensitive to bleaching. Particularly, the dominated Symbiodinium subclade of the solitary Fungia fungites was C27 unlike all other colonial corals. It indicated that different coral species had different adaptation strategies to thermal stress, and adaptability mainly depended on the Symbiodinium density and Symbiodinium subclade in the tropical sea.

P-G3-14-S Indication of macroalgae on the degeneration of coral reefs in the South China Sea

Zhiheng Liao, 1 Coral Reef Research Center of China, Guangxi University, Nanning 53004, China 2 Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 53004, China 3 School of Marine Sciences, Guangxi University, Nanning 53004, China
Kefu Yu, 1 Coral Reef Research Center of China, Guangxi University, Nanning 53004, China 2 Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 53004, China 3 School of Marine Sciences, Guangxi University, Nanning 53004, China
Yinghui Wang, 1 Coral Reef Research Center of China, Guangxi University, Nanning 53004, China 2 Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Nanning 53004, China 3 School of Marine Sciences, Guangxi University, Nanning 53004, China
Presenter Email: 734832054@qq.com

Since the 21th century, most coral reefs in the South China Sea have been undergoing rapid degradation due to anthropogenic stressors and changes in the natural environment. Phase shifts from coral-dominated to algal-dominated occur frequently on the degenerated reefs, which negative affects hard coral growth, fecundity, and recruitment. Here we surveyed benthic cover, coral recruits, and coral-algal interactions in nine reefs of the South China Sea, and how macroalgae impacts the distribution, growth and recruitment of hard coral. We found differences in coral cover (5 to 43 %), macroalgae (fleshy macroalgae, turf algae, Halimeda and CCA) cover (13 to 45 %), and coral recruits (4 to 38 ind m-2) between sites, and the outcomes of coral-algal interaction varied across different

reefs. Comparing with coral reefs in high coral cover, more frequent and harmful of macroalgal contact could be found in reefs that were dominated by fleshy macroalgae and turfs. Turf algae contributes the most on negative impacts corals; macroalgae, except CCA, were negative relationship with coral recruits. CCA were less harmful on corals and positive relationship with coral recruits. Halimeda negative impacts coral only in high cover. As macroalgae increase in degenerated coral reefs, competitive interaction between coral and macroalgae could negative impacts coral growth and coral community, and promote a further collapse of coral reef ecosystems.

P-M1-01-S Temporal and spatial variations of cross-shelf nutrient exchange in the East China Sea, as estimated by satellite altimetry and in situ measurements

Ruibin Ding, 1.Ocean College, Zhejiang University 2.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Daji Huang, 1.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration 2.Ocean College, Zhejiang University
Jiliang Xuan, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Feng Zhou, 1.State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration 2.Ocean College, Zhejiang University
Thomas Pohlmann, Institute of Oceanography, Centre for Marine and Climate Research, University of Hamburg
Presenter Email: kirkding@sina.com

The nutrient exchange at the 200 m isobath in the ECS has been studied extensively both by using in situ observational data and numerical simulated data. However, the former one suffered from spatial and temporal limitations while the latter one suffered from uncertainties due to numerical schemes and driving forces. Based on velocity and nutrient data from satellite and in situ measurements, we studied the temporal and spatial variations of 22-year (1993-2014) cross-shelf nutrient exchange at the 200 m isobath section in the East China Sea. We aimed to (i) objectively explore the spatial and temporal variations in nutrient transport by collecting observational data with a large spatial coverage and a long time span and (ii) explore the governing mechanisms of this transport. The cross-shelf nutrient exchange is explored in a general sense and in detail. Nitrate transport showed a significant 3-D spatial structure with annual and inter-annual variations. The spatial structure of the nitrate transport was determined by velocity in the horizontal direction and nitrate concentration in the vertical direction. Temporal variation in nitrate transport was mainly determined by velocity and particularly by its geostrophic

component.This study will provide a reasonable guide for future study, particularly numerical simulations.

P-M1-02-S Carbonate chemistry along the main routes of the Indonesian throughflow

Faisal Hamzah, State key laboratory of Marine Environmental Science, College of Ocean and Earth Science, Xiamen University, Xiamen, China Institute for Marine Research and Observation, Ministry of Marine Affairs and Fisheries, Bali, Indonesia
Minhan Dai, State key laboratory of Marine Environmental Science, College of Ocean and Earth Science, Xiamen University, Xiamen, China
Zexun Wei, First Institute of Oceanography, State Oceanic Administration, Qingdao, China
Hanif Budi Prayitno, Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia
Presenter Email: faisalhamzah@kkp.go.id

The Indonesian Seas (IS) and their throughflow, referred as Indonesian Throughflow (ITF) are well known to play an important role in the global thermohaline circulation. Much less known is the marine chemistry of the IS. Here, we present a large dataset of the carbonate system parameters collected during cruises to the main routes of the ITF in the transition monsoon season in October 2015 and November 2017. Our study area spanned southern Philippine Sea, the Sulawesi Sea, the Makassar Strait and Lombok Strait. Along the routes, two water masses namely North Pacific subtropical water (NPSW; T = 18-25 ^{o}C, S = 34.6-34.8 and
$_{0}$= 24) and North Pacific intermediate water (NPIW; T = 7-11 ^{o}C, S = 34.3-34.5 and
$_{0}$= 26.5) were revealed in the upper thermocline waters. In the southern Philippine Sea high total alkalinity (TAlk; 2300 μmol kg^{-1}) and pH (8.10) in the upper 50 m water column were observed due to the influence of Mindanao Eddy where lower values of dissolved inorganic carbon (DIC; 1920 μmol kg^{-1}) than expected were found, reflective of freshwater injection from Maluku Sea by the northeastward flow. Such freshwater discharge with salinity ~33.9 from Sulu Sea remained visible in the upper layer 20 m northern Makassar Strait featuring lower DIC, TAlk, and higher pH ranging respectively 1914-1987 μmol kg^{-1}, 2225-2277 μmol kg^{-1} and 8.05-8.10. Along the Makassar Strait (before Dewakang sill), the NPSW appeared at ~ 100 m isodepth characterized by DIC of 2072 μmol kg^{-1}, TAlk of 2291 μmol kg^{-1}, and pH of 7.92. Meanwhile the NPIW was also found along the ~ 300 m isodepth with slightly higher DIC (~ 2206 μmol kg^{-1}) and TAlk (~ 2299 μmol kg^{-1}), but lower pH (7.85). Moreover, in the southern Makassar Strait, the NPSW features high DIC (2100 μmol kg^{-1}) but slightly lower TAlk (2283 μmol kg^{-1}) and pH (7.85), which is distinct from the NPIW. We calculated that the ITF associated carbon flux was 194.8±194 Tg C y^{-1} along the main routes of Mindanao-Sulawesi passage. The net flux to the Indian Ocean from the Makassar Strait was 202±69 Tg C y-1, among which ~40 Tg C y^{-1} was via the

Lombok Strait. This study demonstrated that the carbonate chemistry along the main routes of the ITF were primarily shaped by the combination of water mass mixing and freshwater discharge played a significantly important role.

P-M1-03-S Controls on molybdenum and uranium isotopic signatures in pore waters and sediments on continental margin off Namibia

Zhiwei He, CAS Key Laboratory of Crust-Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, Anhui, China
M. O. Clarkson, Institute of Geochemistry and Petrology, Department of Earth Sciences, ETH Zurich, Clausiusstrasse 25, 8092 Zurich, Switzerland
Corey Archer, Institute of Geochemistry and Petrology, Department of Earth Sciences, ETH Zurich, Clausiusstrasse 25, 8092 Zurich, Switzerland
Derek Vance, Institute of Geochemistry and Petrology, Department of Earth Sciences, ETH Zurich, Clausiusstrasse 25, 8092 Zurich, Switzerland
Presenter Email: hezw@mail.ustc.edu.cn

The abundance and isotope composition of molybdenum (Mo) and uranium (U) in ancient sedimentary rocks are widely used to reconstruct the redox evolution of paleo-marine systems. The application of Mo-U systematics generally relies upon our understanding of their behavior in modern oceanic settings. However, although a broad framework currently exists for understanding the mechanisms leading to sedimentary accumulation of Mo, U and the associated isotopic fractionations, the extent of Mo and U isotope variation of sediment pore waters in ocean margin regions has not yet been examined. Here we have measured coupled Mo and U data for pore waters and sediments from 3 sites along a transect across the Namibia upwelling area (26 oS), which crosses a redox gradient in bottom water conditions. With the site becoming more reducing, the average Mo concentration in the sediments increases from 2.6 ppm to 6.5 ppm with average d98Mo increasing from 0.85‰ to 1.5‰ approaching modern seawater value (2.3‰). Meanwhile, the average U concentration in the sediments decreases from 11 ppm to 8 ppm with average d238U increasing from -0.26‰ to -0.10‰ positively shifting from the modern seawater value (-0.40‰). The variation patterns of Mo and U concentration and isotope composition in the pore water profiles reveal that the mechanisms controlling the Mo and U signatures of the sediments are strongly dependent on the early diagenetic behaviors of Mo and U within the pore waters in context of different redox conditions.

P-M1-04-S Spatial variability in nutrients and phytoplankton biomass in eastern Indian Ocean during spring inter-monsoon

Kanchana Priyadarshani, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Guangzhou, China. Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Matara, Sri Lanka.
Jie Xu, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Guangzhou, China
Gayan Pathirana, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Guangzhou, China. Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Matara, Sri Lanka.
Jianzu Liao, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Guangzhou, China
Ruihuan Li, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Guangzhou, China
W.N.D.S. Jayarathna, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Guangzhou, China. Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Matara, Sri Lanka.
Dongxiao Wang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Guangzhou, China
Presenter Email: hpkdarshi@gmail.com

A field survey along the 85E transect (from 6N to 10N) in the eastern Indian Ocean was conducted during spring inter-monsoon (25 April - 28 April, 2018) in order to examine spatial variability in the concentrations of nutrients and phytoplankton biomass and their regulators. Our results showed that the nutricline deepened and the Chlorophyll a (Chl a) concentrations at the deep chlorophyll maximum (DCM) decreased northwards, accompanied by shoaling of the mixed-layer depth, along the 85E transect. Dynamics of nutrients and Chl a concentrations was closely related to physical processes. The shoaling of the mixed-layer depth weakened replenishment of deep nutrients to the upper layers, which was responsible for a decrease in Chl a levels at DCM from the south to north along the 85E transect.

P-M1-05 Interpretation of ocean circulation by Adjusted Layer Integrated Vorticity Equation (ALIVE)

Chiwing Hui, Department of Mathematics The Hong Hong University of Science and Technology
Jianping Gan, Department of Mathematics & Department of Ocean Science The Hong Hong University of Science and Technology
Presenter Email: macwhui@ust.hk

Circulation and associated dynamics in the ocean can be favorably depicted by vorticity

dynamics in various vorticity equations. Yet, the form and physical interpretation of these equations remain ambiguous. In this study, we analyze the widely-used depth-integrated (DIV; take curl of depth integrated velocity), the depth-averaged (DAV; take curl of depth averaged velocity) and depth-dependent vorticity (DDV; take curl of depth dependent velocity) equations to understand respective physics represented by them. Despite unanimous representation for dynamics of the rotational motion with different mathematic expressions, the physical meaning embedded in these vorticity equations vary and represent different aspects of the circulation dynamics. Besides, as compared with DIV and DAV, DDV is physically more sensible, and DIV and DAV represent the DDV minus/plus Joint Effect of Topography and Velocity (JETV). However, the important flow-topography dynamics can only be reflected by DIV and DAV equations through respective topographic pressure torque (TPT) and Joint Effect Baroclinicity and Relief (JEBAR). We conduct a numerical study to elucidate and consolidate understanding of extrinsic-intrinsic forcing in the semi-closed South China Sea basin. We found that DIV equation, through the domain-integration, can explicitly isolate the extrinsic/intrinsic dynamic circulation. To explicitly display the topography and extrinsic linkage as well as to retain the physically sensible of the equation, an adjusted DIV equation/ Adjusted Layer Integrated Vorticity Equation (ALIVE) should be utilized.

P-M1-06-S Deterministic and neutral processes in shaping planktonic and benthic microeukaryotes in the intertidal zones of southeast Fujian, China

Jie Kong, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, College of the Environment and Ecology, Xiamen University
Ying Wang, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, College of the Environment and Ecology, Xiamen University
Qiaoguo Tan, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, College of the Environment and Ecology, Xiamen University
Bangqin Huang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361005, China
Ping Sun, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, College of the Environment and Ecology, Xiamen University
Presenter Email: fromkongjie@163.com

Little is known about intertidal microeukaryote communities, the same as the relative effects of deterministic and neutral processes in driving community assembly. By using RNAEmploying high throughput sequencing on rRNA gene transcript, we investigated the diversity and distribution patternbiogeography of both planktonic and benthic microeukaryotes and the relevant effects of environmental and spatial variables in intertidal zones of Xiamen, Fujian Province, China. , and also evaluated the effects of deterministic and neutral processes in driving intertidal microeukaryote communities. Our

results showed that sediments might harbor greater diversity than water with observed richness ranging from 53 to 356. Alveolata and Stramenopiles prevailing in water, while Stramenopiles dominating in sediment. Planktonic and benthic microeukaryote communities differed significantly, with benthic communities of different seasons further clustering into separate groups, and size fractionated planktonic communities into different groups. Among all factors measured in this study, Cd, As, Cu and spatial factors played important roles in shaping intertidal microeukaryote community diversity and structure.Combining with environmental parameters measured in this study, effects of environmental and spatial factors on community structure were also evaluated that revealed Heavy metals had important roles in shaping community diversity and structure. However, only small proportions of plankton and benthos community variations could be explained by environmental and spatial factors or neutral community modelIn summary, small proportions of plankton and benthos community variations could be explained by environmental and spatial factors, so did the neutral processes, indicating that the underling mechanisms in shaping intertidal microeukaryote communities were complicated.

P-M1-07-S Effects of a typhoon on the carbonate system in the Southern East China Sea

Wei-Jen Huang, Department of Oceanography, National Sun Yat-sen University, Kaohsiung
Kai-Jung Kao, Department of Oceanography, National Sun Yat-sen University, Kaohsiung
Gwo-Ching Gong, College of Ocean Science and Resource, National Taiwan Ocean University, Keelung
Presenter Email: Kaokj9710143@gmail.com

Recent studies illustrate that climate change may enhance the frequency and strength of typhoon. But the impact of a typhoon on carbonate parameters is still unclear. On the Northeast Pacific Ocean, a region usually affected by tropical cyclones, we surveyed the Southern East China Sea (SECS) and collected dissolved inorganic carbon (DIC) and total alkalinity (TA) water samples. In particular, one leg of this cruise (from July 6th to 9th 2018) is right before the Typhoon Maria (July 10th to July 11th 2018) and the other leg is right after this Typhoon (July 13th to 17th 2018). The preliminary results displayed an upwelling at waters off the northeastern Taiwan. In surface waters, higher DIC concentrations were observed at this upwelling region than those values in the rest area before typhoon. Furthermore, these surface DIC concentrations were largely increased after this typhoon. The implication of this typhoon will be discussed in this poster.

P-M1-08-S Viral impact on the growth and mortality of picophytoplankton in the South China Sea, during summer

Changlin Li, Xiamen University, China
Xin Liu, Xiamen University, China
Bangqin Huang, Xiamen University, China
Presenter Email: lichanglinxmu@163.com

Autotrophic picoplankton are abundant and important primary producers, especially over the vast tropical and subtropical regions of the oceans. Viruses are important mortality agents for marine picophytoplankton. Through the lysis of their autotrophic hosts, viruses regulate primary production and have major efforts on nutrients and energy flow in the ocean. However, to date there are few published studies that have investigated picophytoplankton group-specific viral lysis rates. Using a modification of the seawater dilution approach, we quantify growth and mortality rates for prochlorococcus, *synechococcus* and picoeukaryotes in the South China Sea during summer. Unlike others studies, our most experiments yield negative rates of viral lysis, i.e. the removal of viruses reduces the growth of the picophytoplankton, either because viruses reduce competition by lysing other populations or enhance growth indirectly by accelerating the recycling of potential growth-limiting nutrients. We also observe a significant negative relationship between viral lysis rate and the abundance of hosts.

P-M1-09-S Distribution and changes of pH along the East Coast of USA

Xinyu Li, University of Delaware
Baoshan Chen, University of Delaware
Yuanyuan Xu, University of Delaware
Qian Li, University of Delaware
Najid Hussain, University of Delaware
Wei-Jun Cai, University of Delaware
Presenter Email: xinyuli@udel.edu

Ocean acidification has raised increasing worldwide concerns. It includes reducing seawater pH and saturation states of calcium carbonate minerals, which can have a dramatic effect on calcifying species and fisheries. As part of program monitoring process of ocean acidification, East Coast Ocean Acidification 2 (ECOA2) cruise was conducted from June 25, 2018 to July 31, 2018. total alkalinity(TA) and dissolved inorganic carbon(DIC) were measured. Parameters including pH, total alkalinity(TA) and dissolved inorganic carbon(DIC) were measured during the cruise. We used automated system AS-spec-pH1 Analyzer (Apollo SciTech) with purified meta Cresol Purple(mCP) dye for high precision spectrophotometric pH measurements. All pH data was calculated to in situ temperature. Results exhibited generally high pH (7.7653-8.0362) in southern waters (East Florida and South Atlantic Bight) and low pH (7.5867-8.0029) in northern waters (Mid Atlantic Bight

and Gulf of Maine). Low pH is observed nearshore, where fresh water input is strong. Additionally, we calculated pH using DIC and TA data through CO2SYS. Differences between measured pH and calculated pH can indicate other control factors on pH. Besides, we compared pH data from ECOA2 cruise with pH results from previous cruises, Gulf of Mexico Ecosystems and Carbon Cruise1&2 (GOMECC1 & 2) and ECOA1. The broad patterns and changes of pH over 10 years along the East coast can be described by the impact of large scale circulation, source water contributions and anthropogenic influences.

P-M1-10-S Characteristics of the East China Sea shelf carbonate system in the early summer

Jing Liu, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Richard Bellerby, 1. State Key Laboratory of Estuarine and Coastal Research, East China Normal University; 2. Norwegian Institute for Water Research, Norway
Xiaoshuang Li, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Anqiang Yang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University
Presenter Email: 51173904025@stu.ecnu.edu.cn

Coastal and shelf carbonate chemistry of the East China Sea is strongly influenced by physical and biological processes often over short time periods. In order to better understand the tight coupling between coastal physics, pelagic plankton production and carbon biogeochemistry, we followed a drogued patch in two regions to the south and north of the Changjiang River estuary over a three week period in May 2017. We report here modifications in marine carbonate chemistry in relation to rapid changes in phytoplankton and nutrient fields. pH varied from 7.932 ~ 8.268 in the southern region of the Changjiang River estuary and from 7.911 ~ 8.471 in the northern region. High pH values were detected in the surface with relative high phytoplankton biomass. The pH value would increase by an average about 0.2 pH units in high productivity regions. The partial pressure of CO_2 (pCO_2) had a similar distribution as the total dissolved inorganic carbon (CT), which was opposite to the varying trend of pH. In the high productivity regions, pCO_2 and CT values would decrease. AT ranged from 2181μmol/kg ~ 2262μmol/kg in the southern study region and from 2132μmol/kg ~ 2264μmol/kg in the northern study region, with such a distribution trend, high AT values were detected in the bottom and low values were distributed in the surface. In the surface layer, AT values varied narrowly when the phytoplankton biomass changed greatly, because it is not directly affected by biological processes. Relationships between carbonate parameters and environmental factors were studied through the Pearson Correlation Analysis and multiple linear regressions (MLRs). Better relationships were found between AT and salinity (P <

0.01), pH and nutrients, Chl-a, confirming the big influences of physical and biological processes.

P-M1-11 Temporal and spatial patterns of phytoplankton: comparison between the East China Sea and the South China Sea

Xin Liu, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen 361102, China.
Wupeng Xiao, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen 361102, China.
Bangqin Huang, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, Xiamen 361102, China.
Presenter Email: liuxin1983@xmu.edu.cn

Phytoplankton are the primary producers of marine ecosystems and respond to global changes. Compared with open oceans, the temporal and spatial patterns of phytoplankton in marginal seas are complex and changeable, which leads to a series of complex biogeochemical processes in marginal seas. The East China Sea and the South China Sea are one of the most important marginal seas in the Northwest Pacific Ocean. They are both affected by the Kuroshio and the river plume water from the mainland China. However, they are also found to have distinct seasonal variations in phytoplankton. Under the control of the East Asian monsoon system, the concentration of chlorophyll a in the East China Sea is higher in spring/summer and lower in winter, but these are opposite to the South China Sea. In this study, the spatial and temporal variations of chlorophyll a, primary productivity, growth rate and community structure of phytoplankton in the East China Sea and the South China Sea were studied by using field observation and satellites remote sensing data. The results showed that there were significant differences in the seasonal variation of phytoplankton biomass, growth rate, ingested mortality and other parameters between the two systems, indicating the differences in the mechanisms of bottom-up and top-down controls, which eventually led to the differences in temporal and spatial patterns of phytoplankton between the two ecosystems.

P-M1-12-S Dynamics of daily nitrate assimilation in the two contrast time-series stations in the northern South China Sea during summer

Lingqi Ma, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Xin Liu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Bangqin Huang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: lingqi.ma@hotmail.com

The results from two cruises that were conducted in 2014 were used to elucidate the spatial and temporal dynamics of nitrate assimilation in the northern South China Sea (SCS).The spatial variation study based on the results of two cruises compared the differences among the shelf, slope and basin of the SCS in the summer.We conducted time-series stations to clarify the different characteristics of nitrate assimilation and phytoplankton distribution on the slope to the sea basin.Averaged surface nitrate assimilation measured in oligotrophic basin was 4 nmol N L-1 d-1, while that in slope was more than 100 nmol N L-1 d-1.The pigment results clearly showed that phytoplankton diversity in surface decreased from shelf to basin, as well as diatom biomass showed the same trend.Morever, in the light of time-series stations, daily nitrate uptake rate in the slope area was not so stable as we assumed, and it might be influenced by the physical process.In oligotrophic stable station, it still can be observed some multiple variabilities in lower nitrate uptake level.

P-M1-13-S Vertical structure of 234Th deficit in the euphotic zone of the oligotrophic South China Sea

Yifan Ma, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Weifang Chen, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Kuanbo Zhou, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: yivanma@stu.xmu.edu.cn

We conducted high-resolution profiling of 234Th in the euphotic zone to examine the fine structure of export productivity based on a cruise in the summer of 2017 to both the northern (Station SEATS at 18N, 116E) and southern basin (Station SS1 at 14N, 116E) of the South China Sea (SCS). Samples for total and particulate 234Th and particulate organic carbon (POC) were collected with a depth interval of 10 m in the euphotic layer. Using our unique data set, we are able to examine the partitioning in export fluxes between the nutrient-depleted layer (NDL) above the nutricline and the nutrient-replete layer (NRL) below the nutricline. The activity of total 234Th in the euphotic zone ranged from 1.98 to 2.60 dpm/L for these two stations. Small but visible deficit in 234Th relative to 238U was observed in the NDL at station SEATS. As expected, the lowest activity of total 234Th (2.00 dpm/L) appeared at 65 m around the deep chlorophyll maximum (DCM) at station SEATS. While a similar 234Th pattern held at station SS1 in the southern SCS where the lowest activity of total 234Th (1.98 dpm/L) also appeared at the DCM (75 m) in the NRL, 234Th was nearly in equilibrium with 238U in the NDL in the southern SCS. At

station SEATS, the total 234Th flux was 583.9 dpm/m2/day, among which 299.0 dpm/m2/day was from the NDL, close to that from the NRL (284.9 dpm/m2/day). In contrast, at station SS1, though the total 234Th export flux was similar, amounting to 529.1 dpm/m2/day, the flux from the NDL was much lower (143.4 dpm/m2/day) as compared to that at SEATS while the fluxes in NRL was 385.7 dpm/m2/day. Such difference in 234Th export partitioning between the NDL and NRL at these two stations might be related to the differing nutrient sources in the NDL between southern and northern SCS.

P-M1-15-S Anthropogenic Carbon in the northern South China Sea basin

Elliott Roberts, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
William M. Smethie Jr, Lamont-Doherty Earth Observatory, Columbia University, New York, U.S.A.
Eugene Gorman, Lamont-Doherty Earth Observatory, Columbia University, New York, U.S.A.
Sam Shen, Department of Mathematics and Statistics, San Diego State University, San Diego, CA 92182, U.S.A.; and Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92037, U.S.A.
Presenter Email: 2046938467@qq.com

Little is known about anthropogenic carbon dioxide (CO2) concentrations and distributions within marginal sea systems that are subject to complex physical and biogeochemical variability. Cruises were conducted from 2009-2011, 2014, and 2016 as part of the CHOICE-C I and CHOICE-C II in the northern South China Sea basin. These high-spatial-resolution measurements were compared with one another and with prior investigations to assess the spatial, seasonal, and interannual variability of anthropogenic CO2 based on both back-calculation and transient-time distribution approaches. From examining summer 2009, summer 2014, spring 2011, and spring 2016 datasets, the average increases in the surface water were ~21.6-26.5 μmol kg-1 over a 5-year period at the same stations (n=10-13). A comparison on the approaches for the summer 2014 dataset showed that anthropogenic CO2 has penetrated into the deep water, ranging between 6.11 ± 4.88 μmol kg-1 (n=102) and 6.41± 0.79 μmol kg-1 (n=16) between 2000-3800m. Based on same station comparisons (n=4 for spring, n=5-10 for summer), the aragonite saturation state (ΩAr.) horizon in summer 2009 (ΩAr. = 0.98 ± 0.5, n=10) was at ~870 ± 116m, whereas the ΩAr. horizon (ΩAr. = 0.98 ± 0.5, n=10) in summer 2014 (ΩAr. = 1 ± 0.6, n=10) was ~586 ± 119m. These findings were associated with an increase of ~7.0-19.3 μmol kg-1, n=5 in anthropogenic carbon. The annual ΩAr. horizon decrease in the summer

based on these two datasets is 57m yr-1. This differed from the ΩAr. horizon temporal evolution during spring, where anthropogenic CO2 stagnated at ~800m at 12.32 µmol kg-1 ± 4.03 during spring 2011 (ΩAr. = 0.95 ± 0.5, n=4) to 12.23 µmol kg-1 ± 9.53 during spring 2016 (ΩAr. = 0.96 ± 0.6, n=4). Yet, the average anthropogenic CO2 during spring increased by ~8.56 µmol kg-1 at 300m and ~6.67 µmol kg-1 at 2000m (n=3). This unique inconsistency in temporal variations in anthropogenic carbon concentrations highlights the need for spatially resolved data in these coastal systems, particularly in regions subjected to anthropogenic influences with overprints in both seasonal and spatial changes. As a whole, the 32-39% increase in anthropogenic carbon in the surface waters within 5 years that is affecting the entirety of the water column is alarming. Continued basin-wide inter-annual and seasonal investigations are needed to determine the rate of ΩAr. decline as this has deleterious consequences on the marine ecosystem.

P-M1-16 Early Diagenesis of Silica in the Arctic Ocean Sediments Inferred by Porewater Stable Si Isotopes

Xiaole Sun, Baltic Sea Center, Stockholm University, SE-10691, Stockholm, Sweden
Carl-Magnus Morth, Department of Geological Sciences, Stockholm University, SE-10691, Stockholm, Sweden
Christoph Humborg, Baltic Sea Center, Stockholm University, SE-10691, Stockholm, Sweden
Per Andersson, Department of Geosciences, Swedish Museum of Natural History, SE-10405, Stockholm, Sweden
Zhouling Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University, 361102 Xiamen, China
Volker Bruchert, Department of Geological Sciences, Stockholm University, SE-10691, Stockholm, Sweden
Presenter Email: xiaole.sun@su.se

The major sink of silicon in the ocean is by burial in marine sediments, half of which takes place in nearshore and continental shelf sediments. The quantification of this sink still remains a major challenge due to multiple simultaneous reactions of silicon during early diagenesis. We used two sediment cores from the Arctic continental shelf taken during the Swedish-Russian SWERUS-C3 expedition on icebreaker Oden in the summer 2014 to investigate early diagenetic silicon reactions by combining major and trace element analyses of porewaters with stable silicon isotope analysis. In both cores there was a characteristic sharp increase by several hundred moles in dissolved Si (DSi) over the first centimeters of sediment below which DSi gradually decreased again. The increase in porewater DSi was associated with a pronounced increase in the ^{30}Si from +2.1 to +4.4‰ in the uppermost 10 cm and a subsequent decrease back to the bottom water ^{30}Si value. Porewater dissolved iron concentrations followed the same trend of an initial increase and subsequent decrease. Measurements of bacterial sulfate reduction rates indicated that there was no significant removal of iron by iron sulfide formation, so that the observed decrease in dissolved iron was likely due to secondary precipitation of Fe-rich clay minerals. The data suggest that the elevated DSi concentrations and steep Si isotope gradients were caused by simultaneous dissolution of biogenic Si and authigenic clay mineral formation. The latter was suggested to fractionate Si isotopes by -2‰, which is consistent with our observations. Authigenic clay mineral formation appeared to be limited by the availability of reactive iron below the surface so that dissolution of biogenic silica controlled porewater ^{30}Si values at depth. We have employed a Si reactive-transport model to assess the rate of clay mineral formation and other interacting geochemical processes. Our results suggest that authigenic clay mineral formation plays an important role in controlling marine silicon burial and Si isotope fluxes between sediments and the overlaying water.

P-M1-17-S Variability of the Cyclonic-Anticyclonic-Cyclonic circulation in the South China Sea

Yao Tang, Division of Environment and Sustainability and Department of Mathematics, The Hong Kong University of Science and Technology
Jianping Gan, Department of Mathematics & Department of Ocean Science The Hong Hong University of Science and Technology
Presenter Email: ytangba@connect.ust.hk

Recent studies have revealed that the three dimensional circulation in the South China Sea (SCS) exhibits a Cyclonic-Anticyclonic-Cyclonic (CAC) circulation pattern in the upper (<750 m), middle (750-1500 m) and deep (>1500 m) layer, which is driven mainly by the planetary vorticity influx from surrounding seas. This study investigates the spatiotemporal variability of the CAC intrinsic circulation in response to the influx in the SCS, which remains largely unknown. Based on the daily relative vorticity over 1992-2011 from the CMOMS (China Sea Multi-Scale Ocean Modeling System) model, we found that: (1) the intensity of the circulation and its variability in the upper and deep layer are much stronger than those of the middle layer; (2) positive relative vorticity at the northeast (hotspot1), western boundary (hotspot2) and SCS central basin (hotspot3) contribute to almost 90% of the upper cyclonic circulation. The hotspots 1 and 2 extend downward and account for over 70% of the whole anti-cyclonic circulation in the middle layer, while hotspot 1 continues to appear at the southwestern part of the deep basin; (3) the signal of seasonality dominates variability in upper layer, whereas the variability of middle and deep layers show not only seasonality (much weaker than that in upper layer), but also energetic intra-seasonal signal. All the three layers manifest inter-annual variability. Reasoning of these spatiotemporal variability will be presented.

P-M1-18-S Northwest Atlantic coastal acidification under climate change

Yuan-Yuan Xu, University of Delaware
Wei-Jun Cai, University of Delaware
Baoshan Chen, University of Delaware
Presenter Email: yyx@udel.edu

Coastal acidification is a complex problem due to multiple interactions of the coastal water with the land, the open ocean, and the atmosphere. It also affects calcifying species and threatens the coastal ecosystems. Based on five cruise observations since 1994, we found the on-going acidification in the South Atlantic Bight (SAB), but the acidification signal is concealed in the Mid-Atlantic Bight (MAB). To extend the temporal coverage, we use Surface Ocean CO2 Atlas fugacity of CO2 (fCO2) data product to develop empirical equations for DIC estimation and validate the empirical equations using mooring data. Then we reconstruct the aragonite saturation state (arag) time series from 1958 to 2017 using DIC and salinity-derived TA. Furthermore, we predict future DIC and arag variations for the MAB and the SAB up to 2100. Over a long period (decades and longer), we observe DIC increase and arag decrease in both the MAB and the SAB. However, the acidification signal is dampened in the MAB because of temperature increase and is intensified in the SAB due to cooling. It is critical to consider the temperature influence on DIC and arag through its influence on fCO2 solubility and thus air-sea CO2 flux in the estimate of carbonate system trends in regional models.

P-M1-19-S Dynamics of the carbonate system on the shelf of northern South China Sea

Wei Yang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Xianghui Guo, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Yi Xu, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Liguo Guo, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Minhan Dai, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
Presenter Email: yangwei@stu.xmu.edu.cn

Based upon surveys conducted in four different seasons during 2009-2011, the distribution and dynamic of carbonate parameters on the shelf of Northern South China Sea (NSCS) were investigated. We observed obvious seasonal cycle of the carbonate system largely controlled by complex circulation modulated by the seasonally reversing monsoon as well as the variable geometry of the coastline and bottom topography. In winter, the inner shelf of the NSCS was influenced by the China Coastal Current (CCC), which is characterized by low salinity (~32.2-33.5), low temperature (~16.0-20.0 oC) and high abundant nutrients (~0.8 mol kg^{-1} for PO_4). The saturation state of aragonite (arag) in this area ranged from ~2.5 to ~3.1. Using a three end-member mixing model between CCC, the NSCS surface water and subsurface water, we estimated that the CCC water induced a pCO_2 drawdown of ~-20±13 atm. This CCC led to an increase in arag by 0.9 through both water mixing and biological metabolism. In the offshore areas away from the CCC, the arag in winter was 3.3±0.1. A quantitative analysis suggested that the intensive water mass mixing driven by strong winter monsoon, high biological uptake and strong CO_2 sink contributed -26.4%, 24.5% and -38.3% to its seasonal variation, while the contribution of temperature was minor (-10.7%). In spring, the arag was 3.5±0.1, high temperature increased arag in 29.7%, and water mass mixing, biological process and air-sea CO_2 exchange contributed -27.0%, 22.9% and 20.3%, respectively. In summer, the NSCS was featured by two coastal upwellings (YDU and QDU) and Pearl River Plume (PRP). The arag in the upwelling centers was <3.5, reflective of the upwelling of carbon-enriched subsurface water. In the plume area, the arag was >4.1, likely due to the high biological production sustained by abundant nutrients from rivers. The arag in the offshore area in summer was 3.1±0.1, which was mainly controlled by temperature (47.9%), biological process (25.1%) and air-sea CO_2 excahnge (14.9%), while the contribution of water mass mixing was reduced to -11.9%. In fall, the arag was augmented to 3.4±0.1, which was attributed to the enhanced CO_2 outgassing (41.9%) associated with high wind velocity. Mixing and biological processes were strengthened by the intensive mixing, contributed -25.9% and 23.1%, respectively, while the temperature effect was minor (5.5%).

P-M1-20-S Regulation mechanism of phytoplankton community on Particulate Organic Carbon export based on sediment trap in northern South China Sea

Yiwei Shang, College of Environment and Ecology, Xiamen University
Yong Qiu, College of Environment and Ecology, Xiamen University
Wupeng Xiao, College of Environment and Ecology, Xiamen University
Xin Liu, College of Environment and Ecology, Xiamen University
Bangqin Huang, College of Environment and Ecology, Xiamen University
Presenter Email: yshang@stu.xmu.edu.cn

The oceanic biological pump drives photosynthetically produced organic matter from the surface layer to depth via sinking particles which main composed of phytoplankton, zooplankton fecal pellets (FPs) and organic aggregates. Because of the unique environmental settings in northern south China sea, and the temporal-spatial variations of biological communities, regulation mechanism of phytoplankton community on Particulate Organic Carbon export is still unknown. We investigated phytoplankton community and Particulate Organic Carbon export from coast to basin in the South China Sea during two

cruises in Aug. 2017 and Aug. 2018. Sediment traps were deployed in slope, shelf and basin stations, respectively. Generalized additive models (GAMs) were used to analyze the regulation mechanism of phytoplankton community on zooplankton fecal pellets sinking rates and POC content. From trap samples, it shows that cylindrical fecal pellets from copepods are the main contributors to POC flux. Meanwhile, fecal pellets POC flux (34.2-102.1mg C m-2 d-1) and contribution ratio to total POC flux increased (about 27~84%) at the bottom of euphotic zone in stations located in coast-shelf-slope-basin. In the water column, the cylindrical FPs from copepods are the dominant groups of FPs as well. Besides, POC content of zooplankton FPs decreased, but the contribution ratio to total POC increased (t-test, $p<0.05$, .5) in the section from coast to off-shore. POC content of FPs was positively related to total phytoplankton biomass as revealed by generalized additive models. Moreover, we found that biomass of dinoflagellates and diatoms can explain 60% of variation in the sinking rate of FPs. We concluded that POC content of FPs was controlled by phytoplankton total biomass, while phytoplankton community structure plays an important role in regulating sinking rates of FPs. Large phytoplankton (Diatom and Dinoflagellate) are the main groups affecting the sinking rate of fecal pellets. Thus, the change of phytoplankton community in biomass and structure affect zooplankton fecal pellets POC content and sinking rate, in turn, affect the POC flux, regulating the biological pump efficiency.

P-M1-21-S Intra-seasonal variability of the high chlorophyll-a concentration strip in the western South China Sea in summer 2000

Yuanyuan Gu, Hohai University

Presenter Email: 1152109245@qq.com

Based on the chlorophyll-a (Chl-a) concentration from Sea-Viewing Wide Field-of-View Sensor (SeaWiFS), the intra-seasonal variability of the high Chl-a concentration strip in the western South China Sea (SCS) during summer of 2000 is investigated. In summer, controlled by the eastward current between the eddy pair off the Vietnam coast, the phytoplankton and the nutrients are horizontally advected offshore into the open SCS, which contributes to forming the high Chl-a concentration strip. The high Chl-a concentration strip has a good agreement with the direction of the eastward current. Our analysis indicates that in the western SCS, the summer monsoon occurs over the south of 12°N leading by approximately one week plays a dominant role in the distribution of the high Chl-a concentration strip. Further analysis reveals that influenced by Madden-Julian Oscillation (MJO), the development of monsoon is not a smooth seasonal process but consists of an intense intra-seasonal event. During a typical intra-seasonal event, the enhanced southwesterly monsoon appears to cause the northeastward current to flow eastward, and the high Chl-a concentration strip extends eastward offshore from the coast; As the zonal wind decreases, the offshore current turns northeastward.

Consequently, the high Chl-a concentration strip shows northeastward offshore distribution.

P-M1-22-S Lateral transport of particulate organic carbon constrained by radionuclides (210Po, 210Pb and 234Th) in the northeastern South China Sea

Xiufeng Zhao, College of Ocean and Earth Sciences, Xiamen University
Weifeng Yang, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University
Haoyang Ma, College of Ocean and Earth Sciences, Xiamen University
Yusheng Qiu, College of Ocean and Earth Sciences, Xiamen University
Minfang Zheng, College of Ocean and Earth Sciences, Xiamen University
Presenter Email: zhaoxf@stu.xmu.edu.cn

Abstract Sediment transport across shelf-slope is important for the redistribution of sedimentary chemicals. Here, particles fluxes, based upon radionuclides (210Po, 210Pb and 234Th) at two time-series stations, were examined over the shelf and slope of the northeastern South China Sea (SCS) to study sediment transport. Suspended particulate matter contents were much higher in bottom water than overlying water column on the shelf, indicating resuspension. At the slope station, increased black carbon contents below 50 m proved the lateral transport of re-suspended sediment. 210Po-derived lateral particulate organic carbon (POC) fluxes accounted for 5.6±2.4% and 74.1±9.5% of the total POC fluxes at 150m and 800m. 234Th-derived POC accounted for 6.4±2.6% and 73.5±11.0% respectively. These results indicated that lateral transport seems to less influence the POC flux out of the euphotic zone. Instead, its influence on POC flux in the mesopelagic zone could not be neglected. Thus, quantifying the biological pump efficiency within the mesopelagic water of the SCS needs a well constraint on the lateral POC transport from shelf sediment resuspension. Acknowledgements This work was supported by the National Key Research and Development Program of China (2016YFA0601201) and NSFC (41476061).

P-M1-23-S Phytoplankton community response to coastal upwelling events during the different stages in the northeastern South China Sea

Yanping Zhong, College of Environment and Ecology, Xiamen University
Xin Liu, College of Environment and Ecology, Xiamen University
Jun Hu, College of Environment and Ecology, Xiamen University
Bangqin Huang, College of Environment and Ecology, Xiamen University
Presenter Email: zhongyanping@stu.xmu.edu.cn

Coastal upwelling plays an important role in marine ecosystemthe primary production with nutrient-rich water. However, ecological responses associated with short-term pulsed upwelling events have not been well investigated in the field study especially in the

complicate shelf ofex marginal sea. Ecological responses to periodic upwelling events, especially the changes of phytoplankton community structure, were investigated based on the combination of field surveys (mapping investigations and time-series observations) and satellite data during August 2004 and July 2005 in the northeastern South China Sea (NESCS). The upwelling event had a dramatic influence not only on the distribution patterns of temperature, salinity, and nutrients, but also on the plankton community. According to surface temperature, salinity, nitrate concentrations and chlorophyll-a (Chl-a) concentrations, three stages of upwelling (newly upwelled water, matured water and aged water) in the NESCS were defined. In the initial of upwelling phytoplankton growth rate reached a maximum for high nutrient concentrations and diatoms dominated the phytoplankton community in the first two stage, accounted for above 69% of the total Chl-a concentrations. In the third stage the contribution of *Synechococcus* increased and accounted for 37% of the total Chl-a concentrations as the increase of temperature and decrease of nutrient concentrations. Meanwhile the changes of mircozooplankton community and graze are also the important factors that induce the succession of phytoplankton species during the relaxation of upwelling. In the first stage of upwelling shellless ciliates and tintinnids dominates mircozooplankton communities together and then the biomass of shellless ciliates and heterotrophic flagellate increased in other two stages. Overall, our study revealed the dynamics of phyto plankton structurcommunitye during the difference stages of upwelling events and provide more insights into multiple driving factors such as temperature, nutrients, and microzooplankton graze.

P-M2-01-S Distribution and influence factors of dissolved manganese in the Western Pacific Ocean

Jing Chen, Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 266100, China
Lei Li, Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 266100, China
Jing-Ling Ren, Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 266100, China
Shuo Jiang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China
Wan-Wan Cao, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China
Xiao-Hui Zhang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China
Jing Zhang, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China
Presenter Email: chenjing@stu.ouc.edu.cn

This study focus on the spatial and temporal distributions and influence factors of dissolved (0.4 μm filtered) manganese (dMn) in the western Pacific Ocean during two cruises in October 2016 and November 2017. Two sections located in the 130°E and 20°N were investigated intensively to understand the vertical distributions of dMn in the western Philippine Sea and to trace the intrusion of Kuroshio to the South China Sea (SCS) and the potential impact of cross shelf transport of terrestrial materials from SCS to Kuroshio. The median concentrations of dissolved Mn in the surface layer of the western Philippine Sea were 2.5 nmol/L and 2.7 nmol/L in October 2016 and November 2017, respectively. The concentrations of dMn in the surface layer in November 2017 were significantly higher than that in 2016 (t-test, $p < 0.05$). High concentrations of dMn were observed in the south of the western Philippine Sea and the Luzon Strait, correlating moderately well with the low salinity. The vertical profiles of dMn during the two cruises were similar, with high concentrations in the surface water and decreased gradually with water depth. However, the high concentrations of dMn also occurred in the oxygen minimum zone (OMZ) in the stations located in the northern study area. The variation of dMn among two cruises mainly occurred in the upper waters, there was no significant difference in the water depths below 1000 m (t-test, $p < 0.05$). Relatively high concentrations of dMn and low salinity observed in the surface of the western Philippine Sea indicates the impact of terrestrial inputs from continent (e.g. South China Sea Surface Water etc.). The intermediate water column of northwestern Pacific Ocean was ultimately controlled by the North Pacific Intermediate Water (NPIW) based on the T-S diagram, with the characteristics of existing of the OMZ. A certain regeneration of dMn was also observed in the OMZ which was influenced by the decomposition and reduction of particles.

P-M2-02-S Viral module optimizes marine biogeochemical model performance

Le Xie, State Key Laboratory of Marine Environmental Science, Xiamen University
Rui Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University
Ya-Wei Luo, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: xiele@stu.xmu.edu.cn

Viruses are the most abundant biological entities in the ocean. They infect and kill marine bacteria and other organisms, and meanwhile recycle nutrients and greatly contribute to marine biogeochemical cycles. However, viral component has not been explicitly represented in most marine biogeochemical models, but instead implicitly represented by constant mortality rates of microbes. In a few exceptions of modeling studies, even viruses were explicitly represented, fixed virus-induced mortality was still used. In this study, a viral module was added to a biogeochemical model to simulate the temporal and spatial dynamics between viruses and bacteria. The model was applied to Hawaii Ocean Time-series (HOT) station. Compared to the non-virus model, the new model with the viral module increased the bacterial mortality at surface while decreased it at deep, leading to a

vertical distribution of bacterial abundance better fitted to the observations. Our results tentatively demonstrate the importance of explicit representation of viruses and dynamic viral-induced microbial mortality in marine biogeochemical models, improving the model performance in material cycles and energy flows especially in the microbial loop.

P-M2-03 Reduced nitrogenase efficiency dominates response of the globally important nitrogen fixer *Trichodesmium* to ocean acidification

Ya-Wei Luo, State Key Laboratory of Marine Environmental Science and College of Ocean and Earth Sciences, Xiamen University, Xiamen, Fujian 361102, China
Dalin Shi, State Key Laboratory of Marine Environmental Science and College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China
Sven A. Kranz, Department of Earth, Ocean and Atmospheric Science, Florida State University, Tallahassee, FL 32306, USA
Brian M. Hopkinson, Department of Marine Sciences, University of Georgia, Athens, GA 30602, USA
Haizheng Hong, State Key Laboratory of Marine Environmental Science and College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China
Rong Shen, State Key Laboratory of Marine Environmental Science and College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China
Futing Zhang, State Key Laboratory of Marine Environmental Science and College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China
Presenter Email: ywluo@xmu.edu.cn

The response of the prominent marine dinitrogen (N2)-fixing cyanobacteria *Trichodesmium* to ocean acidification (OA) is critical to understanding future oceanic biogeochemical cycles. Recent studies have reported conflicting findings on the effect of OA on growth and N2 fixation of *Trichodesmium*. Here, we quantitatively analyzed experimental data on how *Trichodesmium* reallocated intracellular iron and energy among key cellular processes in response to OA, and integrated the findings to construct an optimality-based cellular model. The model results indicate that *Trichodesmium* growth rate decreases under OA primarily due to reduced nitrogenase efficiency. The downregulation of the carbon dioxide (CO2)-concentrating mechanism under OA has little impact on *Trichodesmium*, and the energy demand of anti-stress responses to OA has a moderate negative effect. We predict that if anthropogenic CO2 emissions continue to rise, OA could reduce global N2 fixation potential of *Trichodesmium* by 27% in this century, with the largest decrease in iron-limiting regions.

P-M2-04 The compensation depth in the open ocean

John F Marra, Brooklyn College of the City University of New York, Brooklyn, NY. USA
Presenter Email: jfm7780@brooklyn.cuny.edu

The depth of the ocean's productive zone is unknown, except by mutual agreement. To address this unknown, I consider optical data from four, north-south, transects from the WOCE Hydrographic Program, two in the Atlantic (A15, A20), and two in the Pacific (P16, P19). The data were collected using a profiling package consisting of a MER2040 (including PAR), a beam transimissometer, and a fluorometer. An attached sampler and bucket sampling allowed two water samples to be collected with each cast. The overall distributions reflect the basin-scale oceanography. For example, in the Pacific, the deep chlorophyll maximum (DCM) (estimated from in vivo fluorescence) rises to shallower depths across the equator, and deepens in the north and south subtropical gyres. The base of the DCM ranges from 120-170 m. If it is assumed that the productive zone includes all autotrophic biomass (see Marra et al., 2014, Deep-Sea Research, 83:45-50), then the euphotic zone in these data extends much deeper than how it is usually specified, that is, the depth of 1% of surface PAR. The bottom of the deep chlorophyll maximum coincides with the depth of 1% of Ed(488).

P-M2-05-S DOM dynamics in the Low-latitude Western Boundary Current System: insights from optical analyses

Chao Wang, State Key Laboratory of Marine Environmental Science,Xiamen University
Weidong Guo, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: marineswang@163.com

Despite its potential importance in the global carbon cycle, biogeochemical and hydrological behaviors of dissolved organic matter (DOM) in the low-latitude western boundary current system (LLWBC) remained unclear. We report here for the first time on the observations of carbon concentration (DOC), absorption (CDOM) and fluorescence (FDOM) spectra of DOM associated with these currents, made in the tropical Northwest Pacific Ocean. The results showed that there were significant differences of environmental parameters (nutrients, dissolved oxygen and chlorophyll), DOC, CDOM and FDOM among different currents (t-test, $p < 0.05$). The highest DOC but lowest CDOM absorption coefficient and fluorescence intensities of FDOM were observed in the North Equatorial Current (NEC), while the lowest DOC but highest CDOM and FDOM abundances appeared in the North Equatorial Counter Current (NECC). Enhanced inventories of DOC, CDOM and FDOM were found in the quasi-stationary cold eddy, the Mindanao Eddy (ME), associated with the elevated productivity and upwelling inside the eddy. In the aphotic zone, there were significant relationships between DOC, CDOM and FDOM with AOU as well as nutrient concentrations, suggested the consumption of labile organic fraction (a254, protein-like component) and the in situ production of bio-refractory DOM (a350, humic-like

components) during microbial metabolism coupled to the remineralization of biogenic sinking particles. The in situ production rate of humic-like FDOM in the intermediate layer of LLWBC was overall low compared with other region, which could be associated with the oligotrophic upper ocean and low flux of sinking particles in the LLWBC. Although there was relatively large difference of primary production in the different currents, no significant difference of in situ production rates of bio-refractory DOM below the euphotic zone among different currents were observed, which indicated an important role of the strong subsurface countercurrents on the carbon inventory and transport in the subsurface waters of LLWBC

P-M2-06-S A Modelling Study on a Ciliate, *Synechococcus* and heterotrophic bacterial System

Lice Wang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Wenxin Lin,
Qiang Zheng,
Ya-Wei Luo,
Presenter Email: 22320161151344@stu.xmu.edu.cn

Synechococcus is one of main species of marine primary producers. The grazing on *Synechococcus* by zooplankton such as ciliates contribute to the base of the marine foodweb. The heterotrophic bacteria decompose debris and dissolved organic matter (DOM) and can also be predated by cilites, forming the microbial loop. Ciliate thus acts as an important link between the microbial loop and the food chain. Therefore, studying the food preference of ciliate on *Synechococcus* and heterotrophic bacteria is important for understanding the energy flows and material cycles in marine ecosystems. In this study, we cultivated with four levels of initial abundance of Synechoccus and heterotrophic bacteria together, and added one ciliate to each incubation system. They were cultured for 11 days and the daily abundance of these microorganisms was measured. We then constructed a numerical model to simulate this system, and optimization method was used to minimize the difference between the model and the observations. The results show that, contrary to traditional opinions, the ciliates preferred to predate on *Synechococcus* than heterotrophic bacteria, and the relative preference varied with abundance of the prey. The production of DOM and its usage by heterotrophic bacteria appeared to be the key processes for a successful simulation of the system, indicating that the recycle of DOM played an important role in this system.

P-M2-07-S Diel variations of nutrients in the oligotrophic ocean

Zhongwei Yuan, State Key Laboratory of Marine Environmental Science, Xiamen University
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University
Lifang Wang, State Key Laboratory of Marine Environmental Science, Xiamen University
Tao Huang, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: zwyuan@stu.xmu.edu.cn

Studies of the diel pattern of variable nutrients in the oligotrophic surface waters are challenging because their ambient concentrations are typically below the detection limits of standard colormetric methods. Here we conducted a time series analysis of nutrients with approximately 3-hour intervals in the oligotrophic South China Sea (SCS) basin in June 2017 to explore the dynamics of nutrients and their underlying physical and biological controls. We observed remarkably large variations of the "average" nutrient concentrations in the euphotic zone (0-100 m). At station SEATS located in the northern basin of the SCS, the concentrations varied from 19 to 515 nM for soluble reactive phosphate (SRP), from 4 to 7583 nM for inorganic nitrogen (nitrate plus nitrite, N+N) and from 1.9 to 7.4 μM for silicate. The minimum level occurred, and subsequently increased to the maximum at 9:00 p.m. Integrating the concentrations in the upper 100 m of the water column, the nutrient inventories exhibited an identical pattern following the variations of nutrient concentrations, with the minimum (10 mmol m^{-2} for SRP, 91 mmol m^{-2} for N+N, 257 mmol m^{-2} for silicate) at about 12:30 p.m. and the maximum (23 mmol m^{-2} for SRP, 319 mmol m^{-2} for N+N, 402 mmol m^{-2} for silicate) at 9:00 p.m. These diel patterns suggested that phytoplankton uptake peaked in the daytime while remineralization of organic matter that releases nutrients was more significant during the nighttime. We found a similar diel pattern at a more oligotrophic site located in the southern basin of the SCS (Station SS1), but with lower concentrations and inventories, and smaller amplitudes. The difference in the amplitudes in diel variability are likely associated with the differing biological productivity and upward input fluxes from depth between the northern and southern basin of SCS.

P-M2-08-S Correlation analyses of marine nitrogen fixers and dissolved iron in the global ocean

Zuo Haoyue, Zhejiang University
Presenter Email: 3150100177@zju.edu.cn

Iron (Fe) is a widely hypothesized limiting factor on the marine nitrogen fixation. In this study, we analyzed the relationship between abundance of nitrogen fixers (diazotroph) and Fe concentration in the global ocean. Both modeled (CESM) and in-situ measured Fe concentration was used in this study. NifH-gene copies were used to represent diazotroph abundance, including those of *Trichodesmium*, unicellular cyanobacteria (UCYN) groups A,

B and C, and heterocystous groups (Richelia and Calothrix). The diazotroph biomass was also estimated from nifH copies. Simple linear regression was conducted between Fe concentration and these 7 variables. Contradictory to the previous hypothesis, most of our results using global ocean data do not reveal positive correlations between diazotroph and Fe concentration. *Trichodesmium* nifH, UCYN-B nifH and total diazotrophic biomass even had negative relationships with modeled Fe. Only UCYN-C nifH abundance in surface 50 m showed positive correlation with measured Fe concentration data. Analyses in North Atlantic often showed weak correlation between diazotrophs and Fe, except for *Trichodesmium* nifH and total diazotrophic biomass which had negative correlations with modeled Fe. In Pacific, analyses usually revealed strong negative correlations between modeled Fe and diazotrophs, except for UCYN-A nifH which had positive correlation with Fe. Our study raise a question whether Fe limits growth of diazotrophs in the real marine environment.

P-M3-01 Sea level variation in the Arctic Ocean in the past 30 years

Meixiang Chen, Hohai University, College of Oceanography
Kai Xiao, Hohai University, College of Oceanography
Xuezhu Wang, Hohai University, College of Oceanography; Alfred Wegener Institute Helmholtz Center for Polar and Marine Research(AWI)
Qiang Wang, Alfred Wegener Institute Helmholtz Center for Polar and Marine Research(AWI)
Wenhao Zhang, Hohai University, College of Oceanography
Shuyi Xie, Hohai University, College of Oceanography
Presenter Email: chenmeixiang@hhu.edu.cn

The Arctic Ocean is a very important component of the global climate system due to its geographical location, its interaction with the lower latitude atmosphere has significant impact on regional climate and weather patterns, its water exchange with both the Pacific Ocean and the Atlantic Ocean especially the latter, modulates the Atlantic overturning circulation, the formation of deep water and then large scale circulation of the global ocean. Recently, the Arctic Ocean is undergoing unprecedented air temperature increasing (the "Arctic amplification"), sea ice decline, freshening of the surface layer and warming events which are tightly connected with a shift in ocean circulation and physical conditions of the ocean. Here, we will analyze the sea level variation of the Arctic Ocean in the past 3 decades to understand the recent change occurring in this region, basing on a 4.5km resolution Arctic Ocean simulation with the global multi-resolution model FESOM (Finite Element Sea ice-Ocean Model). The model is developed by Alfred Wegener Institute for Polar and Marine Research (AWI), it employs unstructured triangular meshes and allows for variable resolution without traditional nesting and considers the dynamic–thermodynamic processes of the sea ice. The simulation is conducted using the latest

version of the model FESOM1.4, has 1° nominal horizontal resolution in most parts of the world's ocean; the resolution is tripled in the equatorial band and is set to about 24 km north of 45°N and further increased to 4.5 km inside the Arctic Ocean. The model is forced by the JRA-55 data set including both the atmospheric forcing and river runoff at an interval of 3 hours from 1958 to 2016. Monthly output of sea surface height(SSH) is validated using both satellite altimeter (1993-2016) and long term tide gauge observations (1958-2016) and is compared with two reanalysis data sets (SODA and ORAS3) and it is found that FESOM made a much better hindcast of the sea level variation in the Arctic Ocean than the other two reanalysis products. Basing on the output of the last 30 years of the simulation, we will analyze the inter-annual sea level variation and long term sea level trend of the Arctic Ocean, to interpret the connection between the variations of sea level and thermohaline structure and ocean circulation for a better understanding of the changes occurred in the Arctic Ocean in the past 3 decades.

P-M3-02-S Possible role of Arctic surface climate systems in 2018 heatwave

Mingyi Gu, Nanjing University of Information Science & Technology
Presenter Email: 492934389@qq.com

In summer 2018, exceptional heatwaves occurred over Northern continent. Here, we show the hottest day counts of each grid among this summer which showed that there are several areas along around 70°N and 40°N experiencing the highest temperature over past 70 years this summer, especially north-west Canada, north Eurasia, Korea and Japan. We also found in summer 2018, subtropical high is unusually strong and northward at the same time, which is never happened over past 70 years, and we believed it is no doubt have the ability to cause the exceptional heatwaves. We tried to link 2018 heatwaves with the persistent negative sea ice concentration anomaly at Bering Sea and Barents-Kara Sea in March to May 2018 and widely persistent positive surface temperature anomaly since December 2017. For the specific case of 2018, we show that the arctic anomaly and mid-latitude sst anomaly interactions and conbined with climate system contribute to high surface temperatures over northern continent during the heatwave. Anomalies of sea ice, air surface temperature and sea surface temperature in Arctic also give leading signals of continent heatwave pattern.

P-M3-03-S Circulation of the Chukchi Sea shelfbreak and slope from moored timeseries

Min Li, South China Sea Institute of Oceanology, CAS; Guangdong Ocean University
Robert S. Pickart, Woods Hole Oceanographic Institution
Michael A. Spall, Woods Hole Oceanographic Institution
Thomas J. Weingartner, University of Alaska, Fairbanks
Peigen Lin, Woods Hole Oceanographic Institution

G.W.K. Moore, University of Toronto
Yiquan Qi, Hohai University
Presenter Email: limin_gdou@hotmail.com

Data from a year-long mooring array across the shelfbreak/upper-slope of the Chukchi Sea are used to describe and quantify the circulation and water masses of the region. The timeseries revealed the year-round existence of the eastward-flowing shelfbreak jet and, seaward of this, the westward-flowing Chukchi Slope Current. In the mean the slope current is estimated to transport 0.57±0.04Sv of Pacific water, while the bottom-intensified shelfbreak jet transports 0.009±0.003Sv towards Barrow Canyon. The slope current is surface-intensified in summer and fall, and in winter and spring it becomes middepth-intensified, moves shoreward, and weakens. Two extreme states of the circulation were identified: (1) an enhanced slope current and reversed (westward-flowing) shelfbreak jet; and (2) a strong eastward-flowing shelfbreak jet and weak slope current. The former state occurs when the wind stress curl on the Chukchi shelf is positive, and the latter state occurs when the curl is negative. A simple theoretical model is used to determine the changes in sea surface height due to such wind stress curl forcing, which is consistent with the observed changes in flow seaward of the shelf – both in amplitude and phase – via geostrophic set up.

P-M3-05-S Impacts of extratropical storm tracks on Arctic sea ice export through Fram Strait

Jianfen Wei, Nanjing University of Information Science and Technology
Xiangdong Zhang, International Arctic Research Center, University of Alaska Fairbanks
Zhaomin Wang, College of Oceanography, Hohai University
Presenter Email: weijianfen@nuist.edu.cn

Studies have indicated regime shifts in atmospheric circulation, and associated changes in extratropical storm tracks and Arctic storm activity, in particular on the North Atlantic side of the Arctic Ocean. To improve understanding of changes in Arctic sea ice mass balance, we examined the impacts of the changed storm tracks and cyclone activity on Arctic sea ice export through Fram Strait by using a high resolution global ocean-sea ice model, MITgcm-ECCO2. The model was forced by the Japanese 25-year Reanalysis (JRA-25) dataset. The results show that storm-induced strong northerly wind stress can cause simultaneous response of daily sea ice export and, in turn, exert cumulative effects on interannual variability and long-term changes of sea ice export. Further analysis indicates that storm impact on sea ice export is spatially dependent. The storms occurring southeast of Fram Strait exhibit the largest impacts. The weakened intensity of winter (in this study winter is defined as October-March and summer as April-September) storms in this region after 1994/95 could be responsible for the decrease of total winter sea ice export during the same time period.

P-M3-06 The relative roles of atmospheric and oceanic processes in driven the progressive deepening of winter convection in the Labrador Sea from 2012 to 2016

Yang Wu, Hohai University
Presenter Email: yang.wu@hhu.edu.cn

There has been a progressive deepening of winter convection in the Labrador Sea from 2012 to 2016. The relative roles of atmospheric and oceanic processes in driving such variability remain unclear. A global eddy-permitting ocean-sea ice model, which has a good performance in the Labrador Sea deep convection simulation, is used to investigated this progressive deepening. Changes in air conditions and the sea ice melting induced freshwater flux variability contribute to the deep convection significantly. In addition, the relative roles of the preconditioning and the atmospheric forcing are diagnosed, found that the preconditioning is the dominant role in initiating the deep convection.

P-M3-07 Mesoscale eddies modulate meridional heat flux variability in the subpolar North Atlantic

Jian Zhao, Woods Hole Oceanographic Institution
Amy Bower, Woods Hole Oceanographic Institution
Jiayan Yang, Woods Hole Oceanographic Institution
Xiaopei Lin, Ocean University of China
Chun Zhou, Ocean University of China
Presenter Email: jzhao@whoi.edu

The meridional heat flux in the subpolar North Atlantic is pivotal to maintaining a relatively warm climate in Northern Europe. Much of the variability in the basin-wide northward heat flux between Greenland and Scotland occurs in the Iceland Basin (east of the Reykjanes Ridge and west of the Rockall Plateau), where the North Atlantic Current (NAC) carries relatively warm and salty water northward. As a component of the Overturning in the Subpolar North Atlantic Program (OSNAP), WHOI-OUC jointly deployed gliders in the Iceland Basin to continuously monitor the circulation and corresponding temperature flux associated with the NAC. In-situ observations indicate two circulation regimes in the Iceland Basin: a mesoscale eddy like pattern and northward flowing NAC pattern. When a mesoscale eddy is generated, the rotational currents associated with the eddy lead to both northward and southward flow in the Iceland basin. This is quite different from the broad northward flow associated with the NAC when there is no eddy. The transition between the two regimes coupled with the strong temperature front in the Iceland basin can modify the meridional temperature flux by the order of 0.3PW. The dramatic variability induced by alternating eddy and frontal patterns is also found in the high-resolution (1/12 degree) HYCOM simulations. In addition, a separation of large scale and mesoscale process in the

model results suggests that eddies in the Iceland Basin make significant contributions to the variability of the total basinwide poleward temperature flux on time scales from subseasonal to interannual.

P-M4-01 Comparison of dissolved organic matters isolated from resin-in-tandem and electrodialysis coupled with reverse osmosis techniques.

Song Guixue, Institute of Marine Science and Technology, Shandong University, Qingdao, China
Gao Yuhan, The Environmental Science & Engineering Department, Shandong University, Qingdao, China
Shi Quan, State Key Laboratory of Heavy Oil Processing, College of Chemical Engineering, China University of Petroleu, Beijing
Presenter Email: songgx@sdu.edu.cn

Marine dissolved organic matter (DOM) is important for global biogeochemical cycles and also plays imporcomplexicity tant roles in the response of ecosystems to climate change. Isolation and fraction of marine DOM can help us to better understand the composition and structural complexcity of this ubiquitous natural organic matter. Characterization of different marine DOM fractions in molecular level may provide useful hints about labile and refractory DOC. We are carrying out isolation of DOM using DAX-8 and XAD-4 resins-in-tandem and electrodialysis/reverse osmosis techniques for a coastal seawater. The isolated samples are analyzed by 3D fluorescence spectrum, solid-state 13C NMR spectrometry, ultrahigh resolution of FTICR-MS, etc. Key words: DOM, DAX-8, XAD-4, electrodialysis, reverse osmosis, characterization

P-M4-02 Respiration and carbon dynamics of free-living and particle-attached bacteria in coastal waters of NE Pacific

Cui Guo, Ocean University of China
Ying Ke, Hong Kong University of Science and Technology
Hongbin Liu, Hong Kong University of Science and Technology
Presenter Email: guocui@ouc.edu.cn

Bacterial respiration (BR) rates are fundamental to understand the role of bacteria in carbon flow in aquatic ecosystem, and therefore it is critical to obtain reliable measurements. Prefiltration- (mostly 0.6-3um) and dark-incubation- (mostly 24 h) based direct measurements of oxygen consumption have been the most commonly used method for BR. However, the prefiltration procedure and long incubation time may cause change of the bacterial abundance and structure, leading to inaccurate measurements. In this study, we assessed the BR method based on oxygen consumption and attempted to correct the error caused by remove of grazers and particle-attached bacteria measuring bacterial abundance, production and respiration of both particle-attached and free-living bacteria at

two contrasting site in coastal NE Pacific from Nov 2014 to Mar 2015, we found that the bacterial biomass significantly accumulated after prefiltration during 24-incubation, leading to overestimation of ~11% and 40% of measured BR compared with the corrected in-situ BR of total and free-living bacteria, respectively. The particle-attached bacteria played an important role in the coastal carbon cycle. Although they accounted for ~11% of total bacterial abundance, they contributed to 48% of bacterial production and 28% of bacterial respiration due to their higher metabolic activity. The average bacterial growth efficiency calculated by comparable 24 h integrated bacterial production and respiration was 0.46, with higher value for particle-attached bacteria (0.57) than that of free-living bacteria (0.36). Our results confirmed two major flaws in the current BR methodology and the importance of particle-attached bacteria in coastal ecosystems.

P-M4-03 Importance of Bacteria within Cyanobacterial Bloom Aggregates in a Freshwater Lake

haiyuan cai, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences
Presenter Email: hycai@niglas.ac.cn

Aggregates are basic unit of cyanobacterial bloom, which covered by an amorphous mucilage preventing air exchange between inside and outside of aggregates, thus leading high diel variation of DO and pH. The high diel variation, abundant DOC and easy access to sunlight possibly have a selection for the bacteria inhabited within the aggregates. In this study, the composition of free-living bacterial (FLB) and attached bacterial (AB) communities in Microcystis aggregates in a eutrophic lake Taihu were compared. FLB contained significantly more Actinobacter and Pelagibacter than AB, whereas Microcystis aggregates enriched Alphaproteobacteria including Aquidulcibacter sp., Niveispirillum sp., Porphyrobacter sp., Tabrizicola sp., Rhizobium sp., Elstera sp., and Rhodoferax sp. Typical attached strains were isolated using the standard ten-fold dilution plating technique. The genomes of 10 attached bacteria and 5 free-living bacteria were sequenced and compared to reveal indications of potential typical associated bacterial properties. The genomes of assigned attached bacteria revealed distinct signaling features that differed from those detected among free-living bacteria. Genes involved in chemotaxis receptors and transport are more abundantly represented among attached bacteria than free-living bacteria. Genome analysis also revealed that 7 strains had photosynthesis gene clusters, 3 strains had denitrification gene clusters, and 1 strain had N2-fxiation clusters among the 10 attached bacteria. Physiology studies confirmed that these strains had respective abilities. Our studies suggested that strains within aggregates established beneficial (N2-fxiation and nutrient cycling), neutral (photosynthesis) or detrimental (denitrification) associations of varying intimacy with their hosts.

P-M4-04 Community diversity versus predictive functional profiles of bacteria associated with scleractinian corals in the South China Sea

Jiayuan Liang, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Kefu Yu, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Yinghui Wang, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Xueyong Huang, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Wen Huang, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Zhenjun Qin, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Guanghua Wang, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Hongfei Su, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Biao Chen, Guangxi Laboratory on the Study of Coral Reefs in the South China Sea, Guangxi University.
Zhengchao Wu, State Key Laboratory of Tropical Oceanography (LTO), South China Sea Institute of Oceanology, Chinese Academy of Sciences.
Presenter Email: kefuyu@scsio.ac.cn

Coral-associated microbes are the most basic and active components of coral reef ecosystem, which play an important role in coral reefs development, disease prevention, environmental adaptation, and so on. The community composition about these microbes changed significantly with the change of environments. However, more relevant researches for the composition and variation of function for these microbes have been limited because they are difficult to be cultured by artificial means. In this study, 54 scleractinian coral individuals from 6 coral reefs at different latitudes in the South China Sea were collected to investigate the diversity and composition of their associated bacteria based on 16S rRNA gene amplifiers using high-throughput sequencing. And the functional composition of these bacteria was predicted and compared by using PICRUSt tool. The results of alpha- and beta-diversity analyses (Ace values, which reflect community richness; Shannon index, which reflect community diversity; PCoA, principal co-ordinates analysis) showed that the distribution of bacteria exhibited significant regional differences for 6 different coral reefs, but little interspecific differences for different coral species. However, the functional genetic composition of these bacteria was similar, whether

between different coral reefs or different coral species. These results provided insights into the ecological characteristics and functional composition of coral-associated bacteria in the South China Sea. More specifically, it first concluded that the functional composition of coral-associated bacteria was similar and stable, which may be used to characterize the health status of corals in different habitats.

P-M4-05-S Oxidation of dissolved organic carbon by low-wattage ultraviolet irradiation for isotopic analysis

Jin-Jia Liang, Department of Oceanography, National Sun Yat- Sen University
George. S. Burr, Department of Oceanography, National Sun Yat- Sen University
Yu-Shih Lin, Department of Oceanography, National Sun Yat- Sen University
Presenter Email: ss0800449tw@gmail.com

Dissolved organic carbon (DOC) is the largest pool of reduced carbon in the oceans, with the pool size nearly equal to that of atmospheric CO2. Stable carbon isotopic values (δ13C) of DOC provide insights into the source and bioavailability of this important carbon pool, but due to its dissolved nature and coexistence with salts, there are few simple methods for accurate measurement. Photochemical oxidation, with high-wattage mercury ultraviolet irradiation being the prevailing approach, offers the advantages of low background carbon and high recovery. However, the accompanying hazardous substances pose health and safety issues for laboratory personnel. Here, we attempt to develop a new and user-friendly method that involves the combined use of low-wattage UV irradiation and chemical oxidants at a trace level. Our preliminary results show that with this approach, an oxidation efficiency of ~65% can be achieved within 1.5 hr for DOC in surface seawater. Further optimization work, such as lowering of background carbon and improvement of recovery, is currently in progress.

P-M4-06 Standard method development for dissolved organic matter characterization by high resolution mass spectrometry

Quan Shi, China University of Petroleum - Beijing
Chen He, China University of Petroleum - Beijing
Presenter Email: sq@cup.edu.cn

Dissolved organic matter (DOM) is ubiquitous in sea water, as well as other aquatic systems. A deep understanding on chemical composition of DOM is necessary for the studies relevant to environmental chemistry, however it is a big challenge for analytical chemists to characterize the molecular composition and structure of DOM. Recently, high resolution mass spectrometries, such as Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) has been widely used for DOM analysis. It has been known that the FT-ICR MS generally has very poor repeatability / reproducibility for DOM and cannot used for quantitative analysis. We developed a semi-quantitative analysis method for the

molecular characterization of DOM. The instrument was tuned and optimized with a standard DOM sample, namely SRNOM, to obtain a repeatable mass spectrum before sample analysis. Deuterated inner standard was used for the semi-quantitative analysis. The method was evaluated in various laboratories with different types of FT-ICR MS.

P-M4-07-S Picoeukaryotic diversity and activity in the northwestern Pacific Ocean based on DNA and RNA high-throughput sequencing

Feipeng Wang, Xiamen university
Yuyuan Xie, Xiamen university
Wenxue Wu, Yat-sen University
Ping Sun, Xiamen university
Lei Wang, Third Institute of Oceanography, State Oceanic Administration
Bangqin Huang, Xiamen university
Presenter Email: bqhuang@xmu.edu.cn

Picoeukaryotes play an important role in the biogenic element cycle and energy flow in oligotrophic ecosystems. However, their biodiversity and activity are less studied in open ocean systems, such as the northwestern Pacific Ocean, which is characterized by a complex hydrological setting. Here, we investigated the diversity and activity of picoeukaryotes in the northwestern Pacific Ocean using high-throughput sequencing targeting the V9 region of 18S rDNA and rRNA. Our results showed that Chlorophyta, Dinophyta, Ciliophora, MAST and Pelagophyceae were the major taxonomic groups, comprising of 77.17% and 77.53% of the total DNA and RNA sequences, respectively. In the Kuroshio Extension Current and Oyashio Current mixed waters, Chlorophyta was the dominant group in the DNA survey and Ciliophora was the dominant group in the RNA survey. Significant differences were observed in the community composition between DNA-based and RNA-based molecular approaches, and these differences were mainly attributed to Chlorophyta, Dinophyta, Ciliophora and Pelagophyceae. The average RNA: DNA ratio (i.e., relative metabolic activity) of the taxonomic groups showed that the Ciliophora species was highly active, while the Chlorophyta and Dinophyta species only had low activity. Moreover, the RNA: DNA ratios of Chlorophyta, Dinophyta, Ciliophora were significantly correlated with temperature and salinity. Overall, our study shed light on picoeukaryotic diversity and distribution in the northwestern Pacific Ocean and revealed the positive correlation between the relative metabolic activities of marine picoeukaryotes and the characteristics of water masses (e.g., temperature and salinity)

P-M4-08 Surface properties and EPS characterization of Ferroplasma acidiphilum: an extremely acidophilic and cell wall-lacking archaeon

Ruiyong Zhang, Federal Institute for Geosciences and Natural Resources, Hannover, Germany
Wolfgang Sand, Biofilm Centre, University Duisburg-Essen, Essen, Germany
Presenter Email: ruiyong.zhang@bgr.de

Acid mine/rock drainage (AMD/ARD) is a serious environmental problem which occurs when metal sulfides (chiefly pyrite) get oxidized in the presence of oxygen. Metal sulfide dissolution results in metal-rich and extreme acidic solutions. Acidophilic microorganisms are believed to play a key role in metal sulfide oxidation and dissolution. The acidophilic archaea Ferroplasma receive considerable interest with respect to their special physiological characteristics, e.g. extreme acidophiles often detected in AMD and cell wall-lacking. We studied surface properties of F. acidiphilum DSM 28986 by attenuated Total Reflection-Fourier Transformed Infra-Red (ATR-FTIR) spectroscopy and microbial adhesion to hydrocarbon (MATH) techniques. In addition, extracellular polymeric substances (EPS) were characterized by fluorescence lectin-binding analysis (FLBA) and conventional colorimetric analysis. Results showed that: 1) cell hydrophilicity/hydrophobicity and surface components varied among different growth conditions, as revealed by MATH and ATR-FTIR, respectively; 2) cells selectively adhered to mineral surfaces and showed maximum attachment to pyrite of approx. 50% within 30 min; 4) EPS synthesis by F. acidiphilum DSM 28986 was influenced by growth substrates; and 5) tightly-bound EPS were composed of carbohydrates and proteins. In contrast, loosely-bound EPS are mainly characterized as carbohydrates. Monosaccharides like glucose, fucose, arabinose, galactose, mannose, and sialic acid were detected in the EPS of F. acidiphilum DSM 28986. This study provides first insight into surface characterization of the cell wall-lacking archaeon F. acidiphilum and facilitates the understanding of interactions of this organism with metal sulfides and other acidophiles in acid environments e.g. AMD.

P-M4-09 Marine microbially-mediated transformations of phytoplankton-derived LDOC into RDOC

Qiang Zheng, State Key Laboratory for Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University, Xiamen 361102, People's Republic of China.
Qi Chen, State Key Laboratory for Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University, Xiamen 361102, People's Republic of China.
Ruanhong Cai, State Key Laboratory for Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University, Xiamen 361102, People's Republic of China.
Nianzhi Jiao, State Key Laboratory for Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University, Xiamen 361102, People's Republic of China.
et al.,

Presenter Email: zhengqiang@xmu.edu.cn

Marine phytoplankton contribute to almost one-half of the global primary production (Falkowski et al., 1998; Field et al., 1998; Azam and Malfatti, 2007). A variable fraction of carbon fixed by phytoplankton is released into seawater as dissolved organic matter (DOM) and particulate organic matter (POM) via secretion, natural death, viral lysis and protists predation. These phytoplankton released organic matters are the foundation of the microbial loop, which are directly processed by heterotrophic bacteria. Bacterially transformed these organic matters has several different fates, and most of them were respired back to CO2. Some of them are converted into microbial biomass which can return into the classic marine food web by prey-predator interaction. A small fraction of microbially released dissolved organic carbon (DOC) resists further degradation and contributed to the huge recalcitrant DOC (RDOC) pool which represents >90% of the total DOC reservoir in the ocean. Microbial production of RDOM with 43 Tg C per year plays significant roles in carbon sequestration in the ocean. However, the chemical complexity of DOM and genetic diversity of microbes hampered our understanding about their interactions. With the development of high throughput sequencing, a great number of studies report the marine bacterial metabolic potential. How marine bacteria transform phytoplankton-derived carbon into RDOC is still a puzzle.In this study we tried to reveal the process from photosynthate to marine RDOC.

P-M5-01-S Stoichiometry of marine nitrogen functional microbe by using stable isotope probing based Raman spectroscopy at single-cell level

Lianghao Ge, Xiamen University
Shuh-Ji Kao, Xiamen University
Presenter Email: 15092160058@163.com

Nitrogen (N) is an essential biophilic element in biosphere. Nitrogen limits the productivity in most areas of global ocean, thus, regulating the capability of biological carbon pump largely. Beyond the euphotic zone, nitrogen cycles involve multiple nitrogen species with wide valence state. Almost all processes of marine N transformation are mediated by microorganisms which including various chemoautolithtrophic microbes responsible for carbon fixation and N2O generation. Overall, N cycle is a driver and a responder for climate change. However, the stoichiometric relations of these thermodynamically favorable reactions with involvement of microbes remain underexplored. The stoichiometric understanding of individual functional microbe is the foundation to comprehend the biogeochemical role of complex microbial N-cycling networks in community level. Raman spectroscopy is a powerful nondestructive method capable of providing semi-quantitative information at single-cell level about the chemical bonds of various biomolecules of bacteria. Single cell Raman spectroscopy can reflect the functional cells incorporate substrates based on Raman shift which induced by substitution of heavier isotope. Combine with 15N/13C tracer, Raman spectroscopy will be a promising method to detect N-C cycle especially for C/N assimilation during chemoautolithtrophic processes.

P-M5-02-S Significant Microbial Nitrogen Loss in the Land-Sea Interface of Low Permeable Sediments

Lijing JIAO, South China Sea Institute of Oceanology,Chinese Academy of Sciences
Yiguo HONG, Guangzhou University
Jiapeng WU, South China Sea Institute of Oceanology,Chinese Academy of Sciences
Xiang HE, Guangzhou University
Xiaomei WEN, Guangzhou University
Yiben LI, Guangzhou University
Ji-Dong GU, Hongkong University
Presenter Email: jiaolijing16@mails.ucas.ac.cn

The land-sea interface is a unique site playing an important role in the biogeochemical processes of nutrients, but it is unclear whether it acts as a sink or source for coastal nitrogen loading. In this study, we analyzed the potential activity, microbial abundance, diversity as well as distribution pattern of both denitrification and anammox processes at a land-sea interface of Renshan in order to decipher the microbial nitrogen loss in intertidal low permeable sediments (LPS). Stable isotopic nitrogen tracer assay showed that potential rates of denitrification were much stronger than that of anammox, ranged from 0.61 to 13.47 mol N kg-1 h-1 sediments. Meanwhile, the abundance of denitrifiers was observed obviously higher than that of anammox bacteria by 1-2 order of magnitudes in the LPS. Based on the high-throughput sequencing analysis, high diversity was found for denitrifiers with gamma-proteobacteria, alpha-proteobacteria and beta-proteobacteria as the major components of the microbial community in the region. Anammox bacteria, including Ca. Scalindua, Ca. Kuenenia and Ca. Brocadia, were observed in the same transect. Geochemical and hydrological analyses indicated that hydrological processes, weak ammonium-borne freshwater advection, upper nitrate-borne brackish water diffusion and oxygenated seawater intrusion, may be important factors affecting the microbial nitrogen removal. Collectively, our results suggest that the land-sea interface with low permeable sediment is a microbial active zone with denitrification as the dominant contributor to nitrogen loss, resulting in the attenuation of reactive nitrogen from groundwater to the ocean in this region.

P-M5-03 Analytical techniques and applications for quantifying 15NO3- in isotope-enrichment experiments using a membrane inlet mass spectrometer

Xianbiao Lin, Laboratory of Microbial Ecology and Matter Cycles, School of Marine Sciences, Sun Yat-Sen University
Presenter Email: linxianbiao2099@163.com

Using 15N stable isotopes to quantify nitrogen (N) transformation rates has been proven to be a powerful approach for increasing understanding of N cycles in various ecosystems because they can contribute both source-sink and process information. One major challenge in methods for determination of 15NO3– concentrations is reducing the test cost via replacing expensive equipment and at the same time decreasing the pretreatment times and sample volumes. Here we describe a novel method (Zn-OX/MIMS) of determining 15NO3– concentrations for isotope-enrichment experiments via membrane inlet mass spectrometer (MIMS). We reduce dissolved 15NO3– to 15NH4+ using zinc powder under an optimized condition based on lots of preliminary experiments and oxidize 15NH4+ to 29N2 and/or 30N2 completely by hypobromite iodine solution, and then analyze produced gases with MIMS. The Zn-OX/MIMS method provides an accurate and precise approach to quantify 15NO3– concentrations in water samples over a range of salinities (R2 ≥ 0.9997, p < 0.0001) and a 2 M KCl solution (R2 = 0.9996, p < 0.0001). For applications, this method provides a convenient way to measure the gross nitrification and 15NO3– immobilization rates by isotope dilution in various ecosystems. In addition, using Zn-OX/MIMS method for determination of 15NO3– concentrations in aqueous samples can significantly simplify equipment and experimental procedure, and decrease the pretreatment times, cost, and sample volumes. Therefore, this method will promote the application of MIMS in N cycle research and contribute enormously to our understanding of N transformations, fate, and overall dynamics in numerous ecosystems in the future.

P-M5-04-S The transformation processes of ammonium at the Pearl River Estuary in summer

Ling Chen, State Key Laboratory of Marine Environmental Science, Xiamen University
Jing Liu, State Key Laboratory of Marine Environmental Science
Shuh-ji Kao, State Key Laboratory of Marine Environmental Science
Presenter Email: chenling522@stu.xmu.edu.cn

Nitrification is a two-step process whereby ammonium (NH4+) is oxidized to nitrite (NO2-) and then to nitrate (NO3-). It is an essential process in nitrogen cycle for it helps to regulate the overall distributions of different nitrogen species. Besides, nitrification would contribute to hypoxia development in coastal oceans. NH4+ is the substrate for nitrification, meanwhile, phytoplankton also use NH4+ for assimilation even in completely dark condition. NH4+ is the highest concentration of nutrients in the Pearl River Estuary

(PRE), in order to understand the transformation processes in dark condition,we determined the bulk nitrification rate (NRb) and NH4+ uptake rate (UR) along the PRE, especially for hypoxia zone in July 2017 by nitrogen isotope tracer technique. The NRb of section A ranged from undetectable up to 2.3 umol L-1 d-1, peaking at a salinity of 0.1. As for section 01, the maximum value (0.8 umol L-1 d-1) of NRb occurred at 1F701, which owns the highest concentration of NH4+. UR was almost higher than NRb in the surface, while UR was lower than NRb in the bottom, indicating that NH4+ is mainly absorbed by phytoplankton for assimilation in the surface even in completely dark condition, however, as for bottom water, nitrifier can compete with phytoplankton and make use of NH4+ for nitrification. Through principal component analysis (PCA), we found both NRb and UR presents positively correlation with NH4+ concentration, suggesting the importance of NH4+ in the transformation processes of nitrogen in the Pearl River Estuary.

P-M5-05 Spatial variability of turnover rates of polyamines and dissolved free amino acids in the ocean

Qian Liu, Second Institute of Oceanography SOA
Xue-Wei Xu, Second Institute of Oceanography SOA
Ye Lu, Shanghai Jiaotong University
Jun Xu, Shanghai Jiaotong University
Chun-Sheng Wang, Second Institute of Oceanography SOA
Presenter Email: liuqian@sio.org.cn

Polyamines are a group of aliphatic organic nitrogen compounds that are dissolved in seawaters and potentially contribute to bacterial nitrogen production. Previous studies have shown that turnover of polyamines in nearshore waters was rapid, similar to that of dissolved free amino acids (DFAA). Bacterial uptake of polyamines could contribute to over 10% of bacterial nitrogen demand, suggesting a significant role of polyamines in nitrogen cycle. In this study, we measured the turnover of polyamines and two DFAA (arginine and glutamic acid) using radioisotope tracing method in the water column of continental shelf and open ocean at the northern South China Sea (SCS) where dissolved organic nitrogen is suggested to be the predominant nitrogen source. Results showed that polyamines were actively utilized through the water column, while DFAA were mostly recycled within euphotic zone. This suggests that the biogeochemical pathways of these two groups of DON are different in northern SCS, possibly due to differences in their sources and sinks. It was estimated that polyamines may contribute up to ~5% of bacterial nitrogen demand at this region.

P-M5-06-S Effects of antibiotics on multiple nitrogen transformation processes in aquatic environments

Ru Wan, Xiamen University
Shuh-ji Kao, Xiamen University
Presenter Email: wantangshi1105@163.com

Nitrogen is a crucial element in amino acid of all living organisms. Versatile microorganisms compete for bioavailable nitrogen (e.g., ammonium and nitrate) for growth forming a complex reaction networks connecting to carbon cycle and greenhouse gas(N2O) emission, thus, playing a role in climate change. Antibiotics are widely used as human and veterinary medicines to treat diseases, thus, promoting survival rate and growth in livestock and aquaculture operations. Unavoidably, antibiotic residues may diffuse into estuary and coastal waters leading to environmental threats and disturbing the pristine nitrogen cycle. To date, most of researches of antibiotics were focus on the development of antibiotic resistance in pathogens or nonpathogenic bacteria with limited attention on the risk of antibiotics to environmental health, not mentioning microbial-mediated nitrogen processes. We use 15>N-NH4+ and 15N-NO3- labeling technique to quantitatively examine how antibiotics may regulate nitrogen transformation pathways, such as phytoplankton assimilation, nitrification and denitrification in estuarine waters, where anthropogenically induced excess nitrogen and enriched antibiotics were observed previously. Moreover, N2O production rate and yield of nitrification and denitrification will be presented. Similar technique was also applied onto estuarine sediments to comprehensively understand the effect of antibiotics on phytoplankton bloom, nitrogen transformation and N2O production in a eutrophic estuarine ecosystem.

P-M5-07-S Higher diversity of anammox bacteria in the deep-sea surface sediments of South China Sea than previously known

Jiapeng Wu, State Key Laboratory of Tropical Oceanography (LTO), South China Sea Institute of Oceanology, Chinese Academy of Sciences
Yiguo Hong, School of Environmental Science and Engineering, Guangzhou University
Presenter Email: wujiapeng@scsio.ac.cn

Ca. Scalindua is an exclusive genus of anammox bacteria known to exhibit low diversity found in deep-sea ecosystems. In this study, the community composition of anammox bacteria in surface sediments of the South China Sea (SCS) was analyzed using high-throughput sequencing techniques. Results indicated that the dominant OTUs were related to three different genera of anammox bacteria, identified as Ca. Scalindua (87.29%), Ca. Brocadia (10.27%) and Ca. Kuenenia (2.44%), in order of decreasing abundance. Quantitative PCR analysis of anammox-specific 16S rRNA and hzsB genes confirmed that the abundance of anammox bacteria in deep-sea surface sediments ranged from 4.34 × 10^5 to 3.91 × 10^7 and 1.62 × 10^5 to 1.63 × 10^8 copies per gram, respectively. The

ACE, Chao1 and Shannon estimators for anammox bacteria were significantly higher than those reported in previous studies. Pearson correlation and redundancy analyses indicated that depth and temperature were the key factors affecting the distribution, abundance and diversity of anammox bacteria in deep-sea sediments. We herein report the wide distribution of Ca. Kuenenia and Ca. Brocadia in deep-sea sediments and provide comprehensive information on the distribution and ecological significance of anammox bacteria in deep-sea environments.

P-M5-08-S Isotope constraints on the forming mechanism of Primary Nitrite Maximum (PNM) in the South China Sea

Siqi Wu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Shuh-ji Kao, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: wusiqi@stu.xmu.edu.cn

Nitrogen (N), as a biologically important nutrient element, plays an important role in the ocean, modulating primary production and carbon cycle in the euphotic zone. Among N species, nitrite (NO2-) with N of intermediate valence state, is an important intermediate connecting with a number of biological N processes. Since NO2- is chemically metastable, it has fast turnover rate and its concentration is usually under detection limit except a ubiquitous layer at the bottom of the euphotic zone where NO2- accumulates to considerable concentration, named Primary Nitrite Maximum (PNM). Given that PNM layer is close to the deep chlorophyll maximum (DCM) and ammonium maximum layer, various accumulation mechanisms (e.g., dominated by ammonium oxidation or phytoplankton nitrate reduction) of the metastable NO2- and its forcing factor (e.g., light or temperature) determining the location of PNM had been long proposed yet remains debatable to date. In this study, we presume that combined light and temperature effects on NO2- related processes determines PNM’s location and formation. To test this hypothesis, stations with different water mass characteristics were chosen for manipulation experiment, which combined light (~100 mol photons m-2 s-1, ~30 mol photons m-2 s-1(~1% PAR), dark) and temperature (in situ temperature and in situ temperature ±5oC) with multiple tracer addition (15N-NH4+, 15N-NO2-, 15N-NO3-). Our incubation experiment contains total 9 light and temperature combination potentially to resolve the synergistic effect. Further, combining molecular biological information such as genetic information on NO2- source and sink processes and plankton community structure, our results might give new insights into the universal forming mechanism of PNM and the response of PNM to the global change such as enhanced stratification and global warming.

P-M5-09-S Nitrogen loss by denitrification and anammox in sediments of Daya Bay, China

Haitao Xie, Guangzhou university
Yiguo hong, Guangzhou university
Presenter Email: 584415278@qq.com

The community structure and function on nitrogen loss of denitrification and anammox in the coastal subsurface sediments remain poorly understood. In the present study, we conducted 15N-labeled incubation, qPCR and high-throughput sequencing technique to analyze the activity, abundance, and community composition of denitrifiers and anammox bacteria in sediment cores from Daya Bay. Results indicated that activities and abundances of both denitrifiers and anammox bacteria were observed even below the surface sediments with low concentration of DIN and total nitrogen (TN). In the surface, denitrifiers have significantly higher activity and abundance than those of anammox bacteria, but the relative contribution to nitrogen loss by anammox increased to more than 60% in the subsurface sediments. Phylogenetic analysis revealed that nirS-type denitrifiers were affiliated to 10 different clusters and Ca. Scalindua dominated the anammox community in the whole sediments. Furthermore, both denitrification and anammox bacterial communities in the subsurface were remarkably distinct from that in the surface. Combined results suggested that denitrification and anammox play significant roles in removing fixed nitrogen and the availability of electronic acceptor (e.g. nitrite and nitrate) strongly influenced the nitrogen loss activities in the subsurface, emphasizing its role as a sink for the buried nitrogen.

P-M5-10-S Nitrogen cycling in the Jiulong River Estuary evidenced from the stable isotopes ratios of dissolved inorganic nitrogen

Dan Yu, College of the Environment and Ecology, Xiamen University
Julie Granger, Department of Marine Sciences, University of Connecticut, USA
Craig R. Tobias, Department of Marine Sciences, University of Connecticut, USA
Huasheng Hong, College of the Environment and Ecology; Fujian Provincial Key Laboratory for Coastal Ecology and Environmental Studies;State Key Laboratory of Marine Environmental Science, Xiamen University
Nengwang Chen, College of the Environment and Ecology; Fujian Provincial Key Laboratory for Coastal Ecology and Environmental Studies;State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: yudan417@163.com

The Jiulong River is a eutrophied system that discharges into a macro-tidal estuary in the west of the Taiwan Strait. Inorganic nitrogen species in the river (nitrate, nitrite, and ammonium) occur at relatively elevated concentrations in the upper estuary especially in spring and mix non-conservatively with lower concentration marine end-members. To

better understand the cycling and fate of dissolved inorganic nitrogen in the Jiulong River estuary, we sampled surface water and measured the naturally occurring nitrogen (and oxygen) isotope ratios of nitrate, nitrite, and ammonium with concentrations along the river-estuary-bay transect in April 2018. Net production of nitrate and nitrite in the estuary was suggested by non-conservative mixing. Relatively low δ15N values of the added nitrate and nitrite are consistent with production by nitrification. The net removal of ammonium in the estuary was apparent from non-conservative mixing, in tandem with a δ15N increase (0.08-4.8 ‰ deviated from the mixing curve), consistent with isotopic discrimination during ammonium oxidation. In all, N cycling in the estuary during our cruise was dominated by nitrification.

P-M5-11-S Effects of Ocean Acidification on *Trichodesmium* IMS101 under Phosphorus Limited Condition

Futing Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University
Haizheng Hong, State Key Laboratory of Marine Environmental Science, Xiamen University
Dalin Shi, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: futing163479@stu.xmu.edu.cn

The filamentous diazotrophic cyanobacterium *Trichodesmium* introduces fixed nitrogen (N) to the N-depleted oligotrophic oceans where it inhabits. The growth and N2 fixation of *Trichodesmium* are often limited by the low availability of phosphorus (P) and/or iron in the vast regions of open oceans. Previous work mostly focus on the effect of ocean acidification on *Trichodesmium* under nutrient sufficient and iron-limited conditions. Here we used P-limited chemostats to show that the model strain *Trichodesmium* IMS101 contained less chlorophyll a, assimilated less carbon, and had lower nitrogen fixation rate per cell at high CO2. Consistently, the cellular particulate carbon (C) and N quota were significantly lower at high CO2. The particulate P quota, however, was slightly higher under acidified conditions due largely to the increase of inorganic polyphosphate (polyP), which likely plays an important role in cytosolic pH homeostasis. The resulting C:P and N:P ratios were significantly lower under high CO2 conditions, suggesting that *Trichodesmium* fixed less C and N per quota of P under P-limited conditions in response to increasing CO2. Comparative transcriptomic analysis showed that 189 genes are differentially expressed in response to acidification, including those involved in P acquisition and metabolism. For example, acidification led to up-regulatiuon of Tery_0365-68 a putative phosphonate or phosphite uptake system genes and down-regulation of Tery_1770 the inorganic polyphosphate/ATP-NAD kinase. Our study suggested that to cope with acidified conditions *Trichodesmium* increased P uptake but decreased NADP(H) utilization to maintain a high polyP content for maintaining cytosolic pH homeostasis.

P-M5-12-S Salinity effect on nitrification efficiency and N2O production pathway in eutrophic estuarine

Yutong Zhou, author
Ehui Tan, colleague
Wenbin Zou, colleague
Shu-Ji Kao, supervisor
Presenter Email: ytzhou@stu.xmu.edu.cn

Strongly influenced by anthropogenic excess nutrient, estuaries are areas of intense biogeochemical processing, transporitng terrestrial inputs of fixed N to coastal waters as well as releasing greenhouse gas N2O to the atmosphere. Owing to the influence of tide and wave, estuaries experience a wide salinity range, making the complex N cycle even more tricky. Nitrification, including ammonia oxidation to nitrite and nitrite oxidation to nitrate, decides the forms and distribution of inorganic N, also serve as major contributor to atmospheric N2O. The two steps of nitrification are carried out by different performers - ammonia oxidizing microbe and nitrite oxidizing bacteria. It is reported,that these two groups of microorganisms show different sensibility to salinity shock and some may get inhibited on their activities of N2O reductase. However, not only are these existing studies almost exclusively based on bioreactors, but also the quantitative results as well as specific mechanisms behind yet to be clarified. In this study, water sample was taken at the fresh water side of Jiulong River, a typical eutrophic estuary in south-east of China, a gradient of NaCl was then added to different cultivation systems adjusting the final salinity to 1, 2, 3, 4, 5, 7, 10 and 25. By applying isotope labeling technique, we would like to figure out at what extent do ammonia oxidation and nitrite oxidation decouple when saline water invades, moreover, how would this alter N2O production among different pathways. This work aims to further our awareness of salinity effect on N cycle in field study, it may also give clues on other biogenic elements studies such as C, P, O, S and Fe which tightly intertwine with N cycle.

P-OB-01-S Comparison of surface salinity products from SMOS, Aquarius and SMAP satellites

Senliang Bao, National University of Denfense&Technology
Ren Zhang, National University of Denfense&Technology
Huizan Wang, National University of Denfense&Technology
Henqian Yan, National University of Denfense&Technology
Bo Song, National University of Denfense&Technology
Presenter Email: 799296775@qq.com

Global surface ocean salinity measurements have been available since the launch of SMOS in 2009 and coverage was further enhanced with the launch of Aquarius in 2011 and SMAP in 2015. Due to SMOS, Aquarius and SMAP differ in requirement, retrieval algorithm and

error correction strategy, the quality of their gridded products are different. We access three satellite products with in situ salinity measurements from the accuracy of products and the ability to resolve ocean phenomena. Compared with in situ measurements, Aquarius CAP data are of best quality , which have reached the design accuracy (0.2PSU) in open ocean. SMOS and SMAP agree well with in situ data in the tropical ocean and away from the coast. The RMSE of SMAP is smaller than SMOS in near-shore areas and at high latitudes. Meanwhile, A quantitative comparison between satellite SSS products and in-situ measurements in resolving salinity variation through singularity analysis, local variance, entropy and wavenumber spectra analysis is presented. The results show that the satellite data resolve considerably more detailed structures than in situ gridded data. The SMOS characterize the eastern edge of warm pool salinity front better, the SMAP fields are dominated by small-scale noise.

P-OB-02-S Determination of Trace Dissolved Reactive Phosphorus and Chromium (VI) with an Integrated Syringe-Pump-Based Environmental-Water analyzer (iSEA) Coupled to a Liquid Waveguide Capillary Cell

Jian Ma, Xiamen University
Yao Deng, Xiamen University
Xiangyu Zhu, Xiamen University
Peicong Li, Xiamen University
Presenter Email: 527924115@qq.com

With the development of the liquid waveguide capillary cell (LWCC), the method sensitivity can be easily achieved by increasing of the flow cell length. Now, LWCC has been applied to field studies in the open ocean. For the robust, reliable, autonomous environmental monitoring instrument, we development of an combined with LWCC (iSEA-LWCC). The iSEA-LWCC consists of a syringe pump equipped with a 9-port valve and controlled by software written in LabVIEW. The optical flow cell was 2.5-m LWCC. The iSEA-LWCC has been applied for, the determination of trace elements in water. The main contents and results are summarized as follows:

(1) Phosphorus is an essential nutrient element used by marine phytoplankton. As the major component of inorganic phosphorus, dissolved reactive phosphorus (DRP) plays an important role in the marine biogeochemical cycle of phosphorus. The process of chemical reactions is based on phosphorus molybdenum blue spectroscopic spectrophotometry coupled with a 2.5-m LWCC, a convenient method for determination of trace of SRP was established. The sample throughput was 12 per hour. The relative standard deviation (n=66) was 0.98% for a sample with concentration of 80 nmol/L. The detection limit is ~1 nmol/L.

(2) Chromium (VI) is a recognized hazardous substance in drinking waters. Therefore, effective monitoring and assessment of the risks posed by Cr (VI) are important analytical

objectives for both environmental science and human health. Here, we developed a simple and sensitive method for analysis of Cr (VI) at nanomolar levels. The measurement chemistry is based on a reaction with diphenyl carbazide under acidic conditions, with a 2.5-m LWCC and spectrophotometric detection. The instrument is controlled by software written with LabVIEW. The determination of a sample only needed 4 min. The linear calibration range from 0 to 100 nmol/L with detection limit of ~0.3 nmol/L.
The iSEA-LWCC instrument has the potential for long-term online monitoring of trace nutrients and metals in environmental water samples. More evaluation and applications are under development.

P-OB-03-S Research on the indophenol method for the determination of ammonium in natural waters using o-phenylphenol

Jian Ma, State Key Laboratory of Marine Environmental Science,College of the Environment and Ecology, Xiamen University
Peicong Li, College of the Environment and Ecology, Xiamen University
Presenter Email: 977968997@qq.com

Ammonium, as one of the most important nutrients, occupies a central role in nitrogen biogeochemical cycles. Accurate and sensitive determination of ammonium is of great interest and challenging for both environmental scientists and oceanographers. The indophenol blue (IPB) method based on Berthelot's reaction is still the most widely used method, and routine analysis based on IPB method is the most popular technique for the automated ammonium measurement. However, the existing analytical methods have the shortages of high toxicity, interference with salinity, high reagent consumption and difficulties in application in-field. Herein, a new analytical method and a relative compact, robust and portable instrument for ammonium determination have been developed. The main contents and results are as follows: (1) A salinity-interference-free indophenol method for the determination of ammonium in natural waters using o-phenylphenol was developed. The normally used toxic and odorous phenol was replaced by the less toxic, stable flaky crystalline compound, o-phenylphenol. The reaction can be finished within 20 min at room temperature and the formed color compound is stable for 24 h. Under the optimized conditions, the method was salinity-interference-free, it shows high reproducibility (relative standard deviations of 0.64–1.71%, n=11), highly linear calibration up to 100 μM and a low detection limit of 0.2 μM. This method was successfully applied to measure ammonium in Min river, Jiulongjiang estuary and Xiamen coastal area. This work has been published on "Ma et al., Talanta, 2018, 179, 608-614". (2) An integrated syringe-pump-based environmental-water analyzer (iSEA) and its application for spectrophotometric determination of ammonium is presented. The iSEA consisted a mini-syringe pump equipped with a selection valve. The principle of chemistry method was based on method (1). This fully automated analyzer had a detection limit of 0.12 μM with sample throughput of 12 h-1. Relative standard deviations at different concentrations (0-20 μM) were 0.23-3.36% (n=3-11) and 1.0% (n=144, in 24-h continuous measurement, ~5 μM). Calibration curves were linear (R2=0.9998) over the range of 0-20 μM and 0-70 μM for detection at 700 nm and 600 nm, respectively. The iSEA was applied in continuous real-time monitoring of ammonium variations in a river for 14 days and a shipboard underway analysis in Jiulongjiang estuary and Xiamen coastal area. This work has been published on "Ma et al., Analytical Chemistry, 2018, 90, 6431-6435".

P-OB-04-S On-site and rapid detection of tropane alkaloids in drinking water by Surface-enhanced Raman Spectroscopy

Jianglong Lu, State Key Laboratory of Marine Environmental Science,College of the Environment and Ecology, Xiamen University, Xiamen 361005, China
Guokun Liu, State Key Laboratory of Marine Environmental Science,College of the Environment and Ecology, Xiamen University, Xiamen 361005, China
Presenter Email: 302825876@qq.com

Tropane alkaloids, the secondary metabolites occurring in several plant families, including solanaceae plants, are the highly toxic chemicals to human health. The qualitative and fast determination of such chemicals deliberately dosed in drinking water and foods plays the key role towards the public security issue. Up to now, the qualitative and quantitative analysis of scopolamines in plants, drugs or drinking water, has been performed using liquid chromatography (HPLC) with the precise quantitation, however, the lab equipment and the tedious pretreatment hindered the quick response in case of emergency. Surface-enhanced Raman spectroscopy (SERS) is one powerful analytical tool with low cost, high selectivity, extraordinary sensitivity and good compatibility in aqueous environments. Here, we developed SERS based protocol for the quick, qualitative and quantitative to detect several scopolamines in various drinking waters. The initial result indicated that the lowest detectable concentration was at 1 μg/L and each scopolamine can be distinguished when the mixture was at 10 μg/L.

P-OB-05-S Isotope insights for the trophic ecology of vent crabs in shallow hydrothermal system

TIAN Xifan, Xiamen University
Presenter Email: xftian@stu.xmu.edu.cn

Hydrothermal represents one of the most extreme environments on earth. Chemolithotrophic bacteria are common residents in such ecosystems. These bacteria are believed not only to enable their hosts to adapt the extreme environment but also act as food source to support their host animals. A shallow-water hydrothermal vent near the Turtle Island off the northeast coast of Taiwan provides a unique opportunity to explore the trophic ecology of a vent system influenced by the phototrophic ecosystem. We examined isotopic compositions of various potential food items and crab's tissues from water column and vent floor, including zooplankton both living and dead, particulate organic matter, bacterial mat, and various tissues of sulfur-tolerant the vent crabs. The similar δ13C and δ15N values of crabs' stomach content and dead zooplankton mixture suggested that both zooplankton and bacteria are the food sources for the vent crab. This result confirms that the vent crab is an opportunistic, which means that they have a remarkable adaptation to their living surroundings. The vent crab is an amazing creature living in extreme environment. We could data back to the evolving history of the earth living things through our results. Simultaneously, there might exist an implied connection between the deep sea Hydrothermal vent ecosystem and the shallow sea Hydrothermal vent ecosystem.

P-OB-06-S Sediment transport in a plume to plume interaction area of Lingdingyang Estuary

Huang Weihao, School of Marine Sciences, Sun Yat-sen University, Guangzhou, China, 510275
Gong Wenping, School of Marine Sciences, Sun Yat-sen University, Guangzhou, China, 510275
Zhang Heng, School of Marine Sciences, Sun Yat-sen University, Guangzhou, China, 510275
Zhang Guang, School of Marine Sciences, Sun Yat-sen University, Guangzhou, China, 510275
Presenter Email: huangwh55@mail2.sysu.edu.cn

The co-effects of longitudinal and lateral freshwater runoff represent a particular plume to plume interaction (PPI) in the Lingdingyang Estuary. In order to study the estuarine dynamics and sediment transport discipline in the PPI area, field observations were implemented in the western area of Lingdingyang Estuary between 2015 and 2016 by combining the observation methods of shipborne full-profile observation and mooring observation tripod. Hydro-dynamic parameters such as water depth, flow velocity, salinity, temperature, suspended sediment concentration (SSC), erosion/siltation of the bottom seabed were recorded in deep channel and shallow shoal in the west part of Lingdingyang Estuary for complete tidal cycles during spring and neap tides in wet and dry seasons. Squared mean shear (S2), buoyancy frequency (N2), gradient Richardson number (Rig), bottom shear stress (τ), vertical fluctuant SSC flux (<SSC'w'>) and other microcosmic parameters for each measurement were well calculated. Erosion/siltation rate on the seabed shows a continuous siltation in the channel but a continuous erosion on the shoal during neap tide of wet season and a periodic erosion-siltation cycle on the channel and shoal in the rest tidal cycles. The SSC at the bottom of the deep channel shows a good correlation with the τ, while a poor correlation on the shallow shoal. All of these indicate an

evident trap effect for the advective suspended sediment in the deep channel. As most of the advective suspended sediment silted in the seabed, the SSC is mostly formed by the resuspension process. While the advective part of SSC on the shallow shoal failed to silt or the remaining quantity is non-negligible compared to the amount of resuspension part, revealing a poor correlation between τ and bottom SSC. In order to further confirm the correctness of the results, recorded SSCs by mooring tripod were divided into an advective part and resuspended part by the local bottom erosion/siltation rate. A good correlation is then proved out between bottom bed shear stress and resuspended sediment concentration.

P-OB-07-S Improved Multi-Fractal Fusion Method to Blend SMOS Sea Surface Salinity based on Semi-Parametric Weight Function

Hengqian Yan, College of Meteorology and Oceanography, National University of Defense Technology
Ren Zhang, College of Meteorology and Oceanography, National University of Defense Technology
Gongjie Wang, College of Meteorology and Oceanography, National University of Defense Technology
Huizan Wang, College of Meteorology and Oceanography, National University of Defense Technology
Jian Chen, Beijing Institute of Applied Meteorology
Senliang Bao, College of Meteorology and Oceanography, National University of Defense Technology
Presenter Email: brainholeqian@163.com

The multi-fractal fusion method has proved to be an effective algorithm to mitigate the noise of the sea surface salinity (SSS) of Soil Moisture and Ocean Salinity (SMOS) mission. However, the traditional non-parametric weight function used in this method is unable to capture the dynamic evolution of oceanic environment. Considering the multi-scale, non-uniform, anisotropic and flow-dependent nature of the ocean, the improved method with so-called “flexible circle” weight function and “flexible ellipse” weight function with a set of pre-defined parameters is proposed in this paper. The improved weight function can draw dynamic information from the sea surface temperature, Rossby radius of deformation and surface geostrophic flow to complement the poor remote sensing SSS. The validation against the in-situ data indicates that the improved weight function performs better than the traditional one with reduced root mean squared error (RMSE) and higher correlation coefficient. What’s more, the salinity map based on “flexible ellipse” weight function can reflect more mesoscale signals without the sacrifice of computational efficiency.

P-OB-08-S Short-Term Variations in the Surface Upwelling off Northeastern Taiwan Observed via Satellite Data

Wenbin Yin, Ocean College, Zhejiang University/State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Daji Huang, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Presenter Email: yinwenbin@zju.edu.cn

Short-term biweekly variations in the surface upwelling off northeastern Taiwan are well documented. However, due to limitations in the spatiotemporal resolution and coverage of the observed data, the lifecycle and associated dynamics are poorly understood. In this study, a gradient-based edge detection algorithm is proposed to detect the surface upwelling. The sea surface temperature (SST) data of geostationary satellite Himawari-8 were used to explore a complete short-term process as a case study. The evolution was analyzed in terms of an upwelling index measured via the temperature difference between upwelled and surrounding water and the area and shape of the surface upwelling. The process lasted approximately 17 days as the upwelling moved northeastward under the advection of the Kuroshio Current and included two stages: intensification and decay. The last eight years (2010-2017) of multisatellite combined SST data were examined to verify the results obtained in the case study. A statistical analysis shows that most of the short-term processes occur in the summer with an average lifecycle of approximately 15 +/- 5days. The trajectories of the upwelling center can be grouped into three types: quasi-stationary near the shelf break, moving northward across the shelf break, and moving northeastward along the shelf break. A preliminary discussion suggests that the observed variations may be caused by the collective effects of multiple dynamical mechanisms, such as fluctuations in the Kuroshio Current, surface wind curl, and typhoons. This study furthers our knowledge of the surface upwelling off northeastern Taiwan and provides constraints for numerical simulations.

P-OB-09-S Forecasting the sea ice drift in the Liaodong Bay using GOCI data

Gong Wenping, Zhang Rui, Center for Coastal Ocean Science & Technology Research, School of Marine Sciences, SunYat-sen University, Guangzhou 510275, China
Presenter Email: 815382241@qq.com

Abstract: The monitoring and forecasting of sea ice drift has profound implications for fisheries, port trade, transportation, oil platforms and economic growth. In this paper, a novel method was developed with an aim to monitoring the sea ice thickness in the Liaodong Bay, based on Rayleigh-corrected reflectance of four GOCI (Geostationary Ocean Color Imager) images in the Feb. of 2012. The result indicates the sea ice thickness by remote sensing retrieval can be well consistent with empirical interpretations. We analyzed the relationship among the surface temperature, rainfall, wind, thickness and sea ice drift.

A multiple regression model was obtained to predict the drift distance of sea ice, with the correlation coefficient R up to 0.79, which shows the model can effectively predict the sea ice drift. Key words: forecasting; Sea ice; drift; Liaodong Bay; GOCI; remote sensing retrieval

P-OB-10-S Towards measuring air-sea interface parameters within an eddy

Zhaohui Chen, Key Laboratory of Physical Oceanography/Institute for Advanced Ocean Studies, Ocean University of China, Qingdao, China
Yueqi Zhang, Key Laboratory of Physical Oceanography/Institute for Advanced Ocean Studies, Ocean University of China, Qingdao, China
Presenter Email: zyq@stu.ouc.edu.cn

The Kuroshio extension (KE) region has been identified as a key location in the extratropics in the North Pacific where sharp oceanic fronts and energetic mesoscale oceanic eddies induce considerable sea surface temperature (SST) variability, leading to intensive air-sea interaction. Understanding these frontal- and mesoscale air-sea interaction has important implications to improve future climate modelling, prediction and application at the midlatitude. Until very recently, available observations were inadequate to resolve such small-scale dynamical processes in western boundary current regimes, making it difficult to further investigate the frontal- and mesoscale air-sea interaction. Here we use a new kind low-cost but high-efficiency drifting buoy, which integrates the advantages of Lagrangian drifters and moored buoys, to observe the air-sea parameters like wind, air temperature, air pressure, relative humidity, sea surface temperature, sea surface velocity and other related parameters. This paper will introduce some deployment tests made in KE and the applications in quantifying the air-sea turbulent heat flux.

P-OB-11 Effects of elevated pCO2 on DMS release from bacterial perspective

Sheng-hui Zhang, Key Laboratory of Coastal Environmental Processes and Ecological Remediation, Yantai Institute of Coastal Zone Research (YIC)
Gui-peng Yang, Key Laboratory of Marine Chemistry Theory and Technology, Ocean University of China, Ministry of Education/Qingdao Collaborative Innovation Center of Marine Science and Technology
Da-wei Pan, Key Laboratory of Coastal Environmental Processes and Ecological Remediation, Yantai Institute of Coastal Zone Research (YIC)
Presenter Email: shzhang@yic.ac.cn

Natural A. catenella and sterile A. catenella were used to investigate the microbial community contribution to DMS and DMSP production. Results show that DMS production ability in the sterile A. catenella decreased notably compared with that of natural A. catenella, while Chl a and DMSP concentrations showed no significant difference. These findings suggest that the attached bacteria are dominant in DMS production. In addition,

we found that the DMS-producing isolates behavior differed greatly in MAMS medium, and decreasing pH had variable effects on their abundances and DMS production ability. Meanwhile, elevated pCO2 also had controversial effects on DMS-prodution per cell. Considering the important role of bacteria in DMS prodution, this uncertainty and complexity may be the main reason that previous laboratory incubation, shipboard incubation and mesocosm experiments have not obtained uniform conclusions on the effects of decreasing pH on DMS release.

Modelling the fate and transport of marine debris with TrackMPD: a case study for shipping containers spill in the East coast of Australia

Isabel Jalon-Rojas, The Sino-Australian Research Centre for Coastal Management, School of Physical, Environmental and Mathematical Sciences, UNSW Canberra, Canberra, Australia
Fanglou Liao, The Sino-Australian Research Centre for Coastal Management, School of Physical, Environmental and Mathematical Sciences, UNSW Canberra, Canberra, Australia
Xiao Hua Wang, The Sino-Australian Research Centre for Coastal Management, School of Physical, Environmental and Mathematical Sciences, UNSW Canberra, Canberra, Australia
Erick Fredj, Jerusalem College of Technology, Jerusalem, Israel
Presenter Email: i.jalonrojas@unsw.edu.au

Pollution of coastal and marine environments by plastic and other synthetic materials, so-called marine debris, has become a major issue over the last few decades. In this work, we present TrackMPD, a new user-friendly modelling framework to evaluate and predict the transport and fate of marine debris. Unlike most of previous models, TrackMPD considers a three-dimensional approach, provides compatibility with a variety of ocean models, and includes a wide range of physical processes (advection, dispersion, windage, sinking, settling, beaching and re-floating). In the case of micro-plastic debris, TrackMPD can incorporate its behaviour according to the particle dynamical properties, and the fouling and degradation state. A case study to forecast the spread of a shipping containers spill is used to illustrate the model application. On June 1st 2018, a total of eight-one containers were spilled near Port Stephens (East coast of Australia). Debris was spotted to wash up along the coast of New South Wales, but some containers have not been found to this day. The modelled trajectories of floating debris accurately reproduce the beaching patterns of the spotted debris. Results show that both wind and the eddies of the East Australian Current highly affect the transport of the debris.

P-E1-01-S Interactive effect of copper and temperature on growth and physiology in *Thalassiosira pseudonana*

Wang Cao, Marine Biology Institute, Shantou University, Shantou, Guangdong 515063, China Guangdong Provincial Key Laboratory of Marine Biology, Shantou University, Shantou, Guangdong 515063, China STU-UNIVPM Joint Algal Research Center, Shantou University, Shantou 515063, Guangdong, China

Liai Peng, Marine Biology Institute, Shantou University, Shantou, Guangdong 515063, China Guangdong Provincial Key Laboratory of Marine Biology, Shantou University, Shantou, Guangdong 515063, China STU-UNIVPM Joint Algal Research Center, Shantou University, Shantou 515063, Guangdong, China

Su Xu, Marine Biology Institute, Shantou University, Shantou, Guangdong 515063, China Guangdong Provincial Key Laboratory of Marine Biology, Shantou University, Shantou, Guangdong 515063, China STU-UNIVPM Joint Algal Research Center, Shantou University, Shantou 515063, Guangdong, China

Wenhua Liu, Marine Biology Institute, Shantou University, Shantou, Guangdong 515063, China Guangdong Provincial Key Laboratory of Marine Biology, Shantou University, Shantou, Guangdong 515063, China STU-UNIVPM Joint Algal Research Center, Shantou University, Shantou 515063, Guangdong, China

Ping Li, Marine Biology Institute, Shantou University, Shantou, Guangdong 515063, China Guangdong Provincial Key Laboratory of Marine Biology, Shantou University, Shantou, Guangdong 515063, China STU-UNIVPM Joint Algal Research Center, Shantou University, Shantou 515063, Guangdong, China

Presenter Email: 16wcao@stu.edu.cn

Copper is essential trance metal for many physiological processes (eg. electron transfer reactions and high-affinity Fe transport system) in phytoplankton, however, it can be potentially toxic at high concentrations. In the marine ecosystem, induced tolerance of exposed on phytoplankton cannot be always attributed solely to the present of toxicants as various environment factors, such as temperature. In this study, effects of different concentrations of copper (0, 19.6, 160, 800, 8000 nM) simultaneously applied at two temperatures (20 degree and 25 degree to the centric diatom *Thalassiosira pseudonana* were detected by measuring growth and physiological changes. At the low (0 nM) and high (8000 nM) Cu concentration, growth rate of T. pseudonana was inhibited and increase temperature can reduce the inbibition. The POC and PON content decrease by 11.3% and 14.1% with increasing copper concentration from 0 to 19.6 nM , while increased by 16.1% and 17.7% respectively with increase copper concentration from 19.6 nM to 8000 nM. The Copper content in T. pseudonana range from 0.13 to 13.28 fg/cell to respond the outside copper content increases by adjusting the transcription expression of copper transport genes. It can also change the transcription expression of other genes, including photosynthetic gene and silicon synthesis genes. In brief, our results show that T.

pseudonana can adjust the physiological process and molecular mechanism to respond to the changes in environmental factors.

P-E1-02-S Calculation of the monthly total maximum allocated load of dissolved inorganic nitrogen pollutants in Daya Bay using L-THIA combined 3D model

Yuren Chen, School of Marine Sciences, Sun Yat-sen University
Weicong Cheng, School of Marine Sciences, Sun Yat-sen University
Wenping Gong, School of Marine Sciences, Sun Yat-sen University
Heng Zhang, School of Marine Sciences, Sun Yat-sen University
Presenter Email: 505883357@qq.com

Total maximum allocated load (TMAL) is one of the most important concepts in the local environmental management. Combing the linear programming method, the L-THIA model and the ECOMSED model with a tracer module, the monthly TMAL of the dissolved inorganic nitrogen (DIN) for 49 pollutant outlets in the 3 jurisdictions of the Daya Bay was estimated. Results suggested that the annual TMAL in all outlets was about 8.378 to 103 tons/year, while the monthly TMAL ranged from 3.414 to103 tons/year to 1.225 to 104 tons/year, which was relatively larger in the summer. Since the non-point source pollutants was mainly dominated by the precipitation, the amount of the non-point source DIN, which was almost zero in the dry seasons, was evaluated to be much larger than that of the point source DIN in the rainy seasons. Among all the jurisdictions, the outlets in Huidong Country contributed most to the monthly TMAL steadily, more than 65%, while the contribution of the other two regions, the Longgang District and the Daya Bay Economy and Technology Development Zone (DBETDZ), changed with the seasons significantly. Thus, the outlets in DBETDZ and the bays of the Longgang District was more frequently overloaded for more than 200%. Moreover, the TMAL was found to be negatively correlated with the water age when the water age was larger than 60 hours and stayed nearly zero when the age exceed 120 hours, but this pattern was not obvious when the water age decreased below 40 hours. With the examination of the water quality model, establishing 3 to 5 pollutant outlets outside the bay was proved to be effective for increasing the overall TMAL.

P-E1-03 Variation in the catch rate and distribution of swordtip squid (Uroteuthis edulis) associated with factors of the oceanic environment in the southern East China Sea

Kuo-Wei Lan, Department of Environmental Biology Fisheries Science, National Taiwan Ocean University
Cheng-Hsin Liao, Department of Environmental Biology Fisheries Science, National Taiwan Ocean University
Hsin-Ying Ho, Taiwan Fisheries Sustainable Development Association, Keelung

20224,Taiwan, Republic of China
Yan-Lun,Wu, Department of Environmental Biology Fisheries Science, National Taiwan Ocean University
Presenter Email: kwlan@mail.ntou.edu.tw

Predictions from species distribution models are utilized to parameterize the environmental factors that influence the biology, distribution, and habitats of a species of interest. This study fitted generalized additive models (GAMs) to spatiotemporal fishery data of light fishing from 2009 to 2013 to investigate the catch rates of swordtip squid in relation to changes in oceanographic conditions and developed a habitat preference model. A high Jensen–Shannon divergence (JSD) is considered to be an index of a thermal front. The results obtained using the selected GAMs revealed that the explained deviances in the catch rates pertaining to the oceanographic conditions was 45.10% throughout the year. All the variables used, the sea surface temperature (SST), chlorophyll-a, sea surface height anomaly, and JSD, were statistically significant predictors ($p < 0.05$), and the JSD explained the greatest amount of deviance (17.70%). The model predicted relatively high abundance of swordtip squid at 27–28°N in the southern East China Sea during spring and a decrease from June to August. The high abundance occurred again in September and extended to southwest ward to a region including coastal Mainland China. This demonstrated that the high abundance occurred in the 20.0–26.0°C SST range and 0.35–0.5 JSD range during spring around 27–28°N and movement towards southwest corresponding with shifts in the Kuroshio front (26°C isotherm) in summer and autumn.

P-E1-04 Temporal and spatial characteristics of surface chlorophyll concentration around the reefs and islands in the South China sea

Wuyang Chen, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Junmin Li, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Shilin Tang, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Qingyou He, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Ping Shi, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Presenter Email: jli@scsio.ac.cn

Merged ocean color data from 1999 to 2017 is used to analyze the chlorophyll concentration variations around the reefs and islands in the South China sea. The results show that the islands center has the highest chlorophyll concentration, which decreases with the distance increases between the islands center to outside. The concentration

decreases to the value of open sea area while the distances reach to five radiuses of islands. the level of chlorophyll concentration of the islands area depends on the level of the chlorophyll concentration of the open sea area.
Moreover, the chlorophyll concentration is heavily influenced by monsoons. In winter, monsoon is cool and rapid that leads to the strong effect of ocean surface fluctuation. At that time, the chlorophyll concentration increasing significantly because of the suitable temperature of seawater, which reach to the maximum at January. When monsoon weakened, the chlorophyll concentration decreasing with the temperature of seawater increasing, which reach to the minimum at May. In summer, monsoon comes to frequent so that the chlorophyll concentration increasing again.
Annually, the chlorophyll concentration has significant correlation with Nino 3.4 index. When La Niña happened, the chlorophyll concentration at a low level and increasing gradually. When Nino 3.4 larger than 0.5, El Nino happened, the chlorophyll concentration at a high level and decreasing gradually. The high level of chlorophyll concentration depends on the duration of the trend of Nino 3.4 close to zero.

P-E1-05-S Ecosystem-based management under a changing environment via outputs from coupled marine physical and biogeochemical models and participance of stakeholders

Jie Liu, Department of Biological Sciences, University of Bergen, Postbox 7803, 5020 Bergen, Norway
Richard G.J. Bellerby, Norwegian Institute for Water Research, Thormøhlensgate. 53 D, 5006 Bergen, Norway; State Key Laboratory for Estuarine and Coastal Research, East China Normal University, 3663 Zhongshan N. Road, Shanghai 200062, China
GE Jianzhong, State Key Laboratory for Estuarine and Coastal Research, East China Normal University, 3663 Zhongshan N. Road, Shanghai 200062, China
Presenter Email: Jie.Liu@student.uib.no

As human pressures on the natural environmental increase through the Anthropocene and simultaneously, our demand for marine ecosystem services grow, it is paramount that adequate tools needs to be developed for good marine ecosystem governance and management. The development of such governance and management requires an understanding of the constituent physic-chemical, biological and socio-economic systems, as well as their connectivity. The efficient and relevant development of coastal management protocols could only be realized when there forms a comprehensive understanding of how the ecosystem changes with the changing environment. To realize the goal, both coupled marine physical with ecosystem models and involvement of stakeholders are needed.
Coupled marine physical and biogeochemical ecosystem models are of fundamental importance in fortifying assessment, management and policy support. Outputs from

physical FVCOM (Finite-Volume, primitive equation Community Ocean Model)/ ROMS (Regional Ocean Modeling System) coupled with biological ERSEM (European Regional Seas Ecosystem Model) for both Norwegian and Chinese marginal seas are to be analyzed to develop scenarios for the scale, rate and phenology of critical drivers of organism and ecosystem function.

The natural scientific information about sustainable development of marine ecosystem services concerning how they change in a changing environment would only be ideal but not be meaningful if the social and economic expectations of the stakeholders, who live on take benefits from ecosystem services, are not considered. So we will need to provide targeted knowledge of ecosystem functioning and services changes to different stakeholders, meanwhile, to adjust models analysis according to their needs, thus to help them adapt to global change.

P-E1-06 Morphological characterization of Rhizophora mangrove hybrids on an islet in Malaysia

Wei Lun Ng, China-ASEAN College of Marine Sciences, Xiamen University Malaysia
Hong Wooi Teoh, China-ASEAN College of Marine Sciences, Xiamen University Malaysia
Presenter Email: weilun.ng@xmu.edu.my

With more focus on mangrove research and increasing accessibility to molecular facilities, there have been many reports on mangrove hybrids in recent years. All three species of Indo-West Pacific Rhizophora mangroves occur in Malaysia. In 1996, the first encounter of a Rhizophora hybrid in Malaysia happened on Pulau Burung, a small uninhabited islet off the coast of Port Dickson in the state of Negeri Sembilan. The observation was on a putative hybrid between R. apiculata and R. stylosa (=R. x lamarckii), reported to dominate the islet alongside its parental species. Since then, part of the islet was cleared to make way for the construction of a walkway, and in the process revealed the presence of R. mucronata. In an effort to confirm the identity of the putative hybrid, all four Rhizophora taxa were sampled for genetic analysis. Unexpectedly, a second hybrid was discovered in the process -- one between R. mucronata and R. stylosa, which was reported for the first time. Subsequent genetic analysis demonstrated that this novel hybrid is fertile, bringing up questions on the evolution and classification within the IWP Rhizophora, specifically between R. mucronata and R. stylosa. In this study, we surveyed the composition of Rhizophora taxa on Pulau Burung and characterized the inflorescence of the taxa. Due to the scarce occurrence of Rhizophora hybrids around the world, reports on their morphological characterization are limited and are often based only on few individuals. The dominance of Rhizophora hybrids on Pulau Burung offers a rare opportunity for a comprehensive examination on the morphology of the hybrids, thus providing a better understanding of IWP Rhizophora hybrids.

P-E1-07 Historical seaward mangrove habitat expansion in the Merlimau, Malaysia

Sahadev Sharma, Institute of Ocean and Earth Sciences, University of Malaya
Siti Noor Adibah, Institute of Biological Sciences, Faculty of Science, University of Malaya
Wan Mohd Nabil, School of Biology, Faculty of Applied Sciences, University Technology Mara, Shah Alam
Rozainah Binti Mohamad Zakaria, Institute of Biological Sciences, Faculty of Science, University of Malaya
Harinder Rai Singh, School of Biology, Faculty of Applied Sciences, University Technology Mara, Shah Alam
Albert Apollo Chan, Department of Marine Parks, Malaysia
Presenter Email: ssharma@um.edu.my

Mangrove forest provide important ecosystem services such as timber, fisheries, coastal protection, aesthetic values, nutrient cycle, water purification and climate regulation to surrounding coastal communities. Though they provide many ecosystem services their rate of deforestation is very high across globe. Malaysia has third largest mangrove forest cover in the world with 4691 ha. However, Malaysia has lost 278 ha of mangroves from 2000 to 2014 due to land conversion for agriculture, palm plantation, aquaculture and urban development. Besides that high sedimentation rate is occurring in estuaries due to increased catchment sediment yields, which is overall associated with land-use changes. Consequently, accelerated the filling of estuaries that have become progressively intertidal zone. Mangroves have capacity to trap sediment by dampening currents and attenuating waves thus sediment accumulation rates are highest within the fringing mangroves. Consequently, these intertidal flats have been colonized by mangroves which leads to seaward expansion of mangroves. A quick study was done in Merlimau, Malacca mangrove forest reserve area to quantify mangrove habitat expansion area cover. This study assesses the current extent and historical expansion of the mangroves by analyzing google earth engine images. An analysis of a time series of google earth images, covering the period from 1984 to 2017, has revealed major changes in the distribution of mangroves in the Merlimau. Mangrove-habitat expansion has occurred rapidly over the last 30 years in the 600 ha mangrove area. Mangrove forest now extends to 0.5 km seaward of the 1984 shoreline. Mangrove habitat expansion started from year 1992. Mangrove expansion rate was slower in year 1992 and have increased since year 2009. This may be due to land use land cover change have increased from year 2009. Mangrove habitat expansion has increased twice (300 ha) in last 30 years. At the landward side main species were Rhizophora muronata, Rhizophora apiculata, Bruguiera gymnorrhiza and Bruguiera parviflora, while Bruguiera parviflora and Avicennia marina were dominant species at the seaward side. This might be because of the sedimentation rates, nutrition and sunlight play an important role in the survival of natural regeneration of mangrove species. The

fate of Marlimau mangrove forest will depend on vertical accretion of sediment at a rate equal to or exceeding sea level rise.

P-E1-08-S Distribution of amino acid in DOM and POM in the south china sea.

Silin Ni, Li xiaolin,associate professor in Ocean Carbon Group,MEL.
Presenter Email: silin.ni@qq.com

Labile dissolved organic carbon (LDOC) have a significant influence in the carbon cycle in the ocean. However, as a complex mixture of various matter, DOC can not be directly distinguished by different biological activity. Comparing with other parameters, amino acid is better molecular indicator. The total dissolved concentration,carbon yield and the proportion of special components of amino acid can be more clear and comprehensive indication of DOC biological activity. The biggest problem of researches on amino acid is contamination during each process in the experiment. Therefore, our research spend so much time to adjust each process in the experiment, test method blank with different experimental conditions and finally get good precision,recoveries and reproducibility to guarantee data quality.Samples for particulate hydrolyzed amino acid (PHAA) and total dissolved amino acids (TDAA) were collected during the cruise in June 2018 to the northern South China Sea (NSCS) and West Philippine Sea (WPS) to examine the biological activity of DOC and its transformation when transported from WPS into NSCS through Luzon Strait. The carbon yields to DOC were calculated and patterns of amino acids compositions were quantitatively determined using principle components analysis (PCA). We show that concentrations of TDAA and their yields to DOC decreased from the NSCS continental slope towards the basin area and decreased with depth in the water columns, suggesting a declined trend in biological activity of DOC. The spatial distributions of PHAA presented a similar pattern of TDAA. It is interesting to note that distributions of TDAA and PHAA were impacted by eddies, with addition/removal of nutrients enhanced/inhibited the transformation of DOC.

P-E1-09-S Microplastics and polycyclic aromatic hydrocarbons (PAHs) in Xiamen coastal areas: implications for anthropogenic impacts

Guowen Tang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, China
Mengyang Liu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, China
Kai Chen, Coastal and Ocean Management Institute, Xiamen University, Xiamen 361102, China
Minggang Cai, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, China
Presenter Email: gwtang@stu.xmu.edu.cn

Microplastics (MPs), with a diameter of less than 5 mm, are of growing concern because of their enormous amounts and widespread existence in the rivers, beaches and oceans globally. MPs, a likely source of toxic chemicals added as ingredients during plastic manufacturing, could be ingested easily and thus potentially act as multiple stressors to the organisms. MPs also prone to adsorb various hydrophobic organic contaminants (HOCs), such as polycyclic aromatic hydrocarbons (PAHs), which can be introduced to the marine environment by land runoff or air transport and have toxic, mutagenic and carcinogenic potentials. Therefore, it is of great significance to study MPs associated with PAHs, and to further investigate the role of MPs as vectors for HOCs transfer in the environments.

Xiamen's surrounding sea and Jiulong River Estuary are bound by the southeast of Mainland China and the Taiwan Strait. As one of the first "special economic zones", Xiamen has experienced an extensive urban expansion at the cost of coastal environmental degradation. Rapid population growth and intense human activities have led to high huge pollutant emission. To assess the discharge of MPs and PAHs from the coast to the ocean, and explore the impact of urbanization and industrialization on marine environments, surface water and sediments sampling was conducted in the Xiamen Bay and Jiulong River Estuary, China in March 2017. MPs from water were collected by a manta net for tows, and their chemical compositions were identified by Fourier transform infrared spectroscopy (FTIR) and FTIR microscope system.

Our results showed that surface water near the sewage contained highest abundance of microplastics, suggesting a direct domestic input of MPs such as cosmetic beads and clothing fibers that pass through waste water treatment to the marine environment. The shapes of MPs were dominated by fragments, lines, fibers and pellets, which were mainly identified as polyethylene and polypropylene. Different physicochemical characteristics of MPs from sediments and surface waters were likely to be related to the surrounding industries. The spatial distribution pattern of PAHs was generally similar to that of MPs, indicating the influence of anthropogenic discharge. Attention should be paid to high levels and their risks of MPs existing in Xiamen coast, and their further control.

P-E1-10 Trophic role of hermit crabs in the coastal mudflats: implications for fish production.

Hong Wooi Teoh, Xiamen University Malaysia
Ving Ching Chong, University of Malaya
Presenter Email: hongwooi.teoh@xmu.edu.my

Coastal mudflats fueled by a variety of primary producers such as the mangroves, seagrass, benthic microalgae and phytoplankton, support a great diversity of fauna. High Tidal current brings in phytoplankton from nearshore area while the regular exposure of the mudflat during low tide allow benthic microalgae to proliferate. The soft sediments of the mudflat trap high amount of organic matter that originated from these primary producers, forming an important biota that include a variety of inhabiting primary consumers. The diversity of marine fauna on the Matang coastal mudflats may suggest trophic energy inputs from autochthnous (e.g. benthic microalgae and phytoplankton) and allochthnous (mangrove detritus) sources fueling their abundance on seemingly wastelands that are devoid of vegetation. Among the least conspicuous fauna are the small diogenid hermit crabs that often occur in large numbers on the mudflats. We hypothesize that these hermit crabs serve as intermediary consumer-prey organisms. The study objective is to trace the flow of trophic energy from the potential basal sources to fish predators via the diogenid hermit crabs. Two methods were used; stomach content and stable C and N isotope analyses of both fish predators and the hermit crabs. Results from stomach content analysis reveal that the abundant and commercially important sciaenid fish (particularly Johnius belangerii) fed extensively on the hermit crabs offshore. The stomach contents of hermit crabs comprised of brown amorphous phyto-matter, diatoms and faunal remnants which suggests deposit feeding. Stable isotope analysis provides evidence of the transfer of energy from the sediment-trapped carbon sources. The benthic microalgae are the main contributor of the carbon assimilated by the hermit crabs, followed by phytoplankton and mangrove. The predation on hermit crabs in turn transfers trophic energy to the higher consumers, mainly fish predators. The present finding adds diogenid hermit crabs to the few, but growing versatile marine herbivorous organisms capable assimilating mangrove carbon. However, the dependency of hermit crabs on the mangrove-derived carbon decreased from estuary to offshore, reflecting the substantial carbon contribution of mangrove-fringed mudflat to the coastal food web and the role of the inhabiting primary consumers in mediating the transfer of energy for fish production.

P-E1-11 Spatial and temporal changes in chlorophyll-a concentrations in the Bohai Sea in the past two decades

Tian Hongzhen, Tianjin Polytechnic University
Liu Qinping, Tianjin Polytechnic University
Joaquim I. Goes, Columbia University
Helga do Rosario Gomes, Columbia University
Yang Mengmeng, Nagoya University
Presenter Email: broadsky2008@gmail.com

Chlorophyll-a (chl-a) concentration is an important index of phytoplankton biomass which plays a fundamental role in marine ecosystems. Chl-a derived from both the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) from 1997 to 2010 and the MODerate resolution Imaging Spectroradiometer (MODIS) sensor on satellite Aqua from 2002 to 2018 were combined into one time series to investigate the spatial and temporal variability of chl-a concentrations in the Bohai Sea. Sea surface temperature (SST), wind speed and

precipitation were also analyzed. Annual chl-a concentrations increased 14.1% in the study area over the past two decades. Chl-a concentrations in every season and in all months except for November have increased. Chl-a concentrations increased mainly in the middle part of the sea from the coastal area near the estuary of Luan River to the Bohai Strait. Increases in precipitation over the land around the Bohai Sea through summer to winter, and wind speed in summer and autumn, as well as decreases in SST in autumn, all contributed to the rises of chl-a concentrations.

P-E1-12-S Accumulation, tolerance, subcellular distribution and chemical fractionation of Cadmium in *Sesuvium portulacastrum*

Mohammad Mazbah Uddin, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems,College of the Environment and Ecology, Xiamen University, Xiamen 361005, China
Zhenfang Chen, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems,College of the Environment and Ecology, Xiamen University, Xiamen 361005, China
Lingfeng. Huang, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems,College of the Environment and Ecology, Xiamen University, Xiamen 361005, China
Presenter Email: mazbah_uddin88@outlook.com

The Cd is a non - essential metal and highly toxic to organisms, even in very low concentration. In the coastal marine ecosystems, the removal of heavy metal from the contaminated water, phytoremediation obtained a great concern in the recent years. *Sesuvium portulacastrum* is a halophyte and considered as a potential species of phytoremediation of heavy metal in the coastal regions. Cadmium (Cd) accumulation, subcellular distribution and chemical forms in the roots, leaves and stem of *Sesuvium portulacastrum* were studied hydroponically under exposure to 50 μM - 600 μM Cd stress for 28 days to investigate the potential accumulation capability and tolerance mechanisms. The Plants demonstrated good growth condition until Cd stress of 200 μM, then their growth significantly ($P< 0.05$) reduced with increasing Cd concentrations. Cd accumulation in *Sesuvium portulacastrum* root tissues showed that the bioconcentration factor was >10 and the highest bioaccumulation factor was in the 50 μM and 100 μM of Cd stress, suggesting a strong ability to absorb and accumulate of Cd. In addition, the subcellular distribution of Cd fractionation in aerial parts showed the following order of distribution soluble fraction>cell wall>organelle>cell membrane and soluble fraction was predominant in roots. Moreover, Cd speciation in leaves and stems mainly composed of NaCl and deionized water extracted form, suggesting a strong binding ability with pectin and protein as well as organic acid. We can presume that the cell wall fixation and vacuole compartmentation is the main fundamental mechanism to resilience to Cd toxicity and

considered as a potential phytoremediator because of solid bioaccumulation.

P-E1-13 Effects of Asian Dust Input on Eukaryotic Phytoplankton Community Structure in the open areas in Northwestern Pacific Ocean

Weimin Wang, 1. Center for Ocean and Climate Research, First Institute of Oceanography, State Oceanic Administration, Qingdao, China; 2. Laboratory for Regional Oceanography and Numerical Modeling, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China; 3. The Key Laboratory of Marine Environmental and Ecology, Ministry of Education, Ocean University of China, Qingdao, China
Huan Zhang, 1. The Key Laboratory of Marine Environmental and Ecology, Ministry of Education, Ocean University of China, Qingdao, China; 2. Department of Marine Sciences, University of Connecticut, Groton, Connecticut, USA
Hongju Chen, 1. The Key Laboratory of Marine Environmental and Ecology, Ministry of Education, Ocean University of China, Qingdao, China; 2. College of Environmental Science and Engineering, Ocean University of China, Qingdao, China
Yunyun Zhuang, 1. The Key Laboratory of Marine Environmental and Ecology, Ministry of Education, Ocean University of China, Qingdao, China; 2. College of Environmental Science and Engineering, Ocean University of China, Qingdao, China
Yousong Huang, 1. The Key Laboratory of Marine Environmental and Ecology, Ministry of Education, Ocean University of China, Qingdao, China; 2. College of Environmental Science and Engineering, Ocean University of China, Qingdao, China
Guangxing Liu, 1. The Key Laboratory of Marine Environmental and Ecology, Ministry of Education, Ocean University of China, Qingdao, China; 2. College of Environmental Science and Engineering, Ocean University of China, Qingdao, China
Presenter Email: wangweimin@fio.org.cn

As the major source of atmospheric deposition in the Northwestern Pacific Ocean (NWPO), Asian dust modulated the community structure and nutrient utilization of phytoplankton. In order to study the effects of Asian dust input on the eukaryotic phytoplankton community structure, we conducted deck-board incubation experiments were at 2 stations (K3, 26°11'15.48"N, 136°43'38.46"E; B1, 37°56'12.90"N, 146°59'55.26"E) in the open areas of NWPO in spring 2015. Different amount of Asian dust, 0.2 mg L^{-1} (Dust-1) and 2 mg L^{-1} (Dust-2) were added into the incubation system.Daily changes in chlorophyll-*a*, nutrients and eukaryotic phytoplankton abundance were monitored. On the 0^{th}, 2^{nd}, 4^{th} and 7^{th} day, water samples were collected for metabarcoding sequencing.

The results showed that the NO_3^--N concentration increased significantly while concentrations of NO_2^--N, PO_4^{3-}-P and SiO_3^{2-}-Si did not changed due to the dust input. During the incubation, concentration of NO_3^--N and SiO_3^{2-}-Si decreased dramatically in dust-2. Simultaneously, no significant difference was found in concentration variation of

NO_2^--N and PO_4^{3-}-P among control and dust groups. Concentration of chlorophyll-*a* of nano- and micro- eukaryotic phytoplankton increased significantly in dust-2 at 2 stations. However, there was no significant difference of the chlorophyll-*a* concentration of pico-eukaryotic phytoplankton among control and dust groups. By the end of the cultivation, the eukaryotic phytoplankton abundance in dust-2 was 3.0 and 7.5 folds higher than that in control at K3 and B1. The species number in dust groups decreased at K3 because the diatom bloom interfered the growth of other groups. However, the species number in dust groups increased at B1 because when the dust was added, the N-limited condition was remitted and the hypnospore of diatoms germinated. Diatom growth was promoted in dust-2 at 2 stations and the promoting extent was much more dramatic at B1. The growth of dinoflagellates was interfered at K3 and not changed significantly at B1 in dust groups. Moreover, growth of larger sized groups such as *Pseudo-nitzschia*, *Chaetoceros* and *Thalassionema* were promoted significantly, while growth of smaller sized groups such as *Thalassiosira*, *Prorocentrum*, *Heterocapsa*, and *Scrippsiella* were interfered or not changed in dust groups at 2 stations.
The results indicated that Asian dust addition could increase the marine productivity and alter the eukaryotic phytoplankton community structure. This research provides important reference for further investigating the effects of dust input on phytoplankton community structure.

P-E1-14-S The Detection and Distribution of Pharmaceutical and Personal Care Products (PPCPs) in Estuarine Areas

Lin Wen, Lin Wen
Presenter Email: 18359268027@163.com

This article is based on the United States'EPA method improved. In order to set up a method that how to detect the trace PPCPs in natural water samples. BP-3, BP-1, Caffeine, Carbamazepine, libenclamide, emfibrozil, lydrochlorothiazide, Ibuprofen, Naproxen, Triclocarban, Triclosan which are of pharmaceuticals and personal care products are selected as the target objects, and the conditions of solid-phase extraction and detection that used by UPLC-MS-MS instrument are optimized. At last, estimate the concentration of the 11 PPCPs that says above in the areas of Jiulong river estuary by means of detecting collecting water samples and observe the concentration of 11 targets before and after rainstorm to assess the impact of extreme weather condition on 11 targets. In the study site the experimental results suggest that different from the Hydrochlorothiazide, Carbamazepine, Ibuprofen and Triclocarban which remove from estuary, Glibenclamide and Benzophenone-1 have stable input, and only Caffeine and Gemfibrozil show conservative behavior. The experimental results also indicate that unlike caffeine whose concentration increases with the increase of rainfall, Naproxen and Carbamazepine decrease with the increase of precipitation, the concentration of other targets first rise and

then drop with the increase of rainfall.

P-E1-15-S Occurrence and Removal Efficiency of Selected Psychiatric Pharmaceuticals in Wastewater Treatment Plants (WWTPs) of Hong Kong: A Preliminary Study

Mr. Rongben WU, State Key Laboratory in Marine Pollution, City University of Hong Kong
Dr. Yuefei RUAN, State Key Laboratory in Marine Pollution, City University of Hong Kong
Prof. Paul K. S. LAM, State Key Laboratory in Marine Pollution, City University of Hong Kong
Presenter Email: rongbenwu2-c@my.cityu.edu.hk

Pharmaceuticals, regarded as emerging contaminants, have been ubiquitously detected in various environmental compartments. Wastewater treatment plants (WWTPs) are considered to be the one of the main sources of pharmaceutical residues in the environment. They were introduced into the receiving waters because of incomplete removal in the WWTPs. Wastewaters are discharged on a continuous basis, making pharmaceuticals environmentally pseudo-persistent? Among them, special attention has been paid to psychiatric pharmaceuticals due to their high prescription rates, widespread environmental occurrence and neuro-endocrinal toxicity on non-target organisms, as well as their high potential for bioaccumulation. In the present study, a SPE-HPLC-MS/MS method has been developed to investigate the occurrence of 9 selected psychiatric pharmaceuticals in WWTPs of Hong Kong, including 2 antipsychotics, 1 anxiolytics and 6 antidepressants. Four WWTPs with different discharging points, which serve over half of the total Hong Kong population, have been included for this investigation. Different treatment technologies are employed in the selected WWTPs, including chemically-enhanced primary treatment and secondary (biological) treatment with traditional activated sludge. In this preliminary study, antidepressants and anxiolytics were detected at parts-per-trillion level. Our results indicate that most of the target psychiatric pharmaceuticals could not be completely removed after wastewater treatment.

P-E1-16-S The Expression of Toll-like Receptors in Dolphin Skin Fibroblast and Comparison of dolphin and laboratory animal TLR4

Ziyang XIAO, Marine Biology Institute, College of Science Shantou University, Shantou, Guangdong, PR China
Imran Rashid Rajput, Marine Biology Institute, College of Science Shantou University, Shantou, Guangdong, PR China Faculty of Veterinary and Animal Sciences, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Balochistan, Pakistan
Yajing SUN, Marine Biology Institute, College of Science Shantou University, Shantou, Guangdong, PR China
Wenhua LIU, Marine Biology Institute, College of Science Shantou University, Shantou,

Guangdong, PR China
Presenter Email: 16zyxiao1@stu.edu.cn

During the shift from terrestrial to aquatic environment and the diversification into various aquatic environment, dolphins were probably confronted with numerous challenges caused by stressors from the changing environments. Furthermore, dolphins are the main sentinel species because their biological characteristic. Dolphins can expose current or potential negative impacts on individual- and population-level animal health and better characterization and management of impacts that ultimately affect animal and human health associated with the oceans. Therefore, dolphins play the crucial role in marine environment and ecosystem.

The increasing environmental pressure urges cetaceans to own the dynamic immune system that could help them adapted the complex aquatic environment. The immune system plays a crucial role in the survival and reproduction of dolphins in a severe environment. Toll-like receptors (TLRs) as the typical pattern-recognition receptors (PRR) play a crucial role in both innate immune system and adapted immune system.

Our experiment subject is Pantropical Spotted Dolphin fibroblast (PSDF) cell line. Because studies of TLRs in dolphin fibroblast are not clear, we have to confirm the expression of TLRs family in PSDF cell line. After aligning TLR4 sequences among dolphin and other terrestrial mammals, we found dolphin TLR4 is most dissimilar to mouse TLR4 which is the typical laboratory animal. We predicted that dolphins TLR4 caused immune response may vary from laboratory animals.

Interleckin-6(IL-6), interleckin-8(IL-8), interleukin-1β (IL-1β), tumor necrosis factor alpha (TNF-α) as well as TLR4 mRNA expression were measured at four time (0, 6, 12 and 24 hours) after stimulation of E.coli LPS (1000ng/ml) in PSDF and mouse fibroblast (L929). IL-6 is distinctly up-regulate in L929 after treated 24 hours. But in PSDF the top expression of IL-6 is 6 hours group. The expression of IL-8 in L929 is lower than in PSDF. All cytokine results show dolphin can release pro-inflammatory factors quicker than mouse. Autodock vina shows the dock locations of LPS and TLR4 and docking sites are different between dolphin and mouse which might explain probably reason of the immune response differences.

P-E1-17 Effects of black carbon on phosphorus migration and forms distribution in sediment

He Wang, Ocean University of China
Yan Wang, Ocean University of China
Jing Li, Ocean University of China
Xiaoyan Cao, Ocean University of China
Presenter Email: caoxy@ouc.edu.cn

Phosphorus is well known as an important nutrient element associated with eutrophication in the marine ecosystem, and its sorption on sediments plays a key role in the immobilization of phosphorus in the bio-geochemical cycle. Black carbon (BC), generated from incomplete combustion of biomass and fossil fuels, becomes one part of the organic matter in sediments due to sinking into the sea via river transportation and atmospheric deposition. Although the content is low, its high micro-porosity and high specific surface make it play a significant role in sediment-water interface processes. Therefore, we prepared a black carbon from peach wood charcoal (PC) and studied its effects on phosphorus migration and forms distribution in sediment. The BC was derived from PC treated in HCl (2 mol L-1) and HCl-HF (1 mol L-1, 1 mol L-1), respectively. The sediment sample was collected from the East China Sea.

Some main conclusions are as follows, Boehm titration results showed that carboxy group of the BC was 2.149 mmol g-1, the acidic group was 2.412 mmol g-1, while the basic ones could be neglected. The BET surface area was 232.84 m2 g-1.

The sorption/desorption behaviors of phosphorus to BC were studied through batch methods. The isotherm agreed well with both Freundlich and Langmuir equation. As for the latter, Qm was 0.3427 mg g-1and Qm×KL was 0.7651 (mg g-1)(L mg-1), respectively. The hysteresis coefficient HI value is 0.667, showed an obvious sorption-desorption hysteresis.

The addition of black carbon to the sediment increased its qH-qOH, Hs, CEC and decreased pHPZNPC. The influence of BC on phosphorus sorption is significant, as the sorption capacity to BC-sediment increased from 0.0595 to 0.0891mg g-1 with the content of BC increasing from 0 to 7%. The sorption kinetic curves could be described by a two-compartment first order equation. The addition of BC reduced the rapid step fraction Frap and increased the slow step fraction Fslow, showing a significantly sorption-desorption hysteresis. The hysteresis obviously increased with an increase of black carbon contents. The phosphorus sorbed on sediment surface was mainly consisted of Ex-P and Fe-P. After adding BC, the amounts of Ex-P and Fe-P obviously increased. Thus, the Fe and Al in the BC are favorable to the immobilization of phosphorus.

P-E1-18-S Two-generation Toxicological Study of Triphenyl Phosphate (TPhP)in Marine Medaka (*Oryzias melastigma*)

Daiyin Zhong, Xiamen university
Haizheng Hong, Xiamen university
Presenter Email: zhongdy@stu.xmu.edu.cn

Triphenyl phosphate (TPhP), a commonly used additive organic phosphate flame retardant in a wide range of materials, has become a ubiquitous contaminant in the environmental media and biota, including the marine environment and organisms. Since TPhP has been detected in marine fish at a relatively high concentration, its potential adverse effect on marine organisms is of great concern. In order to understand the chronic toxicity of TPhP

to the development of marine medaka, two-generations exposure experiment, as long as 10 months, was conducted in the laboratory. Results showed that TPhP exposure caused severe lethality to marine medaka, especially during the embryo phase, even at the lowest exposure concentration (i.e. 5 ug L-1). In all the exposure groups (5, 10, 50 ug/L), TPhP significantly decreased the embryo heart beats. The malformation rates at the 1st fry and adult fish were also induced by TPhP at a dose dependent manner, with the formation of bent pectoral fin and pericardial and yolk sac edema, and spinal curvature as the most frequently observed malformation in the adult fish. In the adults it was found that TPhP exposure affected the sex ratio obviously and the ratio of Female/Male significantly increased with the increasing doses. Consistently, gonadosomatic index (GSI) in the male adult fish decreased, suggesting the estrogenic effects of TPhP. In addition, hepatosomatic index (HSI) showed negative correlation with the concentrations of TPhP. These results suggested that TPhP exposure markedly affected skeletal/cartilaginous, cardiovascular and liver development, and caused estrogenic effects in marine medaka. The present study provides a set of systematic toxicity data of TPhP on marine medaka and could be of great help for the assessment of the potential risk of TPhP to the marine ecosystems.

P-E2-01-S Marine Resources and Ecosystem Services: Evaluative Approaches for the City-Port Sustainable Development

Stefania Regalbuto, Department of Architecture (DiARC), University of Naples Federico II
Maria Cerreta, Department of Architecture (DiARC), University of Naples Federico II
Eleonora Giovene di Girasole, Institute for Research on Innovation and Services for Development (IRISS), National Research Council of Italy (CNR)
Giuliano Poli, Department of Architecture (DiARC), University of Naples Federico II
Presenter Email: regalbutostefania@gmail.com

Considering the sea resources supply and regulate a series of goods and services (e. g. rainwater, drinking water, climate, food, air and water oxygenation), the DGs, Agenda 2030 goal 14 aims to conserve and sustainably use the oceans, seas and marine resources as a key feature of a sustainable future. In 2016, the first World Ocean Assessment stated that most of the oceans is now seriously degraded, with change in structure, functions and benefits from marine systems. Meanwhile, the earth surface warming due to anthropic impacts and climate change is one of the driving causes of loss of oxygen from oceans and eutrophisation. During the past 50 years, the open oceans have been losing approximately 1% of oxygen, while the extension of oxygen minimum zones (OMZs) has been quadrupling, covering an area approximately the size of the Europe. The IPCC 5th Assessment Report forecasts a gradual decrease of oxygen concentration, by 3-6% during the 21th century, which is detrimental to several marine organisms and terrestrial ecosystems too. Conversely, well-oxygenated oceans and coastal waters provide regulating and supporting services. The Ecosystem Services (ES) are good and services

but also conditions and processes through which natural ecosystems sustain and fulfill human life. The deoxygenation damages goods and services delivered by marine ecosystems to humans. In the context of integrated and transdisciplinary ES framework, which combines ecological, economic and social dimensions, four forms of assets (built, human, social and natural) contribute to human well-being through synergies and trade-offs. As supported by the United Nations Decade for Ocean Science for Sustainable Development, 2021-2030 ? the study of ocean responses to pressures and management actions, through different methods and tools, is a key element for sustainable development. The EU DIRECTIVE 2014/89/UE established a framework for developing of maritime space and integrated management of coastal areas, through which maritime spatial planning is an useful tool for the sustainable use of sea and coastal resources. In particular, the guidelines aim at developing different maritime activities, managing conflicts among different stakeholders, and finally ensuring a good state of ecosystems. Since a complete and structured knowledge is the first step to conceive strategies for a sustainable management of the marine areas, increasing investments in this sector is crucial. In Italy, the 1.3% of Research and Development (R&D) funds have been allocated for the oceanographic research, nevertheless a gap of knowledge about the complex phenomena affecting the marine and coastal areas remains. The contribution aims at investigating the relevance of the aforementioned issues within the European policy for coastal zones management, sustainable planning and complex decision-making, by adopting a multi-dimensional assessment approach. The research field, which has been applying the evaluation as an approach for protection of natural capital and ecosystem services since the end of the 20th century, aids decision makers identifying management and knowledge models towards a sustainable use of ES.

P-E2-02 Port cities as complex value-added systems: decision-making processes for a sustainable regenerative model

Maria Cerreta, University of Naples Federico II
Pasquale De Toro, University of Naples Federico II
Maria Cerreta,
Pasquale De Toro,
Presenter Email: cerreta@unina.it; detoro@unina.it

In general terms, cities along the coast form cosmopolitan sites, open to many cultures, spaces of creativity and innovation for the economy, culture and society. However, they are also places of significant conflicts between economy and ecology, between economy and culture, and between ecology and society. Consumption of natural resources and production of pollutants, together with the intensification of uses aimed at meeting the economic needs of coastal areas, contribute to compromise the complex ecological balance and to alter or destroy specific local characters. In many cases, the processes of environmental degradation and pollution are accompanied by the production of economic wealth, which entail not only ecological costs but also social and cultural costs, along with a progressive reduction in the well-being and quality of life. These cities have extraordinary value added that can play a decisive role in a strategic vision of urban development. In recent years, the concept of ater renaissance has been growing in the urban sphere to define that complex process of redevelopment and revitalization of waterfront areas which has characterized many renewal, recovery and retraining operations and valorisation in many cities around the world 鈥?rediscovering the value of water in the city. The port and coastal areas, therefore, represent sites where multiple contradictions often arise but are also the most suitable places to reduce conflicts and turn them into synergies through innovative approaches to governance, planning and territorial management. Port and coastal cities can become key to the implementation of a new model of sustainable development based on multiple value-added systems, focused on a synergistic and circular approach, capable of breaking the current linear organization of many traditional economic systems and allowing the local economy to strengthen through local resources integration. In this perspective, the study of the Campania Coastal Region and of the Metropolitan City of Naples in Italy analyzes the opportunities for transformation and enhancement that the sea resource can offer to the territory, trying to identify the components that could interact to improve territorial productivity and make the urban and territorial regenerative city model operational, reducing the environmental and social conflicts.

P-E2-03 Multi-criteria and multi-group assessment for the conflict resolution between maritime economic growth and coastal protection in Sicily (Italy)

Pasquale De Toro, University of Naples "Federico II", Italy
Maria Cerreta, University of Naples "Federico II", Italy
Presenter Email: detoro@unina.it

In recent years in some ports of the Mediterranean Sea there was registered a strong growth in freight traffic. The transhipment market in the Central Mediterranean Sea is particularly significant and is managed by some Italian ports and Marsaxlokk (Malta); this is located at the center of the routes coming from the Suez Canal in Egypt and the Western Mediterranean Sea, where transhipment operations are mainly operated in the ports of Valencia and Algeciras (Spain) and Tangiers (Morocco). The strongest growth for this market has been in the ports of: - Valencia (Spain), where it has increased from 207,100 TEUs in 2000 to 2,508,000 TEUs in 2015; - Algeciras (Spain), where it has passed from 1,890,700 TEUs in 2000 to 4,144,000 TEUs in 2015; - Tangiers (Morocco), where it has passed from no traffic in 2000 to 2,849,300 TEU of 2015; - Malta, from 966,400 TEUs in 2000 to 2,943,800 TEUs in 2015. Demand has been stimulated by a very rapid growth in local goods traffic (import/export flows), and the shift to larger ship sizes has been an important catalyst also for the development access terminals (which combine import/export and transhipment). The recent orders of ships from the twenty major shipping companies suggest a further average increase in vessel size in the short term, with possible repercussions on the reorganization of ports and the port-city interface. In order to compete with Malta, an expansion of the port of Gela (in Sicily) has been proposed, with the strengthening of the existing commercial port, which could be transformed into a container terminal through the construction of an artificial island with transhipment function. However, urban and environmental issues have led to the need to carry out financial, multi-criteria and multi-group assessments to address the conflict between economic development and environmental protection. In particular, three different intervention scenarios were developed, i.e. short, medium and long-term. The assessment of the impacts and the obtained results have highlighted the primary importance of the defence of the coast and the sea, opting for a possible extension of the current tourist port with a redevelopment of the relationship with the city, without the need for the construction of an artificial island.

P-E2-04 Transformation Towards Resilient Societies Through Information and Communication Technologies for Planning coastal Cities.

Dr.Paruthummootil Jacob Philip, Institute For Sustainable Development and Research,ISDR,India
Prof.Mario Rosario Losasso, Department of Architecture (DiARC),The University of Naples Federico II|UNINA Forno Vecchio, no. 36, I-80134, Napoli, Italy
Dr.Kalpana Chaudhari, Institute For Sustainable Development and Research,ISDR,India
Presenter Email: pjphilipisdr@gmail.com,mariorosario.losasso@unina.it

As per the United Nations estimates, The world population reached 7.3 billion as of mid-201, implying that the world has added approximately one billion people in the span of the last twelve years. Sixty per cent of the global population lives in Asia (4.4 billion), 16 per cent in Africa (1.2 billion), 10 per cent in Europe (738 million), 9 per cent in Latin America and the Caribbean (634 million), and the remaining 5 per cent in Northern America (358 million) and Oceania (39 million). The total population on earth is predicted to increase by more than one billion people within the next 15 years, reaching 8.5 billion in 2030, and to increase further to 9.7 billion in 2050 and 11.2 billion by 2100. Looking at the ever increasing urbanization, In 2016, an estimated 54.5 per cent of the world populations inhabited in urban region. By 2030, urban areas are projected to shelter 60 per cent of people worldwide and one in every three people will live in cities with at least half a million inhabitants. This presentation deals with issue involved in conclave of issues related to transformation towards resilient societies for sustaining urban development through sustainable use of information and communication technology, media literacy in planning smart cities along coastal region . The presentation focuses on policy formulation for resources planning, risk mitigation and vulnerability , social vulnerability and resilience for gender based planning for creating smart coastal cities.The presentation aims to provide the platform to enable the gender based Knowledge-Action Network communities to work together to create new perspectives on safer , smart and resilient coastal cities through North south Participation that are relevant to Sustainable development Goals including Goal-3. Ensure healthy lives and promote well-being for all at all ages, Goal 5- Achieve gender equality and empower all women and girls, Goal 11-Make cities and human settlements inclusive, safe, resilient and sustainable,Goal 14-life below Water, Goal 16- Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels to aid in coastal urban planning for safer, smart and sustainable cities and communities integrating the Knowledge Action Network for Urbanization.

P-E2-05 The synergistic relationship between strategies for waterfront regeneration and changing in sea level: the case of the city of Pozzuoli (Italy)

Francesca Nocca, Department of Architecture (DiArc), University of Naples "Federico II", Italy
Angela Rizzo, Department of Science and Technology (DiST), University of Naples "Parthenope", Italy
Presenter Email: francesca.nocca@unina.it

Coastal areas are facing three important challenges related to economic, social and environmental aspects and referred to three great changes: demographic changes (i.e. population growth), structural changes (i.e. globalization) and environmental changes (i.e. climate change). All these challenges are interdependent and thus they need systemic solutions. Worldwide, almost half a billion people live in coastal cities and thus the urbanization is here concentrated, resulting the place where the above mentioned changes are more evident and where there is the highest level of vulnerability to changing in marine environment. Coastal areas represent therefore a good observation point to understand the relationship between the urbanization strategies and environmental changes. In accordance with 2030 Agenda for Sustainable Development of United Nations, which aims to take transformation measures to shift the world towards a sustainable and resilient future, this study aims to underline the important role of the integrated planning/management of coastal areas in the sustainable development (particular reference to the goals 11 and 14 of SDGs). The waterfront cannot be considered a simple demarcation between the city and the sea; it represents a complex system characterized by a particular landscape in which socio-cultural, economic and ecological systems are interconnected and where there is a strong relationship between human activities and marine environment. The regeneration and management of coastal regions cannot leave future sea changes out of consideration. Therefore, future scenarios of sea level change

need to be assessed to plan sustainable development of coastal cities. The case study is the city of Pozzuoli (Italy) and in particular the area occupied by the abandoned plants of ex ofer This area is under regulations related to the protection of natural and archaeological resources and is included in the Masterplan of Pozzuoli Coastline. The present planning instruments and some research studies identify different scenarios and a set of functions for the development of this area. In this study, future changes in sea volume caused by the ongoing climate changes are taken into account to assess potential flooding scenarios. The assessment of the zones potentially exposed to sea flooding is based on the combination of future sea level scenarios (IPCC, 2014) with the local topographic information provided by the Italian Environmental Ministry. This study provides a mapping of Pozzuoli coastal area to evaluate which functions can be considered for the sustainable development of the city, integrating environmental aspects with economic and social growth.

P-GS-01-S Diel Vertical Distribution of Plankton in Yongle Blue Hole, Xisha Islands, South China Sea

Chang Chen, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Ruping Ge, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Hongju Chen, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Guanxing Liu, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Yunyun Zhuang, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Dejiang Fan, College of Marine Geosciences, Ocean University of China, Qingdao 266100
Peng Yao, College of Chemistry and Chemical Engineering, Ocean University of China, Qingdao 266100
Naishuang Bi, College of Marine Geosciences, Ocean University of China, Qingdao 266100
Zuosheng Yang, College of Marine Geosciences, Ocean University of China, Qingdao 266100
Liang Fu, Sansha Trackline Institute of Coral Reef Environment Protection, Sansha, 573199
Presenter Email: changchen92@foxmail.com

Yongle Blue Hole located in Xisha Islands, South China Sea, is the deepest blue hole among all known ones in the world. Its special hydrological, geological and chemical characteristics, particularly the existence of anoxic and aphotic layer shaped the ecosystem. As the first attempt, an integrated survey of Yongle Blue Hole and its adjacent waters including lagoon and outer reef slope was conducted in March, 2017, in which diel

vertical distribution of both zooplankton and phytoplankton was examined. The deep chlorophyll maxima shifted from 40m at daytime to 20m at night, and Chl-a was undetectable under 90m. For microphytoplankton, 55 taxa from 5 phyla were identified, among which Bacillariophyta had the highest species richness (34 taxa) while Dinophyta was the most abundant (~54.9%). For picophytplankton, *Synechococcus* appeared mostly above 20m, Prochlorococcus was dominant beneath 40m (81.5-87.2%). The vertical distribution and diurnal pattern of phytoplankton was in concert with that of Chl-a. For zooplankton, a total of 42 taxa and 14 planktonic larvae types were identified in Yongle Blue Hole, which shared 16 common taxa with the lagoon with higher biodiversity in terms of both evenness and richness, while species composition of the outer reef slope differed significantly from that of the other two locations, thus was considered a different community. Cyclopoid copepod Oithona attenuate was the dominant species at both daytime (43.4%) and nighttime (71.0%) in Yongle blue hole, followed with O. rigida (21.4%, daytime) and Scolecithricella longispinosa (12.0%, nighttime). The maximum abundance of zooplankton was observed at the depth of 60-90m in daytime, while at 20-40m in nighttime. The community at the depth of 0-20m in nighttime shared 60% similarity with that of 20-40m in daytime, which was also found between 20-60m in nighttime and 40-90m in daytime (68% similarity). The vertical distribution indicated the diel vertical migration of zooplankton, particularly copepods above the oxycline at 80-90m. However, the relatively high abundance of S. longispinosa (38.3 inds/m3) and O. attenuata (51.0 inds/m3) was also detected at the depth of 90-150m. How the plankton adapted to the special and isolated environment in the Yongle Blue Hole, particularly in the anoxic and aphotic zone needs further study by interdisciplinary approaches.

P-GS-02-S Photosynthetic responses of the red alga *Pyropia yezoensis* to UV and CO2-induced seawater acidification

Di Zhang, Xiamen University, Skate Key Laboratory of Marine Environmental Science, Fujian Xiamen, 361102
Kunshan Gao, Xiamen University, Skate Key Laboratory of Marine Environmental Science, Fujian Xiamen, 361102
Presenter Email: zhangdi910817@163.com

Porphyra yezoensis, an intertidal seaweed, experience a series of environmental changes, such as increasing CO2 concentration and solar UVR in the context of climate change. In the present study, the porphyra yezoensis collected form Gaogong island (34°N, 119°E) were used to investigate the response of photosynthetic electron transport performances to CO2-induced seawater acidification and UVR. Among all treatments, the significant decrease of Fv/Fm indicated a significant PSII photoinhibition in midday. YI showed no significant difference in the diurnal cycle, indicating that PSI kept active. The high activity of PSI might maintain the functional integrity of the photosynthetic apparatus in exposing

to high light or UV-A. However, both PSII and PSI suffered severely photoinhibition under UV-B treatments. When exposed to UVR, the significant decrease of Wk implied that the donor side of PSII was inhibited, especially in UV-B treatments. The significant decrease of φo indicated an inhibition in the PSII acceptor side under low pCO2, and the decrease of φRo indicated an inhibition in the PSI acceptor side. In conclusion, UV showed significant negative effect on the photosynthetic performance of porphyra yezoensis, particularly in UV-B; PSII showed a significant decrease in midday, while PSI kept active throughout day, the active PSI may play an important role in balancing the redox state of photosynthetic electron chain in porphyra yezoensis; compared with low pCO2 treatment, high pCO2 could alleviate the reduction of PSII acceptor side.

P-GS-03-S The variation in responses of different *Phaeodactylum tricornutum* strains to ocean acidification

Ruiping Huang, State Key laboratory of Marine Environmental Science, Xiamen University, 361102, China
Jiazhen Sun, State Key laboratory of Marine Environmental Science, Xiamen University, 361102, China
Xin Lin, State Key laboratory of Marine Environmental Science, Xiamen University, 361102, China
Kunshan Gao, State Key laboratory of Marine Environmental Science, Xiamen University, 361102, China
Presenter Email: rphuang@stu.xmu.edu.cn

Diatoms are major oceanic primary producers, which sustain marine food webs and contribute to carbon export to the depth. Although the effects of ocean acidification (OA) on the physiological performance of diatoms have been extensively studied, there are a few studies concerning the strain-specific variation in response of diatoms to OA. Here four *Phaeodactylum tricornutum* strains Pt1, Pt4, Pt8 and PtSCS isolated from different locations worldwide were used to explore the intra-species variation of this model diatom in response to OA at physiological and molecular levels. Our results showed that OA did not significantly influence the photochemical performance and growth rate of P. tricornutum, but significantly down-regulated carbon affinity for carbon fixation in various magnitudes for all these strains. Furthermore P. tricornutum strains showed various expression regulation patterns of some genes involved in biophysical CO2-concentrating mechanisms (CCMs) and C4 metabolism in response to OA. The downregulation of dissolved inorganic carbon (DIC) affinity mainly resulted from the expression regulation of genes involved in biophysical CCMs under OA conditions. Pt4 showed the significant downregulation ofgenes coding bicarbonate transporters SLC4 that was markedly distinct from other strains, which was the main reason of the largest magnitudes of downregulation in DIC affinity induced by elevated CO2, based on the expression patterns

of selected key genes involved in carbon assimilation. In addition, our data demonstrated that C4 metabolisms may play important roles in changing mitochondrial CO2, dissipating energy and facilitating lipid biosynthesis under OA conditions.

P-GS-04-S Development of an eDNA method for monitoring fish communities: ground truthing in diverse lakes with characterised fish faunas

Jianlong Li, University of Hull
Tristan W. Hatton-Ellis, Natural Resources Wales
Lori-Jayne Lawson Handley, University of Hull
Helen S. Kimbell, University of Hull
Marco Benucci, University of Hull
Graeme Peirson, Environment Agency,UK
Bernd H 盲 nfling, University of Hull
Jianlong Li,
Presenter Email: haikuilee@gmail.com

Accurate, cost-effective monitoring of fish is required to assess the quality of lakes under the European Water Framework Directive (WFD). Recent studies have shown that eDNA metabarcoding is an effective and non-invasive method, which can provide semi-quantitative information on fish communities in large lakes. This study further investigated the potential of eDNA metabarcoding as a tool for WFD status assessment by collecting and analysing water samples from eight Welsh lakes and six meres in Cheshire, England, with well described fish faunas. Water samples (N = 252) were assayed using two mitochondrial DNA regions (Cytb and 12S rRNA). eDNA sampling indicated very similar species to be present in the lakes compared to those expected on the basis of existing and historical information. In total, 24 species with 111 species occurrences by lake were detected using eDNA. Secondly, there was a significant positive correlation between expected faunas and eDNA data in terms of confidence of species occurrence. Thirdly, eDNA data can estimate relative abundance with the standard five-level classification scale (DAFOR). Lastly, four ecological fish communities were characterised using eDNA data which were agreed with the pre-defined lake types according to environmental characteristics. This study provides further evidence that eDNA metabarcoding could be a powerful and non-invasive monitoring tool for WFD purpose in a wide range of lake types, considerably outperforming other methods for community level analysis.

P-GS-05-S Eukaryotic plankton diversity in northern South China Sea

Tangcheng Li, Xiamen University
Guilin Liu, BGI
Jianwei Chen, BGI
Cong Wang, Xiamen university
Xin Lin, Xiamen University
Senjie Lin, Xiamen University& University of Connecticut
Presenter Email: 820195402&qq.com

The protists in marine ecosystem play fundamental ecological roles as producers, consumers, decomposers, and trophic links in aquatic food webs. These links are essential for the biogeochemical processes in the ocean, e.g. plankton communities fix CO2 and other elements into organic matter that lead to the transport of carbon to the deep ocean. Some protists regime shift has been regarded as the indicator of environmental factors change or even the climate change. In this work, we chose two stations (C6 & C9) to sample at different water-column depths and different size fractions and different sampling times to analysis the 18S ribosomal DNA. We have retrieved 2491 operational taxonomic units (OTUs) from all the samples, about 99% of which was assigned to known eight eukaryotic supergroups (Alveolata, Amoebozoa, Archaeplastida, Excavata, Incertae_Sedis, Opisthokonta, Rhizaria, Stramenopiles). After we divide OTUs into abundance OTUs and rare OTUs based on previous report, we found the first degree of segregation is size fraction in total OTUs and abundance OTUs while the water-column depths is the first degree of segregation in rare OTUs. And the result of diversity statistic analysis to abundance OTUs and rare OTUs in different water-column depths and different sampling times revealed that the abundance OTUs was distributed widely than rare OTUs and change significantly over time. This all indicated the different assembly mechanisms to shape abundance OTUs and rare OTUs in different water-column depths. The Biodiversity linkages to environmental conditions and biotic factors are still being analyzed.

P-GS-06-S Screening bacteria and accessing effects on the microalga Nannochloropsis sp. CCAP211/78

Jie Lian, Laboratory of Microbiology, Wageningen University & Research, Stippeneng 4, 6708 WE, Wageningen, The Netherlands
Rene H. Wijffels, Bioprocess Engineering Group, AlgaePARC, Wageningen University & Research, PO Box 16, 6700 AA Wageningen, The Netherlands Nord University, Faculty of Biosciences and Aquaculture, N-8049, Norway
Hauke Smidt, Laboratory of Microbiology, Wageningen University & Research, Stippeneng 4, 6708 WE, Wageningen, The Netherlands
Detmer Sipkema, Laboratory of Microbiology, Wageningen University & Research, Stippeneng 4, 6708 WE, Wageningen, The Netherlands

Presenter Email: jlianxmu@gmail.com

Marine photosynthetic microalgae are ubiquitously associated with bacteria in nature. However, the influence of these bacteria on algal cultures in artificial outdoor bioreactors is still largely unknown. In this study, a culture collection of 18 bacterial strains was obtained from cultures of Nannochloropsis sp. CCAP211/78 in two outdoor pilot-scale tubular bioreactors. The majority of isolates identified by sanger sequencing of 16S rDNAs were members from the classes Alphaproteobacteria and Flavobacteriia. To access the effect of bacteria on the growth of Nannochloropsis sp. CCAP211/78, a LED device was developed to simultaneously compare replicated micro-algal cultures with addition of individual bacterial isolates. In liquid co-cultivation, three bacteria (YP26, YP210, DMSP31) enhance growth of co-cultured microalgae while one bacterium (YP206) inhibits the growth of Nannochloropsis. Furthermore, YP26 also exhibit strong growth stimulation on the algal host as demonstrated by the double-layer agar assay. Co-cultures of algae with YP26 and YP206 were selected for transcriptomic investigation. The transcriptomic data indicate profound association between algae and bacteria. Our study suggests that in algal industry potential influence of the algal microbiome should be considered when carrying out algal production at large scale.

P-GS-07-S Light-Modulated Responses of Growth and Photosynthetic Performance to Ocean Acidification in the *Thalassiosira weissflogii*

LIMing Qu, State Key Laboratory of Marine Enviromental Science, Xiamen University, Xiamen, Fujian, China
Presenter Email: qlmzsdx@163.com

Diatoms are one of the most important groups of phytoplankton in terms of abundance and ecological functionality in the ocean. They usually dominate the phytoplankton communities in coastal waters and have many strategies to accommodate the frequent and large fluctuations in light such as change their cell size. In this study we culture *Thalassiosira weissflogii* under pCO2 (400ppmv, 1000ppmv) under different light levels (100, 200, 400 μmol m2-s-) to examine its physiological performance. It showed that under high light condition (HL, 400 μmol m2-s-), the cell size was smaller about 3% than low light (100μmol m2-s-), however, the relative growth rate was higher about 33.6% and 22.7% than low light (LL, 100 μmol m2-s-) and medium light (ML, 200μmol m2-s-) respectively. There had no significant difference between LC and HC under different light conditions. The ETR(II)400 , rETR and net photosynthesis rate increased with the increasing light intensities, and the their maximum value were found in HL condition. And the contents of Chla in high light were lower than other two light levels, while the Car/Chla was higher than them. We verified that down-regulation of CCM occurred under low light level and HC condition by measuring the activity of external carbonic anhydrase (eCA). The linkage between higher level of the CCMs down-regulation and higher growth rate at HL under OA supports the theory that the saved energy from CCMs down-regulation adds on to enhance the growth of the diatom.

P-GS-08-S The Evolution of Photosynthesis Gene Clusters in Plasmids

Yanting Liu, State Key Laboratory of Marine Environmental Sciences
Qiang Zheng, State Key Laboratory of Marine Environmental Sciences
Nianzhi Jiao, State Key Laboratory of Marine Environmental Sciences
Presenter Email: Yantingl0702@gmail.com

Aerobic Anoxygenic Photoheterotrophic Bacteria (AAPB) play a significant role in the evolutionary history of photosynthesis. A wealth of evidence indicates that the highly conserved photosynthetic gene clusters (PGCs) of AAPB could be transferred between species, genera and even phyla. The Roseobacter clade is one of the major subgroups of AAPB and has a patchy distribution of photosynthetic species. To explore the likely role of plasmids in the transfer of PGCs, we analyzed the PGCs carried by plasmids (pPGCs) in 13 Roseobacter members, as well as their phylogenetically related strains that contain PGCs in chromosomes (cPGCs). The phylogenetic analyses suggested that pPGCs have two distinct evolutionary origins. Additionally, high sequence similarities were revealed between pPGCs and cPGCs contained by distantly related strains, indicating that PGCs may be transferred between chromosomes and plasmids and between these bacterial strains. A comparison of PGC structures implicated that multiple recombination events might happen between chromosomes and plasmids during the evolution of PGCs. Analyses of the relative synonymous codon usage (RSCU) further indicated that the plasmids carrying PGCs may be redefined as bacterial chromids, suggesting they are stable in bacterial cells and PGCs carried by them may be consistently expressed.

P-GS-09-S A double whammy: ocean hypoxia and acidification interact to influence diatom physiology

Jiazhen Sun, State Key Laboratory of Marine Environmental Science & College of Ocean and Earth Sciences, Xiamen University
Tifeng Wang, State Key Laboratory of Marine Environmental Science & College of Ocean and Earth Sciences, Xiamen University
Ruiping Huang, State Key Laboratory of Marine Environmental Science & College of Ocean and Earth Sciences, Xiamen University
Xiangqi Yi, State Key Laboratory of Marine Environmental Science & College of Ocean and Earth Sciences, Xiamen University
Di Zhang, State Key Laboratory of Marine Environmental Science & College of Ocean and Earth Sciences, Xiamen University
Gang Li, Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology

Guang Gao, Marine Resources Development Institute of Jiangsu, Huaihai Institute of Technology
John Beardall, School of Biological Sciences, Monash University
David Hutchins, Marine and Environmental Biology Section, Department of Biological Sciences, University of Southern California
Kunshan Gao, State Key Laboratory of Marine Environmental Science & College of Ocean and Earth Sciences, Xiamen University
Presenter Email: iamvurtne@sina.com

Oxygen is essential to respiration of most marine organisms. However, the oxygen concentration in seawater has been being declining, both in open oceans as well as in coastal waters, as a consequence of global warming and coastal eutrophication1. As a result, the extent of hypoxic waters is expanding2, deteriorating habitable environments for a wide range of marine biota. However, it is still unknown how marine photosynthesis will respond to such climate forcing in combination with ocean acidification. Here, we show that under experimental deoxygenation conditions, the diatom Thalassiosira weissflogi grows faster, respires less and shows faster rates of photosynthesis, with its CO2 concentrating mechanisms (CCMs) significantly up-regulated. Such stimulation of CCMs are associated with inhibition of photorespiration as consequence of Rubisco-catalyzed carboxylation and oxygenation shifting to favor CO2 fixation, that in turn enhances photosynthesis and net O2 production. Field measurements showed increased phytoplankton primary productivity at reduced oxygen concentrations, supporting our laboratory finding that deoxygenation enhances algal photosynthesis. Our results suggest that marine primary producers can benefit from ocean changes in pO2/pCO2.

P-GS-10-S Insensitivities of a subtropical productive coastal plankton community and trophic transfer to ocean acidification: results from a microcosm study

Tifeng Wang, Xiamen University
Peng Jin, Guangzhou University
Mark L. Wells, University of Maine
Charles G. Trick, Western University
Kunshan Gao, Xiamen University
Presenter Email: tifengwang0510@163.com

Ocean acidification (OA) has the potential to affect both calcifying and non-calcifying marine phytoplankton in ways that are only partly understood, but there is even less knowledge about how it may alter the coupling to secondary producers. We investigated the effects of OA on phytoplankton primary production, and its trophic transfer to zooplankton, in a subtropical, eutrophicated coastal water (Wuyuan Bay, China, 24.52ºN, 117.18ºE) using 30 L microcosms. Present day $p\mathrm{CO_2}$ levels (400 µatm) and projected end-of-century concentrations (1000 µatm) were tested in a 7 day bloom experiment. Net

primary production was unaffected by OA, although OA did lead to small decreases in cellular growth rates. OA had no measurable effect on micro-/mesozooplankton grazing rates, suggesting it has little impact on the trophic transfer of energy, at least over the short term. Elevated pCO_2 had no effect on phytoplankton nutritional fatty acids (FA) concentrations during the exponential growth phase, but saturated fatty acids (SFA) increased relative to the control during the declining phase on the bloom. The FA profiles of mesozooplankton differed significantly from that of phytoplankton, and this status was not affected by elevated pCO_2 conditions. Our findings show that short-term exposure of plankton communities in eutrophied subtropical waters to projected end-of-century ocean acidification conditions has little effect on primary productivity and the trophic linkage to mesozooplankton.

P-GS-11-S Response of growth and photosynthesis of *Gephyrocapsa oceanica* to different nitrate availability under fluctuating natural solar light

Xiaowen Jiang, State Key laboratory of Marine Environmental Science, Xiamen University
Kunshan Gao, State Key laboratory of Marine Environmental Science, Xiamen University
Presenter Email: 118901353@qq.com

Gephyrocapsa oceanica is a widespread species of coccolithophore that has a significant impact on the global carbon cycle through photosynthesis and calcium carbonate precipitation. Here, an outdoor experiment was conducted for 12 days with the aim of investigating the effects of nitrate availability on its growth and physiological performance under fluctuating natural solar light. The specific growth rate of HN -cells was significant higher than LN-cells on sunny days with high solar radiation, and decreased when light intensity was low. But for LN-cells, the specific growth rate had no obvious difference between the period of overcast skies and sunshine. The cellular Chl a content for both treatment increased in cloudy days. Comparing with their short-term responses to high light, LN-cells were more sensitive to high light, our results indicated that though the light is the main factor limiting the growth of HN -cells, the nitrate seems to be more restrictive when it is insufficient.

P-GS-12-S Thermal plasticity of nitrogenase activity in Trichodesmium *erythraeum* IMS 101

Xiangqi Yi, Xiamen University
Kunshan Gao, Xiamen University
Presenter Email: yixiangqi0415@126.com

The cyanobacterium *Trichodesmium* is one of the most significant N2-fixing organisms in the tropical and subtropical oceans and plays an important role in the biogeochemical cycles of nitrogen and carbon. Understanding its response to ongoing global warming is one of the keys to predict the potential effects of climate change on marine ecosystems.

Here, we show that the optimum temperature of growth is 27 oC in Trichodesmium *erythraeum* IMS 101, and warming (+4 oC inhibits its growth. However, this thermal effect on growth disappears when growth is limited by light intensity, that is, growth rates of populations grown under 23, 27 and 31 oC are similar at limiting light intensity. This suggests that compared to temperature, light is the primary limiting factor which may cover the effect of temperature on *Trichodesmium*'s growth. We also explore the thermal plasticity of nitrogenase activity in *Trichodesmium*. It is remarkable that the optimum temperatures (Topt) of nitrogenase activity are hardly affected by either growth temperature or growth light intensity except for populations cultured at 31 oC and limiting light intensity whose Topt is about 27 oC, 2 oC lower than those of other populations. The double pressures of warming and light-limitation severely inhibit the performance of nitrogenase activity at high measuring temperature. The activation energy (Ea) of nitrogenase activity, reflecting the thermal sensitivity when measuring temperature is below the optimum temperature, is affected by growth temperature. The nitrogenase activities of high-temperature grown populations are more sensitive than those of low-temperature grown populations. Surprisingly, Ea is not affected by growth light intensity. Further exploration suggests that this should be one of the results of acclimation, because for the same population, Ea is higher when measured at saturating light intensity than at limiting light intensity. The deactivation energy (Eh) of nitrogenase activity, reflecting the decreasing rate when measuring temperature is above the optimum temperature, is lower for populations grown under warming conditions regardless the light intensity, helping the warming-acclimation populations maintain nitrogenase activity at high temperature. However, all in all, it seems that the thermal plasticity of nitrogenase activity gives not much advantages of acclimating to high temperature in *Trichodesmium*, which may constrain its adaptation to global warming.

P-GS-13 Effects of fixation and storage on DNA preservation of copepods and their gut content

Tianqi Hou, College of Environmental Science and Engineering, Ocean University of China
Xinxin Wang, College of Environmental Science and Engineering, Ocean University of China
Yunyun Zhuang, College of Environmental Science and Engineering, Ocean University of China
Huan Zhang, College of Environmental Science and Engineering, Ocean University of China
Guangxing Liu, College of Environmental Science and Engineering, Ocean University of China
Presenter Email: yunyun.zhuang@ouc.edu.cn

DNA barcoding technique is widely used in studying the diversity of copepods and their in situ diet, which promotes the understanding of plankton community structure and marine food web structure. Effective sample preservation is the crucial premise of downstream

analysis including PCR amplification and sequencing. In this study, we evaluated the effects of fixatives and storage periods on the yield and quality of the DNA extracted from copepods and their gut content. The integrity of DNA was determined by amplifying and quantifying target fragment of different sizes by qPCR. Flash frozen in liquid nitrogen was used as a control. Considerable variability was observed among different methods. We found that, RNAlater was the best fixative for copepod DNA with highest DNA yield and integrity over two-month storage and ethanol took the second place. For all methods tested, gut content was successfully detected in the DNA extracted from whole organism, but the yield and integrity of prey DNA was independent on that of copepod-specific DNA. Lugol's and ethanol were the best in preserving the DNA of gut content, indicating the instant stop of copepods' physiological activity and best permeability. The yield and integrity of copepod DNA progressively decreased with increased storage period for all fixatives, but the storage period did not significantly affected prey DNA. Thus, although obtaining the DNA barcodes from copepods and their gut content both start with whole-organism DNA extraction, the choice of fixative depends on the aim of study.

【SPS1-322】 P-SPS1-01 Automated determinations of pH and carbonate ion concentrations in seawater

Jian Ma, Xiamen University
Qipei Shangguan, Xiamen University
Peicong Li, Xiamen University
Huilin Shu, Xiamen University
Kunning Lin, Xiamen University
Robert H. Byrne, University of South Florida
Quanlong Li, Xiamen University
Dongxing Yuan, Xiamen University
Presenter Email: shuilinm@sina.com

Ocean acidification, which is manifested by the long-term trend of decreasing pH and carbonate ion concentrations in seawater, has become a research hotspot in the field of ocean science. The changing inorganic carbon system equilibrium caused by this process can be characterized by four parameters, including partial pressure of carbon dioxide (pCO2), pH, dissolved inorganic carbon (DIC) and total alkalinity (TA). Carbonate ion concentrations ([CO_3^{2-}]) can be calculated from any two of the four parameters. Except for pCO2, samples for other parameters are still collected discretely in most studies, and then analyzed either in shipboard or land-based laboratories. These techniques are labor and cost intensive. Furthermore, sample transferring and storage needs particular considered. Consequently, development of automated instruments for real-time monitoring of seawater carbonate systems will benefit greatly for ocean acidification and ocean carbon cycle research.

Until now, all of the carbonate system parameters can be measured spectrophotometrically with minor modifications. Spectrophotometry has the unique advantage of easiness to be automated. In order to improve instruments' diversity, reliability and cost effectiveness, this work focused on the development and application of automated instruments for determing pH and CO_3^{2-} in seawater. The main results are summarized below:

(1) An automated instrument for pH measurement based on visible spectrophotometry was described. The instrument consisted of a syringe pump equipped with a multiport valve for liquid delivery, LEDs and charge-coupled device for absorbance measurement. Absorbance values of seawater and indicator (meta-Cresol Purple, mCP) mixture at specific wavelengths allow direct measuremnt of pH. Laboratory test showed that the instrument has a precision of ~0.001. The instrument was used to on-line monitor pH variations continuously in a coral reef tank. During the 5-day field test, the pH automated measurement instrument operated properly, and the measurement error was -0.015±0.014 (n=38) compared to calculated values with TA-DIC pair.

(2) The automated CO_3^{2-} measurement instrument was built with similar manifold of pH measurement instrument except ultraviolet detection components. Carbonate ion concentrations can be determined from ultraviolet spectra of Pb(II) and seawater mixture. Laboratory test showed that the instrument has a precision of 1.1% (n=13). During the coral reef tank field test, the measurement error was -2.4±15.7 μmol/kg (n=14). The instrument was tested at sea to perform underway measurements and discrete samples measurement from two vertical profiles. The measurement error in the first stage was -0.5±5.0 μmol/kg (n=31) and 2.1±5.7 μmol/kg (n=22), respectively.

【SPS1-928】 P-SPS1-02-S Development of an underway instrument for accurate measurement of seawater total alkalinity

Quanlong Li, Xiamen University
Qiu Li, Xiamen University
Presenter Email: 1834506052@qq.com

Accurate measurements of total alkalinity (TA) with adequate spatial and temporal resolution is of essential importance in order to better understand the seawater carbonate system. An underway TA instrument is the best tool to achieve that goal. In this study, an underway instrument for TA measurement was built by modifying the automated TA analyzer we developed before, which was based on single-point titration and spectrophotometric pH measurement using the mixture of HCl and bromocresol as titrant. The main modification of the instrument is the use of a thermostat water bath with peltier device, inside which two coils (one for sample, the other for titrant) were installed. When sample and titrant were introduced and stayed in the coils, their temperatures were brought to 25.0 ± 0.1 °C. In addition, the instrument geometry and layout of the parts were optimized. The tests in lab showed that the instrument featured a sample throughput

time of 6.65 min with high precision (±0.64; n=382) and accuracy (-2.9±1.14; n=6). The needs of seawater sample and titrant volumes for one measurement were about 32 mL and 0.9 mL, respectively. Tests in research vessel are going to be carried out.

【SPS1-925】 P-SPS1-03-S Development of an osmotic sampler for time-series sampling of nutrients in surface water

Junxian Pei, Xiamen University
Quanlong Li, Xiamen University
Presenter Email: 496136703@qq.com

High temporal and spatial resolution data of nutrients in aquatic environment are of great importance for studying their distribution, migration and transformation, and environmental effects. In this study, a sampler using osmotic pump (OP) as diving force was developed and applied to obtain time series concentrations of nutrients in surface waters. The sampler mainly consists of an osmotic pump, which operates with osmotic pressure, a sampling coil for sample storage, a filter and an air-bubble injector. When the sampler was deployed underwater, the OP drew the water continuously through the filter at a constant flow rate, and the sample was stored in the sampling coil. Meanwhile, the air-bubble injector delivered air bubble into the coil at fixed time to separate the sample. The air segments could be used as the stamps of the sampling time. After the sampler was retrieved, each sample was expelled from the coil into different vials depending on the air segments. Dissolved total nitrogen, dissolved total phosphorus, dissolved reactive phosphorus and nitrate in the samples were determined, and time-series concentrations of these nutrients were obtained. The sampler was deployed for 20 days and 7 days in riverine and coastal waters, respectively. Its performance was evaluated by comparison with spot sampling. The sampler ran smoothly during the deployments, and the results showed good agreement between the two different sampling methods, indicating the reliability and prosperous application in time-series sampling of nutrients in surface water.

【SPS1-433】 P-SPS1-04-S An automatic reserve flow injection method using vanadium (III) reduction for simultaneous determination of nitrite and nitrate in estuarine and coastal waters

Kunning Lin, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University
Peicong Li, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University
Jian Ma, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University
Dongxing Yuan, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University

Presenter Email: lin1433@163.com

Nitrite and nitrate, which are the essential nutrients for marine phytoplankton growth, play an key role in nitrogen biogeochemical transformations, and exert a major influence on the primary productivity of marine ecosystems. It is necessary to develop accurate, sensitive and automated analytical methods to determine nitrite and nitrate in waters. The widely used spectrophotometric method for determination of nitrite is the Griess assay, which is based on the diazotization reaction of nitrite with sulfanilamide and N-1-naphthylethylenediamine dihydrochloride and the formation of an azo dye under acidic conditions. The determination of nitrate is based on the reduction of nitrate to nitrite and subsequent spectrophotometric determination of the nitrite with Griess assay. The copperized cadmium column is the most commonly used for nitrate reduction to nitrite, due to its high and stable reduction efficiency. However, cadmium is highly toxic, and potentially harmful to human health, so is the generated waste. In this study, an automatic reserve flow injection method using vanadium (III) as a reduction agent for simultaneous determination of nitrite and nitrate in estuarine and coastal waters was reported for the first time. Vanadium (III) chloride was used to replace the toxic cadmium for reducing nitrate to nitrite. The experimental parameters were optimized based on a univariate experimental design. The salinity effect of estuarine and coastal waters was carefully investigated. With the optimized conditions, the detection limit of the proposed method was 0.06 μmol·L-1 and 0.13 μmol·L-1, and the linearity was up to 20 μmol·L-1 and 80 μmol·L-1 for nitrite and nitrate detection, respectively. The relative standard deviations were below 1.5% (n=7). The recovery of spiked estuarine and coastal water samples varied from 100.0±2.5% to 107.5±2.5% for nitrite and 90.7±0.3% to 98.0±1.0% for nitrate. The sample throughput was about 15 h-1. The analytical results obtained with the proposed method showed good agreement with those using a reference method. The proposed method has been successfully applied to analyze the nitrite and nitrate in estuarine and coastal water samples.

【SPS1-291】 P-SPS1-05-S Research on the indophenol method for the determination of ammonium in natural waters using o-phenylphenol

Jian Ma, State Key Laboratory of Marine Environmental Science,College of the Environment and Ecology, Xiamen University

Peicong Li, College of the Environment and Ecology, Xiamen University

Presenter Email: 977968997@qq.com

Research on the indophenol method for the determination of ammonium in natural waters using o-phenylphenol Peicong Li, Jian Ma* State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University, 361102 Xiamen, Fujian, China Abstract: Ammonium, as one of the most important nutrients, occupies a central role in nitrogen biogeochemical cycles. Accurate and sensitive determination of ammonium is of great interest and challenging for both environmental scientists and oceanographers. The indophenol blue (IPB) method based on Berthelot's reaction is still the most widely used method, and routine analysis based on IPB method is the most popular technique for the automated ammonium measurement. However, the existing analytical methods have the shortages of high toxicity, interference with salinity, high reagent consumption and difficulties in application in-field. Herein, a new analytical method and a relative compact, robust and portable instrument for ammonium determination have been developed. The main contents and results are as follows: (1) A salinity-interference-free indophenol method for the determination of ammonium in natural waters using o-phenylphenol was developed. The normally used toxic and odorous phenol was replaced by the less toxic, stable flaky crystalline compound, o-phenylphenol. The reaction can be finished within 20 min at room temperature and the formed color compound is stable for 24 h. Under the optimized conditions, the method was salinity-interference-free, it shows high reproducibility (relative standard deviations of 0.64-0.71%, n=11), highly linear calibration up to 100 μM and a low detection limit of 0.2 μM. This method was successfully applied to measure ammonium in Min river, Jiulongjiang estuary and Xiamen coastal area. This work has been published on "Ma et al., Talanta, 2018, 179, 608-614. (2) An integrated syringe-pump-based environmental-water analyzer (iSEA) and its application for spectrophotometric determination of ammonium is presented. The iSEA consisted a mini-syringe pump equipped with a selection valve. The principle of chemistry method was based on method (1). This fully automated analyzer had a detection limit of 0.12 μM with sample throughput of 12 h-1. Relative standard deviations at different concentrations (0-20 μM) were 0.23-3.36% (n=3-11) and 1.0% (n=144, in 24-h continuous measurement, ~5 μM). Calibration curves were linear (R2=0.9998) over the range of 0-20 μM and 0-70 μM for detection at 700 nm and 600 nm, respectively. The iSEA was applied in continuous real-time monitoring of ammonium variations in a river for 14 days and a shipboard underway analysis in Jiulongjiang estuary and Xiamen coastal area. This work has been published on "Ma et al., Analytical Chemistry, 2018, 90, 6431-6435.

【SPS1-323】 P-SPS1-06 Determination of Trace Dissolved Reactive Phosphorus and Chromium (VI) with an Integrated Syringe-Pump-Based Environmental-Water analyzer (iSEA) Coupled to a Liquid Waveguide Capillary Cell

Jian Ma, Xiamen University
Yao Deng, Xiamen University
Xiangyu Zhu, Xiamen University
Peicong Li, Xiamen University
Presenter Email: 527924115@qq.com

With the development of the liquid waveguide capillary cell (LWCC), the method sensitivity can be easily achieved by increasing of the flow cell length. Now, LWCC has been applied

to field studies in the open ocean. For the robust, reliable, autonomous environmental monitoring instrument, we development of an combined with LWCC (iSEA-LWCC). The iSEA-LWCC consists of a syringe pump equipped with a 9-port valve and controlled by software written in LabVIEW. The optical flow cell was 2.5-m LWCC. The iSEA-LWCC has been applied for, the determination of trace elements in water. The main contents and results are summarized as follows:

(1) Phosphorus is an essential nutrient element used by marine phytoplankton. As the major component of inorganic phosphorus, dissolved reactive phosphorus (DRP) plays an important role in the marine biogeochemical cycle of phosphorus. The process of chemical reactions is based on phosphorus molybdenum blue spectroscopic spectrophotometry coupled with a 2.5-m LWCC, a convenient method for determination of trace of SRP was established. The sample throughput was 12 per hour. The relative standard deviation (n=66) was 0.98% for a sample with concentration of 80 nmol/L. The detection limit is ~1 nmol/L.

(2) Chromium (VI) is a recognized hazardous substance in drinking waters. Therefore, effective monitoring and assessment of the risks posed by Cr (VI) are important analytical objectives for both environmental science and human health. Here, we developed a simple and sensitive method for analysis of Cr (VI) at nanomolar levels. The measurement chemistry is based on a reaction with diphenyl carbazide under acidic conditions, with a 2.5-m LWCC and spectrophotometric detection. The instrument is controlled by software written with LabVIEW. The determination of a sample only needed 4 min. The linear calibration range from 0 to 100 nmol/L with detection limit of ~0.3 nmol/L.

The iSEA-LWCC instrument has the potential for long-term online monitoring of trace nutrients and metals in environmental water samples. More evaluation and applications are under development.

【SPS1-508】 P-SPS1-07 Development and application of an automated analyzer for determination of iron in seawater by on-line chelating resin concentration and chemiluminescence detection

Yongming Huang, State Key Laboratory of Marine Environmental Science, the College of Ocean and Earth Sciences, Xiamen University

Yaqian Zhou, State Key Laboratory of Marine Environmental Science, the College of Ocean and Earth Sciences, Xiamen University

Yihua Cai, State Key Laboratory of Marine Environmental Science, the College of Ocean and Earth Sciences, Xiamen University

Jin Xu, State Key Laboratory of Marine Environmental Science, College of The Environment&Ecology, Xiamen University

Dongxing Yuan, State Key Laboratory of Marine Environmental Science, College of The Environment&Ecology, Xiamen University

Minhan Dai, State Key Laboratory of Marine Environmental Science, the College of Ocean and Earth
Presenter Email: yongminghuang@xmu.edu.cn

Based on flow injection analysis, an automated analyzer for determination of iron in seawater was developed by on-line column preconcentration and chemiluminescence detection. The analyzer is composed of two stacked parts, a flow injection analyzer at the top and a Class-100 laminar flow chamber below for reagent solutions storage. The flow injection analyzer consists two peristaltic pumps, four valves and a packed photomutiplier tube (PMT). A mini column packed with commercial resin with iminodiacetic acid (IDA) group (Toyopearl AF-chelate-650M) was used for on-line preconcentration of iron from seawater matrix at pH 6.2. The iron was eluted from the column by 0.12 M Q-HCl solution and then merged with luminol solution just in front of the PMT window, where the light emitted by the solutions was detected. Under the typical setting with an initial seawater volume of 1.5 mL and a concentration factor of ~ 5, the detection limit reaches 0.05 nM, which suits most oceanic iron determination. The analyzer has been used during a 9-day long test cruise of GEOTRACES-China in March 2018 with a large sample throughput of over 100.

【SPS1-435】 P-SPS1-08-S Development of an integrated universal hardware and software platform for flow analysis instruments

Jin Xu, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University
Kunning Lin, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University
Yongming Huang, State Key Laboratory of Marine Environmental Science,Xiamen University
Xiaochang Zhang, School of Electronic Engineering and Automation, Guilin University of Electronic Technology
Dongxing Yuan, State Key Laboratory of Marine Environmental Science, College of the Environment and Ecology, Xiamen University
Presenter Email: scxujin@stu.xmu.edu.cn

An integrated universal platform comprising multiple bearer sub-systems and multi-control interface has been developed for flow analysis. The platform employing a bus topology was based on distributed control system, and established with communication between main controller and PC using industrial standard communication protocol-MODBUS protocol. The platform could automatically complete the process of sample injection, reagent mixing, signal detection, data acquiring and analysis with upper-computer and lower-controller. The master control board, which embedded a 32-bit programmable ARM microcontroller, was designed to safely and reliably manage the actuation of mechanical devices (pump,

injection valve, multi-position valve and solenoid valve) and synchronize data exchange between hardware sections with MODBUS. A PC program using LabVIEW was compiled for devices control, multi-wavelength signal processing, history data logging and human-machine interface. Both hardware and software components were built and tested to verify the normality of their functions. An application example of the developed platform was a successfully control of a total phosphorus analyzer, which could automatically determine the concentration of organic phosphonate corrosion inhibitors in industrial circulating cooling water. Measurement of the organic polyphosphoric compounds was based on colorimetric method with vanadomolybdophosphoric acid, after being converted to orthophosphate with digesting agent of potassium persulfate and UV-photooxidation. The detection linear range was 0.2 - 50 mg/L, while the limit of detection was 0.05 mg/L. The recovery of several real samples at different concentrations was ranged from 91.5% to 103.8% and analytical result for total phosphorus of a certified reference material (GSBZ50033-95) was 1.50 卤 0.04 mg/L (n=3), which was basically agreed with the certified value (1.51 卤 0.02 mg/L). The platform possessing the integrated software-hardware solution is extremely versatile in its sub-devices control capacity, and suitable for any new flow analysis instruments to be easily customized to fit the experimental design for various environmental water analysis.

【SPS1-1036】 P-SPS1-09-S Allometric equations for determination of above ground biomass and carbon in mangroves, Rhizophora mucronata Lam., in Gzai Bay, Kenya

D. Maringa, Mangrove Research Program, Kenya Marine and Fisheries Research Institute, Gazi Campus University of Nairobi, Department of Biological Sciences, Chiromo Campus
A. Juma, Mangrove Research Program, Kenya Marine and Fisheries Research Institute, Gazi Campus
J. Kairo, University of Nairobi, Department of Biological Sciences, Chiromo Campus
Presenter Email: dmmwasaru@gmail.com

The demand for local allometric equations has greatly increased worldwide with the realization of the significance of carbon-offset projects in combating climate change. Species-specific allometric equations were developed for Rhizophora mucronata in Kinondo natural stand in Gazi Bay, Kenya. Twenty five trees of diameters between 2.5 cm and 20 cm were harvested and separated into their component parts: trunks, leaves, branches and stilt roots. The weight of individual component parts was measured in situ and sub-samples of each component carried to the laboratory for wet-dry weight conversion. Correlations between the total biomass against stem diameter (D130), either alone or in combination with height, were used to develop allometric equations of the form y = axb (where; y = biomass, x = D130 and a and b are constants). The strength of the equations was assessed by the correlation coefficient of determination (r2) and standard error. Stem

diameter (D130) was found to be the best predictor for aboveground biomass with correlation coefficient (R2) of 0.90 for R. mucronata. The equation built was used to give estimates of the above ground carbon pool of R.mucronata. The aboveground biomass for R. mucronata was estimated to be 234±34.85 tons/ha in the Kinondo natural stand. Key words: Above ground biomass; allometric equations; REDD+; mangroves; Kenya

【SPS2-332】 P-SPS2-01 Hydrosphere Microorganism Program: Regulating mechanisms and environmental effects of microbes on carbon sequestration and source in typical seas of China

Nianzhi Jiao, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: Jiao@xmu.edu.cn

This project is a part of NSFC Major Research Program "Hydrosphere Microorganism Program". The Hydrosphere Microbes program represents one of the major national efforts in understanding the roles of microbes in hydrosphere, particularly that related to geochemical cycling which ultimately impacts upon global ecology and environment/climate. The ocean is the largest hydrosphere and active carbon pool on Earth, which is equivalent to the total CO2 in the atmosphere. "Microbial carbon pump" (MCP) is major source and mechanism of marine carbon sink, significantly contributing to the organic carbon sink. The increasing eutrophication of coastal waters in China is often accompanied by environmental problems such as algal blooms, hypoxia and acidification, which may affect the carbon storage efficiency of MCP. The project will follow the overall guidance of the "Hydrosphere Microbiology Project", with the coastal eutrophication as the background, the MCP as the main theme, to investigate the effects and responses of algal blooms, hypoxia and acidification on major ecological processes and microbial communities. This project combines the field investigation, enclosures and laboratory research by using marine microbiology and chemistry to establish the linkages between the microorganism microcosmic process and the macrocosmic effect of the marine carbon cycle.

【SPS2-1007】 P-SPS2-02-S Differential incorporation of one-carbon substrates among microbial populations identified by stable isotope probing from the estuary to South China Sea

Wenchao Deng, State Key Laboratory of Marine Environmental Sciences and College of Ocean and Earth,Xiamen Univerisy
Lulu Peng, State Key Laboratory of Marine Environmental Sciences and College of Ocean and Earth,Xiamen Univerisy
Nianzhi Jiao, State Key Laboratory of Marine Environmental Sciences and College of Ocean and Earth,Xiamen Univerisy
Yao zhang, State Key Laboratory of Marine Environmental Sciences and College of Ocean

and Earth,Xiamen Univerisy
Presenter Email: dengwenchao@stu.xmu.edu.cn

Methanol (MOH) and monomethylamine (MMA) are two typical one-carbon (C1) compounds found in natural environments. They play an important role in marine and atmospheric chemistry, cloud formation, and global climate. The main biological sink of MOH and MMA is rapid consumption by marine microbes. Here, field-based time-series incubations with supplemental 13C-labelled MOH and MMA and isotope ratio analyses were performed. A substantial difference in the MOH and MMA incorporation rates and bacterial taxa were observed between the South China Sea (SCS) and the Pearl River estuary. C1 substrates were assimilated more quickly in the estuary than the SCS shelf where MOH and MMA had similar bio-availability. However, microbial responses to MMA may be faster than to MOH in the coastal and basin surface water of the SCS despite similar active bacterial populations. Three ecological types of bacteria, in terms of response to supplemented MOH and MMA, were identified: rapid incorporation (I, dominant C1-incorporating group), slow incorporation (II, minor C1-incorporating group), and no incorporation (III, C1-non-incorporating group). Members of the families Methylophilaceae (β-Proteobacteria) and Piscirickettsiaceae (γ-Proteobacteria) belonged to type I and actively incorporated substrates in the estuary and SCS, respectively. Diverse MOH and MMA-incorporating type II bacteria were identified by stable isotope probing in the SCS, and could play a more important role in the transformation of C1 compounds in marine environments than hitherto assumed.

【SPS2-211】 P-SPS2-03-S The patterns of DOM transformation and utilization by heterotrophic bacteria in phytoplankton bloom revealed by proteomic and metabolomic analyses.

Yu Han, State Laboratory of Marine Environmental Science, Xiamen University, China.
Kai Tang, State Laboratory of Marine Environmental Science, Xiamen University, China.
Chen He, China University of Petroleum (Beijing), China.
Quan Shi, China University of Petroleum (Beijing), China.
Ruanhong Cai, State Laboratory of Marine Environmental Science, Xiamen University, China.
Nianzhi Jiao, State Laboratory of Marine Environmental Science, Xiamen University, China.
Presenter Email: yuhan1019@foxmail.com

Nutrients pollution and eutrophication have become the main threats to the ecological environment in coastal waters, which have led to algal blooms outbreak frequently in many gulf and estuary. Based on the study of *Akashiwo sanguinea*, gymnodinium bloom in Xiamen coastal ocean, analysis of dominant bacterial community including Flavobacteriales, Rosebacter clade, Oceanospirillales, explaining the micro process of utilization and transformation of dissolved organic matter in algal bloom by heterotrophic

bacteria utilizing proteomics and high-throughput metabolomics (FT-ICR-MS). In terms of proteomics, we found Flavobacteriales expressed nearly 76% of the annotation protein is significantly higher than Roseobacter clade (49%) and Oceanospirillales (56%), of which Flavobacteriales rich in amino acid metabolism related protein expression, and Roseobacter clade and Oceanospirillales prefer to ABC transporter, membrane proteins and two-component system related protein expression. The metabolites of utilization was organic nitrogen (e.g., peptide) on Flavobacteriales, organic sulfur and other substances (such as DMSP) on Roseobacter clade. Therefore, the dissolved organic matter may control the succession of bacterial community in algal bloom, and the bacteria can participate in the circulation of the elements through the transformation of the dissolved organic matter.

【SPS2-851】 P-SPS2-04-S Niche differentiation of ammonia and nitrite oxidizers along a salinity gradient from the Pearl River estuary to the South China Sea

Lei Hou, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361101, China; College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, China
Xiabing Xie, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361101, China
Xianhui Wan, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361101, China
Shuh-Ji Kao, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361101, China; College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, China
Nianzhi Jiao, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361101, China; College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, China
Yao Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361101, China; College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, China
Presenter Email: houleiwz@139.com

The niche differentiation of ammonia and nitrite oxidizers is controversial because they display disparate patterns in estuarine, coastal, and oceanic regimes. We analyzed diversity and abundance of ammonia-oxidizing archaea (AOA) and betaproteobacteria (AOB), nitrite-oxidizing bacteria (NOB), and nitrification rates to identify their niche differentiation along a salinity gradient from the Pearl River estuary to the South China Sea. AOA were generally more abundant than beta-AOB; however, AOB more clearly attached to particles compared with AOA in the upper reaches of the Pearl River estuary. The NOB Nitrospira had higher abundances in the upper and middle reaches of the Pearl River estuary, while Nitrospina was dominant in the lower estuary. In addition, AOB and

Nitrospira could be more active than AOA and Nitrospina since significantly positive correlations were observed between their gene abundance and the nitrification rate in the Pearl River estuary. There is a significant positive correlation between ammonia and nitrite oxidizer abundances in the hypoxic waters of the estuary, suggesting a possible coupling through metabolic interactions between them. Phylogenetic analysis further revealed that the AOA and NOB Nitrospina subgroups can be separated into different niches based on their adaptations to substrate levels. Water mass mixing is apparently crucial in regulating the distribution of nitrifiers from the estuary to open ocean. However, when eliminating water mass effect, the substrate availability and the nitrifiers' adaptations to substrate availability via their ecological strategies essentially determine their niche differentiation.

【SPS2-828】 P-SPS2-05-S Decomposing monthly declines of subsurface-water aragonite saturation state from spring to autumn in the North Yellow Sea

Cheng-long Li, Institute of Marine Science and Technology, Shandong University
Wei-dong Zhai, Institute of Marine Science and Technology, Shandong University
Presenter Email: clli23@126.com

The North Yellow Sea (NYS) is a western North Pacific continental margin of major ecological and economic importance, where monthly/bimonthly declines of subsurface-water pH and aragonite saturation state occur from spring to autumn. To quantify controlling processes of these variations, we employed a Redfield-based methodology to decompose the monthly/bimonthly declines of subsurface-water aragonite saturation state observed in 2011 and 2013. Results showed that the contributions of the NYS cold water mass community respiration, calcification and temperature changes to the monthly declines of aragonite saturation state from spring to summer were 84 ± 9%, 30 ± 16%, and -13 ± 10%, while the contributions of the community respiration, CaCO3 dissolution and temperature change to the bimonthly decline of aragonite saturation state from late summer to autumn were 103%, -5% and 1%. Our results also suggested that the NYS cold water mass net calcification rate declined to nearly zero when the seawater aragonite saturation state reached a critical level of 1.5-1.6. This is much different from a recently published coral reef case observed by Bradley et al. (2018, Science), which suggest that the seawater aragonite saturation state threshold of net calcification rate reaching zero should be 2.9-3.0 in coral reef systems. Thus the relations between biogenic CaCO3 dissolution rate and seawater aragonite saturation state may vary in different systems. Much remains to be investigated in order to quantitatively evaluate the effect of ocean acidification on marine CaCO3 cycles. Based on a future scenario projection to predict the possible impacts of future CO2 changes on seasonal variations in the NYS cold water mass aragonite saturation state, we suggested that the very low aragonite saturation state values of <1.5 may exist all year round in the NYS cold water mass in the 2050s, bringing much stress on local benthic fauna community.

【SPS2-862】 P-SPS2-06-S The diversity and distribution of active protistan assemblages along an estuary to basin transect of the northern South China Sea

Ran Li, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University, Xiamen, China
Presenter Email: 823351598@qq.com

Marine protists are essential for globally important biological processes, for instance, the biogeochemical cycles, the remineralization of organic matter, and climate regulation. Yet, it remains largely unclear which determines the diversity and distribution of active protistan communities at a regional scale. Due to the input of freshwater in the Pearl River and the intrusion of seawater, the South China Sea has significant environmental gradient changes on the spatial scale. We sampled three layers (surface, middle and deep) at eleven sites, which were relatively equidistant, along an estuary to basin transect in the northern South China Sea. The 18S rRNA amplicon sequencing method was used to investigate the diversity and distribution of protistan communities. Overall, the relative abundances of sequences and OTUs of protistan composition was dominated by Stramenopiles, followed by Alveolata. But distinct communities occupied different areas. Our results revealed that depth and environmental variables were vital factors in controlling the distinct vertical and horizontal distribution of protists. In the surface water, both total and abundant protistan communities were extremely significant correlations with geographic distance, while rare protistan communities were extremely significant correlations with environment. The rare community was the most sensitive to the environmental factors and depth, followed by abundant community, and finally total community.

【SPS2-285】 P-SPS2-07-S Metabolism of 2,3-dihydroxypropane-1-sulfonate, an important marine organic sulfur, by marine bacteria

Xiaofeng Chen, State Laboratory of Marine Environmental Science, Xiamen University, China
Xi Dai, State Laboratory of Marine Environmental Science, Xiamen University, China
Yu Han, State Laboratory of Marine Environmental Science, Xiamen University, China
Nianzhi Jiao, State Laboratory of Marine Environmental Science, Xiamen University, China
Kai Tang, State Laboratory of Marine Environmental Science, Xiamen University, China
Presenter Email: 18120757209@163.com

The ocean represents a major reservoir of sulfur on Earth. Microorganisms can use inorganic sulfur, mainly sulfate, to form organic compounds. Among them, sulphoquinovose (SQ) has been known for 50 years as the polar headgroup of the plant and algal sulpholipid (sulfoquinovosyl diacylglycerol, SQDG), which plays a major role in the biological sulfur cycle. It is also found in most photosynthetic bacteria, some

nonphotosynethetic bacteria and some Archaea. The estimated annual production of 1010 t makes SQ one of the most abundant organic sulfur compounds in nature, where it is degraded to 2,3-Dihydroxypropane-1-sulfonate (DHPS) by bacteria. Though the concentration and distribution of DHPS are similar with dimethylsulphoniopropionate (DMSP), an abundant algal product which has received considerable attention in the scientific literature, DHPS has no currently recognized role in the marine microbial food web. Thus, we cultured the bacteria in situ of the Xiamen coastal ocean with 10mM DHPS, and analyzed the response of bacteria to DHPS. We found that Nautella genus, belonging to the Roseobacter clade, made quick response. Furthermore, we cultured four representative strains of Roseobacter, including Roseobacter denitrificans JL7001, Dinoroseobacter shibae DFL12, Ruegeria pomeroyi DSS-3, Nautella italica DSM26436 with extra DHPS, explaining the process of utilization and transformation of DHPS by bacteria utilizing ultrahigh performance liquid chromatography coupled with triple-quadrupole mass spectrometry (UPLC-QQQ-MS) and fluorescence spectroscopy with the fluorescent probes NBI for detecting . We found that all of these strains had the capability to utilize DHPS for growth, and most of them degraded DHPS to HSO3-, which could be released to the environment and used by other bacteria. Therefore, as a potential source of carbon and sulfur for marine bacteria, bacterial transformation of DHPS identifies a missing component of the marine carbon and sulfur cycles.

【SPS2-582】 P-SPS2-08-S *Synechococcus* sp. PCC7002 uses sulfide: quinone oxidoreductase to tolerate sulfide and intense light

Daixi Liu, Shandong University, China
Chuanjuan Lv, Shandong University, China
Jihua Liu, Shandong University, China
Luying Xun, Shandong University, China
Presenter Email: liudaixi@yeah.net

Ocean deoxygenation and eutrophication may occur in coastal waters, especially in areas receiving sufficient nutrients from agricultural activities. Sulfide may accumulate in the oxygen minimum zones, and it has widespread effects on marine life. Cyanobacteria are photosynthetic prokaryotes, playing a significant role in carbon fixation in the ocean. Little is known about the effects of sulfide on cyanobacteria. Here we report that *Synechococcus* sp. PCC7002, harboring a sqr gene encoding sulfide: quinone oxidoreductase (SQR), could survive in sulfide-rich environments, while its sqr mutant could not. Further, SQR facilitated adaption to high light intensity. Preliminary data suggested that polysulfide, the produce of sulfide oxidation by SQR, was a key component of the light adaptation, since polysulfide concentration in the wild type is twice of that in the sqr deletion mutant. Thus, SQR helps *Synechococcus* sp. PCC7002 to tolerate sulfide and adapt to intense light, bridging the marine C and S cycles.

【SPS2-1077】 P-SPS2-09-S Utilization of D-amino acids by marine Thaumarchaeota Nitrosopumilus maritimus SCM1

Yanran Wei, State Key Laboratory of Marine Environmental Science, Xiamen University
Wenhui Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University
Zilian Zhang, State Key Laboratory of Marine Environmental Science, Xiamen University
Nianzhi Jiao, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: weiyanran1832@126.com

Thaumarchaeota Nitrosopumilus maritimus SCM1 is one of the ammonia-oxidizing archaea initially isolated from a tropical marine aquarium in 2005. Most marine microbes can produced D-amino acids (D-AAs), which is the major constituent of marine DOC pool, and a potentially part of component of recalcitrant dissolved organic carbon (RDOC). The fate of D-AAs in the marine environment is unclear. It is evidence that D-AAs can be uptake by marine archaea, however whether they can be utilized by marine archaea is unknown. In this study, we performed the cultivation of the SCM1 with 19 typical D-AAs. The growth and metabolism of SCM1 were monitored by analyses of cell abundance, production of NO2-, and consumption of D-AAs and NH4+. The results indicated that some D-AAs, such as D-Met, D-Glu, and D-Val, could promote the growth of SCM1, while others, such as D-Ser, D-His, and D-Cys, could almost completely inhibit the growth, indicating that different species of D-AAs have different effects on the growth and metabolism of SCM1. The mechanism of different effects of D-AAs on the growth of SCM1 will be investigated.

【SPS2-145】 P-SPS2-10 Pigmented microbial eukaryotes fuel the deep sea carbon pool in the tropical Western Pacific Ocean

Dapeng Xu, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, College of Ocean and Earth Sciences, Xiamen University
Ping Sun, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystem, College of the Environment and Ecology, Xiamen University
Yizhe Zhang, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, College of Ocean and Earth Sciences, Xiamen University
Ran Li, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, College of Ocean and Earth Sciences, Xiamen University
Bangqin Huang, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystem, College of the Environment and Ecology, Xiamen University
Nianzhi Jiao, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, College of Ocean and Earth Sciences, Xiamen University
Alan Warren, Department of Life Sciences, Natural History Museum, London SW7 5BD, United Kingdom
Lei Wang, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystem,

College of the Environment and Ecology, Xiamen University
Presenter Email: dapengxu@xmu.edu.cn

Phototrophic microbial eukaryotes dominate primary production over large oceanic regions. Due to their small sizes and slow sinking rates, it is assumed they contribute relatively little to the downward export of organic carbon via the biological pump. Therefore, the community structure of phototrophic cells in the deep ocean has long been overlooked and remains largely unknown. In this study, we used an integrative approach, including epifluorescence microscopy, sequencing of 18S rRNA and photosystem-II psbA gene transcripts, to investigate phototrophic microbial eukaryotes in samples collected from the tropical Western Pacific Ocean. It was found that: 1) pigmented nano-sized eukaryotes (PNEs) are ubiquitous in the deep Western Pacific Ocean down to 5,000 m depth; 2) the PNE community is dominated by cells 2-5 μm in size; 3) their abundance is significant, averaging 4 ± 1 (± s.e.) cells mL-1 in waters below 1,000 m which is comparable to that of heterotrophic nanoflagellates; 4) the active pigmented microbial eukaryotes in the deep waters are highly diverse and dominated by Haptophyta followed by Chlorophyta and Bacillariophyta; 5) PNEs in deep waters were likely transported from surface ocean by various fast-sinking mechanisms, thus contributing to the biological pump and fueling the deep-sea communities by supplying fresh organic carbon.

【SPS2-876】 P-SPS2-11-S Coupled carbon, sulfur, and nitrogen cycles mediated by microorganisms in the water column of a shallow-water hydrothermal ecosystem

Yufang Li, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, People's Republic of China
Kai Tang, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, People's Republic of China
Lianbao Zhang, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, People's Republic of China
Zihao Zhao, Department of Limnology and Bio-Oceanography, University of Vienna, Althanstrasse 14, A-1090, Vienna, Austria
Xiabing Xie, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361101, People's Republic of China
Chen-Tung Arthur Chen, Department of Oceanography, National Sun Yat-sen University, 80424 Kaohsiung, Taiwan
Deli Wang, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, People's Republic of China
Nianzhi Jiao, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361101, People's Republic of China
Yao Zhang, State Key Laboratory of Marine Environmental Science, College of Ocean and

Earth Sciences, Xiamen University, Xiamen 361101, People's Republic of China
Presenter Email: liyufang5904@163.com

Shallow-water hydrothermal vent ecosystems are distinctly different from deep-sea vents, as other than geothermal, sunlight is also one of their primary sources of energy, so their resulting microbial communities also differ to some extent. Yet compared with deep-sea systems, less is known about the active microbial community in shallow-water ecosystems. Thus, we studied the community compositions, their metabolic pathways, and possible coupling of microbially-driven biogeochemical cycles in a shallow-water hydrothermal vent system off Kueishantao Islet, Taiwan, using high-throughput 16S rRNA sequences and metatranscriptome analyses. Gammaproteobacteria and Epsilonbacteraeota were the major active bacterial groups in the 16S rRNA libraries and the metatranscriptomes, and involved in the carbon, sulfur, and nitrogen metabolic pathways. As core players, Thiomicrospira, Thiomicrorhabdus, Thiothrix, Sulfurovum, and Arcobacter derive energy from the oxidation of reduced sulfur compounds and fix dissolved inorganic carbon by the Calvin-Benson-Bassham or reverse tricarboxylic acid cycles. Sox-dependent and reverse sulfate reduction are the main pathways of energy generation, and probably coupled to denitrification by providing electrons to nitrate and nitrite. Sulfur-reducing Nautiliaceae members, accounting for a small proportion in the community, obtain energy by the oxidation of hydrogen, which also supplies metabolic energy for some sulfur-oxidizing bacteria. In addition, ammonia and nitrite oxidation is another type of energy generation in this hydrothermal system, with the marker gene sequences belonging to Thaumarchaeota/Crenarchaeota and Nitrospina, respectively; ammonia and nitrite oxidation is likely coupled to denitrification by providing substrate for nitrate and nitrite reduction to nitric oxide. Moreover, unlike the deep sea systems, cyanobacteria may also actively participate in major metabolic pathways. This study helps us to better understand biogeochemical processes mediated by microorganisms and possible coupling of the carbon, sulfur, and nitrogen cycles in these unique ecosystems.

【SPS2-217】 P-SPS2-12-S Carbon dioxide sequestration by metabolically diverse marine bacteria for production of bioplastics

Peiwen Zhan, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University
Yu Han, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University
Xiaofeng Chen, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University
Dan Lin, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University
Nianzhi Jiao, State Key Laboratory of Marine Environmental Science, Institute of Marine

Microbes and Ecospheres, Xiamen University
Kai Tang, State Key Laboratory of Marine Environmental Science, Institute of Marine Microbes and Ecospheres, Xiamen University
Presenter Email: zhan-wen@foxmail.com

Polyhydroxyalkanoates (PHA) can be synthesized by various microorganisms as intracellular materials for the storage of carbon and energy. The present work involved investigation of a previously reported carbon concentrating Roseobacter clade bacterial strain Thiobacimonas profunda JLT2016 for production of PHA under different metabolisms. Nile red fluorescence proved the presence of lipidic granules within the bacterial cells. Transmission electron microscopy was also done. PHA produced by JLT2016 was identified as PHB according to the characteristic peaks detected in FT-IR spectrum and further confirmed by 1H and 13C NMR spectrums. T. profunda JLT2016 was incubated under heterotrophic culture, chemolithoheterotrophic culture and mixotrophic culture with glucose, sodium sulphide and sodium bicarbonate served as substrates of energy source. The highest PHA production was obtained under chemolithoheterotrophic culture, in which PHB yields reached 60% of cell dry weight (CDW) and CDW reached 2.872 g/L. The experiments showed feasibility in using waste as raw materials to cut down the production costs through the application of metabolically diverse marine bacteria.

【SPS2-1022】 P-SPS2-13 D-amino acids are refractory for marine bacteria

Rui Wang, Xiamen university
Zilian Zhang, Xiamen university
Kenneth Mopper,
Nianzhi Jiao, Xiamen university
Presenter Email: librareally@163.com

The diverse DOM compounds in the ocean have different biological turnover rates and biological availabilities, which are factors that determine the fate of DOM in the ocean. Amino acids are important biologically active components of the oceanic DOM pool. Among the twenty natural amino acids, except glycine (Gly), all amino acids are chiral. L-amino acids (L-AAs) are mainly used for protein synthesis, while D-amino acids (D-AAs) are fewer in quantity but more diverse in their biological functions. Four D-AAs namely D-alanine (D-Ala), D-aspartic acid (D-Asp), D-glutamic acid (D-Glu), and D-serine (D-Ser), are mainly present in peptidoglycan of bacterial cell wall, so these four D-AAs were defined as peptidoglycan-type D-AAs in this study. In addition to peptidoglycan type D- AAs, it was recently indicated that non-canonical type D-AAs such as D-valine (D-Val), D-leucine (D-Leu), D-methionine (D-Met) were synthesized and released into the environment as free form by diverse bacteria. Although their quantitative significance in marine environments is unknown, some non-canonical type D-AAs were detected in marine DOM. Transformation of DOM is mainly carried out by heterotrophic bacteria and the fate of D-

AAs during DOM cycling is poorly studied. Also, whether the two types of D-AAs have different bioavailability for marine bacteria has not been studied. To address these questions, in this study bioassay experiments were performed with pure marine bacteria strains and bacterial assemblages from coastal waters using D-AAs as sole carbon, nitrogen or nutrition source.

【SPS3-948】 P-SPS3-01 Carbon Cycle in the South China Sea: Budget, Controls and Global Implications (CHOICE-C II)：An overview

Minhan Dai, State Key Laboratory of Marine Environmental Science (MEL), Xiamen University
Weifang Chen, State Key Laboratory of Marine Environmental Science (MEL), Xiamen University
Presenter Email: chenwf@xmu.edu.cn

Influenced by land-ocean-atmosphere interactions, coastal ocean carbon cycling is an important component of the Earth's climate system. However, a mechanistic understanding of the coastal ocean carbon cycle remains limited, leading to an unanswered question of why some coastal systems are sources while others are sinks of atmospheric CO2.

As the largest marginal sea of the North Pacific, the South China Sea (SCS) spans a wide range of latitudinal zones with distinct structures. The northern shelf, which receives land inputs from the Pearl River, can be characterized as a River-Dominated Margin (RiOMar) and a CO2 sink to the atmosphere. The SCS basin, which exchanges with the Pacific, is identified as an Ocean-Dominated Margin (OceMar) and a CO2 source.

Built upon the success of a five-year "973" project, CHOICE-C I on “Carbon cycling in the China Seas - budget, controls and ocean acidification”, CHOICE-C II is a five-year (January 2015 to August 2019) multi-PI interdisciplinary research project funded through National Basic Research Program of China (973 Program) by Ministry of Science and Technology. CHOICE-C II focuses on the northern SCS shelf (RiOMar) and the SCS basin (OceMar). Through an integrated study of the carbon cycling between field observations, remote sensing as well as numerical modeling in the SCS with a comparison strategy, CHOICE-C II aims to determine the source and sink terms of atmospheric CO2 and their associated physical-biogeochemical controlling processes. What follows concentrates on the global implications and the future trends of carbon cycling in the SCS. Four subprojects are designed for CHOICE-C II: 1) Air-sea CO2 flux and its biogeochemical controls in the SCS; 2) Primary productivity and carbon cycle in the SCS; 3) Recycling and export of organic carbon and its coupling with nitrogen and silicon in the SCS; 4) Carbon transport, simulations and future trends in the SCS.

Thus far, the project conducted three cruises in the SCS, one to the northern shelf in summer 2015 and two to the basin in summer and winter 2017. Three biogeochemical

Argo floats were deployed to collect high resolution data to derive the distribution of Chla, particulate organic carbon and other related biogeochemical parameters.
Based on sea surface pCO2 data collected from 36 cruises since 2000, the estimation of air-sea CO2 fluxes in the SCS has been further improved, which is updated to be 13.1 1012 g C yr-1 as a CO2 source to the atmosphere. A "mechanistic semi-analytic algorithm" (MeSAA) was applied to estimate sea surface pCO2 in river-dominated coastal oceans using satellite data. Data synthesis further indicated that the input of exogenous dissolved inorganic carbon (DIC) and nutrients largely influences the temporal-spatial distribution pattern of CO2 fluxes in the SCS. The net DIC and dissolved inorganic nitrogen (DIN) flux transported through the Luzon strait was estimated to be 4295 Tg C yr-1 and 13 Tg N yr-1, respectively. Multi-scale carbonate system, nutrients and related biogeochemical cycles have been simulated through a high-resolution 3D circulation-biogeochemistry coupling model. The spatial variability of vertical DIC transport has been well examined showing the importance of mesoscale and submesoscale variations, which suggests that the horizontal divergence and/or convergence are the main controls. CHOICE-C II also examined the net diapycnal fluxes of DIC and nutrients to the euphotic zone. A higher DIC flux relative to phosphate than the Redfield stoichiometry infers DIC excess in the SCS. More results and progresses of CHOICE-C II will be presented at the 4th Xiamen Symposium on Marine Environmental Sciences (XMAS-IV).

【SPS3-107】 P-SPS3-02 Diagnosis of CO2 fluxes in global coastal oceans

Zhimian Cao, State Key Laboratory of Marine Environmental Science, Xiamen University
Wei Yang, State Key Laboratory of Marine Environmental Science, Xiamen University
Yangyang Zhao, State Key Laboratory of Marine Environmental Science, Xiamen University
Xianghui Guo, State Key Laboratory of Marine Environmental Science, Xiamen University
Zhiqiang Yin, State Key Laboratory of Marine Environmental Science, Xiamen University
Chuanjun Du, State Key Laboratory of Marine Environmental Science, Xiamen University
Huade Zhao, State Key Laboratory of Marine Environmental Science, Xiamen University
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University
Presenter Email: zmcao@xmu.edu.cn

The bulk of global coastal oceans represents an important carbon sink, but due to high spatial-temporal variability within and between coastal systems, a mechanistic-based conceptualization of the coastal carbon cycle remains elusive, hindering its modelling and inclusion in earth system models. Here we show that the latitudinal distribution of global coastal surface pCO2 displays a strong mismatch to temperature, and its inter-seasonal changes are substantially regulated by water mass mixing and biological drawdown. These processes operate in both ocean-dominated and river-dominated margins, with carbon and nutrients sourced from ocean and land interfaces, respectively. These can be conceptualized by an analytical framework that assesses relative consumption between

carbon and nutrients to determine how a coastal system is a carbon source or sink. The framework finds utility in identifying possible missing nutrients and testing hypotheses, and is therefore an essential first step toward comprehensive understanding and modelling of the global carbon cycle.

【SPS3-133】 P-SPS3-03 Partial pressure of CO2 and air-sea CO2 fluxes in the South China Sea-Update and synthesis

Qian Li, Xiamen University & The University of Delaware
Xianghui Guo, Xiamen University
Minhan Dai, Xiamen University
Weidong Zhai, Shandong University
Yi Xu, Xiamen University
Presenter Email: xhguo@xmu.edu.cn

This study reports thus far a most comprehensive dataset of surface seawater pCO2 (partial pressure of CO2) and the associated air-sea CO2 fluxes in the largest marginal sea in North Pacific, the South China Sea (SCS) based on 47 surveys conducted in 2000-2018. We categorized the SCS into five different domains featured with different physics and biogeochemistry to better characterize the seasonality of the pCO2 dynamics and to better constrain the CO2 flux. The five domains are (A) the northern SCS shelf, (B) the northern SCS slope, (C) the SCS basin, (D) West of Luzon Strait, and (E) western SCS. We showed highly dynamic spatial variability of sea surface pCO2 in the SCS except in winter when it ranged in a narrow band of 330 to 370 matm, while pCO2 in other seasons showed large variability. In general, surface water pCO2 in the northern SCS (Domains A, B and D) showed seasonal variation with low values in cold season and high values in warm season, except in the Pearl River plume (200-500 matm) and the area off northwest Luzon where winter upwelling occurred (370-390 matm). In the SCS basin and the western SCS (Domains C and E), surface water pCO2 was generally higher than that of the atmosphere (380-420 matm). Additionally, large intra-seasonal variation occurred. In spring, pCO2 increased with temperature in the northern SCS. It was a CO2 sink in March and CO2 source in May, while it was transitional system from sink to source in April. The area-weighted CO2 flux in the entire SCS was -1.1±2.2 mmol m^{-2} d^{-1} in winter, 0.9±0.9 mmol m^{-2} d^{-1} in spring, 2.5±1.4 mmol m^{-2} d^{-1} in summer and 1.9±1.1 mmol m^{-2} d^{-1} in fall. It is important to note that the standard deviations in these flux ranges mostly reflect the spatial variation of pCO2 rather than the bulk uncertainty. Nevertheless, on an annual basis, the average CO2 influx into the entire SCS shelf was 1.2±1.7 mmol m^{-2} d^{-1}.

【SPS3-28】 P-SPS3-04 Error analysis of gridded pCO2 in the South China Sea

Guizhi Wang, Xiamen University
Samuel Shen, San Diego State University
Minhan Dai, Xiamen University
Xianghui Guo, Xiamen University
Chuanjun Du, Xiamen University
Jianping Gan, Hong Kong University of Science and Technology
Presenter Email: gzhwang@xmu.edu.cn

There are three sources of error in gridded partial pressure of CO2 (pCO2), spatial variance, under-sampling variance, and measurement error. These sources of error in gridded pCO2 in the northern South China Sea were quantified using underway pCO2 data and model-derived pCO2 data. The seasonal signal of pCO2 was interpreted based on gridded pCO2 on 1/2°×1/2° grids. In general, summer has higher pCO2 than the other seasons in the northern South China Sea and winter has the lowest pCO2. This is consistent with previous studies. Greater uncertainty usually appears near the coast, mostly caused by greater spatial variance and a few caused by poor sampling coverage.

【SPS3-331】 P-SPS3-05 Seasonal variation of primary production in the northern South China Sea: integrated effects of drivers

Yuyuan Xie, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, Fujian, China
Lizhen Lin, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, Fujian, China
Haoran Liu, Department of Environmental Sciences, Xiamen University, Xiamen, Fujian, China
Bangqin Huang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, Fujian, China
Presenter Email: xieyuyuan@hotmail.com

The South China Sea (SCS), which is one of the largest marginal seas on earth, is in the edge of the southwestern North Pacific Ocean. The SCS has an area of 3.5*10^6 km2 with the average depth equals 1350 m. The northern boundary between the continent and the basin is the wide shelf of depths < 200 m, while the basin is deep up to 5000 m. Although some current characteristics of the SCS basin mimic those in the major ocean basins, the seasonal pattern of phytoplankton biomass and primary production is on the opposite side. Through the implementation of CHOICE-C I project, we have measured the seasonal variation of primary production in the northern SCS. The CHOICE-C II project continues to dig into the controlling mechanisms. In this study, we employed a diagnostic model to analyze those data for disclosing what aspects of the sea and how they are mastering the contrasting seasonal changes in primary production.

【SPS3-583】 P-SPS3-06-S Satellite-based estimation of particulate organic carbon export in the northern South China Sea

Teng Li, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Yan Bai, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Xianqiang He, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Yuyuan Xie, State Key Laboratory of Marine Environmental Science, Xiamen University
Xiaoyan Chen, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Fang Gong, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Delu Pan, State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration
Presenter Email: LITENGH@126.COM

Knowledge of particulate organic carbon (POC) export flux (EP) is the key to understanding the marine biological carbon pump, which is an important process in ocean carbon sequestration. In this paper, a satellite remote sensing algorithm based on the food-web model established by Siegel et al. (2014) was used to estimate EP in the northern South China Sea (NSCS), which consists of the direct sinking flux of large phytoplankton and associated aggregates by gravity and flux of zooplankton feces by grazing. This is the first time to unveil the fine spatiotemporal variation of satellite derived EP in the NSCS. Compared with the results on 1° spatial scale, the model results based on the satellite products with 1/3° or 1/12° spatial scales showed better consistency with the observations. Validation with in situ EP showed that the model exhibited a fairly good performance in the NSCS basin, but the predicted EP was much smaller than the measurements in the shelf regions. The model-predicted annual mean EP in the shelf areas was 8.47 mmol C·m-2·d-1 and that in the NSCS basin was 5.56 mmol C·m-2·d-1, on the 1/3° spatial scale, with the relative difference of about 50% and 15% for the shelf and basin, respectively. The flux of feces from zooplankton grazing, especially that from micro-zooplankton grazing, might account for the major fraction of EP in the NSCS. Accurate products of OPP and phytoplankton carbon content and size distribution would be helpful in improving the performance of the satellite-based EP model.

【SPS3-588】 P-SPS3-07-S The study of phytoplankton sinking rate in the South China Sea

Jun Sun, College of Marine and Environmental Sciences,Tianjin university of science and technology, Tianjin, 300457, China.
Yingjie Mao, College of Marine and Environmental Sciences,Tianjin university of science and technology, Tianjin, 300457, China.
Presenter Email: phytoplankton@163.com

Phytoplankton sinking rate in the South China Sea (15°~22°N,114°~120°E) was studied during summer 2017. We found that phytoplankton had a total of 186 species and were mainly composed of diatoms. The main dominant species of phytoplankton were *Trichodesmium thiebaultii*, *Prorocentrum lenticulatum*, *Thalassionema nitzschioides*, *Prorocentrum minimum*, *Thalassiosira minima*, *Navicula* spp., *Thalassionema nitzschioides* and *Prorocentrum compressum*, respectively. Phytoplankton sinking rate in the 200m layer of the surveyed area was the highest, followed by the 5m layer, however, the deep chlorophyll maximum (DCM) layer had the lowest sinking rate. As to carbon sinking flux, the 5m layer of which in studied area was the highest, while the DCM layer was the lowest. The carbon sinking flux in 5m layer ranged 0.105 mg C m^{-2} d^{-1} to 40.690 mg C m^{-2} d^{-1}, with an average of 13.00 mg C m^{-2} d^{-1}. While in the DCM layer, they were between 0.186 mg C m^{-2} $d^{-1}$and 5.097 mg C m^{-2} d^{-1}, with the average of 2.09 mg C m^{-2} d^{-1}. Consequently, these studies revealed that the sinking of phytoplankton cells was an important pathway for carbon export from the upper layer to the bottom layer, which provided an useful insight into the process of carbon cycling in the South China Sea.

【SPS3-351】 P-SPS3-08-S Assessment of the (de)coupling between phytoplankton growth and microzooplankton grazing in the euphotic layer in the South China Sea

Kailin Liu, The Hong Kong University of Science and Technology
Zhiyuan Shi, The Hong Kong University of Science and Technology
Zhimeng Xu, The Hong Kong University of Science and Technology
Hongbin Liu, The Hong Kong University of Science and Technology
Presenter Email: kliuah@connect.ust.hk

Microzooplankton (< 200um) herbivory is a main source of global phytoplankton biomass loss, accounting for about 67% of daily primary production and this proportion varies among marine habitats. However, this dataset is heavily depended on the rates estimated in the upper mixed layers, and the data of the deeper depth in the eutrophic zone is still scarce. At different depths, the phytoplankton growth rates will decrease with the depletion of light availability, while the grazing activities of micro-zooplankton may be less subject to light. As a result, the decoupling between growth and grazing rates may be pronounced with the increase of depths. Therefore, a vertical profile of grazing rates is

required to gain insights into the role of micro-zooplankton in marine food-web and carbon cycling. Although significant grazing activities had already been found at the base of euphotic zone in the eastern Pacific Ocean according to Landry et al. (2011), it hasn't been verified in marginal seas such as the South China Sea. In this study, we used a modified "two-points" dilution technique to estimate taxon-specific phytoplankton growth rates and mortality rates due to microzooplankton grazing activities in several depths of the euphotic zone to investigate the phytoplankton dynamics in South China Sea in summer and winter. Based on the preliminary results, the maximum phytoplankton growth rate occurs in the subsurface layer in summer, but in surface in winter. Nutrient limitation and strong light intensity may be the main reasons for the lower growth rate in the surface water in summer. The daily percentage of primary production consumed by microzooplankton of the euphotic water column ranged in 25%-151% in summer but 7%-35% in winter. At the same time, mesozooplankton biomass and herbivory was also measured, which showed that mesozooplankton only consumed a small proportion of phytoplankton growth (<10%), supporting the notion that microzooplankton is the main consumer of primary production and the most important link in both grazing food chain and microbial loop.

【SPS3-1003】 P-SPS3-09 Impact of Kuroshio Current intrusion on N dynamics and the subsequent C cycling in the northern South China Sea

Shuh-Ji Kao, State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University
NCG (Nitrogen Cycle Group), State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University
Presenter Email: sjkao@xmu.edu.cn

Intrusion of Kuroshio Current largely regulates the nutrient and organic matter distribution of the northern South China Sea. Yet little is known about its subsequent biological consequences of such physical process. We examined the ammonia oxidation rates, nitrogen fixation rates, nitrogen and carbon uptake rates along an intrusion gradient in the northern South China Sea. The ammonia oxidation rates ranged from 0.001 to larger than 100 nmol N L-1 d-1 with highest integrated rates located at site with moderate intrusion intensity, suggesting stimulated DON remineralization and NH4+ regeneration during the lateral mixing process. Nitrogen fixation, in another aspect, was positively correlated with the fraction of Kuroshio water, indicating that enhancement of nitrogen fixation was likely due to the introduce of abundant Trichodesmium from Kuroshio water. Interestingly, nitrogen fixation rates shown significant correlation with primary production, demonstrating an important role of nitrogen fixation as a new nitrogen source in supporting the productivity in this region. Moreover, by comparing the DIN (NH4+, NO3-) uptake rates with carbon uptake rates, we found the DIN in this region only account for around 50% of nitrogen source for primary producers, other nitrogen source such as DON must substantially contributed to primary production in this region. Together, these results demonstrate a significant but complex effect of lateral intrusion on the biogeochemistry of western boundary system, more studies are urgent to further disentangle the underlying mechanism.

【SPS3-518】 P-SPS3-10 Nutrient transport and dynamics in the South China Sea: A modeling study

Zhongming Lu, Hong Kong University of Science and Technology
Jianping Gan, Hong Kong University of Science and Technology
Minhan Dai, Xiamen University
Xiaozheng Zhao, Hong Kong University of Science and Technology
Presenter Email: luzm@ust.hk

We investigated nutrient transport and dynamics in the South China Sea (SCS) using the three-dimensional China Sea Multiscale Ocean Modeling System (CMOMS) coupled with a nitrogen-phosphorus-phytoplankton-zooplankton-detritus (NPPZD) ecosystem model. The model was validated by both field and remote sensing observational data. We reveal that the lateral and vertical fluxes associated with three-dimensional ocean circulation, together with the biogeochemical processes, shape the spatiotemporal characteristics of nutrients in both the shelf and basin regions of the SCS. There exists a unique layered distribution of nutrients that increasing from north to south of the upper layer and an opposite condition of the middle and deep layers. The organic forms of nutrients contribute importantly to the overall nutrient budget in the SCS, as nutrients exchange with the adjacent oceans in the upper layer through shallow straits. The nutrients in the euphotic zone of the N-limited oligotrophic SCS basin is mainly derived from the upward flux and remineralization, but it is diluted by influx through the Luzon Strait and consumed by biological production. Influx/outflux to the basin and subsequent vertical flux act as sources/sinks in the middle and deep layers. Remineralization contributes more importantly to PO4 than does NO3 in both the shelf and the basin due to its higher recycling rate. NO3 in the N and P co-limited shelf water comes from river plume and coastal upwelling, but it is consumed by biological production and downward flux, while PO4 mainly comes from remineralization and upward flux due to the strong downward increasing gradient.

【SPS3-76】 P-SPS3-11 Modeling age of Kuroshio water in the South China Sea

Peng Cheng, State Key Laboratory of Marine Environment Science, Xiamen University
Runqing Lv, State Key Laboratory of Marine Environment Science, Xiamen University
Presenter Email: pcheng@xmu.edu.cn

Kuroshio is the major source of energy and mass of the South China Sea. Understanding the dispersion and age of Kuroshio water is crucial to explore the mass transformation and nutrients transport in the South China Sea. A three-dimensional numerical model based on

ROMS was developed for the China seas and the constituent oriented age and residence time theory was applied for tracing water age. The source of tracers were displayed above 600 m depth from the Philippines east coast to 125 oN along 17 oN and the model ran for 10 years. The results showed that the water age was about 2 years at the Luzon Strait and was about 4.5 years at the Karimata Strait, implying that it takes about years for the Kuroshio water transport across the South China Sea. At the Taiwan Strait, the inflow age was a few months older than outflow during winter season which indicates that the Kuroshio water moves along the Taiwan Island east coast and enters the East China Sea, then turns around, moves southward and enters the South China Sea again due to the winter northerly winds. The water age averaged over the entire basin was about 3.5 year in 200 m depth, 5 year in 500 m depth and 6 years in 1000 m depth. Those age differences at different depths gave the vertical water exchange rate. From 100 m to 500 m depth, large rates appeared along the north shelf slope in a range of 2.4.5 m/d; smallest rates appeared in the southern basin. From 500 to 1000 m depth, the strongest vertical exchange occurred along the south slope having a magnitude of 2.5 m/d; the weak vertical exchange appeared in the central and northern basin.

【SPS3-706】 P-SPS3-12 Progress on dynamical modulation, simulation and variation trend of the carbon cycle in the South China Sea

Jianyu Hu, Xiamen University
Jianping Gan, Hong Kong University of Science and Technology
Zhongming Lu, Hong Kong University of Science and Technology
Peng Cheng, Xiamen University
Zhiqiang Liu, Hong Kong University of Science and Technology
Presenter Email: hujy@xmu.edu.cn

Based on several comprehensive cruises of observational data, and long time series of satellite data and reanalysis data, accompanied by advanced numerical modeling, we have made a good progress on the dynamical modulation, simulation and variation trend of the carbon cycle in the South China Sea. So far, we have published about 30 papers on the SCI journals. Here we present some representative results (1) to highlight the main ocean dynamical processes, such as circulation, upwelling and river plume, for modulating the carbon and nutrient transports in the Ocean Dominated Margin (OceMar) and the River Dominated Margin (RioMar) seas; (2) to integrate the numerical simulation and mechanism studies of the three-dimensional circulation, carbon cycle and nutrient transport in the South China Sea using a coupled physical–biogeochemical model; and (3) to estimate the long term trend of the carbon cycle in the South China Sea.

【SPS4-913】 P-SPS4-01 Progress on the Study of Ocean Circulation, Ecosystem and Hypoxia around Hong Kong Waters (OCEAN_HK)

Jianping Gan, Hong Kong University of Science and Technology
OCEAN_HK Team Members, Hong Kong Research Grant Council
Presenter Email: magan@ust.hk

OCEAN_HK (https://ocean.ust.hk/) is under the Theme-based Research Scheme (TRS) funded by Hong Kong Research Grants Council. The team of this interdisciplinary project consists of researchers from five local universities, two Mainland institutions and one Taiwanese university, as well as international collaborators from the USA. The objective of OCEAN_HK is to conduct diagnosis and prognosis of intensifying eutrophication, hypoxia and the ecosystem consequences around Hong Kong waters by conducting coupled physical-biogeochemical-pollution studies. We investigate the status, causes, consequences and trends of eutrophication and hypoxia around Hong Kong (HK) in the vicinity of the Pearl River estuary (PRE), in order to derive a new scientifically based cost-effective water treatment/protection strategy and scheme. Derived from repeated field measurements, laboratory experiments and coupled physical-biogeochemistry-pollution modelling, this presentation highlights our recent achievements on pursuing scientific understanding of eutrophication, hypoxia and acidification in the Pearl River Estuary, Hong Kong waters and adjacent shelf. The new findings on the concerned issue are illustrated in four interlinked aspects of a) sources and sinks of nutrients and biogeochemical controls; (b) ecosystem dynamics and biological controls; (c) pollutant and ecosystem impacts; (d) physical controls, synthesis, and future trends.

【SPS4-915】 P-SPS4-02-S Dynamics of ammonium in the Pearl River Estuary under summer hypoxic conditions

Jing Liu, State Key Laboratory of Marine Science
Yangyang Zhao, State Key Laboratory of Marine Science
Tao Huang, State Key Laboratory of Marine Science
Lifang Wang, State Key Laboratory of Marine Science
Zhongwei Yuan, State Key Laboratory of Marine Science
Minhan Dai, State Key Laboratory of Marine Science
Presenter Email: LiuJing@st.,xmu.edu.cn

We examine ammonium dynamics in the Pearl River Estuary (PRE), a highly eutrophic system where extensive hypoxia is emerging in its lower estuary in the summer time. A total of 312 water samples for ammonium were collected from the PRE in July 2017 when an extensive area in the lower PRE was under hypoxic conditions. Ammonium was measured on board by using the indophenol blue colorimetric method at M level concentrations or by using a more sensitive fluorescence method with preconcentration was at nM concentration levels. Ammonium concentration ranged from 37 M in the upper estuary down to 100nM~2 M in the lower estuary, and to 35 nM~300 nM in the offshore area. Our data showed that ammonium was overall non-conservative during the estuarine mixing showing rapid removal in the upper estuary due probably to nitrification but significant additions in the lower estuary around Shenzhen, Hong Kong and Macau due likely to the sewage discharge. Such ammonium additions were also obvious in the subsurface and bottom waters where we found consistently high concentrations of total suspend matter suggesting that degradation of organic particles is a major source of ammonium therein. We adopted a multiple end-members model to further characterize the ammonium dynamics in different regimes of the lower estuary. Ammonium was slightly removed in the surface layer (0.8±0.3 mol/kg) where nitrate was much more profoundly removed (28±5 mol/kg), indicating that nitrate was the major nitrogen species fueled the phytoplankton bloom. Ammonium was slightly added in the hypoxic bottom water (<0.5 mol/kg) where nitrate was much more significantly regenerated (15±5 mol/kg). This inferred that nitrification contributed to the oxygen consumption in the hypoxic zone. However, the ratio between oxygen consumption vs inorganic nitrogen production amounted to 25±5.1, which was much higher than the Redfield stoichiometry, indicating nitrogen losses relative to the oxygen consumption, the exact reason of which remains however unknown. We contend that ammonia dynamics in the hypoxic zone is much more complex than what was previously thought.

【SPS4-562】 P-SPS4-03-S Eutrophication-enhanced acidification in a large subtropical estuary system: the Pearl River Estuary

Yangyang Zhao, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, China
Jing Liu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, China
Khanittha Uthaipan, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, China
Biyan He, College of Food and Biological Engineering, Jimei University, Xiamen 361021, China
Minhan Dai, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen 361102, China
Presenter Email: yyzhao@stu.xmu.edu.cn

Anthropogenic inputs of nutrients to coastal waters fuel the excessive production of phytoplankton, a process known as eutrophication, and the resultant export of organic matter stimulates microbial respiration in the subsurface waters. In addition to the decline in oxygen levels, the carbon dioxide produced during microbial consumption of organic matter increases acidity. Water mass mixing with different ratios of dissolved inorganic carbon (DIC) to total alkalinity (TA) from the subsurface water also modulate acidity to a large extent. Here, we assess the synergistic impacts of eutrophication and water mass mixing on acidity in a large subtropical estuary system, the Pearl River Estuary (PRE), featured by large freshwater runoff and heavy nutrient loadings from the Pearl River and extensive seasonal hypoxia in summertime. Using data collected in the PRE and its adjacent waters during a cruise under the Ocean-HK project conducted in July 2017, a semi-analytical diagnostic approach was applied to resolve pH dynamics based on a validated multiple-endmember water mass mixing model. We show that the acidification of subsurface waters was exacerbated with the development of hypoxia (dissolved oxygen, DO, less than 2 mg L^{-1} or ~63 滑 mol kg^{-1}) as expected and the drawdown of pH could be up to -0.31 鹵 0.05 units in the hypoxic zone. pH deviations from the modelled pH-DO line due to water mass mixing varied from -0.08 to 0.12 units, depending on the DIC/TA ratios and fractions of freshwater and surface water that advected into the subsurface layer. Using model simulations, we will also present how eutrophication, rise in anthropogenic CO_2 and temperature as well as community respiration rate would modulate the pH, in the future scenarios.

【SPS4-477】 P-SPS4-04 Nitrogen isotopes in a complex urbanized marine environment

Anand Archana, School of Biological Sciences & Swire Institute of Marine Science, University of Hong Kong, Hong Kong SAR
Benoit Thibodeau, Department of Earth Sciences & Swire Institute of Marine Science, University of Hong Kong, Hong Kong SAR
Naomi Geeraert, School of Biological Sciences & Swire Institute of Marine Science, University of Hong Kong, Hong Kong SAR
Min Nina Xu, State Key Laboratory of Marine Environmental Science, Xiamen University, PRC
Shuh-Ji Kao, State Key Laboratory of Marine Environmental Science, Xiamen University, PRC
David M. Baker, School of Biological Sciences & Swire Institute of Marine Science, University of Hong Kong, Hong Kong SAR
Presenter Email: bthib@hku.hk

Elevated nutrient inputs have led to increased eutrophication in coastal marine ecosystems worldwide. An understanding of the relative contribution of different nutrient sources is imperative for effective water quality management. Stable isotope values of nitrate ($\delta^{15}N_{NO_3^-}$, $\delta^{18}O_{NO_3^-}$) can complement conventional water quality monitoring programs to help differentiate natural sources of NO_3^- from anthropogenic inputs and estimate the processes involved in N cycling within an ecosystem. We measured nutrient concentrations, $\delta^{15}N_{NO_3^-}$, and $\delta^{18}O_{NO_3^-}$ in 76 locations along a salinity gradient from the lower end of the Pearl River Estuary, one of China's largest rivers discharging into the

South China Sea, towards the open ocean. NO3- concentrations decreased with increasing salinity, indicative of conservative mixing of eutrophic freshwater and oligotrophic seawater. However, our data did not follow conservative mixing patterns. At salinities <20 psu, samples exhibited decreasing NO3-concentrations with almost unchanged NO3- isotope values, indicating simple dilution. At salinities >20psu, NO3- concentrations decreased, while dual NO3- isotopes increased, suggesting mixing and/or other transformation processes. Our analysis yielded mean estimates for isotope enrichment factors (15ε = -2.02‰ and 18ε = -3.37‰, Δ(15,18)=-5.5‰ and δ15NNO3- - δ15NNO2- = 12.3‰. After consideration of potential alternative sources (sewage, atmospheric deposition and groundwater) we concluded that there are three plausible interpretations for deviations from conservative mixing behaviour (1) NO3- uptake by assimilation (2) in situ NO3- production (from fixation-derived nitrogen and nitrification of sewage-derived effluents) and (3) input of groundwater nitrate carrying a denitrification signal. Through this study, we propose a simple workflow that incorporates a synthesis of numerous isotope-based studies to constrain sources and behaviour of NO3- in urbanized marine environments.

【SPS4-276】 P-SPS4-05-S The role of atmospheric deposition in the generation of eutrophication, hypoxia and harmful algal bloom in Hong Kong

Yau Yu Yan Yvonne, Department of Earth Sciences and SWIRE Institute for Marine Science, The University of Hong Kong
Naomi Geeraert, School of Biological Sciences and SWIRE Institute for Marine Science, The University of Hong Kong
David M Baker, School of Biological Sciences and SWIRE Institute for Marine Science, The University of Hong Kong
Benoit Thibodeau, Department of Earth Sciences and SWIRE Institute for Marine Science, The University of Hong Kong
Presenter Email: u3511209@connect.hku.hk

Humans have significantly altered the global nitrogen cycle by artificially fixing N2 in the last century. Anthropogenic creation of reactive nitrogen (N) from fossil fuel combustion and fertilizer production increased ten-fold between 1860 and 2000. A large part of this N is released to the atmosphere, transported over short to large distance and deposited over coastal and marine areas. This new bioavailable N from the atmosphere can act as a fertilizer to the ocean, enhancing primary productivity and biological oxygen demand, which pose many ecological threats such as eutrophication, hypoxia and harmful algal bloom. Waters surrounding Hong Kong suffer from all these problems but the role of atmospheric deposition in this region is still unquantified. It is thus critical to quantify the atmospheric N input and diagnose the sources of pollution in Hong Kong. In this study, we measured δ15N and δ18O of nitrate in the atmospheric N deposition (wet and dry

deposition and aerosols) in the Hong Kong. The samples are collected in HKU building, which is surrounded by a mix of commercial and residential area, with intense traffic. Based on the data set, we hope to identify the sources of atmospheric N and quantifying their importance for the marine N budget.

【SPS4-603】 P-SPS4-06-S The spatial distribution of mesozooplankton biomass, abundance and size spectra in response to hypoxia in the Pearl River estuary

Zhiyuan Shi, The Hong Kong University of Science and Technology
Mitsuhide Sato, The Hong Kong University of Science and Technology
Yanhong LU, The Hong Kong University of Science and Technology
Zhimeng XU, The Hong Kong University of Science and Technology
Hongbin LIU, The Hong Kong University of Science and Technology
Presenter Email: zshiae@connect.ust.hk

The Pearl River estuary was investigated to examine the distribution patterns of mesozooplankton (200-2000 um size range) and its relationships with hypoxia (< 2 mg/L in dissolved oxygen). Both plankton net towing and high-capacity pump sampling were used to collect mesozooplankton at different stations and water depths. Mesozooplankton had a higher biomass and abundance in the whole water column where bottom water hypoxia was observed. There were higher mesozooplankton biomass in the bottom hypoxic water during the daytime, which suggests possible tolerance to low oxygen of some migratory species. Copepods were the numerically dominant mesozooplankton group at all sampling stations. Stations with bottom hypoxic waters had lower taxonomic diversity and were most dominated by Acartia spp. and Paracalanus spp. The normalized biovolume size spectrum (NBSS) of mesozooplankton was constructed to analyze the trophic structure of the community. The high intercepts of the NBSS indicated a high productivity in the stations with bottom hypoxic waters, which were consistent with the accompanying high mesozooplankton biomass and total Chl a concentration. The higher mesozooplankton biomass in those stations with hypoxia may be supported by the high phytoplankton biomass and the tolerance of some migratory species. Our results indicate the ecological relevance of mesozooplankton to the estuary hypoxia and provide more information for a further understanding of the estuarine ecosystem.

【SPS4-535】 P-SPS4-07-S Microbiological evaluation of anthropogenic pollution in Pearl River Estuary and the adjacent South China Sea

Fangzhou Chen, Division of Environment and Sustainability The Hong Kong University of Science and Technology
Mandy Ly Tang, Department of Ocean Science The Hong Kong University of Science and Technology
Xiu Pei Kou, Division of Environment and Sustainability The Hong Kong University of

Science and Technology
Stanley Ck Lau, Department of Ocean Science and Division of Environment and Sustainability The Hong Kong University of Science and Technology
Presenter Email: fchenac@ust.hk

The Pearl River Delta is polluted by industrial, agricultural, and municipal wastes. Different types of pollution can cause different impacts to the diversity and ecosystem function of the bacterial communities in the receiving waters through the introduction of exogenous bacteria and/or alteration of the indigenous bacterial communities. The exogenous bacteria include the pathogens of humans and different species of farm animals, antibiotic resistant bacteria, metal resistant bacteria, etc. Therefore, the investigation of bacterial community composition and function in polluted waters provide an opportunity to trace the source of pollution and evaluate the ecosystem impacts of pollution. In this study, we collected water samples from various locations in Pearl River estuary and the adjacent South China Sea and analysed the bacterial communities therein for (1) community composition using 16S rRNA genes amplicon sequencing, (2) community function using metagenomic and metatranscriptomic sequencing, and (3) the abundance of class 1 integron as a proxy of the anthropogenic pollution level. Our results thus far indicate that bacterial community composition in the waters changed gradually from the head of estuary to open ocean with freshwater groups such as Actinobacteria and Verrucomicrobia being replaced by marine groups such as the SAR406 clade. Hypoxia appeared to have stronger impacts on particle-attached bacteria than the free-living counterpart. In regard to anthropogenic impacts, the PRE was fecally polluted, with E. coli concentrations exceeding 1000 CFU/100ml being detected at the head of the estuary. The prevalence of class 1 integron genes in E. coli and total bacterial community was higher in PRE than in the coastal water of Hong Kong and South China Sea, suggesting that the bacterial communities in the former are heavily impacted by multi-stressors of anthropogenic sources. The sequence analysis of the class 1 integron gene cassettes as well as the metagenome and metatranscriptome revealed the nature of the stressors and their effects on community functions with respect to pollutant degradation and sequestration, stress response, and the expression of pathogenic genes.

【SPS4-516】 P-SPS4-08 Expanding bottom hypoxia in the Pearl River Estuary and its possible mechanism as inferred from dynamics of plankton communities

Mitsuhide Sato, Hong Kong University of Science and Technology
Yanhong Lu, Hong Kong University of Science and Technology
Ying Ke, Hong Kong University of Science and Technology
Zhimeng Xu, Hong Kong University of Science and Technology
Pui Yee Lee, Hong Kong University of Science and Technology
Minhan Dai, Xiamen University
Jianping Gan, Hong Kong University of Science and Technology

Hongbin Liu, Hong Kong University of Science and Technology
Presenter Email: mitsuhide@ust.hk

In the Pearl River Estuary (PRE), the bottom hypoxia has occurred in summer since 1990s, which resulted from phytoplankton bloom fueled by riverine discharge of bioavailable nutrients. In July of 2017, we observed the largest bottom hypoxia (approximately 1,700 km2) that has been reported ever, spanning from Huangmaohai to Hong Kong Island. From the biological parameters we measured during the cruise, we suggest that the mechanism underlying the formation of the bottom hypoxia and the phase of its development were spatially heterogeneous. In the western area near Huangmaohai, widespread high chlorophyll a concentration > 10 μg L−1 was observed in the surface water. In contrast, primary production was generally low in this area and high only near the river mouths, where the detectable phosphate remained at surface. These observations suggest that additional supply of nutrients, particularly phosphate, from Huangmaohai and western tributaries of the Pearl River fueled primary production in this area. On the contrary, the eastern area near Hong Kong Island was characterized by low chlorophyll a concentration and primary production, and high bacterial abundance and production. These observations suggest that the phytoplankton bloom in this area had reached a decline phase and regeneration production had prevailed. High abundance of *Synechococcus* and the detectable level of ammonium at surface also support this explanation. The present results revealed the importance of nutrient load from Huangmaohai in expansion of phytoplankton bloom and subsequent bottom hypoxia in the PRE.

【SPS4-335】 P-SPS4-09 Occurrence, distribution and risk of contaminants of emerging concern in marine ecosystem of the South China Sea

Mirabelle M. P. Tsui, State Key Laboratory in Marine Pollution (SKLMP), City University of Hong Kong, Hong Kong SAR, China
Lianguo Chen, State Key Laboratory in Marine Pollution (SKLMP), City University of Hong Kong, Hong Kong SAR, China
Qi Wang, State Key Laboratory in Marine Pollution (SKLMP), City University of Hong Kong, Hong Kong SAR, China
Xin Li, State Key Laboratory in Marine Pollution (SKLMP), City University of Hong Kong, Hong Kong SAR, China
James C. W. Lam, Department of Science and Environmental Studies, The Education University of Hong of Kong, Hong Kong SAR, China
Paul K. S. Lam, State Key Laboratory in Marine Pollution (SKLMP), City University of Hong Kong, Hong Kong SAR, China
Presenter Email: mpmtsui2@cityu.edu.hk

Coastal eutrophication is caused by excessive nutrient loading which stimulates

phytoplankton blooms when physical, chemical, and biological conditions are favorable. It may lead to harmful algal blooms (HABs) and hypoxia, both of which threaten the ecosystem. The aquatic environment of the Pearl River Estuary (PRE) is chronically contaminated by contaminants of emerging concern (CECs) such as per- and polyfluoroalkyl substances (PFASs) and organic ultraviolet (UV) filters. These chemicals are released to the aquatic environment during their production, usage and disposal into wastewater treatment plants. They have accumulated in the top predators in the southern China region and are posing a risk to marine wildlife. In this project, our team has conducted chemical and toxicological studies in order to (1) identify pollution sources of various CECs and their effects on HABs, (2) investigate the accumulation and transportation of these contaminants through the food web and (3) assess their eco-toxicological disruption to the ecosystem. In the chemical analysis part, the measured environmental concentrations (MECs) of CECs in water and sediment were determined by validated quantitative analytical methods; while their transport, fate and ecological impacts in the RES were also monitored. Moreover, PFASs can be used as tracers for the identification and validation of ocean circulation; while coprostanol, one of the fecal stanols can be used as a marker of sewage in the river-estuary-shelf system (RES). In the toxicological part, an exposure platform, using marine medaka (*Oryzias melastigma*) as model species, was established in order to study the toxic effects of CECs and determine the predicted no effect concentrations (PNEC) under chronic toxicity condition. Recently, the C-8 PFAS homologue, perfluorooctanesulfonate (PFOS), has been listed as a persistent organic pollutant by the Stockholm Convention, which drives the phasing out of this substance. As an alternative, the shorter chain C-4 perfluorobutanesulfonate (PFBS) is synthesized to meet the market demand. However, the increasing usage of PFBS has led to contamination of environment. The toxicological effects in marine organisms after a life-cycle exposure to PFBS on the disruption of the thyroid endocrine system and the impairment of visual function in eyes were investigated. By combining the data obtained from both chemical and toxicological studies, risk quotients can be calculated and thus environmental risks in the RES can be assessed.

【SPS4-1086】 P-SPS4-10 Harmful algal blooms (HABs) and their impact-Case study on hypoxia zone in Pearl River Estuary

Pengbin Wang, Key Laboratory of Marine Ecosystem and Biogeochemistry, The Second Institute of Oceanography, State Oceanic Administration (SOA)
Douding Lu, Key Laboratory of Marine Ecosystem and Biogeochemistry, The Second Institute of Oceanography, State Oceanic Administration (SOA)
Leo Lai Chan, State Key Laboratory in Marine Pollution, City University of Hong Kong
Xinfeng Dai, Key Laboratory of Marine Ecosystem and Biogeochemistry, The Second Institute of Oceanography, State Oceanic Administration (SOA)

Jiajun Wu, State Key Laboratory in Marine Pollution, City University of Hong Kong
Presenter Email: jiajunwu@cityu.edu.hk

Observations of harmful algal blooms (HABs) are increasing around the world's coastal ocean, with a growing number of reports indicating anthropogenic influences. These phenomena are caused by blooms of microscopic algae. Excessive microalgae growth in response to nutrient increases and/or shifts in nutrient ratios can result in a HABs of a single or several species that has negative ecosystem impacts. As HABs occur and result in the depletion of oxygen (hypoxia) in the water, fishery disasters were reported by many countries. To study the relationship of HABs and hypoxia, we conducted a study on 34 sites via cruise at the Pearl River Estuary from July 10-21, 2017. The temperature and salinity of surface water ranged from 27.9-30.8 oC and 5.4-33.9psu, respectively. The dissolved oxygen (DO) of surface water was from 6.1 to 11.7, while the DO of bottom water was lowest reach to 1.3 and the highest DO were just 7.4, an obvious hypoxia and low oxygen zone were detected. At the same time a wide range of phytoplankton bloom in surface water were observed over 10 study sites over 5000cells/ml and with maximum 45560 cells/ml at site F201. After the principal component analysis, there showed a positive correlation between phytoplankton abundance of surface water and DO of surface water, and a negative correlation were shown between phytoplankton abundance of surface water and DO at bottom layer. Further, with the analysis of Next Generation Sequencing on bacteria composition of sediment, we have detected several typical bacteria may related HABs and hypoxia, such as family Saprospiraceae and class Clostridia, which give some evidence on HABs and its coupled benthic microbial community may trigger and accelerate hypoxia zone formation at the Pearl River Estuary.

【SPS4-60】 P-SPS4-11 Numerical active open boundary conditions for tidally and subtidally forced estuarine-shelf circulation

Zhiqiang Liu, Division of Environment and Sustainability, The Hong Kong University of Science and Technology
Jianping Gan, Department of Ocean Science and Department of Mathematics, The Hong Kong University of Science and Technology
Presenter Email: liuzhq@connect.ust.hk

We investigated performance of an open boundary condition for tidally and subtidally (TST-OBC) forced shelf circulation over a limited-area, one-way downscaling numerical modeling system in the northern South China Sea (NSCS). The circulation in this downscaling modeling system was driven by both subtidal and amplified tidal forces with notable spatial and temporal variations. The TST-OBC numerically and physically well accommodated the circulations driven not only by the regional tides, subtidal forces and external forcing from its upscale solution, but also by the internally generated disturbances. The model well captured the observed characteristics of circulations under complex dynamic environment,

as a result of the numerical and physical advantages in TST-OBC, such as separation of fast tidal and slow subtidal mode, adoptions of active (rather than passive) and dual-wave transmitting scheme, consistent treatments of barotropic, baroclinic circulations, and thermodynamic variables. The results greatly contrasted from those obtained from the frequently adapted Flather-type OBC in the tidally forced open boundary, which over-strongly restored internal to external solutions with creation of a notable accumulation of spurious disturbances along open boundaries. Disturbances travelling across the computational domain and arriving open boundaries were unrealistically swapped by FLA-OBC, and a sensible communication between submodels in the downscaling modeling system was prevented without adopting the advantages of the TST-OBC.

【SPS4-807】 P-SPS4-12 Joint effects of extrinsic biophysical fluxes and intrinsic hydrodynamics on the formation of hypoxia west off the Pearl River Estuary

Zhongming Lu, Hong Kong University of Science and Technology
Jianping Gan, Hong Kong University of Science and Technology
Minhan Dai, Xiamen University
Hongbin Liu, Hong Kong University of Science and Technology
Xiaozheng Zhao, Hong Kong University of Science and Technology
Presenter Email: luzm@ust.hk

Using field measurements and a process-oriented three-dimensional coupled physical-biogeochemical numerical model, we investigated the physical and biogeochemical processes governing the bottom hypoxia zone in the western shelf off the Pearl River Estuary. The intensity and area of the hypoxia grew with increasing total nutrient input from the Pearl River that has increased continuously in recent decades. The hypoxia zone was formed and maintained largely associated with the stable water column where the stability was provided simultaneously by wind stress and freshwater discharge, favourable local hydrodynamics for flow convergence, and westward organic matter transport. Wind stress altered the stratification, and freshwater discharge changed the stratification and baroclinic velocity shear simultaneously. Two-layered flow with a cyclonically-rotating current around a salient edge of the western shelf off the estuary hydrodynamically enhanced the local convergence, allowing sufficient residence time for the remineralization of organic matter produced in the hypoxic zone and organic matter transported into the region. Our results suggest that a combination of unique local hydrodynamic feature and decomposition of organic matter in water column and sediment are the cause of the formation and maintenance of the bottom hypoxia in the western shelf of the estuary during summer.

【SPS4-398】 P-SPS4-13-S Integration of catchment model and river delta network for improving simulation of fresh water discharges from outlets to estuary: a case study of Pearl River Delta and Estuary

Xiao Feng, The University of Hong Kong
Ji Chen, The University of Hong Kong
Zhongming Lu, Hong Kong University of Science and Technology
Presenter Email: xfeng19@hku.hk

Estuary waters are strongly affected by river fresh water discharges from the upstream basins; nevertheless, the fresh water discharges at an estuary is difficult to monitor due to the mixture of seawater intrusion to the river delta. This is a research gap in the world to rationally estimate the fresh water discharges into estuary. Moreover, it is of great importance to improve the simulation skills of discharges from outlets to estuary for study of coastal waters and better understanding of influence on estuary from river basin. In this study, the Pearl River estuary in South China is selected as the study area. Due to its complicated upstream river network and frequent human activities in the Pearl River delta, the estimation of discharges from the Pearl River delta to the estuary is rather challenging. SWAT (Soil and Water Assessment Tool) model is selected to simulate the terrestrial processes including streamflow, sediment and water quality in the Pearl River basin. Three scenarios for representing different diversion methods are used to test the influence of fresh water discharges on salinity of the estuary water. For validation, a coastal model is used to confirm the results from three scenarios through using salinity observations. This study will provide a method for the integrated study of river basin and estuary and can be applied in other regions in the world.

【SPS5-138】 P-SPS5-01 MARine CarbOn sequestration in marginal sea ecosystems (MARCO): multiscale regulation and response to global changes-Overview and Progress

Bangqin Huang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Guangxing Liu, Key Laboratory of Marine Environment and Ecology, MOE, Ocean University of China, Qingdao, China
Dalin Shi, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Gangjian Wei, State Key Laboratory of Isotope Geochemistry, Institute of Geochemistry, CAS, Guangzhou, China
Presenter Email: bqhuang@xmu.edu.cn

Ocean is the largest carbon stock in the Earth, it plays an important role in the global carbon cycle, and significant impact on the Earth's climate system. Biological pump (BP) and microbial carbon pump (BCP) are two of the most important pathways for the carbon

sequestrations, the efficiency of which determined the carbon stock changes in the ocean and atmosphere. The on-going research program MARCO aims to clarify the ocean carbon sequestration mechanism and interpretation of ocean acidification effect on carbon sequestration and storage, establish the ocean sedimentary carbon stock changes linked to global changes, further analysis in the process of marine ecosystem carbon storage multiscale regulation mechanism in marginal sea ecosystems. 4 themes "carbon fixation process -carbon storage mechanism-acidification effect-sediment carbon stock changes" were set up around the core scientific question. Three typical ecological systems (continental shelf, basin and coral reefs) in the northern South China Sea with significant differences of biological community structure and carbon library changes were taken as the study sites. The MARCO will be initiated from the modern biogeochemical process, to demonstrate marine ecosystem carbon process and mechanism of carbon storage and its response to ocean acidification at different levels (gene protein-individual-population-community-ecosystem), Combined with different carbon stock changes of sedimentary systems in 2000 years and high-resolution sea water temperature, pH and carbon library records since the industrial revolution, to explore the ocean carbon stock changes to natural climate changes and human activities in response mechanism, to clarify regulation mechanism of the biological pump and microbial carbon pump. The implementation of the MARCO will be a significant boost in the marine carbon cycle and carbon storage mechanism research in marginal sea ecosystems. Significant progress has been made since the project was initiated in 2016, for example, temporal and spatial variations of phytoplankton community, group niches and environmental influence, size-fractionated and group-based primary production, plankton community influence on POC export in contrast ecosystems in South China Sea, ocean acidification on nitrogen fixation, and response of coral reef ecosystems to global warming and ocean acidification. Keywords: carbon sequestration; biological pump; microbial carbon pump; ocean acidification; sediment core record; global changes

【SPS5-643】 P-SPS5-02-S Controlling mechanism of size-specific photosynthetic parameters of phytoplankton in the Taiwan Strait

haoran Liu, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
yuyuan Xie, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
bangqin Huang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: liuhaoran123@qq.com

In the marine ecosystem, the phytoplankton photosynthesis in the sunlit layer drive the transmission of substance and energy in the ecosystem. The photosynthesis of phytoplankton play a critical role in global carbon cycles and regulating the earth's climate. Size structure is an important biological feature of the phytoplankton. The study of size structure and photosynthetic physiology of phytoplankton contribute to the further analysis of the structure and function of marine ecosystem. In this study, size-fractionated (>2μm and <2μm) photosynthesis-irradiance experiments coupling temperature, irradiance, phytoplankton community structure were conducted in the temperate monsoon-driven Taiwan straits during November 2015, March-April 2016, July 2016 and August 2016, respectively. Our study explored the seasonal variability and control on size-dependent photosynthetic parameters of phytoplankton in the temperate monsoon-driven Taiwan Strait. The main results were:

(1) The depth-integrated primary production in the euphotic layer ranged from 242.7-1174.1 mg C m-2 d-1 in autumn, 171.4-1000.0 mg C m-2 d-1 in spring and 129.3-4328.3 mg C m-2 d-1 in summer, respectively. The depth-integrated primary production showed positive correlation with the euphotic layer depth-integrated Chl a ($p < 0.001$). Moreover, the depth-integrated primary production was significantly correlated with the contribution of >2 μm phytoplankton biomass to total biomass ($p < 0.001$). The size-dependent euphotic layer depth-integrated Chl a and primary production revealed obviously seasonal variation in the Taiwan Strait. The >2 μm size phytoplankton contributed mostly of depth-integrated Chl a and primary production during autumn, the contribution of <2 μm size phytoplankton increased during spring, moreover, <2 μm size phytoplankton contributed most of biomass and primary production except the coastal stations which influenced by physical process during summer.

(2) The phytoplankton assimilation numbers were significantly correlation with the phytoplankton size structure, assimilation numbers were positive correlated to >2 μm phytoplankton contribution to total biomass in summer ($p < 0.01$), whereas showed negative relationship in spring ($p < 0.05$). and α showed the highest value during autumn cruise, which might associated to the lowest irradiance during autumn and low-light acclimation accelerating the phytoplankton photosynthetic pigment synthesis and enzymatic reactants (ATP, NADPH). In addition, the and αB were similar in size during autumn, which might correspond to the constrain to PSI and PSII in both size phytoplankton. and α of pico-phytoplankton were greater than large phytoplankton during spring, which might in related to the package effect that <2 μm phytoplankton own the higher light absorption coefficient. However, The of >2 μm phytoplankton sustained higher than pico-phytoplankton and α was similar in size in summer, suggesting the absorption of irradiance might not the effect that constrain the photosynthesis and the higher might associated to the higher PSII efficiency or the higher nutrient storage ability of >2 μm phytoplankton. The Ek of >2 μm phytoplankton was significantly greater than the pico-phytoplankton, which may indicate that causing the package effect, the pico-phytoplankton have lower irradiance requirements than large size class phytoplankton to

saturate photosynthesis. In addition, the APP index increased with the irradiance, and Ek showed positive correlation to the APP index. In autumn cruise, the and ɑ demonstrated no significantly discrepancy in optical depth, whereas both size of and ɑ was decreased with optical depth increased in spring and summer (: $p < 0.05$, ɑ: $p < 0.05$, Spring; : $p < 0.001$, ɑ: $p < 0.001$, Summer, Mutil-ANOVA Analysis), suggesting the distinct photoacclimation mechanism in mixing water and stratification water.

【SPS5-585】 P-SPS5-03 The modulation of nonlinear circulation to the biological productivity in the summer Vietnam upwelling system

Wenfang Lu, Fuzhou University; Xiamen University; University of Delaware
Enhui Liao, Princeton University
Xiao-Hai Yan, University of Delaware;Xiamen University
Lie-Yauw Oey, Princeton University
Wei Zhuang, Xiamen University
Yuwu Jiang, Xiamen University
Presenter Email: luwf@fzu.edu.cn

Biological productivity in the summer Vietnam boundary upwelling system in the western South China Sea, as in many coastal upwelling systems, is strongly modulated by winds. However, the role of ocean circulation and mesoscale eddies has not been elucidated. Here we show a close spatiotemporal covariability between primary production and kinetic energy. High productivity is associated with high kinetic energy, which accounts for ~15% of the production variability. Results from a physical-biological coupled model reveal that the elevated kinetic energy is linked to the strength of the current separation from the coast. The separated current forms an eastward jet into the interior South China Sea, and the associated southern recirculation traps nutrient and favors productivity. When separation is absent, the model shows weakened circulation and eddy activity, with ~21% less nitrate inventory and ~16% weaker primary productivity.

【SPS5-330】 P-SPS5-04 Diel patterns of variable fluorescence and carbon fixation of picocyanobacteria Prochlorococcus-dominated phytoplankton in the South China Sea basin

Yuyuan Xie, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, Fujian, China
Edward A. Laws, Department of Environmental Sciences, Louisiana State University, Baton Rouge, Louisiana, United States
Lei Yang, Department of Environmental Sciences, Xiamen University, Xiamen, Fujian, China
Bangqin Huang, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, Fujian, China

Presenter Email: xieyuyuan@hotmail.com

The various photosynthetic apparatus and light utilization strategies of phytoplankton are among the critical factors that regulate the distribution of phytoplankton and primary productivity in the ocean. Active chlorophyll fluorescence has been a powerful technique for assessing the nutritional status of phytoplankton by studying the dynamics of photosynthesis. Further studies of the energetic stoichiometry between light absorption and carbon fixation have enhanced understanding of the ways phytoplankton adapt to their niches. To explore the ecophysiology of a Prochlorococcus-dominated phytoplankton assemblage, we conducted studies of the diel patterns of variable fluorescence and carbon fixation by phytoplankton in the oligotrophic South China Sea (SCS) basin in June 2017. We found that phytoplankton photosynthetic performance at stations SEATS and SS1 were characterized by a nocturnal decrease, dawn maximum, and midday decrease of the maximum quantum yield of PSII (Fv(')/Fm('), which has been denoted as both Fv/Fm and Fv'/Fm') in the nutrient-depleted surface layer. That these diel patterns of Fv(')/Fm(') were similar to those in the tropical Pacific Ocean suggests macro-nutrient and potentially micro-nutrient stress. However, the fact that variations were larger in the central basin than at the basin’s edge implied variability in the degree of nutrient limitation in the basin. The estimated molar ratio of gross O2 production to net production of carbon (GOP:NPC) of 4.9:1 was similar to ratios reported across the world’s oceans. The narrow range of the GOP:NPC ratios is consistent with the assumption that there is a common strategy for photosynthetic energy allocation by phytoplankton. That photo-inactivated photosystems or nonphotochemical quenching rather than GOP accounted for most of the radiation absorbed by phytoplankton explains why the maximum quantum yield of carbon fixation was rather low in the oligotrophic SCS.

【SPS5-410】 P-SPS5-05-S Assessment of primary production in the South China Sea: A comparison of fast repetition rate fluorometry and 14C measurement

Lei Yang, State Key Laboratory of Marine Environmental Science(Xiamen University)
Yuyuan Xie, State Key Laboratory of Marine Environmental Science(Xiamen University)
Haoran Liu, State Key Laboratory of Marine Environmental Science(Xiamen University)
Bangqin Huang, State Key Laboratory of Marine Environmental Science(Xiamen University)
Presenter Email: lyang@stu.xmu.edu.cn

Phytoplankton primary productivity is most commonly measured by 14C assimilation, which is invasive, requiring bottle incubation for up to 24 h. However, as an alternative, FastOcean APD based on Fast Repetition Rate fluorometry (FRRf), can estimate photosystem II (PSII) electron transport rate (ETR) on wide temporal and spatial scales within aquatic systems, It is more labor-saving and needs short measurement time. Light energy absorbed by chlorophyll molecules can undergo three fates: photosynthesis (photochemistry), heat or light-chlorophyll fluorescence. In the photosynthetic system,

linear electron flow begins with excitation of the photosynthetic reaction centers, PSII and PSI, and with splitting of water by the oxygen-evolving complex of PSII. Electrons are passed from PSII to the plastoquinone (PQ) pool and then to PSI, where NADPH is formed. However, the electrons emitted from water molecule in PSII is not all transported into carbon fixation in the dark reaction. And our work concentrates on studying the variability of ETR/CO2 uptake rate. The reported ratios of ETR/CO2 uptake rate range from 2.5 to 12 mol e-[mol CO2]-1, which is an approximately 5-fold range in the currency conversion rate, and the theoretical value of ETR/CO2 uptake rate is 4. Our studies show that it has much connection with the water parameter characterization. The range of ETR/CO2 uptake rate variation in oligotrophic ocean is much smaller, comparing with the eutrophic water.

【SPS5-982】 P-SPS5-06-S Metabarcoding reveals the diel vertical distribution and metabolic activity of mesozooplankton in the northern South China Sea

Ruping Ge, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Chang Chen, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Yutao He, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Yunyun Zhuang, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Hongju Chen, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Huan Zhang, Department of Marine Sciences, University of Connecticut, Groton, CT 06340, USA
Guangxing Liu, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100
Presenter Email: 2276310319@qq.com

Diel vertical migration (DVM) of zooplankton plays a large role in the active transport of organic matter to the deep ocean. To unveil the active migration population and their potential roles in biological pump, we studied the diel vertical distribution and metabolic activity of the mesozooplankton at the continental shelf (station C6) and slope (station C9) of the Northern South China Sea. At each studied site, mesozooplankton were collected every 6 hrs over 24 hrs by vertical hauls of 2 or 3 depth strata with 200μm-mesh plankton nets. The triplicate net tows were used for microscopic, rDNA and rRNA analysis, respectively. rRNA and rDNA were used to characterize the metabolic activity and relative abundance of each group. Eukaryotes-universal primers embracing V4 region of 18s rDNA were applied to generate more than 100K metabarcodes per rDNA or rRNA sample. Clustering at 97% identity yielded 10,110 OTUs, of which 6,573 were represented by more

than two reads and 620±132 OTUs were identified for each sample. Metabarcodes were mainly represented by 11 groups of metazoan and protist, with Copepoda as the most abundant (65.1-96.3%) in most of the samples, followed with Tunicate at C6 (0.6-19.5%) and Hydrozoa at C9 (0.1-28%) , respectively. The community structure of mesozooplankton at C6 and C9 was significantly different with <40% similarity. Vertical community structure of different depth strata was similar at noon and midnight, while differed significantly at dawn and dusk, indicating that DVM is regulated by diel variations in solar illumination. Diel vertical distribution suggested that DVM occurred mainly at <200m strata at night with Copepoda migrated upward while Hydrozoa migrated downward suggesting different strategies in utilizing food sources. Analyses of rRNA: rDNA ratio showed that the metabolic activity of rare group (rDNA relative abundance <0.01%) was generally higher than that of the abundant group (>1%), among which Acantharia, Ciliaphora and Annelida showed the highest rRNA: rDNA ratio.

【SPS5-617】 P-SPS5-07 An integrative approach reveals an unexpected high diversity and distinct community structure of ciliates in mesopelagic water of the northeastern South China Sea

Ping Sun, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystem, College of the Environment and Ecology, Xiamen University
Liying Huang, Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystem, College of the Environment and Ecology, Xiamen University
Presenter Email: psun@xmu.edu.cn

Ciliates play key roles in the microbial loop of marine ecosystems. However, the partitioning of spatial, temporal, and environmental effects on ciliate distribution in transitions between environments remains largely unknown. An integrative approach was used to analyze ciliate communities by combining high-throughput cDNA sequencing and the quantitative protargol stain on seasonal samples collected along a transect from coastal to oceanic regions at depths ranging from the surface to 1000 m. Surprisingly, the alpha-diversity in the surface (3 m) and mesopalegic (200-1000 m) waters were comparable. Integrating size observations from morphological examination, we found this unexpected deep ocean diversity mainly came from small-sized (<60 μm, mostly 20-40 μm) ciliates. Distinct community composition above and below the photic zone was revealed and commensal/parasitic OTUs affiliated with Astomatida and Apostomatida (Oligohymenophorea) were more abundant in mesopelagic waters than above, hence implying they are an important component of food webs in the mesopelagic zone. Depth and its related environmental factors, not either geographic distance or time, were the best predictors of ciliate diversity and community structure. Collectively, these findings expand the knowledge of the diversity, community structure and forcing factors of ciliates in the environment, particularly in the mesopelagic waters

【SPS5-628】 P-SPS5-08-S Rhodopsin gene polymorphisms of dinoflagellates in the Taiwan Strait and South China sea

JieruiI Wang, State Key Laboratory of Marine Environmental Science
Presenter Email: 22320161151343@stu.xmu.edu.cn

Recently many studies suggest that dinoflagellates have proton-pumping rhodopsins.In this study, we used PCR and metatranscriptomics to test the samples (size 3 to 200 um) from the Taiwan Strait and South China sea .The results show that the rhodopsins are highly abundant. This suggest that the rhodopsins may play an important role in the energy circulation of dinoflagellates, even can provide a more favorable conditions for dinoflagellates in extreme environment.

【SPS5-313】 P-SPS5-09-S Physiological and molecular responses of *trichodesmium erythraeum* IMS101 involved in acclimatization to iron deficiency

Ran Duan, State Key Laboratory of Marine Environmental Science (Xiamen University), China
Presenter Email: 178416430@qq.com

Trichodesmium is one of the vital cyanobacterial taxa responsible for nitrogen fixation in the oligotrophic tropical and subtropical oceans where iron concentrations are extremely low. While it has been reported frequently on Trichodesmium physiology and ecology under iron limited conditions, the changes in cellular and molecular responses of Triochodesmium across an iron concentration gradient are less known. In order to better understand the dynamics involved in Trichodesmium acclimatization to iron stress, we cultivated *Trichodesmium erythraeum* IMS101 in medium prepared with the South China Sea surface water supplemented with different concentrations of iron. We measured a suite of physiological parameters, such as chlorophyll a-derived specific growth rate, photochemical efficiency, rate of nitrogen and carbon fixation etc., and conducted gene expression analysis of the iron stress indicator genes (idiA and isiA) using the real-time quantitative PCR technique. Our data reveal the differential growth rates, productivities and gene expressions of Trichodesmium corresponding to the iron concentration gradient. This study has implications in understanding the core physiological and molecular responses involved in Trichodesmium acclimatization to the rapidly changing ocean.

【SPS5-921】 P-SPS5-10 Spatiotemporal variability in bacterial metabolic activity in the Pearl River Estuary: Influence of the river discharge

Xiangfu Li, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Jie Xu, State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences
Presenter Email: lixiangfu1988@126.com

Heterotrophic bacteria play a significant role in carbon cycling in marine environments. Bacterial production (BP), respiration (BR) and growth efficiency were simultaneously determined along an environmental gradient in the Pearl River Estuary in the wet season (May 2015) and the dry season (January 2016), in order to examine bacterial carbon processing in Pearl River Estuary. Our results showed that the Pearl River discharge delivered labile dissolved organic matters (DOM) with low C:N ratio, resulting in a clear gradient in dissolved organic carbon (DOC) concentration and DOC:DON ratios. BP and BR responded differently to environmental variability. BP and the cell-specific bacterial production decreased, while the cell-specific bacterial respiration increased likely due to enhanced energetic cost for cell maintenance and require, in response to a decline in the quality and quantity of dissolved organic matter along the estuary. As a result, BP (2.09 to 144 μg C L-1 d-1) was to greater extent variable than BR (64.6 to 567 μg C L-1 d-1), leading to decreasing bacterial growth efficiency along an environmental gradient. Interactions between the freshwater and seawater from the South China Sea changed the quality and quantity of DOM, ultimately modulating bacterial metabolic activity in the Pearl River Estuary.

【SPS5-481】 P-SPS5-11-S Use of ESI-FTICR-MS to characterize dissolved organic matter in Luzon Strait

Peng Jiang, State Key Lab of Marine Environmental Science, Xiamen University, Xiamen, China
Xiaolin Li, State Key Lab of Marine Environmental Science, Xiamen University, Xiamen, China
Presenter Email: patrick@stu.xmu.edu.cn

Dissolved organic matter (DOM) in the ocean is involved in remineralization, nutrients supply as well as carbon sequestration by bacteria utilization and alteration. During the degradation process, DOM might show different composition because of the different bio-availability of DOM (labile DOM, semi-labile DOM, and refractory DOM). In July 2017, We collected 61 SPE-DOM samples on SCS-Luzon Strait summer cruise and chose 20 samples to do FT-ICR-MS (Fourier-transform ion cyclotron resonance mass spectrometr) analysis. The results indicate that there are a lot of similar molecular structures exist in all SPE-DOM no matter where the samples are collected from, which means those molecules might be refractory DOM. Also, we observe the degradation process of DOM between 5m and 3500m through the disappearance of high O/C and H/C part where is the region of carbohydrate, amino acid, and sugar. It suggests a preference of bacteria degradation for labile DOM. However, the surface and deep samples share more than 70% peaks on the mass spectrum; and two surface samples collected from different areas share more than 80% peaks on ESI- mode. Most of the overlapping peaks locate in 'CRAM' (carboxyl-rich alicyclic molecules) region on Van Krevelen Diagrams. Furthermore, we are trying to use HPLC-

QTOF -MS to do the same samples and compare with FT-ICR-MS to see different characterization information from HPLC and daughter ion spectrum, and the work is underway.

【SPS5-621】 P-SPS5-12 Stable isotope composition and turnover of organic carbon in the upper reach of the Pearl River Estuary

Feng Ye, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Gangjian Wei, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Zhibing Wang, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Yiwei Chen, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Presenter Email: yefeng@gig.ac.cn

The Guangzhou reach is a hot-spot of active carbon cycling in the Pearl River estuarine system due to high carbon loads discharged by human activities. In this study, we analyzed stable isotope signatures of water column organic carbon in winter and summer 2017. Overall spatial patterns of δ13C in dissolved organic carbon (DOC) reflect the predominant influence of soil-derived organic carbon from the upstream rivers. On a small scale, our data identify sewage effluents as an important DOC source and indicate active biodegradation. The dual isotopic composition of dissolved inorganic carbon (DIC) and particulate organic carbon (POC) indicates that phytoplankton biomass was the main source of POC in the study region, thus differing from that of DOC.

【SPS5-140】 P-SPS5-13 Carbon burial in the northern South China Sea in response to climate change and ocean acidification since the last 2 ka

Gangjian Wei, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Zhonghui Liu, Department of Earth Science, the University of Hong Kong
Wenfeng Deng, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Feng Ye, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Presenter Email: gjwei@gig.ac.cn

Our researches focus on reconstructions of the high-resolution records of paleoclimate (such as temperature, pH) and carbon burial in the northern South China Sea over the last 2 millennia based on multiple geochemical proxies, aiming to elucidate the response of carbon burial to climate change and ocean acidification. The main findings are as follows: (1) Our paired Sr/Ca and δ18O records in the corals from the northern SCS revealed that the climate of the Medieval Climate Anomaly (AD 900-1300) was similar to that of the Current Warm Period (AD 1850-present), suggesting that anthropogenic influences on SST warming are not significant in tropical marine systems (Deng et al., 2017; Xiao et al., 2017). Meanwhile, the long-chain alkenones records in the high-resolution offshore sediment cores showed that the SST variation in the marginal seas over the last 2 millennia matches or opposites to that of the global/northern hemisphere temperature changes, which is governed by changes in the Asian summer/winter monsoon and oceanic circulation (Kong et al., 2017; Liu et al., 2018). (2) The coral δ13C and δ11B records in the northern SCS indicated that the carbon source utilized for calcification is strongly influenced by atmospheric CO2 while pH in calcification fluid began to decrease since the Industrial Era (Deng et al., 2017), demonstrating a very important role of anthropogenic factors on calcification or inorganic carbon burial on coral reefs. In addition, more metabolic carbon with more negative δ13C was preferentially utilized for coral calcification after three super El Niños (Wang et al., 2018). On the basis of a series of coral records in the SCS, we found that coral calcification generally showed an increasing trend over the past 200 years, which is probably due to the gradual rising of the SST after the Industrial Era, and the negative effect on coral calcification by ocean acidification induced by rising atmospheric CO2 appear to be concealed by SST rising. (3) Based on a more comprehensive suite of proxies such as GDGTs, the sources and compositions of surface sedimentary organic carbon (OC) are better constraint in the coastal systems of the northern SCS (Liao et al., 2018a, 2018b), which is crucial to more accurately describe how the carbon burial in response to changing climate. Multiple geochemical records in the coastal SCS demonstrated that organic carbon burial rates increased remarkably over the last millennium, as a result of the enhanced human activities (Huang et al., 2018).

【SPS6-834】 P-SPS6-01 The South China Sea Deep

The South China Sea Deep Office, Tongji University
Presenter Email: scs-deep@tongji.edu.cn

The South China Sea-Deep program was launched by the NSF China in 2011-2019 with a total budget of 190 million RMB (~30.6 million US$) to study the deep sea process and geological evolution of the South China Sea, the largest marginal sea in the western Pacific. By dissecting this particular case, the program aims to reveal the evolution patterns of marginal seas and their effects on submarine resource and macro-environment development, since the deep sea process could be the breakthrough point of today’s ocean science and Earth system science frontiers.

Therefore, the overall scientific objectives of the program are 1) Rediscovering the seafloor spreading history of the South China Sea and its pre- and post-spreading evolution; 2) Revealing the patterns of bottom circulation and the deep sea response to sea level change; 3) Discovering the deep biogeochemical process and evolution; 4) Investigating resource and environment effects of the deep sea process evolution.

And key scientific questions include

1) Age and process of seafloor spreading.
2) Time and cause of the volcanic seamount chain activities.
3) Response of the deep sea sedimentation process to sea basin evolution.
4) Variation of bottom circulation and sediment transport mechanism.

5) Development and effect of carbonate platforms.
6) Distribution and effect of submarine overflows and down-hole fluids.
7) Deep sea carbon cycle and the function of microorganism.8) Biogeochemical background of deep sea energy resource formation.
The South China Sea-Deep program has supported 59 projects in all during execution period. By the effort of hundreds of scientists and their students from tens of universities and institutions, many substantial and significant discovery and insight of the South China Sea have been gained. 2019 is the last year of the program, an overall and deep understanding of the deep sea process and geological evolution of the South China Sea would be achieved on the basis of synthesis research.

【SPS6-132】 P-SPS6-02 Integrated study on biological carbon sequestration mechanisms in the South China Sea

Nianzhi Jiao, Xiamen University
Presenter Email: yaozhang@xmu.edu.cn

This project follows the overall design and objectives of “South China Sea Deep” (SCSD) Research Program, integrate the outcomes from the five on-going relevant SCSD projects towards a better understanding of the key processes and mechanisms of carbon sequestration in the ocean. The research focus on the interactions between the biological carbon pump (BP) and microbial carbon pump (MCP) and its effects on carbon sequestration under different environmental conditions. The integration is featured by coupling the epipelagic and deep waters, the water column and sediments, the micro- and macro-scale biogeochemical processes. Research contents include primary production and microbial respiration, physical and chemical variables, biomarkers for sedimentation and decomposition, along environmental gradients and temporal-spatial dimensions. This research will establish conceptual models (focusing on the process and mechanism), box-type model (focusing mainly carbon reservoirs and their interface fluxes) and ecosystem dynamics model / numerical model (with emphasis on physical - biological coupling for potential manipulation and prediction).

【SPS6-764】 P-SPS6-03 Three-dimensional pathways of water masses in the South China Sea: a modeling study

Zhiqiang Liu, Division of Environment and Sustainability, The Hong Kong University of Science and Technology
Jianping Gan, Department of Ocean Science and Department of Mathematics, The Hong Kong University of Science and Technology
Presenter Email: liuzhq@connect.ust.hk

We conduct a numerical Eulerian analysis on the Lagrangian characteristics of South China Sea (SCS) water masses. This is the first study to investigate the water pathway and residence time in response to time-dependent, three-dimensional basin circulation in the SCS. The circulation of the SCS is largely determined by westward intrusions of the northwestern Pacific waters in the upper layer (0-750 m) and deep layer (>1500 m), and by an eastward extrusion in the intermediate layer (750-1500 m) through Luzon Strait (LS). The waters in these three layers are interlinked to sustain the three-dimensional circulation in the SCS. The upper intrusive waters flow cyclonically and have a residence time of ~3 years before they subduct into a deeper layer or exit the SCS through surrounding straits. The intrusive denser waters in the deep layer flow along the northern slope and reside for ~25 years in the northern basin (north of 13°N), where a strong subduction occurs. A cyclonic circulation exists in the deep layer in the southern basin (south of 13°N), where a subduction of intermediate waters occurs over its eastern side and a deep upwelling exists over its western side. The water in the deep southern basin has a residence time of ~40 years. The upwelled deep waters and the subducted waters from the upper layer form the intermediate water, where waters circulate anti-cyclonically towards LS and have a longest residence time (~42 years). These findings are supported by the spatial variation in the observed potential density variance.

【SPS6-958】 P-SPS6-04 Comparative study of carbonate system and oxygen in the northern and southern South china Sea Basin

Xianghui Guo, Xiamen University
Liguo Guo, Xiamen University
Wei Yang, Xiamen University
Yi Xu, Xiamen University
Minhan Dai, Xiamen University
Presenter Email: xhguo@xmu.edu.cn

The South China Sea (SCS) is the largest marginal sea in the North Pacific with deep basins. The northern SCS basin is connected to the North Pacific through Luzon Strait and might be affected by the Kuroshio, while the southern basin is far away from the Luzon strait. To reveal the major difference and controls of the carbonate system parameters in the northern and southern SCS basins, a cruise was conducted to the SCS basin in June of 2017. Dissolved inorganic carbon (DIC), total alkalinity (TA), pH and dissolved oxygen (DO) were collected during the cruises.In the waters deeper than 2500 m, all the parameters were consistent between the northern and southern SCS basin. However, in the waters shallower than 300 m, the northern SCS was characterized by relatively lower temperature and pH, but higher salinity, DIC and TA, which might due mainly to the influence of the Kuroshio in the northern basin. In the Euphotic zone, the parameters in the northern basin showed significant diurnal variations, which was influenced mainly by the internal wave propagated from the Luzon Strait. However, the southern SCS was very “quiet” and the parameters were fluctuated within a very small range. Comparison and

controlling mechanisms between the northern and southern SCS basins will be presented in detail.

【SPS6-805】 P-SPS6-05 Cycling of DIC and DOC in the deep South China Sea as revealed from their radiocarbon ages

Xuchen Wang, Ocean University of China
Ling Ding, Ocean University of China
Presenter Email: xuchenwang@ouc.edu.cn

Radiocarbon measurements of dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) in the ocean provide useful information not only on their sources but cycling timescales of each different carbon pools. Here we report our concentration and 14C results measured for both DIC and DOC collected from six deep stations in the South China Sea (SCS). The concentrations of DIC ranged in 1776-2328 μmol/kg and generally increased with depth; while concentrations of DOC ranged in 38-95 μM and decreased rapidly with depth, especially in the upper 200m. Below than 1000 m depth, both DIC and DOC concentrations remained relatively constant. The values of 14C-DIC ranged in 54‰ to -227‰ with high values in the surface and decreased rapidly with depth. The 14C-DOC values were much lower (by -300‰) than 14C-DIC, ranging from -258‰ to -557‰ also decreased rapidly with depth. The calculated 14C ages indicate that DOC were 2000-2500 years (before present) older than DIC. The ages of DOC in the deep water were about 6200 years that is similar to the DOC ages in the deep waters of the Central North Pacific and Southern Pacific. Our 14C-DIC results suggest that the South China Sea is largely influence by the Kuroshio Current and the intermediate water mass has been well mixed to the upper 500 m depth. In contrast, the deep layer (> 1500 m) in the South China Sea has been relatively stable or the water resident time is longer than that in the upper 500m depth. The hydrodynamic mixing and circulation pattern have major influence on the distribution and cycling of DIC and DOC in the SCS especially in the deep waters.

【SPS6-822】 P-SPS6-06 S-MCT: Microbially mediated carbon transformation in marine sediments

Fengping Wang, Shanghai JiaoTong U
Yinzhao Wang, Shanghai JiaoTong U
Minyang Niu, Shanghai JiaoTong U
Presenter Email: fengpingw@sjtu.edu.cn

Marine sediment is one of the Earth's largest organic carbon sinks. Microbial transformation of carbon is considered a key process influencing the carbon flow in sediment and ultimately atmospheric oxygen and carbon dioxide concentrations. Nevertheless, the controls on microbial organic carbon cycling are not well understood, including the biogeochemical role of Archaea, which are often abundant in marine

sediments. We conducted a series of studies on the roles of microbes in organic matter transformation in the sediments of South China Sea, particularly focusing on recalcitrant carbon degradation and methane transformation. In correspondence to microbial carbon pump in marine sea water, we propose a schematic model S-MCT to guide our understanding and further studies on microbial roles in carbon remineralization and sequestration in marine sediments.

【SPS6-875】 P-SPS6-08-S Carbonate factory turnovers influenced by the Monsoon (Xisha Islands, South China Sea)

Feng Wu, China University of Geosciences
Xinong Xie, China University of Geosciences
Xushen Li, Zhanjiang Branch of China National Offshore Oil Corporation
Christian Betzler, Universität Hamburg
Zhilei Shang, China National Offshore Oil Corporation Research Institute
Presenter Email: finncug@hotmail.com

Carbonate factory turnovers can be the integrated results of climatic, oceanographic and biological controls. As an important part of the global climate system, the monsoon has a significant potential to influence such turnovers (Betzler et al. 2009, 2016). Sedimentological, geochemical and paleontological data from core XK-1 drilled in the Xisha Islands, South China Sea, reveal that photozoan to heterozoan carbonate factory turnovers during the Early and Middle Miocene in isolated carbonate platforms were mainly caused by changes in the upwelling regime. A heterozoan open bank association thrived in tropical shallow water under conditions of nutrient excess, indicated by high Ln(Cu/Ti) and Ln(Ba/Ti), and by the increased abundances of rhodoliths and some foraminifer genera. During the Early and Middle Miocene, episodes characterized by a heterozoan carbonate production correlate with times of East Asian Summer Monsoon strengthening, especially from 21.2 to 17.3 Ma and from 15.6 to 11.6 Ma (Clift, 2006; Clift et al., 2014). This study thus provides new insights into the variability of shallow water carbonate deposition in monsoon-influenced areas and also shows that shallow carbonate factory turnovers can help to reconstruct the monsoon evolution in monsoon-affected regions elsewhere.

【SPS6-783】 P-SPS6-09 Neodymium isotopic evidence of abruptly intensified Deep South China Sea overflow and gradually strengthened East Asian Monsoon in the Plio-Pleistocene

Jun Tian, State Key Laboratory of Marine Geology, Tongji University
Ke Li, State Key Laboratory of Marine Geology, Tongji University
Presenter Email: tianjun@tongji.edu.cn

The Pacific Deep Water (PDW) intrudes the South China Sea (SCS) through the Luzon Strait, forming the robust overflow. It acts as an engine of the SCS deep circulation, which

as an important part of global thermohaline circulation plays an important role in modulating global climate. However, the forming time and evolving process of the deep SCS overflow remains unclear. Moreover, how the East Asian Monsoon (EAM) affects the SCS deep water is not clear. Here we present two 6-Myr fossil fish teeth neodymium isotopic (eNd) records from the SCS. One is from Ocean Drilling Program (ODP) Site 1148 (18°50.169′N, 116°33.939′E, water depth 3294 m) in the northern SCS and the other is from ODP Site 1143 (9°21.72′N, 113°17.11′E, water depth 2772 m) in the southern SCS. The eNd of the fish teeth is a reliable quasi-conservative ocean circulation tracer. Modern observation demonstrates that the seawater eNd of the SCS is a mixture of the eNd of the oceanic and continental end members, namely the intruded West Pacific water masses and the sediment supplied to the SCS from the surrounding continents. The eNd records of the continental end member show constant changes over the past 6 Myr, but that of the oceanic end member is more variable. The fish teeth eNd at ODP Sites 1148 and 1143 change between -4 and -7, apparently in between the continental and oceanic end members. The eNd record of the fish teeth at ODP Site 1143 in the southern SCS is quite stable over the past 6 Myr, within a narrow range of -6 to -7. Between ~4.88 Ma and ~4.12 Ma, however, a significantly rapid increase as much as 2.6 (from -6.82 to -4.22) is seen in the eNd record of the fish teeth at ODP Site 1148 in the northern SCS, and a remarkably secular decrease as much as 3.27 (from -3.52 to -6.79) after that is observed between ~3.02 Ma and 1.314 Ma. The relatively constant eNd of the fish teeth at ODP Site 1143 indicates continuously prevailing influences of the surrounding rocks on seawater eNd in the southern SCS over the past 6 Myr. Whereas, the more positive and variable eNd at ODP Site 1148 in 4.88-1.314 Ma indicates dominated influences of PDW on seawater eNd in the northern SCS during this period. At ODP Site 1148, the steep increase in the fish teeth eNd from 4.88 Ma to 4.12 Ma indicates abruptly strengthened deep SCS overflow, whereas the gradual decrease from 3.02 Ma to 1.314 Ma suggests gradually intensified East Asian summer monsoon during this period.

【SPS6-931】 P-SPS6-10 International Ocean Discovery Program expeditions 349, 367 and 368 explore the initiation of the South China Sea

Zhen Guo, The IODP China Office, Tongji University
Shouting Tuo, The IODP China Office, Tongji University
Tingyu Wen, The IODP China Office, Tongji University
Presenter Email: zhenguo@tongji.edu.cn

International Ocean Discovery Program (IODP) is an international collaborative research organization focusing on exploring Earth's history and dynamics by recovering information recorded in the seafloor sediments and rocks. The IODP, dated from 1968, has made the most significant contribution to understanding the history of the Earth and is still playing an important role in the geoscience research. China jointed the IODP (ocean drilling

program, ODP at that time) as the first associate member in 1998 and became an official member of IODP in 2013. The IODP expeditions 349, 367 and 368 were designed mainly by Chinese scientists and conducted in South China Sea (SCS) in 2014, 2017 and 2017 respectively. These expeditions aimed to understand the opening of the SCS and the mechanisms of lithosphere extension during continental breakup at a non-volcanic rifted margin. The magnetic surveys and igneous cores in Expedition 349 suggest that the seafloor spreading started about 33 Ma ago with a full spreading rate between about 20 and 80 km/Myr in the northeastern SCS (Li et al., 2014). The Mid-Ocean Ridge Basalt (MORB) in SCS is composed similarly to that in the Pacific Ocean, suggesting that the magmatism in SCS is tightly related to that in the Pacific Ocean. The MORB cores from Expeditions 367 and 368 and seismic survey in SCS support the existence of hyperextended margin, which is considered as the "missing link" between the magma-rich and magma-poor margins in North Atlantic (Larsen et al., 2018). The model suggests that the seafloor spreading of SCS is forced by magmatism at the thin crust resulting in weakening the mantle lithosphere and massive extrusive activity along the entire rift zone.
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【SPS6-849】 P-SPS6-11 New constraints from macrostructure analysis of IODP Expedition 349 core samples and geophysical data: Implications on the latest spreading history of the South China Sea

Zhen Sun, CAS Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Guangzhou 510301, China
Weiwei Ding, Second Institute of Oceanography, State Oceanic Administration, Hangzhou 310012, China
Xixi Zhao, State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, China
Ning Qiu, CAS Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Guangzhou 510301, China
Jian Lin, Department of Geology and Geophysics, Woods CAS Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Guangzhou 510301, China;Hole Oceanographic Institution, Woods Hole, MA 02543 USA
Chunfeng Li, Ocean College, Zhejiang University, Zhoushan 316021, China
Presenter Email: zhensun@scsio.ac.cn

The inconsistency of the NS-trending fracture zones and the NW-SE-oriented extension during the latest spreading stage remains to be a problem in understanding the evolution

of the South China Sea (SCS). Expedition 349 of the International Ocean Discovery Program (IODP) successfully drilled and cored five sites (Sites U1431-1435) close to the relict spreading centers and to the continent-ocean transition zone (COT), providing critical information on the spreading process. We analyzed macrostructures (over 300 fractures, veins, and slickensides) identifiable from the basalt and consolidated sediment samples. Compared with post-spreading volcanism, seismic interpretation, and focal mechanisms, as well as new-acquired free-air gravity anomaly and magnetic anomaly data, the latest spreading history of the SCS was explored. Post-spreading consolidated sediments are dominated by WNW- and nearly EW-trending planes with slickensides, consistent with the orientation distribution of the long axes of post-spreading volcanism, which suggests a relationship with the South China Sea eastward-subduction toward the Luzon Arc. The fractures and veins in the basalt oriented differently from the slickenside-bearing planes in sedimentary sequences, suggesting a NS-trending syn-spreading tendency. Magnetic anomalies suggest that the latest East Sub-basin's relict ridge (ERR) may coincide with the trace of the seamount chain and trend roughly EW, where lower P-wave velocity in the upper crust was detected by Ocean Bottom Seismometer (OBS) experiments. The NS-trending Zhongnan–Liyue Fracture Zone (ZFZ) connects the East and Southwest relict ridges and was conjectured to be a fracture zone (relict transform faults). Although this tectonic event lasted only for a very short period of time, it was recorded by macrostructures at Site U1431 and U1433 accurately. These results resolve the previously identified inconsistencies and reveal for the first time the existence of latest NS spreading in this area. This study also provides a new angle to elucidate the kinematics of sea basin evolution through joint analysis of macro-scale structure and larger scale geophysical data.

【SPS6-843】 P-SPS6-12 The configuration of the South China Sea oceanic domain at the end of spreading

Minghui Zhao, Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301
Xinming Pang, Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301
Jean-Claude Sibuet, Ifremer Centre de Brest, 29280 Plouzané, France and 44 rue du Cloitre, 29280 Plouzané, France
Siqing Liu, Guangzhou Marine Geological Survey, Guangzhou 510760
Jonny Wu, University of Houston, Department of Earth and Atmospheric Sciences, Science & Research Building 1, 3507 Cullen Boulevard, Houston, TX 77204, USA
Enyuan He, Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301
Xuelin Qiu, Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301

Presenter Email: mhzhao@scsio.ac.cn

The South China Sea (SCS) oceanic domain is critical to understand theformation and evolution of the SCS. The wide-angle refraction profiles collected in the northeastern South China Sea (SCS) show that the crust is a 12 to 15 km-thick thinned continental crust intruded by post-rifting volcanics with a high velocity layer at the base of the lower crust interpreted as underplating (e.g. Liu et al., 2018). Based on magnetic anomaly maps and the resulting localization of magnetic lineations C12 (?) and younger and on the interpretation of MCS and wide-angle seismic profiles, the location of the boundary between thinned continental and oceanic crust (COB) is proposed. The unfolded Manila slab attached to the SCS along the Manila trench extends 400-500 km to the east of the Manila trench. Mid-slab positive dVp values generally correspond to oceanic domains while negative values correspond to thinned continental domains, giving for the first time a complete picture of the geographical extension of the SCS at the end of spreading. The northern COB (red line in the Figure) separates a thinned continental crust with slightly negative dVp values to the north that reconstructs below the western Ryukyu subduction zone from a >300 km wide area to the south with positive dVp values corresponding to typical oceanic crust. Amongst the numerous consequences of the new location of the COB, we show that, at the end of the SCS opening, the thinned continental crust identified at the northeastern SCS stepped 400 km northwards from 20°N to 24°N, implying the existence of a north-south portion of Eurasian margin near 122°E prior to Taiwan collision. In the future, we plan to better define the COB (where it is presently define by a green line (Sibuet et al., 2016), in particular in the southern SCS.This research was granted by the Natural Science Foundation of China (91428204, 41730532, 41674092 and 41676043).

【SPS6-827】 P-SPS6-13 Crustal and mantle structure of the Indochina Peninsula and its implications for the tectonic evolution of the South China Sea

Youqiang Yu, State Key Laboratory of Marine Geology, Tongji University
Ting Yang, School of Oceanography, South University of Science and Technology of China
Mei Xue, State Key Laboratory of Marine Geology, Tongji University
Stephen Gao, Geology and Geophysics Program, Missouri University of Science and Technology
Kelly Liu, Geology and Geophysics Program, Missouri University of Science and Technology
Tran Danh Hung, State Key Laboratory of Marine Geology, Tongji University
Khanh Phon Le, Faculty of Oil and Gas, Hanoi University of Mining and Geology
Presenter Email: yuyouqiang@tongji.edu.cn

While the northward indentation of the Indian into Eurasian plates has been intensively investigated, its oblique subduction beneath the Indochina Peninsula (ICP) and the role it played on crust and mantle structure and dynamics remain enigmatic. Here, we have conducted receiver function investigation of the crust and mantle transition zone (MTZ)

discontinuities and employed the shear wave splitting (SWS) technique to systematically illuminate upper mantle anisotropy beneath the Indochina Peninsula with an unprecedented data coverage. Crust beneath the Khorat Plateau, which occupies the core of the Indochina Block, has relatively large thickness with a mean of 36.9 km and small Vp/Vs measurements with an average of 1.74, which indicates an overall felsic bulk composition. The laterally heterogeneous distribution of crustal properties and its correspondence with indentation-related tectonic features suggest that the Indochina lithosphere is extruded as rigid blocks rather than as a viscous flow. Systematic spatial variations of MTZ thickness with departures between -21 and +24 km from the globally averaged value are revealed, providing independent evidence for the presence of slab segments in the MTZ beneath the central and a slab window beneath the western ICP. The results also support the existence of broad mantle upwelling adjacent to the eastern edge of the slab segments, which might be responsible for the widespread Cenozoic volcanisms and pervasively observed upper mantle low velocities in the area. The resulting 409 SWS measurements show that upper mantle anisotropy beneath the vast majorty of the study area is characterized by dominantly E-W fast orientations which are nearly orthogonal to the strike of most of the major tectonic features in the study area, ruling out significant lithospheric contributions to the observed anisotropy. This observation, when combined with results from seismic tomography, numerical modeling, surface movement, and focal mechanism investigations, suggests that the observed azimuthal anisotropy is mostly the consequence of absolute plate motion or the westward rollback of the oceanic Indian slab. The flow system induced by the rollback or absolute plate motion may experience regional alteration from mantle upwelling along the eastern edge of the slab and through the detected slab window, leading to local variations in the observed splitting parameters.

【SPS6-1028】 P-SPS6-14 Geodynamic modeling of mantle evolution of the South China Sea and surrounding subduction systems

Zhiyuan Zhou, Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China
Jian Lin, Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, USA
Presenter Email: zyzhou@scsio.ac.cn

The South China Sea (SCS) and adjacent basins are surrounded by multiple subduction zones, including the Sumatra, Java, Philippine, and Manila subduction systems. Previous studies have revealed that the subducting Indian and the Philippine Sea plates may have reached mantle depth of 1000-1200 km beneath the SCS. We first used the plate reconstruction software GPlates to calculate the velocities of the global plates since 100

Ma. We then constructed 3-D models of the global mantle dynamics using the spherical harmonic simulation platform of Advanced Solver for Problems in Earth's ConvecTion (ASPECT). Constant temperatures were assumed at the Earth surface and core-mantle boundary, respectively. The mantle convection was driven from both the surface plate motion as prescribed by the GPlates model and the buoyancy-driven mantle flow. The SCS and its surrounding subduction systems were modeled with much finer grids within the global mantle convection framework. Preliminary results show that the overall geometry of the subduction zone systems in the Southeast Asia has evolved gradually from the early "V" shape to the present-day "U" shape. The Izanagi plate, which has been subducted beneath the Eurasia plate until about 55 Ma, has a profound impact on the mantle evolution of the eastern China and the SCS. Modeling results suggest that the opening of the SCS might have broken up the remnant Izanagi subduction slabs under the SCS. Although the SCS has ceased spreading at 15-16 Ma, the surrounding subduction systems continue to influence the mantle convection and evolution of the SCS and adjacent basins. Furthermore, modeling results reveal that subduction-induced flow may lead to the formation of isolated plume-like mantle upwelling features beneath the SCS.