ANNUAL REPORT

MEL 2024

年度报告

近海海洋环境科学国家重点实验室（厦门大学）

State Key Laboratory of Marine Environmental Science (Xiamen University)

MEL INTRODUCTION

近海海洋环境科学国家重点实验室（厦门大学）（英文缩写MEL）于2005年3月启动建设，2007年6月通过科技部验收，2010、2015年连续获评优秀国家重点实验室。实验室现有固定科研人员100人，技术人员及研究助理121人，行政人员7人。实验室瞄准全球变化这一国际前沿，面向碳中和、海洋强国、生态文明等国家战略需求，立足基础研究和应用基础研究，以多学科交叉和技术创新为动力，主攻海洋生物地球化学与生态系统动力学。实验室坚持走国际化发展道路，科学研究力求具备全球视野，管理体系参比国际标准，文化建设崇尚自由宽松，努力建设成为具有重要国际影响力的海洋环境科学研究和创新人才聚集基地。

实验室学术委员会

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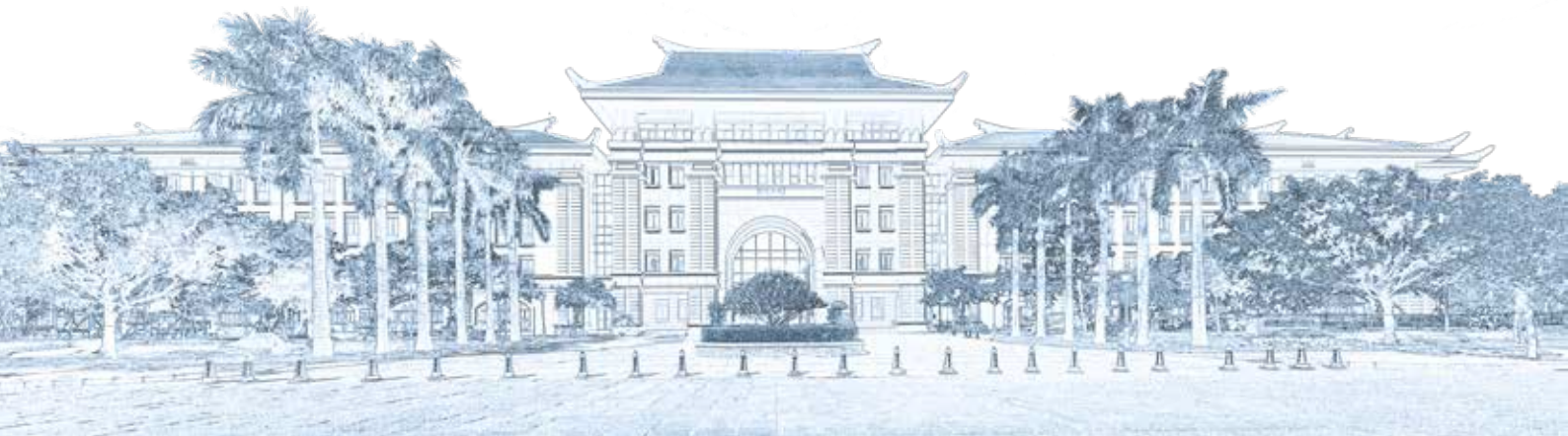

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青春无界，未来无限

2025 年的第一缕朝阳与 2005 年有何不同？初启鹏程与二十加冠的心境已迥然相异，让我们在 MEL 成立 20 周年之际倍感历久弥坚。然而，奔涌不停的岁月长河里，总有一种精神永远年轻；复杂多变的时代浪潮中，唯一不变的是对“明天”的期盼与追求。青春与未来，一个无法以年岁衡量，一个不可用时间限定。言念及此，20 年前的春天似乎又与今日合二为一；视角轮转，MEL 的 2024 年意义尤为深远——在 20 岁“生日”来临之际，我们激荡着青春的力量，向着充满无限可能的未来挺进。

“峻极之山非一石所成，凌云之榭非一木所构”，团队的力量汇聚成洋，个人的光芒也能燎原。青年人才崭露头角，接续获批国家杰出青年科学基金、国家高层次青年人才等项目，获得第八届曾呈奎海洋科技奖“青年科技奖”。“海洋新陈代谢与元素循环”研究团队获国家自然科学基金创新研究群体项目资助。顶尖学者持续领航，当选美国地球物理联合会会士并获地球与空间科学大使奖，众多翘楚上榜爱思唯尔 2023 年中国高被引学者榜单。

“板凳甘坐十年冷，文章不写半句空”，科研攻坚道阻且长，行则将至。夯实理论根基，发现开阔大洋向边缘海输运人为 CO_2 的新路径，揭示光强对于固氮来源新氮在海洋真光层中归宿的调控效应与机理；颠覆传统认知，解析西北太平洋副热带流涡区气旋涡的浮游生物生态和生物泵过程，构建系统的氨氧化古菌谱系框架；加速成果应用，牵头制定的微型生物碳库贡献调查技术规程获批行业标准，自主研发的海洋监测仪器 *i*SEA 实现国产化。

“一花独放不是春，百花齐放春满园”，和合发展方成和谐共生。第九届青年地学论坛吸引 6000 余名青年学者汇聚厦门，合力探索地球科学科创新路径。与英国普利茅斯大学海洋研究所建立合作关系；再获太古集团支持，实施海洋生态保护及教育计划，谱写交流合作新篇章。“海洋负排放”国际大科学计划主导全球首个海洋碳中和国际标准提案获 ISO 立项，参与编撰的《浮游生物宣言》在联合国大会发布。

序言

“十年树木，百年树人”，蔚蓝之海托举明日之星。主办“海洋放射科学”国际讲习班，组织“共享航次计划”首席科学家培训航次，为海洋研究培育卓越蓝色生力军。海洋科学开放日创新升级，海洋科普直播讲堂跨越“山”“海”传递海洋及科考知识，为青少年播撒海洋梦想的种子。教师节前夕，MEL 收获教育部“全国教育系统先进集体”荣誉，更笃定了教育、科技、人才融合发展之路。

日月更迭，情怀如初。廿载风雨兼程，我们资历有别，却都秉持着“勇攀高峰迎旭日，敢踏巨浪驭长风”的科学精神和青春担当。站在 20 岁的门槛，MEL 完成了重组申报，即将开启全国重点实验室新篇。未来，我们将勇于探索“无人区”，实现基础研究与原创成果的重大跨越，让科技赋能海洋强国梦，奔赴无垠且无悔的未来！

共欢新故岁，迎送一宵中。谨此向全体 MEL 成员道一声辛苦，向关心 MEL 发展的海内外同仁及各界伙伴致一句问候！祝愿各位乙巳蛇年祥蛇献瑞，创新篇章！

主任：史大林

2024 年 12 月 31 日

大事记
2024 Headlines

1 月

◎ *Nature Ecology & Evolution* 发表有关红树林生态系统生产力在气候变化响应方面较陆地生态系统的特异性和贡献度的研究成果

◎ 国家重点研发计划青年科学家项目“基于环境基因组的近海生物多样性解析”启动

3 月

◎ MEL 11 位学者入选 2023 年爱思唯尔中国高被引学者榜单

4 月

◎ MEL 领衔的中国首个海草床碳汇方法学通过专家评审

◎ MEL 与香港城市大学签署合作备忘录

5 月

◎ *Science Advances* 发表关于海洋微生物群落功能上的垂直连通性相关成果

◎ “全球海洋生物碳泵估算研究”获“2023 年度中国海洋科技十大进展”

◎ 承办第九届青年地学论坛

◎ 主办“海洋观测和生物地球化学模式协同作用范围界定”国际研讨会

6 月

◎ 刘志宇、李姜辉获评“中国工程前沿杰出青年学者”

◎ 举办第 1278 期南强学术讲座，邀请挪威气候与环境部长安德烈亚斯·埃里克森探讨“蓝色经济与海洋可持续发展”

◎ 国家重点研发计划项目“西北太平洋生物碳泵的氮磷铁调控及演变趋势”、青年科学家项目“基于能量过程的年代际气候变化机理和预测”启动

7 月

◎ 第五届厦门大学“海丝学堂”本科生实习航次启航，前往南海海域开展海洋科学教学实习与研究，并在新加坡、马来西亚及香港举办“嘉庚”号科考船开放日

8 月

◎ “海洋新陈代谢与元素循环”研究群体获批国家自然科学基金创新研究群体项目

◎ “海洋放射科学”国际讲习班在厦门大学马来西亚分校举办

9 月

◎ 依托“嘉庚”号组织国家自然科学基金共享航次计划“2024 年首席科学家培训航次”及“2023 年度南海中部海盆科学考察实验研究”

◎ MEL 获教育部“全国教育系统先进集体”荣誉称号

◎ 戴民汉当选美国地球物理联合会会士并获地球与空间科学大使奖

◎ 曹玲、王传超获批国家杰出青年科学基金项目

◎ *Science Advances* 发表关于开阔大洋向边缘海输运人为 CO_2 新路径的研究成果

◎ MEL团队与厦门斯坦道科学仪器股份有限公司签约，推动自研海洋监测仪器 *i*SEA 实现商业化

10 月

◎ 王为磊获第八届曾呈奎海洋科技奖“青年科技奖”，其团队科研成果“全球海洋生物碳泵估算研究”入选 2023 年度中国海洋与湖沼十大科技进展

◎ *Nature Communications* 发表关于光强驱动固氮来源氮在真光层氮循环中的整合的相关成果

◎ 举办“海洋负排放”大科学计划第三届开放科学大会，发布《宜居地球》本研一体化课程等系列教育成果

11 月

◎ “海洋负排放”国际大科学计划主导全球首个海洋碳中和国际标准提案并推动其立项

◎ 太古集团再次捐资“厦门大学东山太古海洋观测与实验站海洋生态保护及教育计划”

◎ MEL 与英国普利茅斯海洋实验室签署合作备忘录

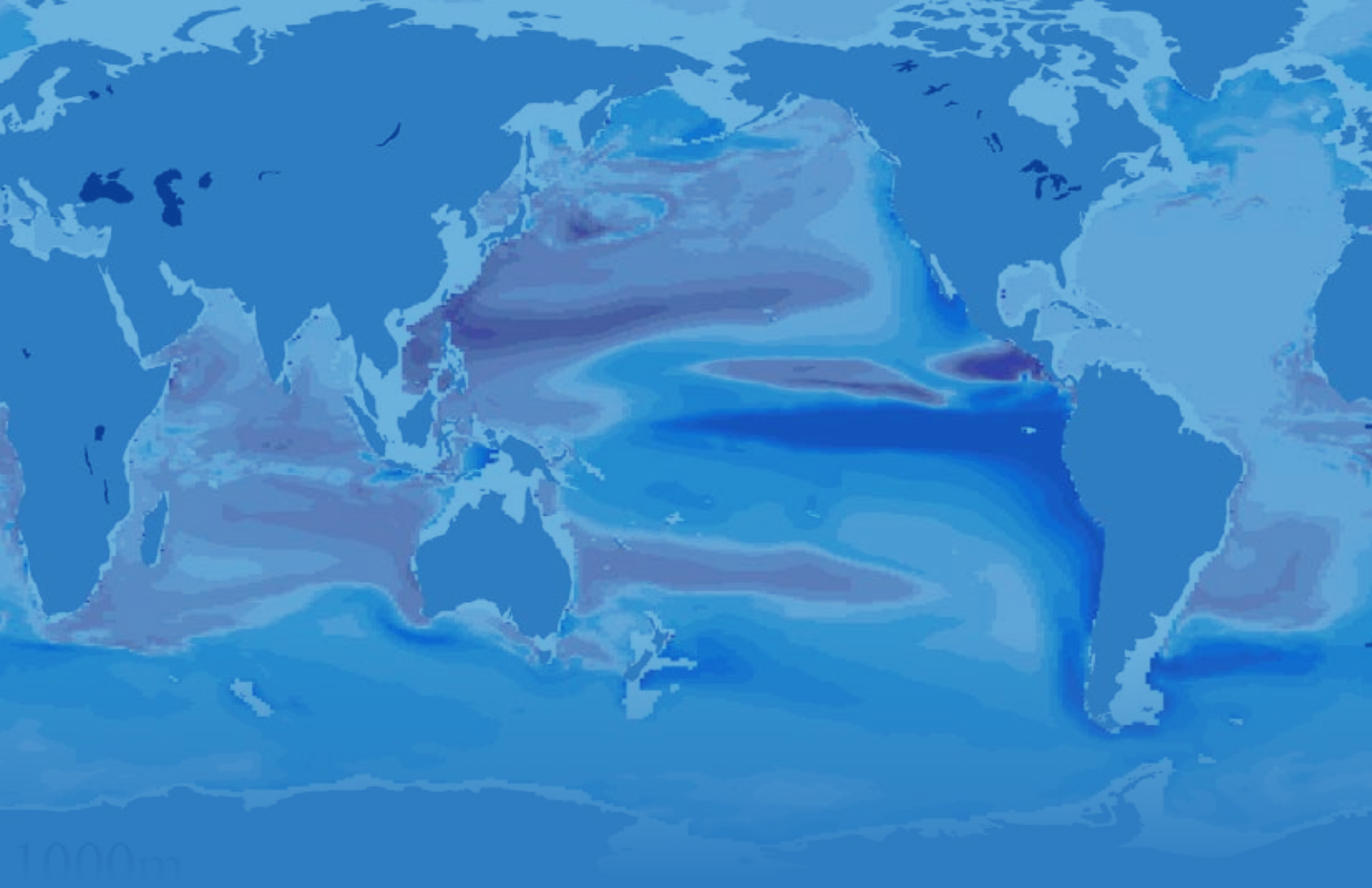
◎ MEL 与法国巴黎地球物理研究所签署合作备忘录

◎ 依托“嘉庚”号开展西北太平洋副热带逆流区涡旋观测航次

◎ 举办第十三届厦门大学海洋科学开放日

12 月

◎ 纪荣嵘入选 2024 国际模式识别协会会士



研究亮点
Research Highlights

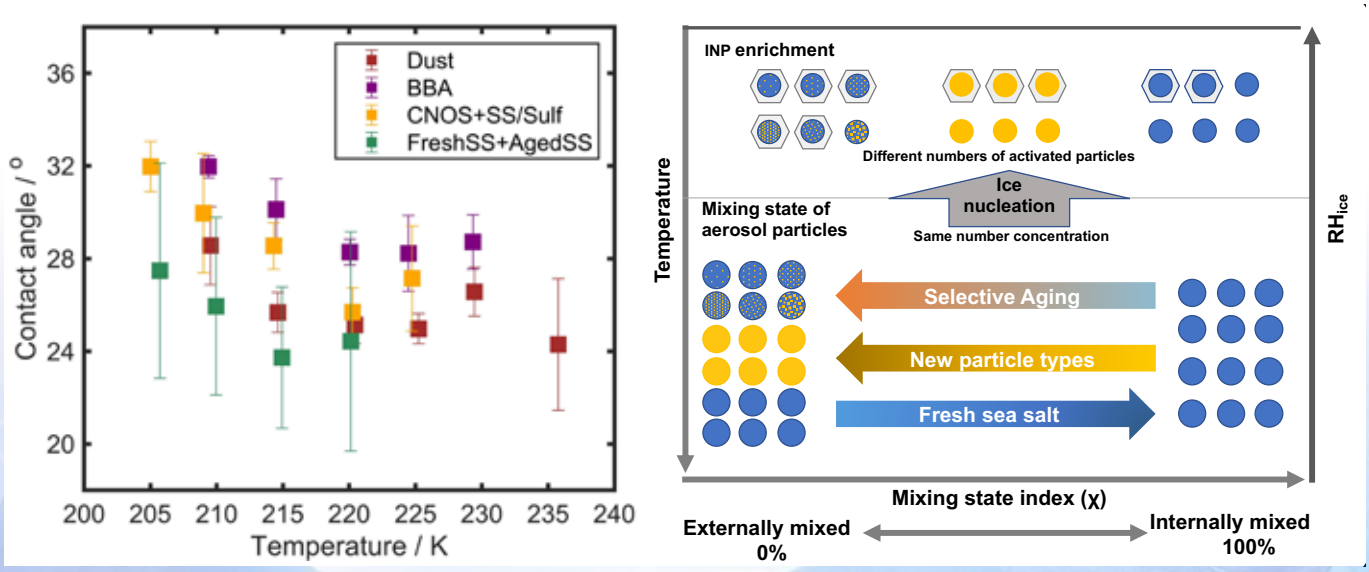
西太平洋和南大洋大气颗粒物的混合状态和冰核性能

大气颗粒物能够影响云的形成和降水，在全球辐射平衡中扮演重要角色。然而，目前对于海洋大气中颗粒物做为冰核形成冰晶的性能仍知之甚少。

本研究发现海洋气溶胶的混合状态随新鲜海盐颗粒物的增加趋向于内部混合，但随非均一老化反应或其他来源颗粒物的增加而趋向于外部混合。不同来源海洋气溶胶的冰核性能存在明显差异，其中由有机物包裹的新鲜海盐颗粒物冰核性能最优，而受澳大利亚森林大火影响的颗粒物结冰性能最差。大气中占主导的颗粒物均能成为有效冰核；老化海盐和硫酸盐混合颗粒物在冰核中有一定的富集。本研究发现海洋气溶胶的凝华冻结冰核性能受颗粒物组分及其物理和化学混合状态共同影响，提出了不同来源海洋气溶胶的异质结冰速率系数和接触角参数化方案，有助于云模式或地球系统模式中气溶胶气候效应的准确模拟。

> 以上工作于 2024 年 7 月发表于 *Atmospheric Chemistry and Physics* 期刊，2024 届博士毕业生薛姣为第一作者，汪冰冰教授为共同通讯作者。

Reference:
Xue, J; Zhang, T; Park, K; Yan, JP; Yoon, YJ; Park, J*; Wang, BB* (2024). Diverse sources and aging change the mixing state and ice nucleation properties of aerosol particles over the western Pacific and Southern Ocean. *ATMOSPHERIC CHEMISTRY AND PHYSICS*, 24(13): 7731–7754.



海洋上空不同过程对大气颗粒物混合状态和冰核的影响

二氧化碳对海洋固氮蓝藻氮同位素组成的影响

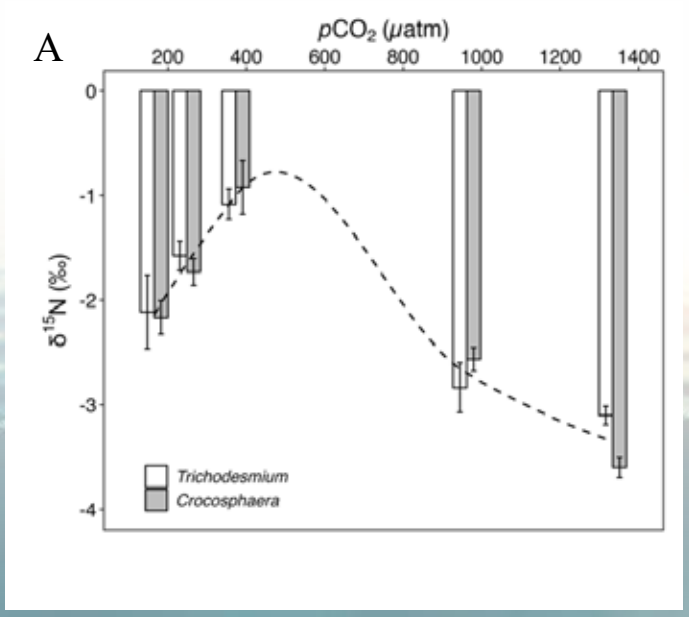
生物固氮作用对支撑海洋生产力具有重要意义，其氮同位素分馏效应是理解古海洋和现代海洋氮循环过程的关键参数之一。已有研究发现 CO_2 浓度升高导致的海洋酸化可显著降低固氮蓝藻束毛藻的固氮酶效率。固氮酶效率则与氮同位素分馏效应密切相关。由此推测，CO_2 浓度的改变可能通过影响固氮酶效率，从而调控固氮作用的氮同位素分馏。

通过开展不同 CO_2 分压条件下（180 μatm 至 1400 μatm）海洋代表性固氮蓝藻束毛藻和鳃球藻的受控培养实验，发现相较于现代水平（~380 μatm），CO_2 浓度降低或升高均显著降低固氮生物的氮同位素组成（$\delta^{15}N_{biomass}$）。进一步分析证实，CO_2 浓度变化通过影响固氮酶的效率和生长速率显著调控固氮蓝藻的 $\delta^{15}N_{biomass}$。该成果为沉积记录中观测到的 $\delta^{15}N$ 波动和地质历史时期的氮循环过程提供新见解。

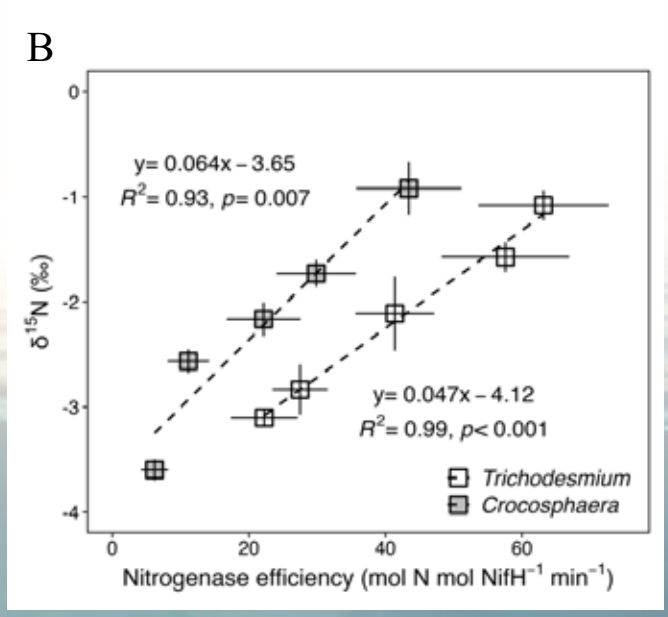
以上工作于 2024 年 10 月发表于 *Geophysical Research Letters* 期刊，温作柱副教授和 2019 级博士生姜若桐为共同第一作者，史大林教授为通讯作者。

Reference:

Wen, ZZ; Jiang, RT; He, TL; Browning, TJ; Hong, HZ; Kao, SJ; Yang, JYT; Shi, DL* (2024). Effects of CO_2 on the nitrogen isotopic composition of marine diazotrophic cyanobacteria. *GEOPHYSICAL RESEARCH LETTERS*, 51(19), e2024GL110599.



CO_2 对代表性固氮蓝藻束毛藻和鳃球藻氮同位素组成（$\delta^{15}N_{biomass}$）的影响



固氮生物氮同位素组成与固氮酶效率的相关性

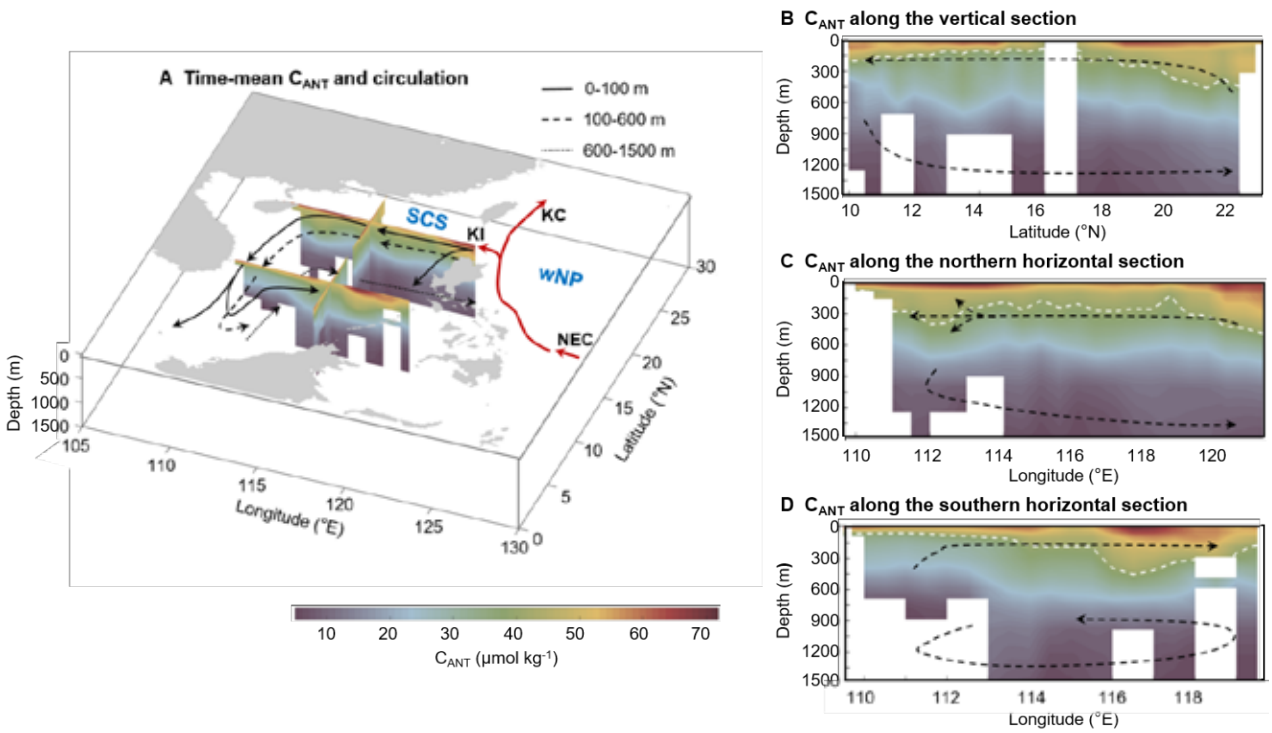
海洋中人为 CO_2 输运的独特路径：从开阔大洋到边缘海

边缘海和开阔大洋之间的水体交换往往是三维动态的，存在显著的时间和区域变异性，为研究边缘海人为 CO_2 的来源、变化和效应带来了严峻挑战。南海是典型的大洋主控型边缘海，因其与西北太平洋之间的水体交换具有独特的“三层”环流结构，是解析上述问题的典型区域。

本研究优化了计算海洋人为 CO_2 浓度的 TrOCA 法（溶解氧 + 溶解无机碳 + 总碱度示踪法），并基于南海近二十年的长期观测数据，构建了迄今为止最全面的南海人为 CO_2 数据集；证明了南海人为 CO_2 的主要来源是黑潮入侵携带的太平洋人为 CO_2，而非海 - 气交换（人为 CO_2 进入海洋的常规方式）及陆源输入。揭示这一开阔大洋向边缘海输运人为 CO_2 的新路径，对厘清边缘海人为 CO_2 分布、通量与演变，以及全面理解边缘海碳循环具有重要意义。

以上工作于 2024 年 9 月发表于 *Science Advances* 期刊，2024 届博士毕业生王志轩为第一作者，戴民汉教授和曹知勉教授为共同通讯作者。

Reference:
Wang, ZX; Cao, ZM*; Liu, ZQ; Zhai, WD; Luo, YH; Lin, YX; Roberts, E; Gan, JP; Dai, MH* (2024). Pacific Ocean-originated anthropogenic carbon and its long-term variations in the South China Sea. *SCIENCE ADVANCES*, 10, eadn9171.



南海人为 CO_2 的纬向梯度和经向梯度均与南海流场有较高的一致性，尤其是其浓度随黑潮入侵向西降低

西北太平洋颗粒态镉与磷的非耦合循环

金属镉对人类具有高度毒性，却是海洋生物可利用的痕量营养盐。现代海洋中溶解态镉与磷酸盐的浓度分布具有显著的相似性，因此沉积记录中的镉常被用来推算海水的磷酸盐浓度，从而反演古生产力。然而，现代海洋中镉和磷的循环机理仍不完全明晰。

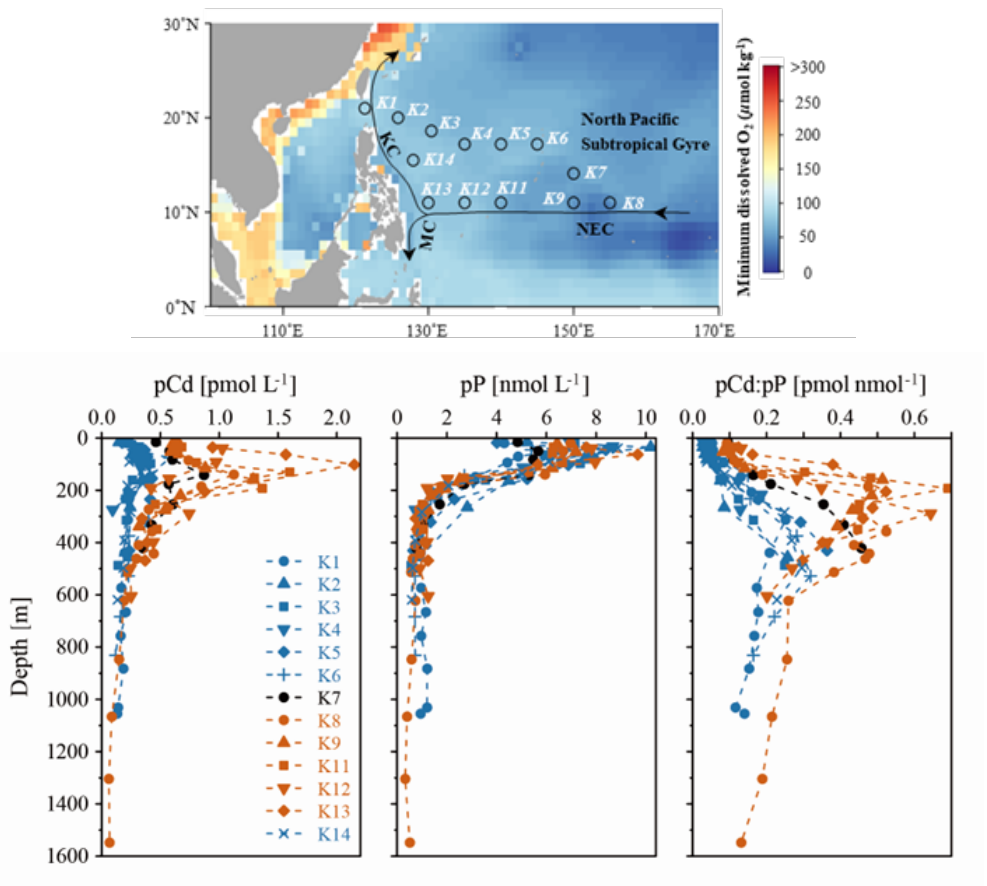
本研究通过调查西北太平洋副热带流涡区的颗粒态镉（Cd）和磷（P）浓度剖面，揭示了二者在生物吸收、有机质再矿化等过程中的非耦合性。真光层中，铁、锌等痕量营养盐的相对不足导致浮游植物上调对镉的吸收利用。弱光层中，磷相较于镉优先矿化，致使再矿化比率 ΔCd:ΔP 随深度发生变化。

研究不仅为评估海洋颗粒物对 Cd 与 P 循环的影响提供实测数据支持，二者的非耦合性也提示以镉作为古磷酸盐指标来重建古海洋生产力的方法尚存在较大的不确定性。

> 以上工作于 2024 年 8 月发表于 *Limnology and Oceanography* 期刊，张衍博士为第一作者，戴民汉教授为通讯作者。

Reference:

Zhang, K; Zhou, KB; Cai, YH; Yuan, ZW; Chen, YJ; Xu, FP; Liu, X; Cao, ZM; Dai, MH* (2024). Decoupled cycling of particulate cadmium and phosphorus in the subtropical Northwest Pacific. *LIMNOLOGY AND OCEANOGRAPHY*, 69: 1941-1954.



西北太平洋 GEOTRACES GP09 航次颗粒物采样站位
及颗粒态镉、磷、镉与磷比值的深度剖面

海洋中微生物群落功能的垂直连通性

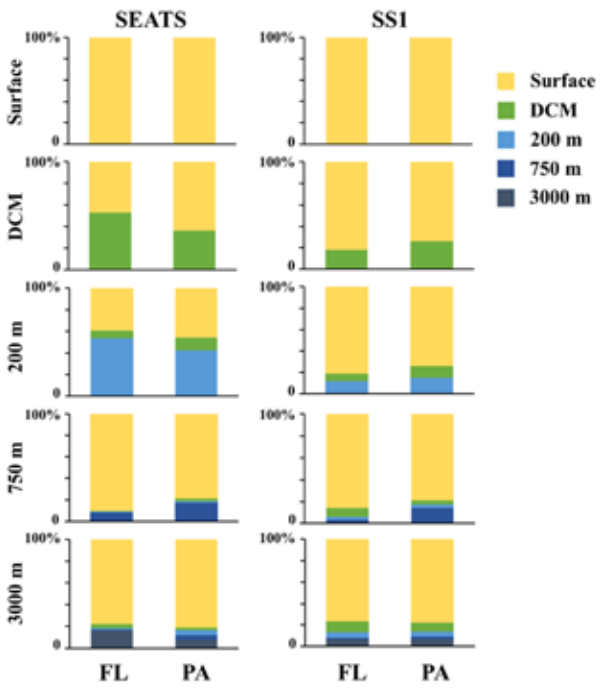
沉降颗粒介导海洋表层微生物向海洋内部迁移。表层与深海微生物群落组成的垂直连通性已经被证实，然而，海洋水柱微生物群落的功能垂直连通性仍处于研究空白。

本研究综合运用 16S rRNA 扩增子测序和宏蛋白质组学探索了南海两个水柱不同水层中自由生活（FL）和颗粒附着（PA）微生物群落的组成和代谢特征，发现微生物群落在组成和功能上存在显著的垂直连通性。海洋螺菌（Oceanospirillales）、交替单胞菌（Alteromonadales）和红杆菌（Rhodobacterales）是水柱中的关键功能类群。有趣的是，许多蛋白在各水层中都存在，且在 200 m 以深水层的丰度比其上水层的还高，即所谓的（“seed protein”）。研究提示表层微生物抵达深海后仍具有功能活性。它们的水层分布状况表明，随颗粒沉降的表层微生物通过维持细胞基础代谢的稳定表达可调节水解酶、转运蛋白和环境响应相关蛋白以应对沉降过程中深海不利环境胁迫，从而维持存活并参与深海生物地球化学循环。

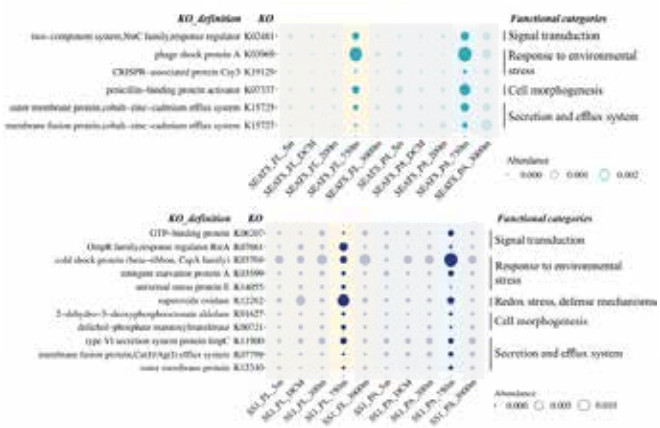
本研究首次论证了海洋微生物群落功能上的垂直连通性，并提示表层微生物对深海生物地球化学循环的影响被严重低估。研究成果丰富了海洋生物泵和海洋微生物生态学的理论，深化了学界对深海生态系统及海洋不同生境系统生物连通性的理解。

以上工作于 2024 年 5 月发表于 *Science Advances* 期刊，2021 届博士毕业生陈诗为共同第一作者，王大志教授为共同通讯作者。

Reference:
Chen, S; Xie, ZX; Yan, KQ; Chen, JW; Li, DX; Wu, PF; Peng, L; Lin, L; Dong, CM; Zhao, ZH; Fan, GY; Liu, SQ; Herndl, GJ*; Wang, DZ* (2024). Functional vertical connectivity of microbial communities in the ocean. *SCIENCE ADVANCES*, 10(2), eadj8184.



南海 SEATS 和 SS1 站水柱较浅水层的微生物群落蛋白质组对较深水层群落的贡献度



与环境压力响应相关功能的 seed proteins 丰度在水柱上呈现水层特异性分布趋势

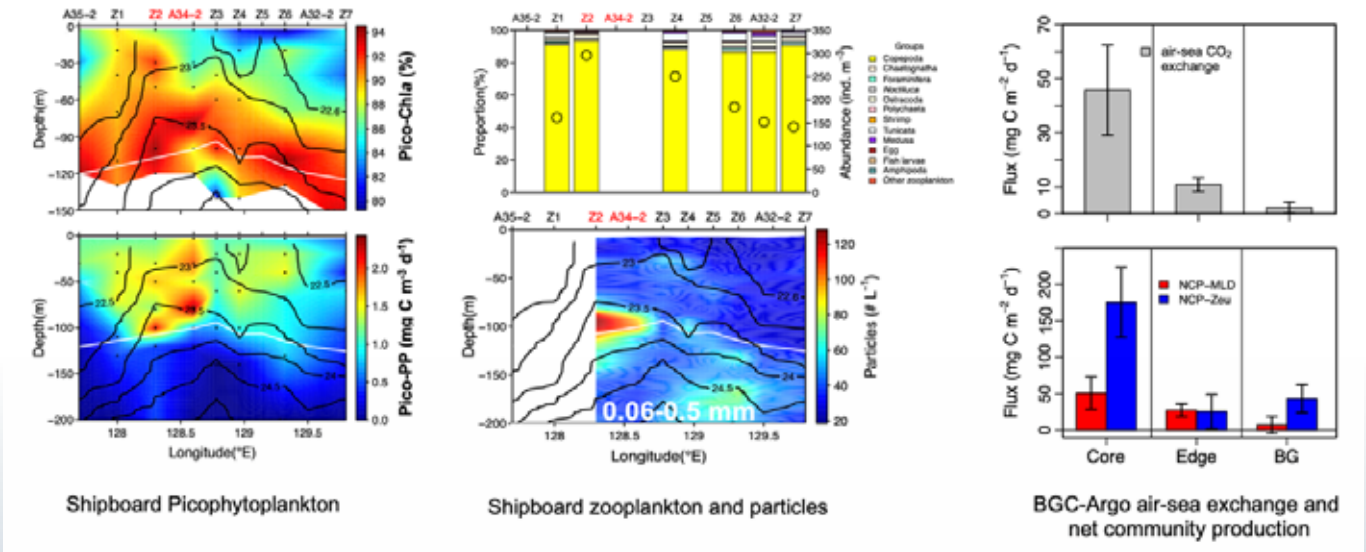
海洋中尺度涡生物泵作用过程与效应研究新进展

寡营养海区的气旋涡能驱动富含营养盐的深层海水向上涌升，对维持副热带流涡区初级生产和生物泵具有重要影响。然而，由于缺乏多学科协同的直接证据，至今关于气旋涡能否显著提升浮游生物的碳生物量和颗粒有机碳输出仍存在争议。

本研究基于卫星遥感数据，有针对性地组织高频船基现场过程观测，并结合生物地球化学浮标（BGC-Argo），通过多学科交叉解析了西北太平洋副热带流涡区气旋涡的浮游生物生态和生物泵过程。研究发现，西北副热带流涡区的气旋涡驱动的营养盐跃层抬升主要促进了微微型浮游植物初级生产并提升了次表层叶绿素 a 浓度。不过，因浮游植物和浮游动物之间快速且紧密的生长 - 摄食关系，致使真光层积分的浮游植物现存生物量并未显著增加。但浮游植物初级生产与浮游动物摄食速率都显著提升，依然使得涡旋中心中型浮游动物和可沉降的大粒径颗粒物浓度显著增加。水温下降、生产力增加以及强风应力共同作用，致使 BGC-Argo 观测到涡旋中心明显的大气 CO_2 汇。这些多学科协同的现场观测结果表明，在广袤的海洋荒漠区，气旋涡强化营养盐供应的上行效应确实能促进浮游植物生长，但生物量水平也受动物摄食下行效应的控制。这也意味着以浮游植物叶绿素 a 浓度或者碳生物量为单一指标，无法准确评估气旋涡的固碳和储碳能力，需要在特定的时空尺度下全面的考虑生态系统的碳汇功能。

以上工作于 2024 年 4 月发表于 *Limnology and Oceanography* 期刊，2023 届博士毕业生刘浩然为第一作者，柳欣教授为通讯作者。

Reference:
Liu, HR; Browning, TJ; Laws, EA; Huang, YB; Wang, L; Shang, YW; Xing, XG; Zhou, KB; Jiang, ZP; Liu, X*; Huang, BQ; Dai, MH (2024), Stimulation of small phytoplankton drives enhanced sinking particle formation in a subtropical ocean eddy. *LIMNOLOGY AND OCEANOGRAPHY*, 69: 834-847.



中尺度气旋涡真光层生物碳泵过程关键参数的响应

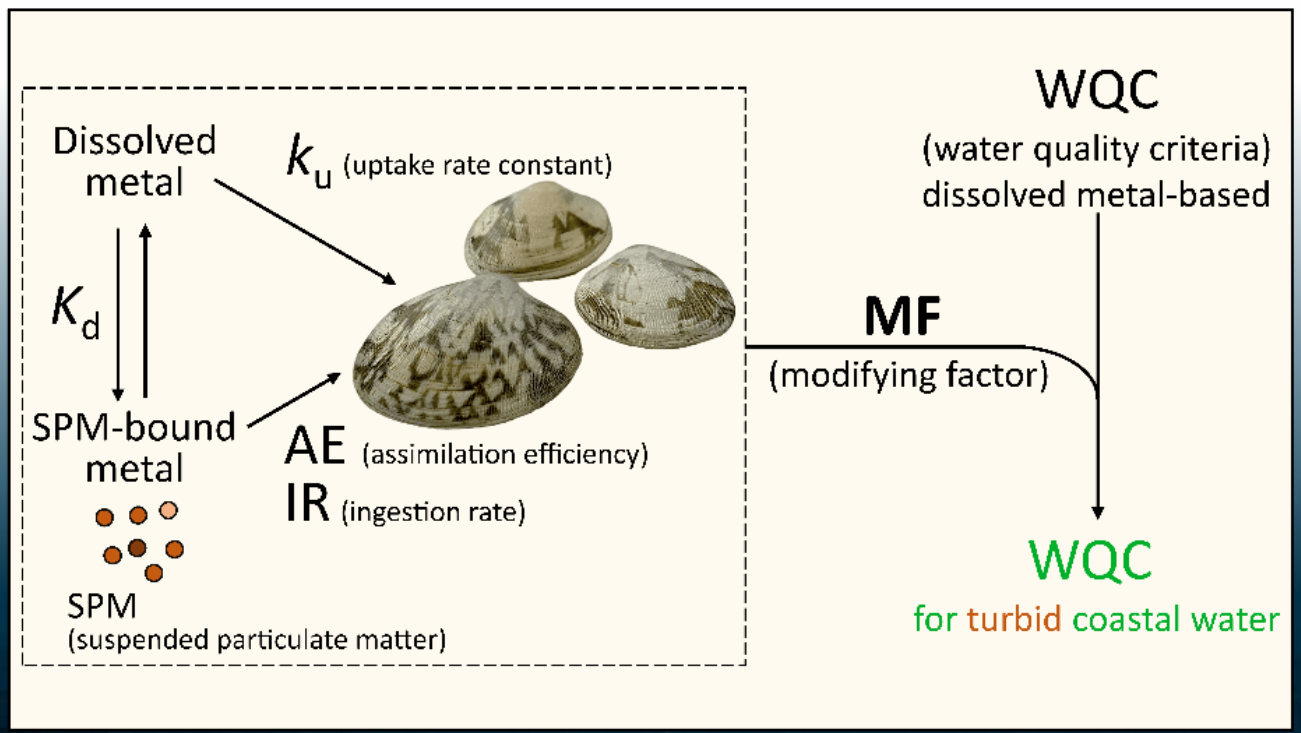
浑浊近海水体中颗粒态金属的生物有效性定量与水质基准调整

在近海浑浊水体中，重金属主要以颗粒态存在。然而，国内外现行的海水水质评估和基准仍以溶解态重金属作为评价指标，忽略了颗粒态重金属的潜在生态风险。以我国《海洋监测规范》为例，规定在水样采集后需立即使用 0.45 μm 滤膜进行过滤处理，以去除颗粒态重金属。此做法虽然相对简单，但也因此降低了重金属风险评估的准确性，难以有效保护浑浊水体的生态健康。

本研究聚焦浑浊水体中重金属的生物累积风险，采集我国沿海 23 个站位的悬浮颗粒物，开发一种新方法测定颗粒态重金属的生物有效性。研究选取了广泛分布的滤食性生物菲律宾蛤仔作为代表物种，结果表明：颗粒态 Zn、Cd、Cu、Ni 和 Pb 的平均生物可利用率分别为 42%、26%、20%、8% 和 6%。基于颗粒态重金属的生物可利用率，结合重金属在浑浊水体中的分配特征，研究采用蒙特卡罗方法计算了水质基准的校正因子。依据校正因子，可计算浑浊水体的水质基准，即基于溶解态重金属暴露制定的水质基准除以校正因子，本研究为完善浑浊水体的水质基准和保护近海生态系统提供了基本准则。

> 以上工作于 2024 年 3 月发表于 *Environmental Science & Technology* 期刊，2021 级博士生钱静为第一作者，谭巧国教授为通讯作者。

Reference:
Qian, J; Hu, TS; Xiong, HY; Cao, X; Liu, FJ; Gosnell, KJ; Xie, MW; Chen, R; Tan, QG* (2024). Turbid waters and clearer standards: Refining water quality criteria for coastal environments by encompassing metal bioavailability from suspended particles. *ENVIRONMENTAL SCIENCE & TECHNOLOGY*, 58(12): 5244-5254.



浑浊水体中水质基准的完善方法

升温与紫外辐射协同削弱颗石藻病毒的侵染力

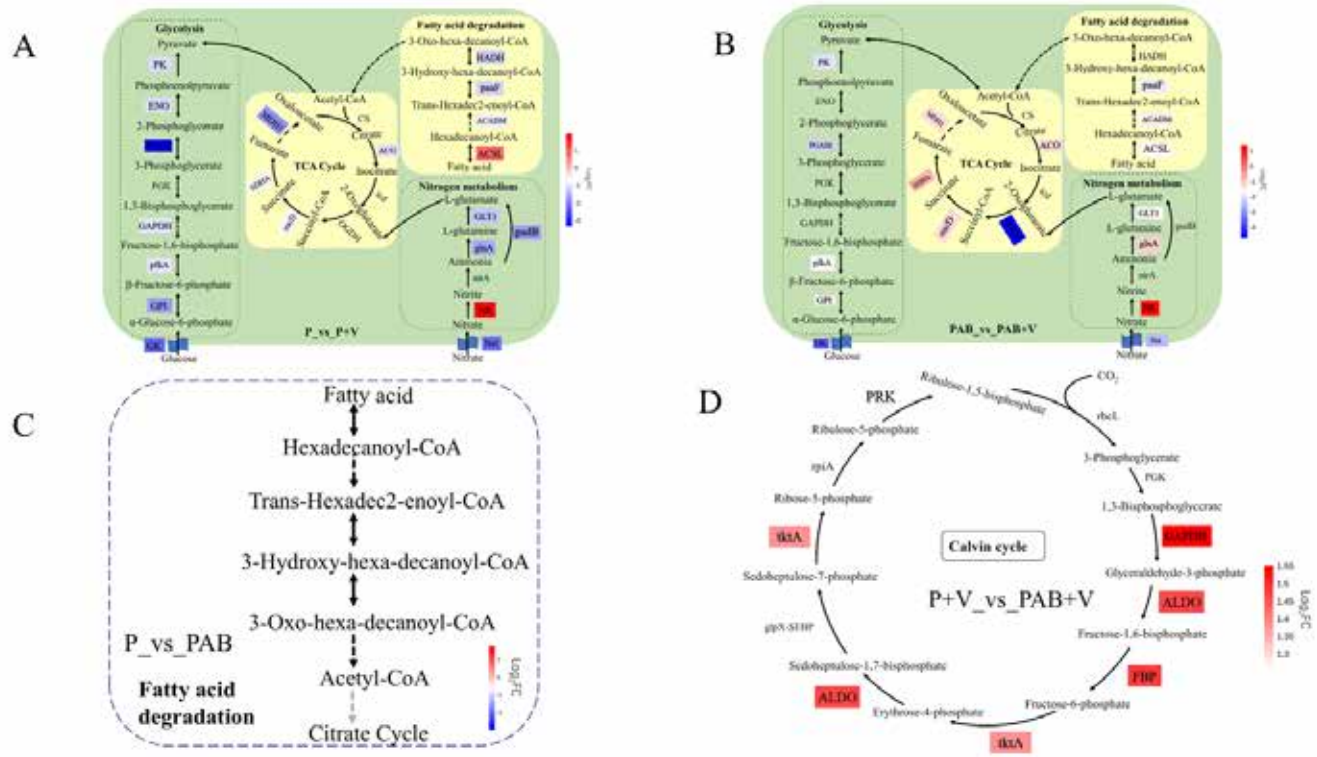
颗石藻类通过光合作用与钙化作用参与海洋生物碳泵与碳酸盐反向泵，与海气界面 CO_2 通量变化密切相关，其在海表形成大规模藻华的衰退与病毒侵染有关。

本研究发现，病毒侵染显著降低颗石藻的生长和固碳量，然而，紫外辐射会通过损害病毒的 DNA 削弱其侵染力。DNA 转录结果表明，病毒侵染降低了颗石藻能量代谢效率，下调了其脂肪酸降解和光捕获相关路径。升温与紫外辐射复合影响下，受病毒侵染后的颗石藻固碳量增加了 13 倍，这是因为紫外辐射与升温降低了病毒侵染作用的同时，上调了该藻光反应及卡尔文循环相关基因的表达。海水动力过程会驱使浮游植物从表层到深层或从较深层到表层，时常经受温度与紫外辐射暴露水平的变化。本研究结果表明，升温与紫外辐射下，颗石藻病毒对其宿主的侵染能力显著下降，暗示海洋暖化与上部混合层变浅 (紫外辐射暴露量增大) 会延长颗石藻藻华的爆发期。

> 以上工作于 2024 年 11 月发表于 *Plant Cell and Environment* 期刊，2023 届博士毕业生付倩倩为第一作者，高坤山教授为通讯作者。

Reference:

Fu, QQ; Huang, RP; Li, FT; Beardall, J; Hutchins, DA; Liu, JW; Gao, KS* (2024). Warming and UV radiation alleviate the effect of virus infection on the microalga *Emiliania huxleyi*. *PLANT CELL AND ENVIRONMENT*, DOI: 10.1111/pce.15262.



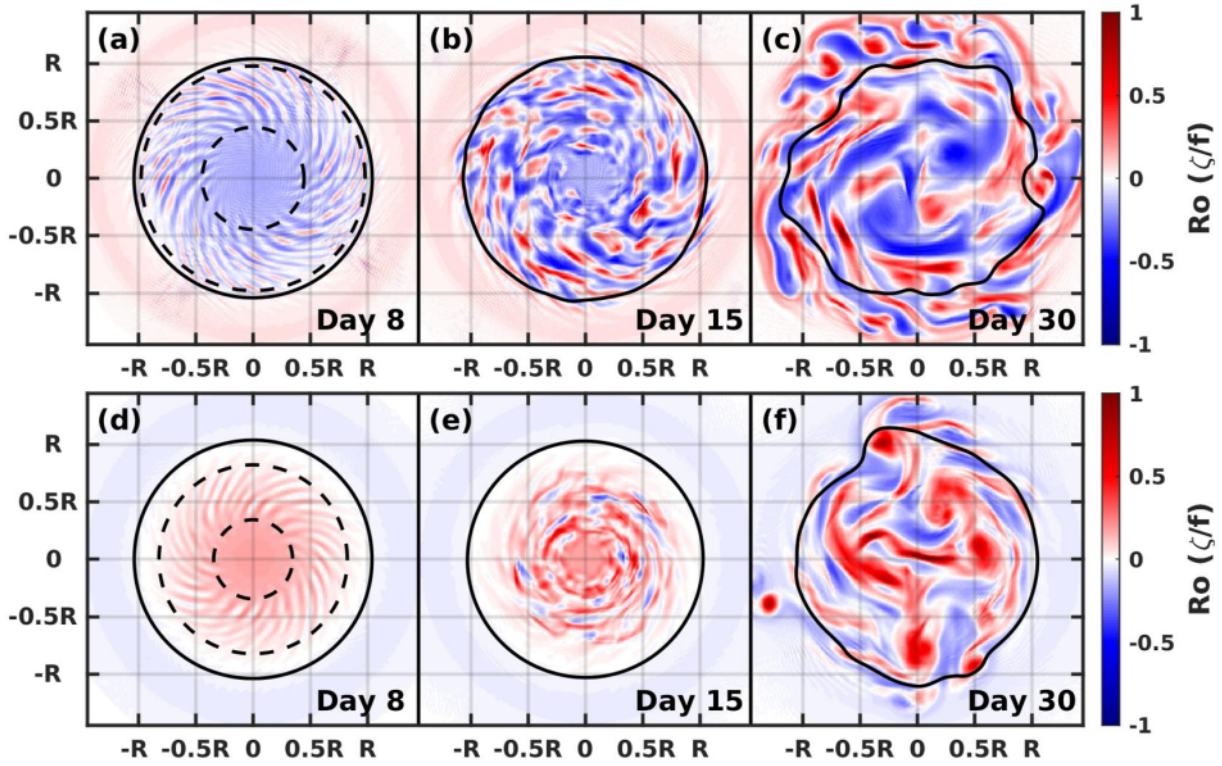
在 P (可见光)(A) 和 PAB (P+UVA+B) (B) 条件下被病毒（+V）侵染颗石藻不同代谢途径的变化

气旋涡与反气旋涡中亚中尺度不稳定的不对称性研究

近年的观测与数值模拟结果均表明中尺度涡边缘比涡中心存在更活跃的亚中尺度活动，但这样的空间分布在气旋涡与反气旋涡中是否存在差异仍有待研究。本研究聚焦气旋涡与反气旋涡中亚中尺度不稳定的不对称性分布与演化特征，融合理论分析以及可解析亚中尺度过程的理想中尺度涡数值模拟试验，结果表明气旋涡和反气旋涡中的亚中尺度涡丝均从水平浮力梯度最大的区域开始生成，但两者涡丝的后续演化却不同；具体来说，反气旋涡中的涡丝朝涡边缘向外旋转，而气旋涡中的涡丝朝涡中心向内旋转，从而导致反气旋涡边缘和气旋涡中心的亚中尺度过程更活跃。该不对称性分布主要是由于中尺度涡演化所引起的背景层结变化所致，活跃的亚中尺度过程朝气旋涡中心演化导致气旋涡核心结构易遭破坏，而反气旋涡核心结构则受影响不大。

以上工作于 2024 年 1 月发表于 *Geophysical Research Letters* 期刊，2024 届博士毕业生施伟安为第一作者，林宏阳副教授为通讯作者。

Reference:
Shi, WA; Lin, HY*; Deng, Q; Hu, JY (2024). Asymmetry of submesoscale instabilities in anticyclonic and cyclonic eddies. *GEOPHYSICAL RESEARCH LETTERS*, 51(2), e2023GL106853.



反气旋涡（上）与气旋涡（下）内不同时段的相对涡度空间分布，体现亚中尺度涡丝的不同演化特征

基于观测数据的拉布拉多海水团转化与生成速率研究

拉布拉多海水团（LSW）是大西洋深层水团关键组成部分，其生成强度直接影响深海温盐分布和环流结构。目前对 LSW 生成速率的估计多基于数值模式或逆方法，不确定性较大，且多强调海 - 气通量的主导作用，尚缺乏基于观测数据的稳健估计和归因。

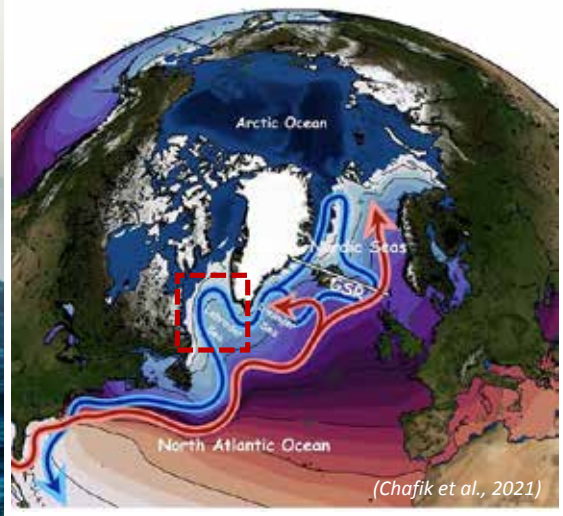
本研究利用多源观测数据估计 LSW 多年平均生成速率，指出跨等密度面混合起主导作用，驱动了 63% 的 LSW 生成速率。此外，研究进一步分析了 LSW 温盐变异机制，揭示了海 - 气热通量和边界混合驱动 LSW 温盐变化的关键过程。

研究结果强调了海洋内部混合对 LSW 生成和温盐变化的重要影响，对深入理解大西洋深层水团形成机制具有科学意义，同时为海洋和气候模型正确模拟大西洋深层温、盐、流提供了观测参考。

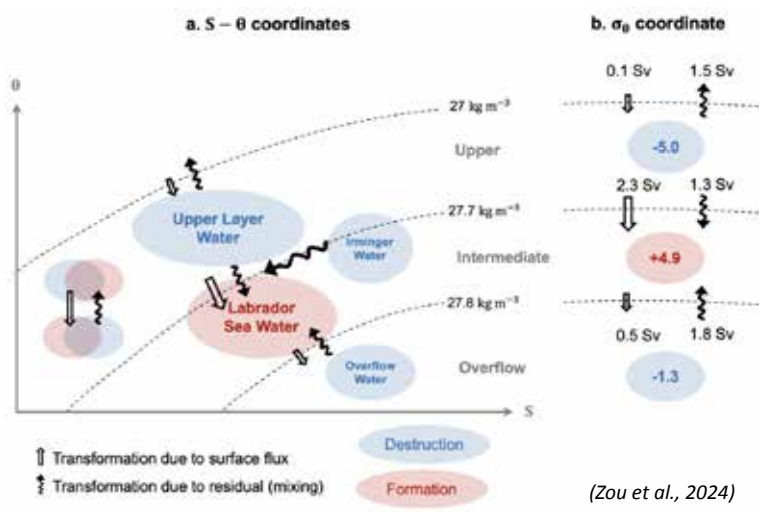
> 以上工作于 2024 年 7 月发表于 *Journal of Physical Oceanography* 期刊，邹斯嘉教授为第一作者兼通讯作者。

Reference:

Zou, SJ*; Petit, T; Li, FL; Lozier, MS (2024). Observation-based estimates of water mass transformation and formation in the Labrador Sea. *JOURNAL OF PHYSICAL OCEANOGRAPHY*, 54(7): 1411–1429.



大西洋环流结构示意图及拉布拉多海位置



拉布拉多海水团转化与生成速率

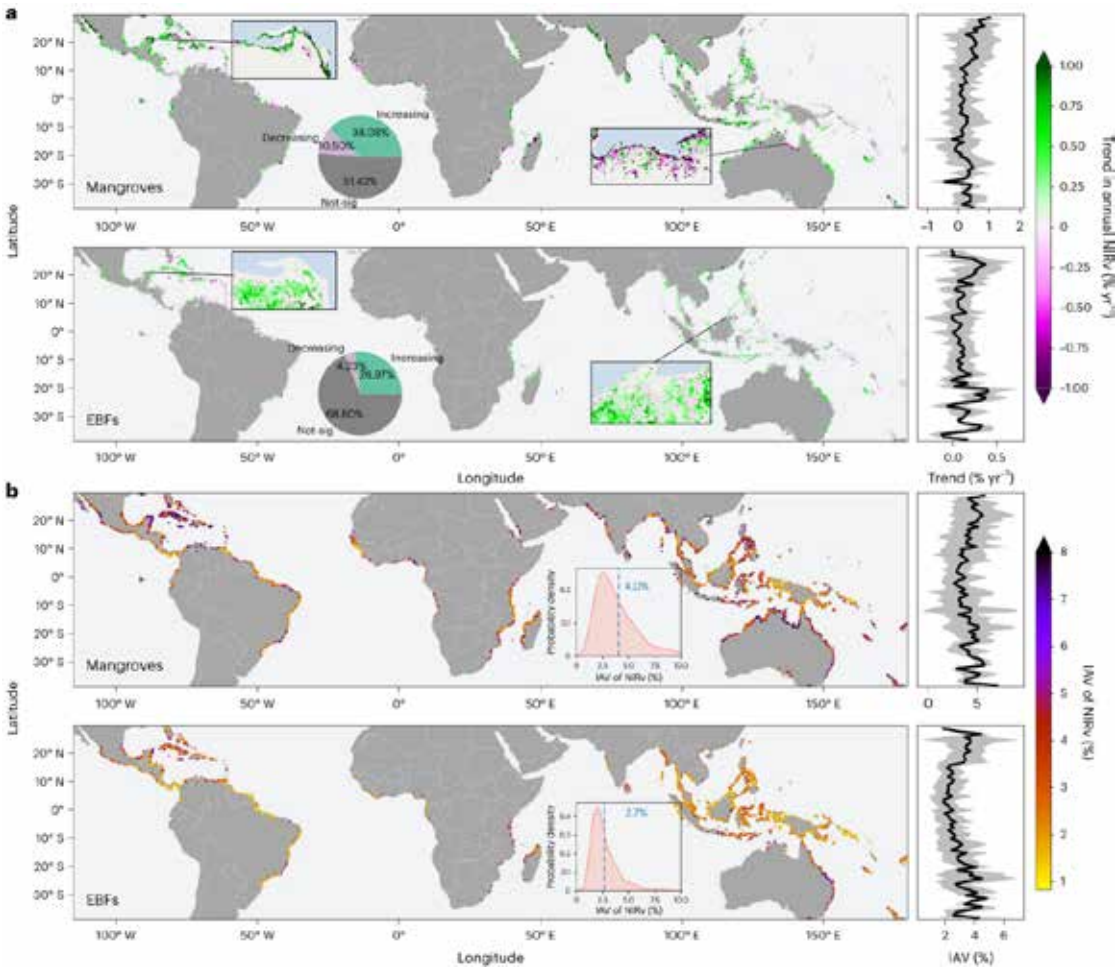
红树林较之陆地森林有更强的绿化趋势和年际变异

红树林是一种重要的蓝碳生态系统，但现有研究极少关注红树林在响应气候变化方面相较陆地森林的特异性，且目前针对陆地生态系统的研究也常因使用低分辨率数据而忽略了面积相对较小的红树林生态系统。

本研究运用遥感 MODIS 较高分辨率（250 m）波段数据分析了全球红树林和其邻近常绿阔叶林（EBFs）在 2001-2020 年的趋势和年际变异，发现红树林发生了显著且广泛的生产力增加现象，生产力增长趋势较陆地森林更强，但与此同时也显示出更大的生产力年际波动性。通过构建多变量线性模型进行各因子贡献度分解，研究进一步揭示红树林生产力比邻近 EBFs 受到更强的 CO_2 施肥效应，二者生产力增加趋势的差异可被 CO_2 施肥造成的趋势差异解释，而温度、降水、风速和水汽压赤字等气候因素对生产力趋势影响较小。红树林生产力更大的年际波动性可归因于其受到海平面年际波动的独特影响以及比陆地森林更高的降雨敏感性。红树林对降雨等水文气候条件更强的敏感性以及 CO_2 施肥效应更强的原因是其有更少的冠层蒸腾和更高的边际水分利用效率，因此在水分可获得性增加或气孔导度下降引起的水分丧失减少（即间接的水分增加）的情况下红树林生产力会有更大的变化。

> 以上工作于 2024 年 1 月发表在 *Nature Ecology & Evolution* 期刊上，2019 级博士生张振为第一作者，李杨帆教授为共同通讯作者。

Reference:
Zhang, Z; Luo, XZ*; Friess, DA; Wang, SH; Li, Y; Li, YF* (2024). Stronger increases but greater variability in global mangrove productivity compared to that of adjacent terrestrial forests. *NATURE ECOLOGY & EVOLUTION*, 8(2): 239-250.



2001-2020 年全球红树林及其邻近陆地常绿阔叶林生产力指标近红外反射率 (NIRv) 时空变化

河流输入的陆源岩性颗粒压载效应对海洋 POC 通量的影响

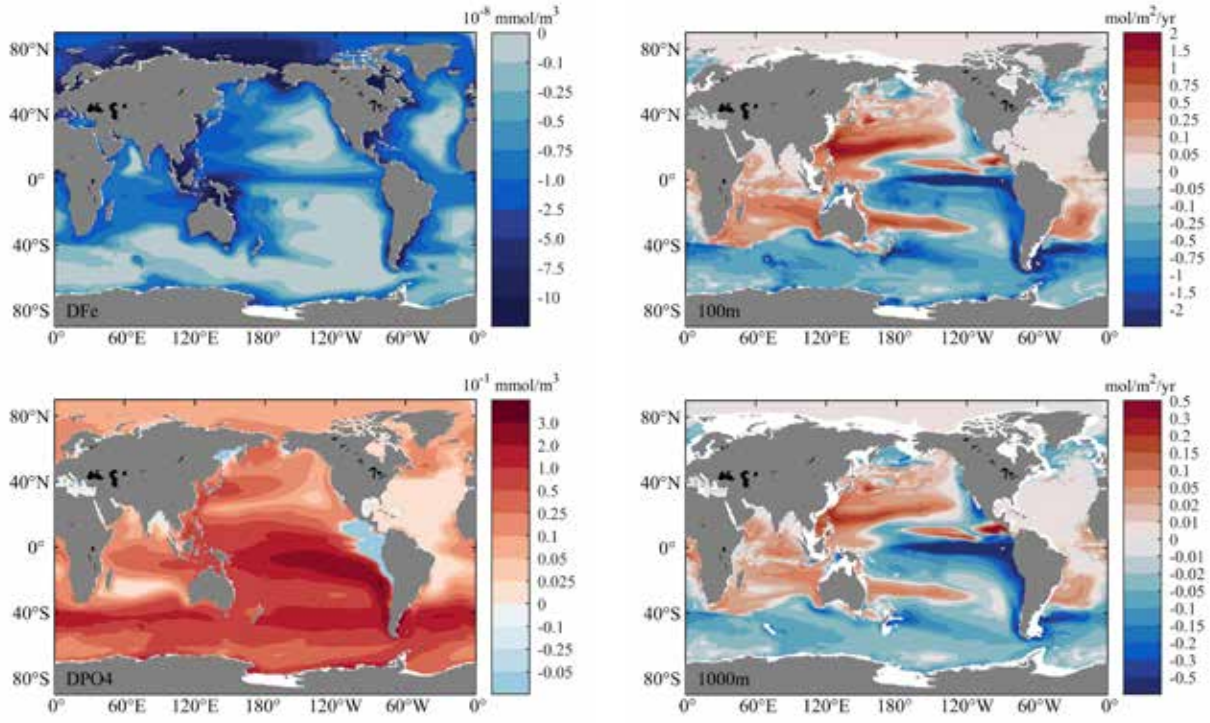
海洋中矿物对颗粒有机碳的压载效应，是指通过增加颗粒聚集体的密度或者保护有机质免受快速的再矿化，从而促进有机碳向深层海洋沉降，这种现象对生物碳泵至关重要。近年来的研究表明，河流或海岸侵蚀入海的陆源岩性颗粒在到达海洋后可能发生跨陆架（和陆坡）输送，从而对大陆边缘甚至开阔大洋的 POC 通量产生重大影响。

为探究这一问题，本研究利用耦合海洋生物地球化学循环过程的地球系统模型开展了一系列敏感性模拟试验，估算了河流输入的陆源岩性颗粒对全球海洋 POC 通量及其他生物地球化学循环的潜在影响。结果显示，陆源岩性颗粒沿陆架（和陆坡）底部向外海输送时，模拟的全球海洋 POC 通量（此处关注 100 m 及以深的通量）发生强烈变化。模拟达到稳定状态时，POC 通量在亚热带地区增强，而在热带太平洋和中高纬度地区减弱。这是由于陆源岩性颗粒的压载作用初期立即促进了 POC 沉降，导致大陆边缘海溶解铁被大量清除并埋藏，进而影响溶解铁的侧向平流以及上层海洋的常量营养盐分布。其结果使南大洋和热带海洋上升流区的铁限制随之增强，导致这些区域的常量营养盐累积，随后通过 Ekman 输运扩散至邻近的亚热带环流区。最终，全球海洋的生物可利用铁和常量营养盐分布的改变，使亚热带环流区域的 POC 通量随着常量营养盐限制的减弱而提高，而受铁限制的南大洋和热带上升流区域的 POC 通量显著下降。整体上，全球海洋 100 m 深度处的 POC 通量减少了 0.9 Pg C/a，表明忽略陆源岩性矿物压载效应的海洋生物地球化学模型可能高估生物碳泵，指出在模型中添加陆源岩性矿物压载作用的必要性。

> 以上工作于 2024 年 5 月发表于 *Global Biogeochemical Cycles* 期刊，2019 级博士生李莎莎为第一作者，王杉霖教授为通讯作者。

Reference:

Li, SS; Li, HL; Tang, TT; Wang, SL* (2024). The ballast effect of terrigenous lithogenic particles from rivers and its influence on POC fluxes in the ocean. *GLOBAL BIOGEOCHEMICAL CYCLES*, 38(5), e2024GB008155.



陆源岩性颗粒沿陆架和陆坡底部向外海输送时的结果模型中含有 / 忽略陆源岩性颗粒压载效应时，模拟的 0~100 米的溶解铁 (a) 和磷酸盐 (b) 浓度差异、100 米 (c) 和 1000 米 (d) 的 POC 通量差异

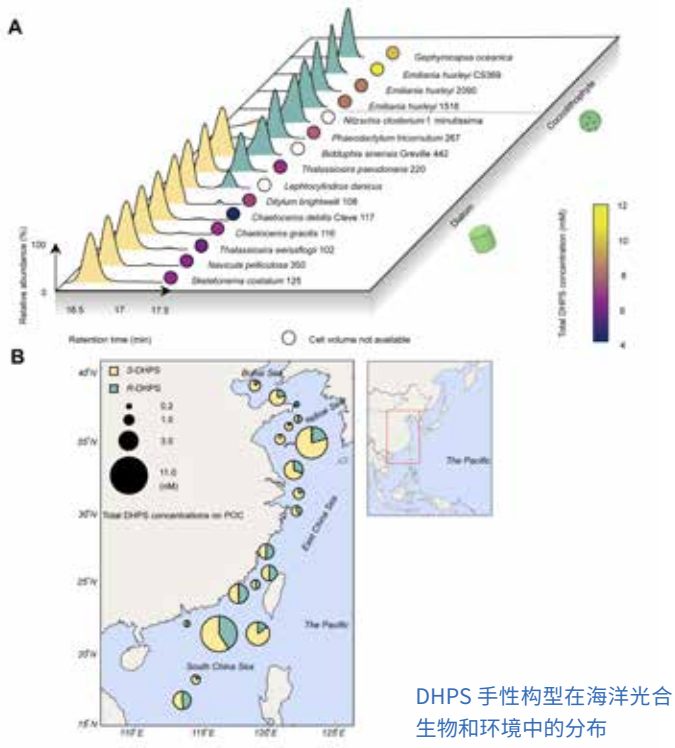
海洋细菌对浮游植物中二羟基丙磺酸盐的手性选择性转化

手性是自然界的一种基本属性，在海洋有机质的循环中被忽略。2，3-丙二醇磺酸盐（dihydroxypropanesulfonate，DHPS），被认为是广泛且大量存在于自然界的有机硫分子，作为“化学货币”从海洋浮游植物向异养细菌传递物质和能量。然而，迄今为止，DHPS 在自然界中的手性以及微生物对 DHPS 手性对映体的转化过程以及分子机制尚不清楚。

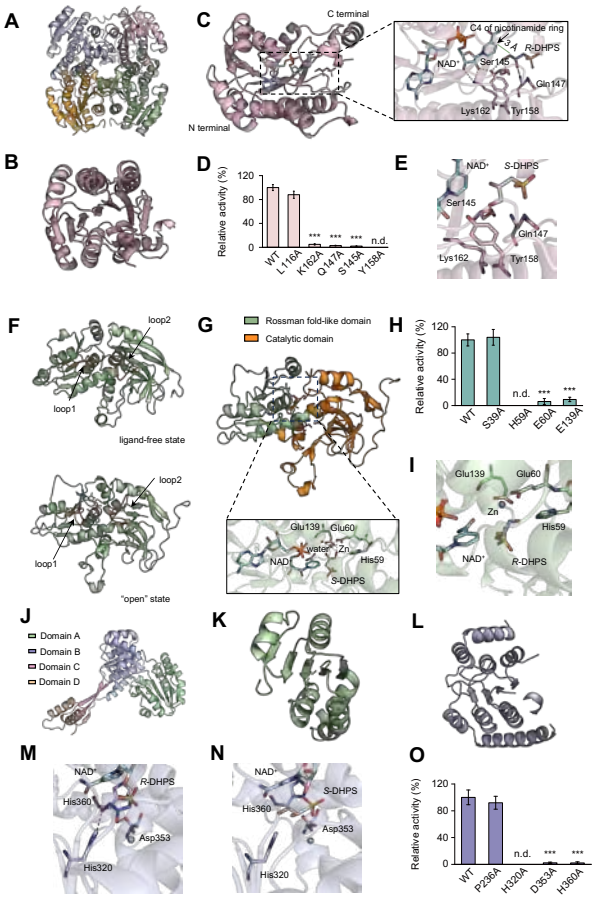
本研究基于新建立的 DHPS 手性对映体拆分方法，对 DHPS 在浮游植物和海洋环境中的手性分布进行了分析。研究发现，硅藻和颗石藻可以产生至少一种手性构型的 DHPS，在我国近海水域（渤海、黄海、东海、南海）的颗粒物上存在两种手性构型的 DHPS（R-DHPS 和 S-DHPS）。此外，研究聚焦异养细菌对 DHPS 的代谢通路以及手性选择的分子机制进行了研究，重构了 R-DHPS 与 S-DHPS 的代谢通路，通过蛋白结构解析揭示了 DHPS 代谢酶的手性选择分子机制。酶的活性位点与 DHPS 手性中心的特定相互作用力是酶手性选择催化 DHPS 的关键因素。并进一步指出，酶的杂泛性在海洋细菌进化出代谢 DHPS 手性对映体的能力中起到了重要的作用。研究为手性参与浮游植物与细菌之间的代谢过程提供了证据，强调了代谢物的手性以及酶的手性选择性在海洋有机质循环中的重要性。

以上工作于 2024 年 5 月发表于 *The ISME Journal* 期刊，2023 届博士毕业生刘乐为第一作者，汤凯教授为通讯作者。

Reference:
Liu, L; Gao, X; Dong, CJ; Wang, HY; Chen, XF; Ma, XY; Liu, SJ; Chen, QR; Lin, D; Jiao, NZ; Tang, K* (2024). Enantioselective transformation of phytoplankton-derived dihydroxypropanesulfonate by marine bacteria. *THE ISME JOURNAL,* 18(1), wrae084.



DHPS 手性构型在海洋光合生物和环境中的分布



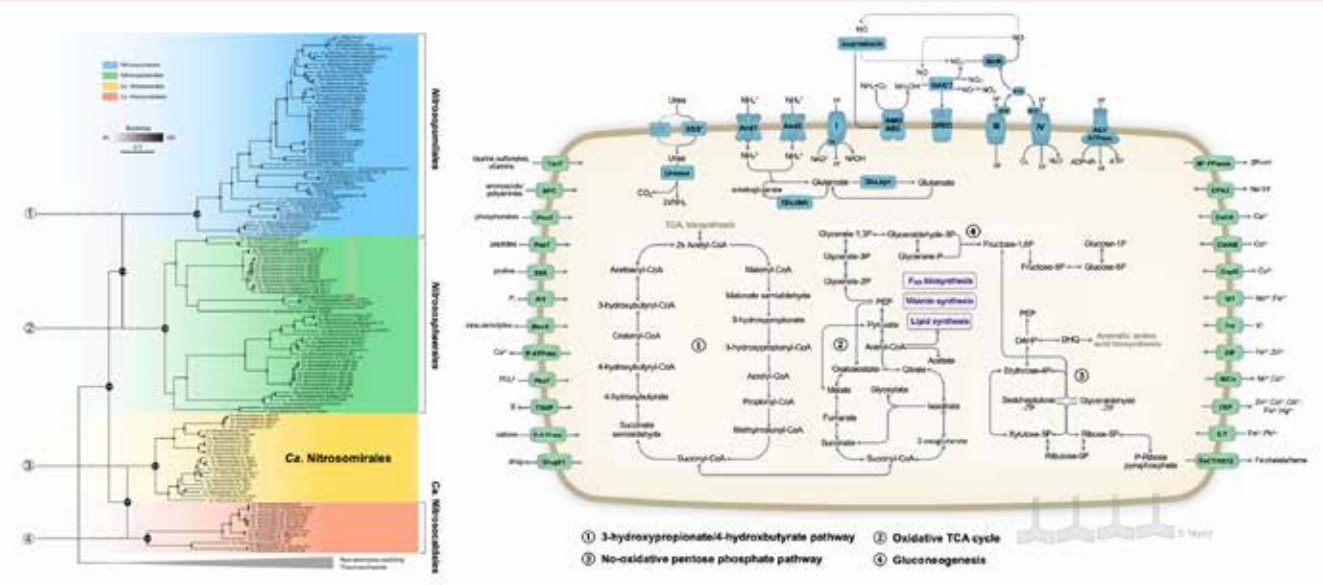
DHPS 代谢酶 HpsO、HpsP、HpsN 的蛋白结构分析

海洋氨氧化古菌新类群

氨氧化古菌作为地表系统分布最为广泛的微生物之一，对氮素在地球生态系统中的形态转换和流动至关重要。研究人员已从全球淡水、海水、土壤、热泉等各类生境中分离出不同种类的氨氧化古菌。目前广泛认为氨氧化古菌在目水平上分为三大类群：Nitrosopumilales、Nitrososphaerales、*Ca*. Nitrosocaldales。然而，深入分析环境宏基因组样品发现，尚有部分遗传信息无法归类到传统的氨氧化古菌谱系，这对已有氨氧化古菌的分类学提出了新的挑战。

本研究在传统氨氧化古菌三大类群的分类基础上，发现了第四个单独的类群，并命名为 Candidatus Nitrosomirales。从生境分布上，发现 *Ca*. Nitrosomirales 的分布涵盖了陆地和海洋生态系统，尤其是在深海海绵共生体等系统。从代谢潜能上，*Ca*. Nitrosomirales 具备使用甲酸作为电子供体和硝酸盐作为电子受体的相关基因，这拓展了关于氨氧化古菌只能利用氨氮作为电子供体和氧气作为电子受体这一代谢路径的传统认知。从进化路径上，本研究发现 *Ca*. Nitrosomirales 跨越了陆地 - 海洋、高温 - 常温的生境，表明氨氧化古菌的物种进化路径不止传统认识的单一生境扩张和进化途径。基于上述发现，本研究构建了一个系统的氨氧化古菌谱系框架，为氨氧化古菌的生态分布规律和环境适应机制提供了新的见解。

> 以上工作于 2024 年 1 月发表于 *The ISME Journal* 期刊，郑越副教授为第一作者。



氨氧化古菌第四大类群（*Ca*. Nitrosomirales）及其代谢通路

Reference:
Zheng, Y; Wang, BZ; Gao, P; Yang, YY; Xu, B; Su, XQ; Ning, DL; Tao, Q; Li, Q; Zhao, F; Wang, DZ; Zhang, Y; Li, M; Winkler, MKH; Ingalls, AE; Zhou, JZ; Zhang, CL; Stahl, DA; Jiang, JD*; Martens-Habbena, W*; Qin, W* (2024). Novel order-level lineage of ammonia-oxidizing archaea widespread in marine and terrestrial environments, *THE ISME JOURNAL*, 18(1), wrad002.

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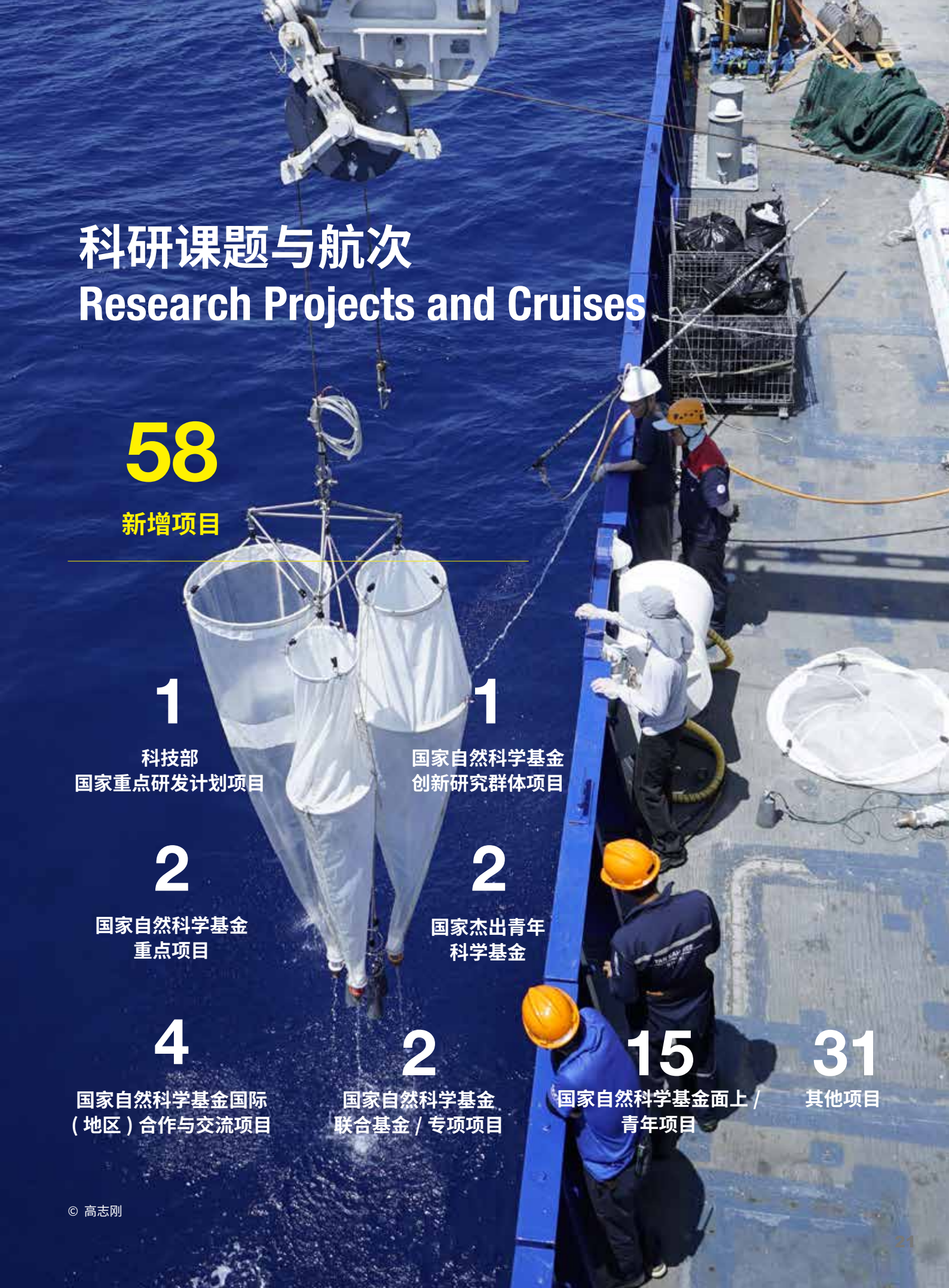

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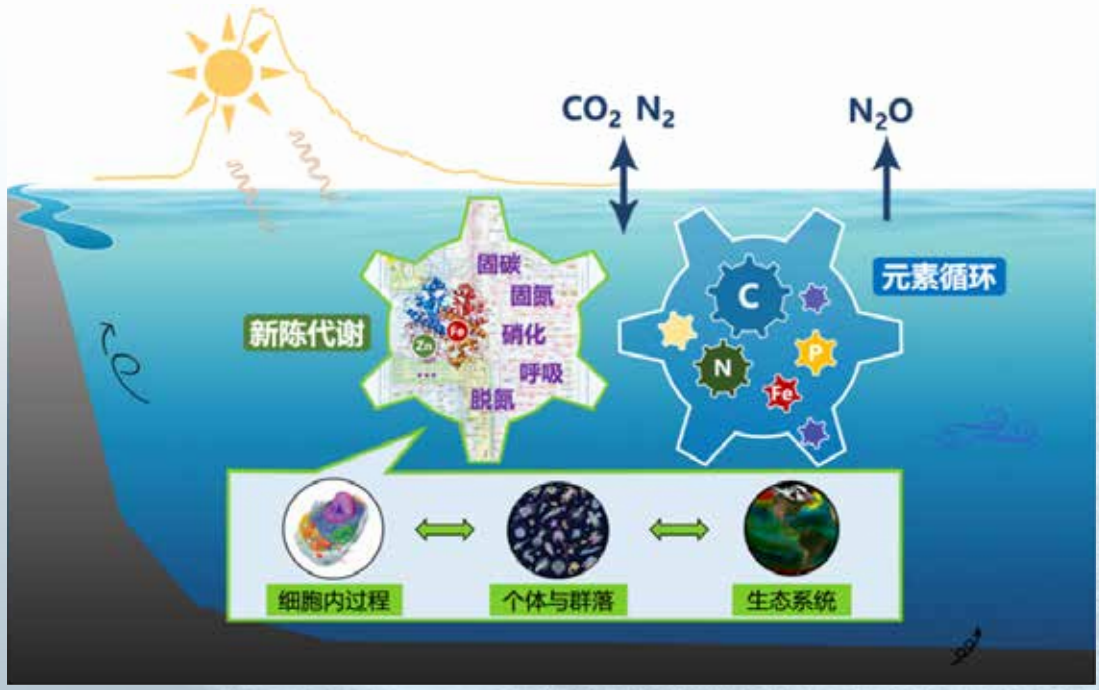
海洋新陈代谢与元素循环

国家自然科学基金创新研究群体项目 2025-2029 | 史大林、张瑶、洪海征、曹知勉、柳欣、沈渊

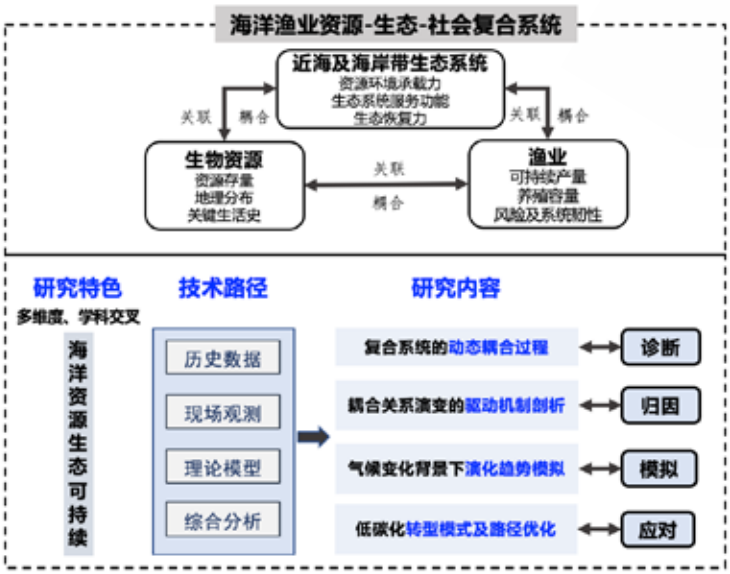
群体汇聚海洋生理生态学、微生物海洋学、海洋生物地球化学的优势力量，围绕“海洋新陈代谢与元素循环”这一前沿研究方向，在海洋微生物代谢与碳氮循环、浮游植物碳氮及能量代谢、痕量元素生物地球化学循环等方面取得一系列重要进展。群体成员将进一步深化合作研究，揭示海洋浮游生物新陈代谢的时空格局和调控因子，阐明其与元素循环的耦合关系和机制，进而评估和预测其对全球变化的响应和反馈，以期在海洋浮游生物新陈代谢与元素循环领域取得突破性成果，在国际上占有一席之地。



海洋生物资源保护与可持续利用

国家杰出青年科学基金项目 | 曹玲

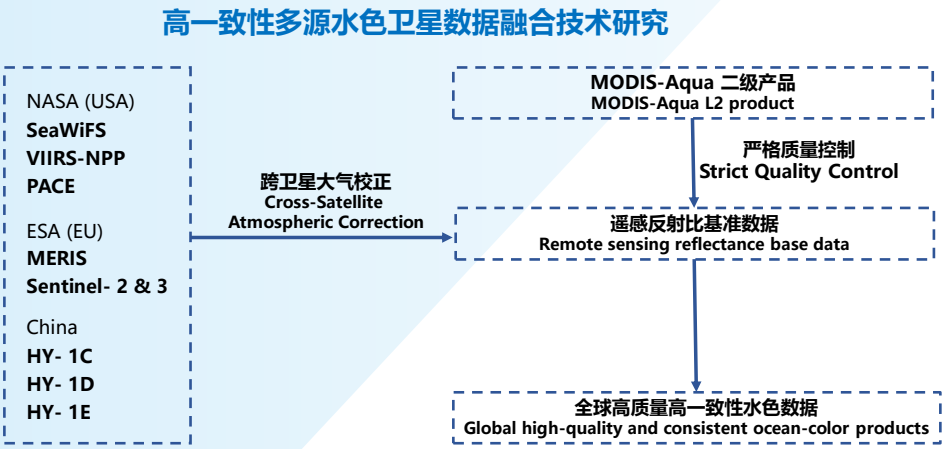
项目针对我国海洋生物资源开发利用过程中已经累积和正在形成的生态环境和产业效能问题，重点建立全球变化压力下近海渔业资源 - 生态 - 社会复合系统耦合互馈的动态综合分析框架，依据诊断 - 归因 - 模拟 - 应对的多层次研究路径，探究气候变化下的近海渔业资源 - 生态 - 社会复合系统动态演变、响应特征及协同机制，定量评估并识别多维风险，提出兼顾资源养护、生态安全、减碳增汇、价值产出的协同可持续发展与调控策略。



高一致性多源水色卫星数据融合技术研究

国家自然科学基金重点项目 2025-2029 | 李忠平等

项目通过研发新的水色卫星数据处理方案，显著提升不同水色卫星间产品的一致性，从而构建一个可靠、长期且覆盖全球尺度的上层海洋生物光学数据集。该“遥感大数据”是评估海洋生态系统现状及其气候相关动态的基础。项目提出了跨卫星大气校正这一原创性水色卫星数据处理概念，结合人工智能技术，确保不同卫星间遥感反射比的一致性。项目将通过融合多种水色卫星数据，拓展空间覆盖范围并延长时间序列，所形成的数据集对于监测海洋生态系统变化、研究海洋在碳循环中的作用，以及评估气候变化的影响至关重要。此外，基于人工智能的跨卫星大气校正方案为未来的水色卫星数据处理设定了新基准，标志着水色数据处理进入了一个新时代：从传统的辐射传输方法转向基于数据的人工智能系统。



全球暖化下海洋典型自养微生物的生态进化策略及其对元素循环的影响

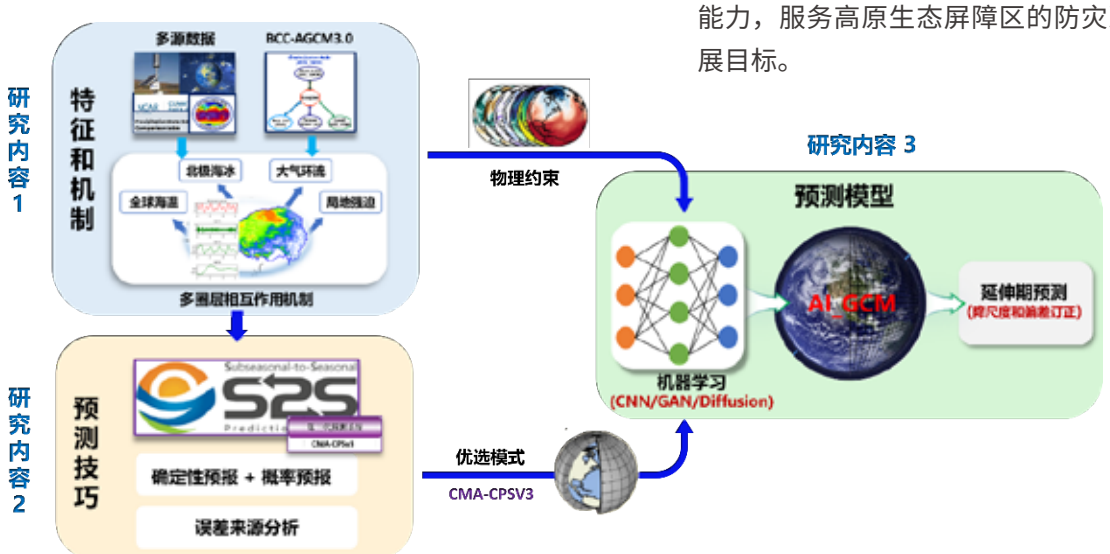
国家自然科学基金重点项目 2025-2029 | 张瑶等

项目拟聚焦海洋最优势的自养微生物——真光层光合自养的原绿球藻和深海化能自养的硝化菌，通过结合室内长期传代实验、海域现场观测、全球宏组学分析和地球系统数值模拟，开展海洋典型自养微生物的基因组演化、物质和能量代谢的响应、进化和生态学策略及其对全球尺度海洋生态系统和元素循环的影响研究。项目将明确典型物种对海洋升温的短期响应和长期适应的差异，揭示其长期适应下的基因组演化特征、生理表型的变化，以及种间关系的演变趋势；阐明温度对种群结构、关键功能基因特征和表达谱、微生物介导的固碳储碳、氮磷吸收和转化、产氧耗氧等重要元素循环关键过程的调控机理；形成一套升温影响下的典型物种、种群、群落生长和代谢过程参数，通过优化构建模型，预测全球变暖驱动的自养微生物变迁对海洋关键元素循环的影响和对气候变化的反馈。

青藏高原夏季极端降水事件成因和预测模型研究

国家自然科学基金气象联合基金重点支持项目 2025-2028 | 段安民等

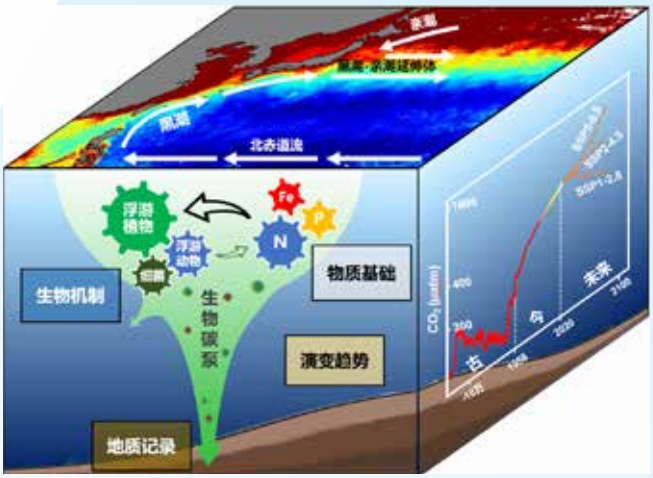
青藏高原极端天气气候事件对当地生态环境安全具有重要影响。然而，当前有关青藏高原夏季极端降水事件的时空变化特征和成因缺乏深入认识，准确模拟和预测青藏高原极端降水仍面临很大挑战。项目拟利用多源资料，通过气候动力学诊断和气候系统模式模拟相结合的研究手段，重点探讨青藏高原夏季极端降水事件的时空变化特征，从海 - 陆 - 冰 - 气多圈层相互作用的全局角度出发，揭示多圈层关键驱动因子对青藏高原夏季极端降水的影响过程、相对贡献和物理机制。在此基础上，进一步基于多模式预测产品，评估青藏高原夏季极端降水的预测技巧和偏差成因，并结合机器学习开展青藏高原夏季极端降水的预测。项目将有助于深入理解青藏高原地区极端天气气候事件的时空变化特征和成因，项目发展的预测模型有望提升青藏高原夏季极端降水的预测能力，服务高原生态屏障区的防灾减灾需求和可持续发展目标。



西北太平洋生物碳泵的氮磷铁调控及演变趋势

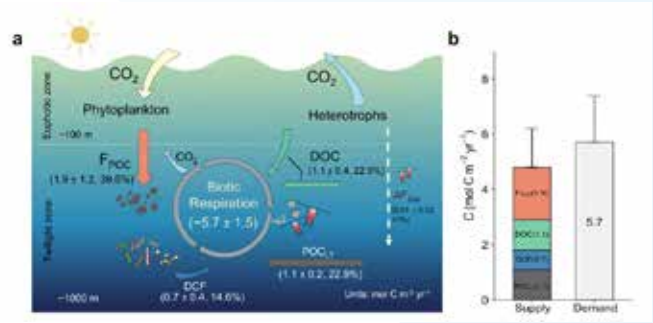
国家重点研发计划“地球系统与全球变化”重点专项 2023-2028 | 史大林等

项目聚焦西北太平洋生物泵的氮、磷、铁调控及碳汇演变趋势，通过不同时空尺度的比较研究，揭示氮、磷、铁等元素循环的特征，阐明其对生物泵关键过程的调控机理；重建古生物泵演变历史，诠释气候变化对其的影响，最终评估西北太平洋碳汇的演变趋势。项目执行一年以来，通过梳理整合西北太平洋中低纬度海区的历史资料和观测数据，并结合室内实验等，在既定的研究方面取得了一系列进展：1）揭示了海水稀土元素的分布格局；2）解析了浮游微型真核生物多样性和分布模式，阐明了营养盐对固氮作用和碳输出的调控机制；3）分析了末次冰消期以来沉积物中陆源有机碳的来源及年龄变化；4）明确了海洋酸化对固氮生物氮同位素组成的影响。

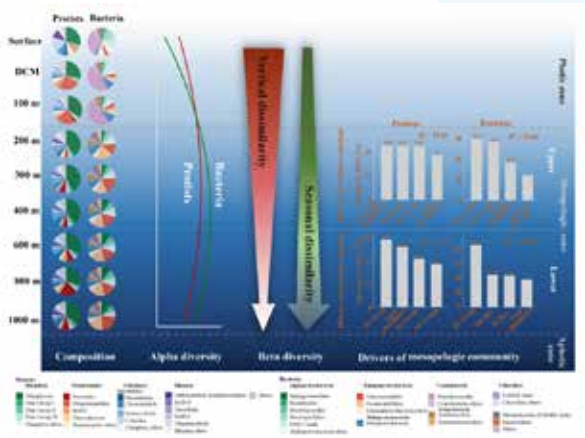


南海及邻近西太平洋浮游生物异养过程对生物泵的调控机制研究：深化和集成

国家自然科学基金重点项目 2022-2026 | 黄邦钦等



a) 区域碳收支过程示意图； b) 南海海盆区碳收支估算



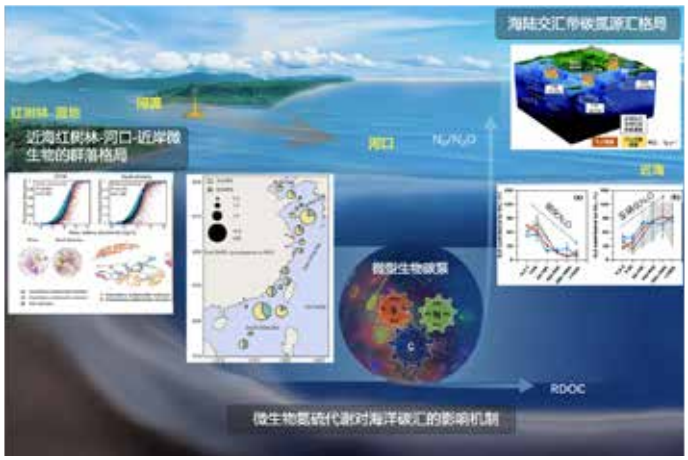
边缘海寡营养系统弱光层微生物群落组成、α- 和 β- 多样性分布模式及其驱动因素的概念框架

项目针对“低纬度边缘海寡营养海区浮游生物异养过程如何调控生物泵碳输出”这一核心科学问题，围绕“异养 - 自养耦合”、“真光层 - 弱光层耦合”的研究主线，开展生物泵的深化与集成研究，取得如下进展：1）在海盆尺度上综合运用船基培养实验、自动化观测设备、同位素示踪、遥感反演和历史数据集成等多样化手段，通过交叉比较和集成分析，精确量化了南海弱光层有机物再矿化速率，揭示多种有机碳输入对平衡弱光层碳收支的关键作用。2）于双台风期间在南海北部的跨羽流 - 上升流断面开展了多次重复观测，探讨了台风如何通过改变局地物理过程来重塑浮游植物群落结构，从而揭示台风事件在特定环境下可能导致浮游植物生物量下降的机理。3）提出用于描述边缘海寡营养系统弱光层微生物群落组成、α- 和 β- 多样性分布模式及其驱动因素的概念框架，突出了真光层净群落生产力（NCP）和混合层深度（MLD）等过程的时间滞后效应对弱光层浮游微生物群落季节性变化的重要影响。

典型海陆交汇关键带微生物驱动碳氮硫循环的机制与碳源汇效应集成研究

国家自然科学基金重大研究计划集成项目 2023-2024 | 汤凯等

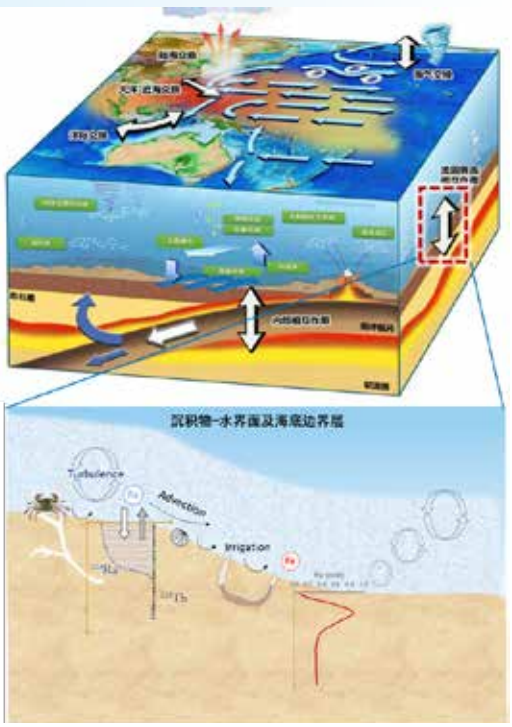
项目聚焦于河口、滨海湿地和近海交汇区域，旨在研究微生物驱动的碳、氮、硫循环过程对海洋碳汇的影响及其对全球变化的响应，以系统提升对海陆交汇带宏观碳氮源汇效应的认识。项目实施了长江口、珠江口、九龙江口、舟山、深圳和珠海红树林等多个区域的联合调查，系统揭示了中国红树林湿地微生物群落的分布格局，发现了红树林中新型古菌及其独特的生理功能。项目阐明了近海微型生物的时空分布特征及其受环境因素的调控机制，并深入解析了长江口微生物对缺氧环境的适应策略，以及淡咸水交界处微生物对有机碳转化的影响。项目还揭示了颗粒物附着微生物在有机质降解中的作用，发现颗粒物相关的反硝化过程是富氧河口水体产生 N_2O 的主要原因，研究了沉积物硝化 - 反硝化过程对碳汇的影响，以及抗生素对氮去除的干扰。揭示了海洋真光层硫脂分子与碳循环的联系，并发现了元素循环中隐含的手性现象。通过定量黄渤海海 - 气 CO_2 通量，解析了珠江口温室气体收支，并定量化碳氮循环过程，系统评估了海陆交汇带的温室气体效应。



沉积物 - 水界面流固相互作用及铁的传输机制

国家自然科学基金重大研究计划重点支持项目 2021-2024 | 蔡平河等

项目聚焦沉积物 - 水界面的流体交换及其动力机制，从厘米级尺度上建立沉积物 - 水界面流体交换的普适性动力方程，定量解析流固相互作用的动力机制及其物质通量的时空变化规律。项目已执行了多个西太平洋及其边缘海调查航次，在既定的三个研究方面均取得了进展：1）建立了 Michaelis-Menten 动力方程，发现夏季有机碳被短暂储存在边缘海海底，冬季被季风重新搅起、分解，冬季风引发的海底扰动是近海沉积物有机质降解的一种新的动力机制；2）借助 $^{224}Ra/^{228}Th$ 同位素体系，发现生物 / 物理扰动、Fe^{2+} 的氧化作用和铁氧化物吸附三者的耦合过程共同控制着河口沉积磷和铁的再生；3）建立了精确测量深海沉积物 – 水界面溶解物质通量的新方法—$^{226}Ra/^{230}Th$ 同位素体系，获得硅酸盐及硝酸盐在西太平洋深海盆的界面交换通量，发现二者均具有稳定的深度分布模式。



MEL 航次

74
海上科学调查航次

610
参与科考人次

1127
累计航次作业天数

© 高友炎 航拍

“海丝学堂”本科生实习航次

航次编号：KK2404（厦门 - 新加坡 - 马来西亚）、KK2405（马来西亚 - 香港 - 厦门）、KK2406（厦门 - 厦门）

首席科学家：周宽波副教授（KK2404）、张润教授（KK2405）、白晓林副教授（KK2406）

航次时间：7 月 11 日至 8 月 28 日

航行里程：2148 海里（KK2404）、2387 海里（KK2405）、415 海里（KK2406）

参航人员：10 所国内外高校的 102 名科考人员（含 77 名学生）

航次目标：提升我校海洋本科科研实践能力，推行中国海洋科学卓越人才培养计划，锻造享誉海内外的海洋科学综合实践平台

航次内容：CTD 剖面作业、单层生物拖网、多层生物拖网、箱式采泥、重力柱、水声通讯测试和底栖生物拖网等

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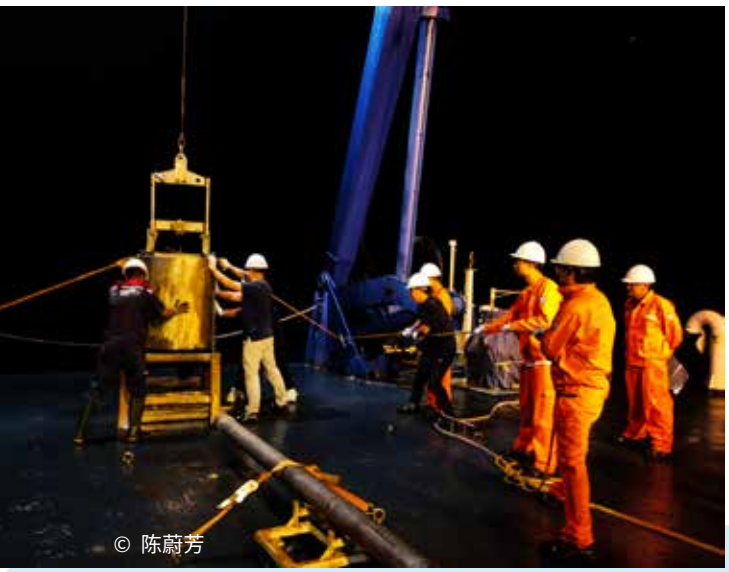
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© 冯威棚

国家自然科学基金“共享航次计划 2024 年首席科学家培训航次”

航次编号：KK2407


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- **首席导师：**天津大学魏皓教授、中国科学院海洋研究所张鑫研究员、厦门大学曹知勉教授
- **航次时间：**8 月 31 日至 9 月 6 日
- **航行里程：**377 海里
- **参航人员：**17 所涉海高校和研究所的 20 名青年科学家
- **航次目标：**我国海洋科考人才队伍建设，提升国家自然科学基金委共享航次计划项目的实施成效
- **航次内容：**CTD 剖面作业、单层浮游生物拖网、箱式采样、柱状采样和岩石拖网作业

国家自然科学基金“共享航次计划 2023 年度南海中部海盆科学考察实验研究

航次编号：NORC2024-06

- **航次编号：**水文生化航段（KK2408）、地质地球物理 + 水文生化航段（KK2409）
- **首席科学家：**肖武鹏副教授（KK2408）、陈洪梅副教授（KK2409）
- **航次时间：**9 月 8 日至 10 月 28 日
- **航行里程：**5602 海里
- **航次搭载国家自然科学基金委项目：**31 项
- **参航人员：**15 所涉海高校和研究所的 66 名科考人员
- **航次目标：**聚焦南海中部海盆生源要素循环和生物生态系统结构功能的时空差异及其关键调控因子、海盆环流模式、动力过程及大气 — 水文 — 生物化学耦合作用机制，以及海底热液活动、地质构造成因与岩石圈结构及古海洋学记录特征等关键科学问题，着重开展海盆气象、大气化学、海洋化学、生物生态和沉积学等多学科综合观测与实验。
- **航次内容：**CTD 剖面作业、多层生物拖网、痕量小绞车采集痕量金属水样、大体积泵原位过滤、箱式表层沉积物、重力柱沉积物和走航多波速浅剖及测线。


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西北太平洋副热带逆流区涡旋观测航次

航次编号：KK2410

- **首席科学家：**张瑶教授
- **航次时间：**11 月 1 日至 12 月 6 日
- **航行里程：**5136 海里
- **参航人员：**厦门大学、中国海洋大学等 5 所高校科研院所的 36 名科考人员
- **航次目标：**探究中尺度过程如何影响上层海洋浮游植物群落组成与颗粒有机碳 / 氮 / 磷及生源硅的输出，阐明涡旋时空演变对生物泵固碳、储碳效率及 CO_2 源汇格局的调控作用
- **航次内容：**CTD 剖面作业、大体积泵采样、分层生物拖网、沉积物捕获器、BGC-Argo、走航式海洋多参数剖面测量、Glider、无人船、漂流浮标等

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© 汤承轩

交流与合作
Exchanges and Collaborations

9
组织大型活动

150
大会报告人次

24
学术期刊任职

26
学术组织任职

22
访问学者人数

36.1%
产出成果国际合作占比

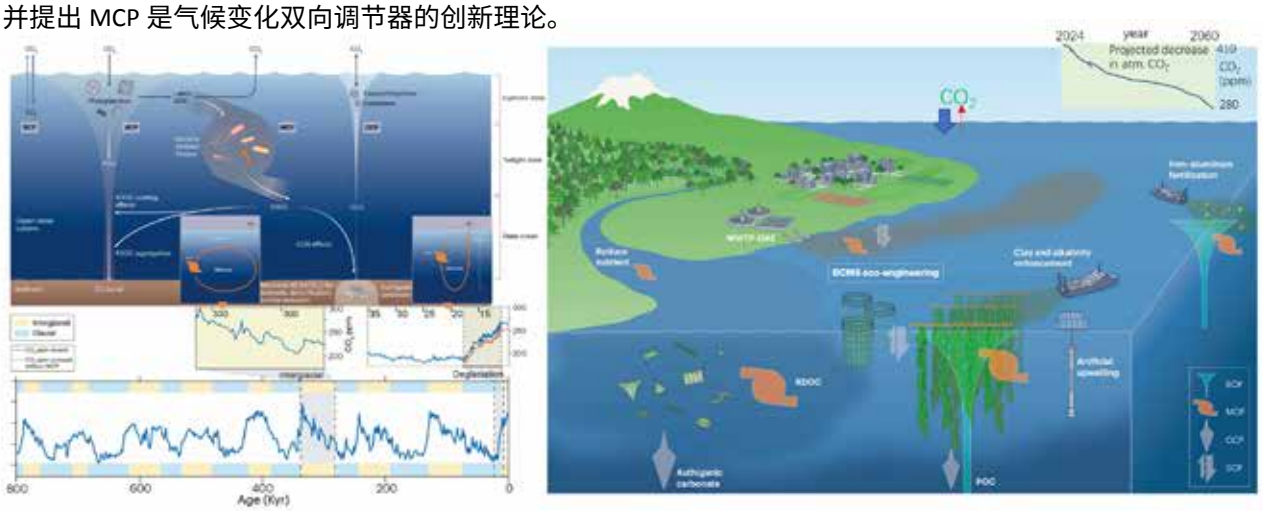
© 王晓依

海洋负排放（Global-ONCE）

Global-ONCE 是“联合国海洋科学促进可持续发展十年（2021-2030）”倡议计划框架（“海洋十年”）下的大科学计划，由焦念志院士发起，基于“微型生物碳泵（MCP）”原创理论框架，通过多学科交叉融合，创建“生物碳泵（BCP）- 碳酸盐泵（CCP）-MCP- 溶解度泵（SCP）”综合储碳理论体系（BCMS）。自 2017 年启动以来，Global-ONCE 已吸引了来自全球 33 个国家 79 所科研院校的数百位专家学者参与。

◉ 3 月

首席科学家焦念志院士在 *Nature Reviews Microbiology* 发表综述，揭示微型生物碳泵（MCP）对气候变化的响应，并提出 MCP 是气候变化双向调节器的创新理论。



微型生物碳泵与全球气候变化（© 焦念志等）

◉ 10 月

第三届 ONCE 开放科学大会在厦门大学举办，以教育、科技、人才一体化发展为主题，邀请中国教育部部长怀进鹏、联合国秘书长海洋特使彼得·汤姆森、菲尔茨奖获得者埃菲·杰曼诺夫等出席。期间，发布《宜居地球》本研一体化课程等系列教育成果。

第三届 ONCE 开放科学大会受邀嘉宾（© ONCE 秘书处）

◉ 11 月

国际标准化组织（ISO）宣布全球首个海洋碳中和国际标准提案《海洋负排放与碳中和 —— 总则和要求》发布并立项。

海洋碳中和国际标准提案正式发布（© ONCE 秘书处）

“融通科学、管理和社会参与：助力海岸带可持续发展”（COASTAL-SOS）

COASTAL-SOS 由 MEL 携手国内外多家高水平科研单位、龙头企业、非营利性基金会、国际组织共同策划，为“海洋十年”项目。项目拟建立利益相关者之间的新型伙伴关系，通过共同设计、执行科学研究方案，通过多学科、跨领域、跨区域的合作，科学创新实践及其成果的有效转化，促进科学、管理和社会参与的切实融合，为海岸带的可持续发展提供解决方案。

1 月

COASTAL-SOS 示范项目 BLUE-CARE 蓝碳项目举办蓝碳生态系统国际专题研讨会，吸引了来自各国的海洋蓝碳与碳金融学者。

© BLUE-CARE 蓝碳项目
蓝碳生态系统国际专题研讨会

4 月

首席科学家戴民汉院士参加 2024 年海洋十年大会和第 2 届联合国海洋十年区域大会，在多个场合向国际社会展示 COASTAL-SOS 项目及其在近海脱氧、数字孪生海洋领域取得的最新进展，与其他国际组织负责人共话未来合作。

© 王贵华

戴民汉院士参加第 2 届联合国海洋十年区域大会
© Khanittha Uthaipan

6 月

BLUE-CARE 蓝碳项目举行蓝碳科普游园会，通过不同类型的活动推进蓝碳知识普及，共 300 多名厦门小学生参加。

蓝碳科普游园会
© 陈艺敏

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9 月

COASTAL-SOS 厦门预研项目顺利通过验收，项目聚焦厦门海陆交互带，启动前期研究，为助力厦门海洋国际合作、进一步实施海洋可持续发展政策打下基础。

“表层海洋 - 低层大气研究”计划（SOLAS）

SOLAS 于 2004 年启动，旨在研究海洋与大气间的生物地球化学与物理过程和机理，揭示海洋 - 大气圈层相互作用对气候和环境变化的影响和反馈。SOLAS 国际项目办公室于 2021 年 1 月落户于 MEL，戴民汉院士于 2021 年 -2023 年担任国际科学指导委员会共同主席，李黎博士为执行主任（2021 年至今）。2024 年，SOLAS 国际项目办公室持续为 SOLAS 33 个国家 / 区域科研网络、17 个资助 / 认证科学项目和 4 个海 — 气整合观测站提供宣传渠道和搭建交流合作平台。

10 场
国际会议

23 份
国家地区报告

2 份
活动总结报告

12 期
通讯月刊

34 项
社区公告

149 条
推文

◉ SOLAS 在期刊 *Elementa: Science of the Anthropocene* 上组织题为 “Boundary Shift: The Air-Sea Interface in a Changing Climate” 的特刊。该特刊收录 12 篇邀请论文，围绕 SOLAS 2015-2025 科学计划，评估海气交换研究现状和未来研究的关键方向。

◉ 4 月，于 2024 联合国海洋十年大会期间携手联合国海洋十年项目 “Observing Air-Sea Interactions Strategy (OASIS)” 共同举办题为 “Unifying Strategies to Develop Integrated Global Air-Sea Community Networks（发展一体化全球海 - 气共同体社群的统一战略）” 的边会。该边会旨在为发展全球一体化海 - 气共同体形成统一战略，并利用科学解决方案扩大海洋行动，期望为实现《2030 年海洋愿景》做出贡献。

◉ 11 月，第九届 SOLAS 开放科学大会暨庆祝 SOLAS 正式启动二十周年活动于印度阿果举办。会议围绕 SOLAS 五个核心主题和三个交叉主题展开，共同探讨全球海洋和大气领域最新研究成果与进展，吸引超过 25 个国家约 220 名科研工作者参会。

第九届 SOLAS 开放科学大会合影 (©National Institute of Oceanography, Goa, India)

第九届青年地学论坛

5 月 17-20 日 · 厦门

由青年地学论坛理事会主办，MEL、中国科学院城市环境研究所及自然资源部第三海洋研究所承办。

论坛邀请厦门大学戴民汉院士、中国科学院城市环境研究所贺泓院士、中国科学技术大学沈延安教授、中国科学院大学王艳芬教授、中国科学院地质与地球物理研究所李金华研究员共 5 名专家作主旨报告。

论坛获得中新网、央广网、福建日报、东南网、海博TV、厦门网、海峡导报和海西晨报等各大新闻媒体联合宣传。


戴民汉


贺泓


沈延安


王艳芬


李金华

6600 余人参会，创下历史新高

20 个主题，**280** 个专题

4538 篇口头报告，近 **950** 张展板报告，创历史新高

陆海之书 青春共读

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“海洋观测和生物地球化学模式协同作用范围界定”研讨会

5 月 21-23 日·厦门

由 MEL 与福建海洋创新实验室（筹）承办，研讨会吸引来自 8 个国家的近 40 位知名海洋领域专家参与。厦门大学柴扉教授和法国国家科学研究中心 Veronique Garçon 研究员共同主持。

柴扉

研讨会围绕 3 大目标：

◎探索将观测数据纳入模型的有效策略，提高模型的准确性和可靠性，提高预测技能；

◎以自主平台（如 BGC Argo、滑翔机、风帆无人机、波浪滑翔机等）和遥感技术为例，探索数据收集和模型开发的新途径；

◎通过数据同化、深度学习模型数据应用、突现约束和海洋数字孪生等，探讨 BGC 观测和预测的集成。

研讨会聚焦 4 大议题：

◎生物地球化学数据用于未来气候情景的新兴约束

◎生物地球化学数据用于模型验证

◎数字孪生和人工智能技术在生物地球化学和海洋生态系统的应用

◎海洋生物地球化学和生态数据在预测预报系统的同化

Veronique Garçon

“同一个海洋：加速推进蓝色转型与 碳中和”主题论坛

10 月 10-12 日·北京

由中国环境与发展国际合作委员会（国合会）海洋治理专题政策研究项目工作组（戴民汉教授任中方组长）牵头组织，围绕基于海洋的可持续发展解决方案、海洋价值核算与蓝色金融，及塑料污染国际文书与海洋减塑等重要议题深入研讨。

“碳中和愿景下粤港澳大湾区可持续蓝色经济发展”高级别论坛

10 月 8-9 日·香港

由国合会海洋治理专题政策研究项目工作组牵头组织，聚焦大湾区可持续蓝色经济发展及湾区协同发展与海洋综合治理等重要议题，为大湾区可持续海洋经济高质量发展建言献策。

第四届离岸碳捕集、利用与封存论坛

10 月 12 日 -15 日 · 杭州

由 MEL 与中国太平洋学会联合主办，自然资源部第二海洋研究所承办，论坛以“多圈层碳循环与离岸碳捕集、利用与封存耦合协同”为主题，汇聚国内外科研机构、企业及研究学者 200 余人，共同探讨离岸碳捕集、利用与封存的发展之路，旨在为我国实现“双碳”历史战略目标探索一条新兴低碳产业的发展路径，并为全球离岸碳捕集、利用与封存的发展贡献中国智慧。

访问学者与开放课题基金

MEL 于 2009 年设立访问学者基金，并将其与开放课题基金结合执行，以便资深科学家前来进行科研合作与指导，同时为青年学者前来开展科研培训提供平台和资助，资助期限为 1-6 个月。2024 年度共有 22 名学者获批，含 4 名杰出 (郑重杰出) 访问学者，11 名高级访问学者基金及 7 名青年访问学者。

以色列海法大学 Michael Krom 教授

22 名
学者获批

4 名
杰出 (郑重杰出) 访问学者

美国缅因大学 Mark Wells 教授

11 名
高级访问学者基金

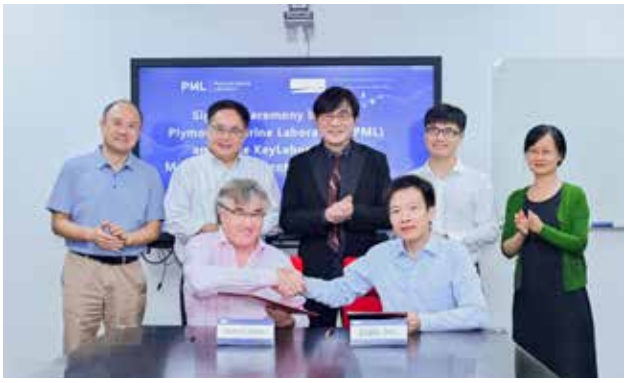
7 名
青年访问学者

高级访问学者、伊朗渔业科学研究所博士 Nima Pourang 在 MEL 午餐会上作学术报告

高级访问学者、加纳能源与自然资源大学副教授 Berchie Asiedu 午餐会后与师生交流

新增合作伙伴

4 月，MEL 与香港城市大学海洋污染国家重点实验室续签合作备忘录



11 月，MEL 与英国普利茅斯海洋实验室签署合作备忘录

IPGP Sciences pour la planète

11 月，MEL 与法国巴黎地球物理研究所签署合作备忘录

其他交流与合作

196 国内外来访人次

含学术报告、讲授课程、合作研究等多种形式

30 讲

“周一午餐交流会”及学术讲座

7 讲

凌峰论坛

印尼国家研究创新署海洋研究中心所长 Udhi Eko Hernawan 一行来访

挪威气候与环境部长安德烈亚斯·埃里克森作南强学术讲座，并参加“蓝色经济与碳中和对海洋可持续性的协同作用”高峰座谈会

中国科学院沈阳自动化研究所所长于海斌院士一行来访

意大利海洋研究所代表团来访

学术组织新任职

国际任职

◉ 柴　扉 Member / Digital Twins of the Ocean (DITTO) Steering Committee
◉ 柴　扉 Member / Partnership for Observation of the Global Ocean (POGO) Board of Trustees
◉ 修　鹏 Member / Ocean Predict Marine Ecosystem Analysis and Prediction Task Team (MEAP-TT)
◉ 薛惠洁 Member / CoastPredict Steering Committee

国内任职

◉ 陈鹭真 中国地理学会海洋地理专业委员会副主任委员
◉ 刘向阳 中国新材料发展产业联盟副理事长
◉ 史大林 国家自然科学基金委地球科学部专家咨询委员会委员
◉ 张　瑶 中国古生物学会地球生物学分会理事

学术期刊新任职

国际任职

◉ **鲍红艳** Early Career Editorial Fellow / *Journal of Geophysical Research: Biogeosciences*
◉ **戴民汉** Editorial Board Member / *Global Ocean Science Report (GOSR-III)*
◉ **李杨帆** Editorial Board Member / *Ocean & Coastal Management*
◉ **刘国坤** Editorial Board Member / *Environmental Analytical Chemistry*
◉ **柳　欣** Associate Editor / *Limnology and Oceanography: Methods*
◉ **吕柯伟** Early Career Editorial Fellow / *Fundamental Research*
◉ **谭巧国** Editor / *Environmental Toxicology and Chemistry*
◉ **汪冰冰** Editor / *Aerosol Research*
◉ **徐大鹏** Editorial Board Member / *Microorganisms*
◉ **余凤玲** Special Issue Editor / *Geomorphology*
◉ **张　瑶** Editorial Board Member / *Marine Life Science & Technology*
◉ **朱旭东** Associate Editor / *Remote Sensing in Ecology and Conservation*

国内任职

◉ 曹知勉、李非栗、林宏阳、吕柯伟、王为磊、余凤玲《海洋学报》青年编委
◉ 李杨帆 《海洋开发与管理》编委
◉ 刘志宇 《海洋预报》副主编
◉ 上官明佳 《大气与环境光学学报》青年编委
◉ 谭巧国 《生态毒理学报》编委

海丝卫星二号拍摄的青海湖

代表性国际 / 国内大会报告

- CAO Ling. Blue food futures. Marine Socio-Ecological Systems Symposium 2024. June 2-8. Yokohama, Japan. (Invited talk)
- CAO Ling. Development of marine protected areas in China - A policy perspective. Hong Kong Marine Protection Alliance 2024 Quarterly Members Meeting. Hong Kong, China. (Invited talk)
- CHEN Luzhen. Introduction of standard development in coastal blue carbon WG5. The 43rd plenary meeting of the International Standardization for Organization Technical Committee 8 “Ships and Marine Technology”. September 21-29. Panama. Panama. (Invited talk)
- CHEN Nengwang. Marine cloud: A digital support system. 2024 Chinese Engineers Forum and Chinese Engineering Pavilion. September 17-22. Kuala Lumpur, Malaysia. (Invited talk)
- DAI Minhan. Coastal ocean under intensifying human activities and changing climate: From science to sustainability and needs for a digital twin platform. Joint Conference of ISEH ICEPH & ISEG. August 11-18. Galway, Ireland. (Invited talk)
- DAI Minhan. Predominant biological consumption over physical transport on nutrient budget within mesoscale eddies in the oligotrophic ocean. The 3rd Hong Kong and Macau Ocean and Areas Excellence (AOE) Forum. Hong Kong. China. (Invited talk)
- JIAO Nianzhi. Microbial carbon pump and climate change: A new insight for Ocean Negative Carbon Emissions (ONCE). American Geophysical Union Annual Meeting 2024. December 9-13. Washington, D.C., United States. (Sessions invited talk)
- LIU Guokun. AI + SERS analysis of trace targets in complex matrices. The 12th Singapore International Chemistry Conference. December 9-13. Singapore. (Invited talk)
- LIU Zhiyu. Dynamical decomposition of multiscale oceanic motions. Workshop on Physics of Wave Turbulence and Beyond. September 2-6. Les Houches, France. (Invited talk)
- LU Yonglong. Sustainable path of China under global environmental change. Sustainable Asia Conference 2024. Inchon, South Korea. (Plenary talk)
- MA Jian. New development of an integrated syringe-pump-based environmental-water analyzer (*i*SEA). The 23rd International Conference on Flow Injection Analysis and Related Technigues. December 3-7. Chiang Mai, Thailand. (Invited talk)
- TAN Qiaoguo. Metal risks in turbid coastal waters. Society for Environmental Toxicology and Chemistry 14th Asia-Pacific Biennial Meeting. September 21-25. Tianjin, China. (Invited talk)
- WANG Weilei. A global estimate of the biological carbon pump and its application in carbon sequestration. Society for Environmental Toxicology and Chemistry 14th Asia-Pacific Biennial Meeting. September 20-23. Tianjin, China. (Keynote Speech)
- 陈能汪 . 陆海界面碳氮循环与温室气体排放 . 首届流域碳中和学术大会 . 5 月 10-12 日 . 中国北京（邀请报告）
- 陈能汪 . 海洋云与决策支持 . 中国环境科学学会环境规划专业委员会 2024 年学术年会 . 9 月 24 日 -25 日 . 中国石家庄（主题报告）
- 戴民汉 . 科技助力海洋强国建设 . “ 海上中国 ” 专题报告会 . 11 月 15 日 . 中国福州（主题报告）
- 黄邦钦 . 中国海浮游植物群落时空演变与固碳储碳 . 海洋元素地球化学循环驱动的近海增汇机制与潜力国际会议暨 2024 年 NSFC-RGC 青年学者论坛会议 . 10 月 31 日 -11 月 2 日 . 中国宁波（特邀报告）
- 焦念志 . 碳中和背景下的海洋碳汇和海洋储碳技术 . 第三届生态环保产业服务 “ 双碳 ” 战略院士论坛 . 9 月 12 日 . 中国北京（主旨报告）
- 李杨帆 . 海城耦合与海岸带可持续发展 . 第四届海洋空间规划与海岸带综合管理学术研讨会 . 11 月 29 日 -12 月 1 日 . 中国青岛（特邀报告）
- 李忠平 . 遥感反射比的水面上测量法：现场测量及数据处理要点 . 第二十二届中国水色遥感大会 . 4 月 12 日 -14 日 . 中国上海（主旨报告）
- 上官明佳 . 单光子水下激光雷达在水体剖面参数探测和水下目标成像中的应用 . 第八届中国激光雷达遥感学术交流会 . 4 月 12-14 日 . 中国上海（特邀报告）
- 史大林 . Biological nitrogen fixation in the tropical western North Pacific. 全球变化生态学前沿论坛 . 9 月 19-21 日 . 中国北京（主旨报告）
- 王克坚 . 海洋动物新型抗菌肽的发现及其产品创制与应用 . 2024 港珠澳海洋产业发展论坛暨中国 — 东盟海水养殖产业发展论坛 . 3 月 5-7 日 . 中国珠海（大会报告）
- 王克坚 . 第十届闽台水产学术研讨会 . 海洋动物新型抗菌肽的研究与利用 . 6 月 28 日 . 中国厦门（主旨报告）
- 王为磊 . Global biogeochemical cycle of carbon, phosphorus, and nitrogen. 第二十届中美前沿科学研讨会 . 11 月 18 日 -20 日 . 中国北京 .（邀请报告）
- 王为磊 . 全球海洋生物泵的估算及其增汇应用 . 海洋与湖沼年会暨曾呈奎海洋科技奖颁奖大会 . 10 月 27 日 -28 日 . 中国连云港（大会报告）
- 张 宇 . 海豚超声发声机制与仿生声源研究 . 2024 年声学科学与技术高端论坛 . 6 月 14-17 日 . 中国厦门（特约报告）

人才培养
Education

259
硕士生在读

177
博士生在读

111
硕士毕业生

40
博士毕业生

22
在站博士后

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MEL 海洋环境创新型人才国际合作培养项目

在国家留学基金委创新型人才国际合作培养项目“国家重点实验室专项”支持下，MEL 于 2020 年起设立该项目，每年向美国特拉华大学、德国亥姆霍兹基尔海洋研究中心、法国索邦大学滨海自由城海洋学实验室选派联合培养博士研究生、博士后及访问学者。

本年度，

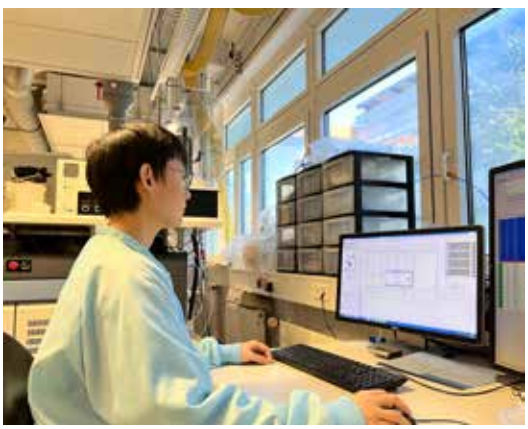
新增 **6** 人，**6** 人完成项目，

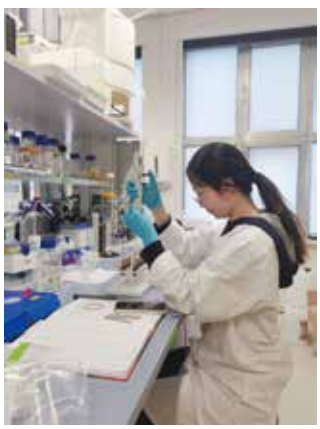
10 人开展联培

发表论文于期刊 *Reviews of Geophysics*、*Environmental Science & Technology*、*Talanta*、*IEEE Transactions on Geoscience and Remote Sensing*


Remote Sensing Estimations of the Seawater Partial Pressure of CO_2 Using Sea Surface Roughness Derived From Synthetic Aperture Radar


韩郁烨（前排左二）参加东地中海 M197 航次


袁毅 (GEOMAR) 在实验室测样


殷笑晗 (GEOMAR) 在实验室做 muniton 提取

MEL 杰出博士后基金

MEL 于 2014 年设立“杰出博士后基金”，吸引国内外优秀博士毕业生开展博士后研究，以此促进学科交叉，提高人才培养能力。2024 年有 5 人入选，分别是江炜敏、程硕、刘灵珂、陈琳、常天易。

- **本年度，发表论文 10 篇**

  于 *Limnology and Oceanography*、*Communications Biology*、*Environmental Research* 等期刊

- **孙斌入选欧盟玛丽·居里学者（MSCA-PF），该奖项是欧盟资助个人科研最高奖项之一**

- **江炜敏入选国家级人才项目（博士后）**

- **2 人获批国家自然科学基金青年科学基金项目**

  4 人获得国家各类博士后基金资助

  2 人获批国家留学基金委创新人才国际合作培养项目

https://marie-sklodowska-curie-actions.ec.europa.eu/calls/msca-postdoctoral-fellowships-2024

王智博士“嘉庚号”新加坡公众开放日中讲解

沈雅威博士（右三）赴泰国参加第二届联合国海洋十年区域会议暨第 11 届西太平洋国际海洋科学会议并获最佳青年科学家口头报告奖

2022 级优博张明真（右三）赴香港大学助理教授罗新课题组交流

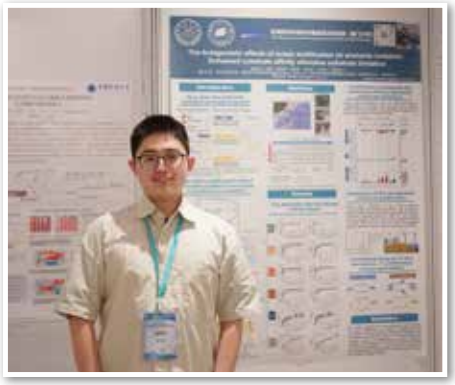
MEL 博士生奖学金

MEL 于 2016 年设立“MEL 优秀博士生奖学金”，每年提供 10 个资助名额，旨在吸引国内外优秀生源，培养杰出的博士研究生。

◉ 本年度，新增 7 人，8 人完成项目，30 人在资助期，发表论文 16 篇

于 *Talanta*、*Remote Sensing of Environment*、*Global Biogeochemical Cycles* 及 *Marine Chemistry* 等期刊

◉ 张明真获批 2024 年度国家自然科学基金青年学生基础研究项目（博士研究生）



2021 级优博获得者童森炜在中国微生物学会第十二届地质微生物学学术研讨会（武汉）作墙报展示

2023 级优博获得者赖文典参加第五届学生凌峰论坛并作口头报告

胡晓华（2020 级）

卢聚滢（2020 级）

汤锦铭（2021 级）

邹世娴（2022 级）

2024 年度考核“A”级学生

MEL 研究生学术论坛

7 月 18 日 -21 日 · 东山站

以“Deeper Blue, Deeper Thoughts（以深蓝启深思）”为主题，希望推动青年学子进一步认识海洋、经略海洋，并通过深入思考，助力海洋科学研究走向深度探索。来自厦门大学、北京大学、上海海洋大学的 80 名师生参与交流。

- **6** 大专题、**48** 个口头报告、**18** 个海报
- 破冰活动、圆桌讨论、专题研讨会
- 福建省东山第一中学、第二中学及县第二实验小学的 **70** 余位中小学生参与“**立体海洋**”游园科普活动

水环境科学研究高校联盟研讨会

6 月 11 日 -16 日 · 东山站

以“Ocean: Bridging Science and Humankind, Past and Future（海洋：架起科学与人类、过去与未来的桥梁）”为主题，旨在强调海洋连接人类和科学的纽带作用，希望以海为鉴、向海求新，同时为区域间环境科学领域青年学子提供良性交流平台，共享前沿研究成果。来自厦门大学、香港大学、台湾海洋大学、台湾中山大学的 51 名师生参与交流。

- **6** 场主旨报告、**33** 个口头报告，完全由研究生组织
- R 语言技能培训工作坊、趣味辩论、水环境科学剧场
- “**蓝色星球，人海共生**”主题科普和东山野外调研

海洋环境科学本科生暑期科研奖学金

7-9 月于 MEL 开展，鼓励本科生强化科研训练，培养学生创新能力和学术精神。

◉ 学员来自美国宾夕法尼亚大学、巴西圣保罗大学、中国海洋大学、哈尔滨工业大学等国内外 **18** 所高校

◉ **26** 个课题，**6** 场学术讲座，**3** 场研究生分享，**2** 次科普活动，**2** 个野外实践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“海洋放射科学”国际讲习班

8 月 19 日 - 23 日，主题为“海洋放射科学”的国际讲习班（Training Workshop on Marine Radioactivity）于厦门大学马来西亚分校举办。该系列国际讲习班由厦门大学戴民汉院士与美国伍兹霍尔海洋研究所 Ken O. Buesseler 研究员联合国际海洋学研究委员会（SCOR）第 146 工作组（Radioactivity in the Ocean, 5 Decades Later, Rio5) 自 2016 年发起，已于中国厦门、法国巴黎、澳大利亚郡德勒普、波多黎各圣胡安先后举办。本次讲习班得到了联合国海洋十年倡议（UN Ocean Decade Activity）的认证支持。

讲习班遴选了来自中国、日本、印度尼西亚、马来西亚、泰国、阿尔及尼亚以及肯尼亚等 **14** 个国家的 **27** 名学员参加。


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公众教育
Outreach

© 70.8 海洋媒体实验室

聚力传递科学之声

张鑫

海洋演说大会主讲嘉宾
少年蓝色先锋培养计划项目科学顾问
中国科学院海洋研究所研究员

“作为 MEL 的老朋友，无论是在科研领域还是科普事业，我们始终是合作伙伴。中国科学院海洋研究所将与 MEL 携手推进海洋科普工作，共同实现将海洋科学发展与国家需求、社会需要相结合的最终目标。”

林昕

厦门市松柏小学科学副校长
70.8 海洋媒体实验室室务委员
厦门大学海洋与地球学院副教授

“自 2020 年起，我陆续参与了海洋科普工作，见证了厦门大学海洋科普从线下到线上，再到线上线下结合的全过程。科普作为国家教育发展的重要战略，需要汇聚科研平台、中小学及社会各界的力量，整合各方资源，共同打造一个广泛的社会大课堂。”

王智

2024 嘉庚号海洋大讲堂直播嘉宾
2024 海丝学堂开放日科普主创成员
厦门大学海洋与地球学院副教授

“我始终保持对海洋科普活动的热情，每一次科普活动都全力以赴。在此过程中，我们逐步完善了‘讲解－展示－参与’体系，同时也在实践中不断创新升级，尝试融合多学科知识点，期待为更多的青少年和社会大众揭秘神奇的海洋世界。”

汤锦铭

科学论文解读及科普文章编辑
厦门大学海洋与地球学院
2021 级博士生

“参与科学论文的编辑和科普文章的撰写，使我深刻认识到科学传播的重要性——这不仅是实验室里的数字和公式，不仅是对研究成果的解读，更需要将复杂的科学知识转化为普通大众易于理解的语言，使更多人了解海洋对人类未来的影响。”

饶宇洛

2024 少年蓝色先锋培养计划科学导师
厦门大学海洋与地球学院
2021 级博士生

“在繁忙的科研工作中有机会参与到高中生的科普教育项目，我很惊喜。少蓝学员不仅顺利完成科创课程，还自主将实验流程记录并形成一份面向同龄人的教学手册，让我们听到了来自他们的声音，这是一个互相学习、共同成长的过程。”

何诗凡

海洋媒体训练营成员
厦门大学环境与生态学院
2022 级硕士生

“来到厦大求学之前，我便通过海洋媒体训练营与科普结缘；步入厦大后，MEL 丰富的科普活动进一步拓宽了我的实践平台。每一个作品的打磨、每一次活动的策划，虽充满挑战，却也是成长的宝贵经历，期待有更多同学投身科普，共同在更多人心中播撒科学的种子。”

第九届青年地学论坛系列科普活动

◉“我们的地球”艺术展

邀请国家海洋博物馆、法国驻华大使馆、法国国家科学研究中心、法国发展研究院、中央美术学院实验艺术与科技艺术学院以及厦门华锐莱普顿学校参与创作，面向所有论坛参会者展出各单位提供授权的系列主题展览作品以及中学生创作作品。

◉“青少年可持续工坊”

来自中国科学院生态环境研究中心、兰州大学、自然资源部第二海洋研究所、自然资源部第二海洋研究所、浙江大学、厦门大学的专家带来 6 场科普报告，并与到场中小学科学教师与科学家交流互动。探索工坊中，高中生们围绕《水资源大作战》《浮游植物的生存游戏》《生态平衡》三个不同的探索课题，思考解决可持续发展问题的方案。发布五四青年力量专题、社会热点专题、会议亮点议题专题科普推文，从具体的案例分析地球科学的应用与成果，从更多元的角度拉近科学与大众的距离。

少年蓝色先锋培养计划

自 2022 年起连续举办，累计培养超过 60 名来自世界各地的高中生。2024 年少蓝计划以“科学促进可持续发展”为核心主题，设计科学家代表团“面对面沙龙”、出海采样及室内实验、鲍鱼场 / 海洋牧场 / 红树林保护区实地参观、海洋社区走访等。暑期培养阶段结束后，少蓝学员们自发在社区、学校发起一系列海洋相关活动，充分发挥少蓝学员的未来潜力。

“科考启航，强国之梦”海洋科普直播讲堂

恰逢国家自然科学基金委“共享航次计划”15 周年，MEL 联合福建广播影视集团开展“科考启航，强国之梦”海洋科普直播讲堂，由来自厦门大学、上海海洋大学、南京信息工程大学、南方科技大学的科学家代表和中小学副校长组成中国海洋科学考察科普专项工作组，通过直播的方式，依托“嘉庚”号科考船，解答中小学生关于海洋科考的问题，打造了“科学知识点 - 有故事的科学考察 - 弘扬科学家精神”的传播链路。

40+
全网新媒体平台报道

1594.9 万次
观看量

23.6 万次
互动量

© 70.8 海洋媒体实验室

第十三届厦门大学海洋科学开放日

活动共设立 70 余个原创科普展位，参与实验室超 50 个，集合 700 多名厦大在校师生，开展六大主题 25 场次科创实验课堂、10 多个主题互动内容，与 13 个企业、科研机构、海洋保护组织携手举办“可持续生活方式”主题市集。通过创新升级往年的特色科学展位，并引入蓝碳共享空间、共享航次联合 COASTAL-SOS 国际大科学计划科普等 20 多个创新展位，从科学、艺术、人文多个角度认识海洋，更好联结海洋与人类的未来。

平台设施
Facilities

© 周宽波

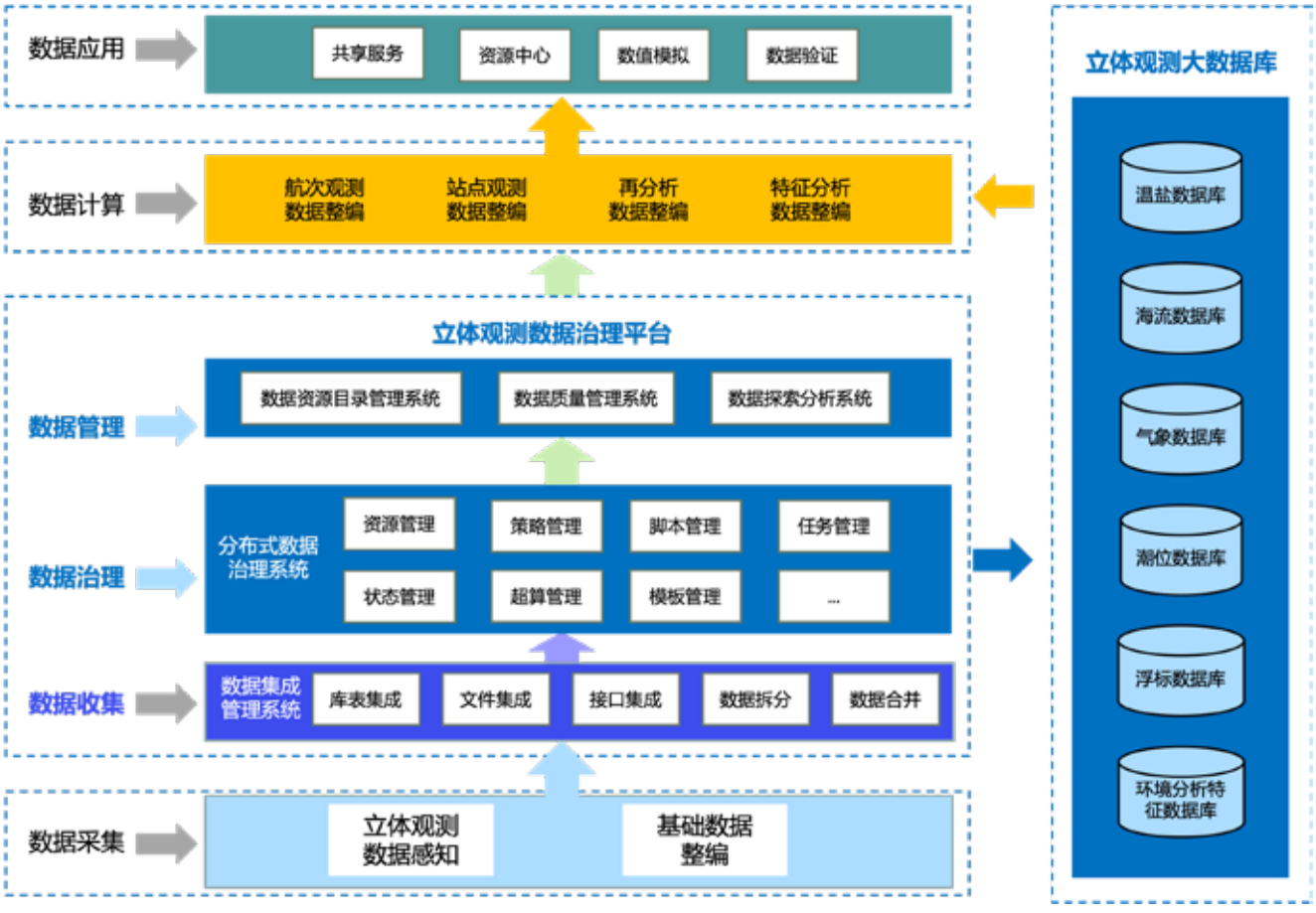
大型仪器与技术服务平台

MEL 于 2008 年建立大型仪器与技术服务中心（“COMET”），共有五个中心平台和十三个功能实验室。COMET 整合了所有大型装备，全面向科研人员提供开放服务，并建成良好的仪器运行管理体系，解决创新性科研发展过程中使用大型仪器难、维修费和运行费过高等障碍，使实验室仪器得以顺利运转，为科学研究提供了更好的技术服务与支撑。

COMET
Center of Major Equipment and Technology

立体观测大数据库及服务系统

COMET 海洋观测技术与数据中心立足海洋立体观测体系，以海洋观测为基础，以科学数据为核心，服务科学研究和国防安全重大战略需求。中心搭建专业化技术团队，打通仪器、观测、数据、应用服务链条，提供高质量标准化数据产品，同时着手构建全新立体观测大数据库及服务系统，2024 年已完成 20 个航次和 50 个固定站点数据整编任务，相关工作有序推进。



立体观测大数据库及服务系统结构

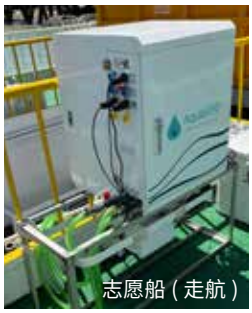
海洋仪器研发中心

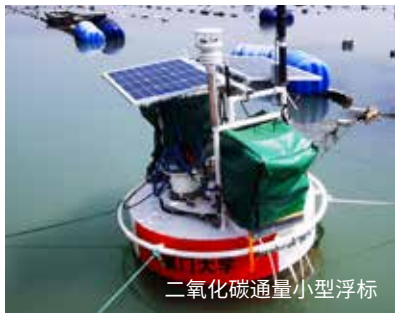
海洋仪器研发中心（Ocean-IDEA）作为 MEL 的特色科研支撑平台之一，聚焦于海洋科学采样、观测与实验仪器的研发，围绕海洋观测平台、生物地球化学传感器、生物地球化学保真采样、水下机器视觉等方向开展核心技术攻关和新方法的研究，自主研发或协助课题组进行原创性海洋传感器、仪器、装备及核心部件的研制，为厦门大学海洋学科发展及打造国内一流海洋仪器创新中心提供支撑保障。

海洋仪器研发中心提供从结构设计、外观优化、仿真测试（流体分析、结构分析、受力分析、耐压分析、电路分析等）、电路开发、硬件集成、软件编写、交互界面设计、信息化管理等全链条闭环式海洋观测与实验仪器、装备的研发、测试及应用服务。

方向一：海洋观测平台

基于浮标、海底有缆系统、海床基、岸基、船基、井基、无人船等观测平台的结构设计、传感器集成、数据采集及通讯、数据管理系统及样机研制。


志愿船（走航）


二氧化碳通量小型浮标

方向二：生地化传感器及观测仪器

研发应用于生物地球化学参数观测的湿化学、光学、电化学的传感器，以及基于生物光学的生物传感器；研制在线及水下检测样机。


小型流通式分子荧光光度计


深海 pH 传感器（4000 m 级）


浮游植物光学分类传感器 (POD)

方向三：生地化采样与实验仪器

研发水下原位保真采样技术及痕量样品采集设备，研发基于水下原位连续培养技术和标志物示踪技术的生物地球化学动力参数测量方法及设备。


水下自动洁净采样系统


基于水下滑翔机的生物生产连续培养装置

方向四：水下机器视觉技术

面向海洋观测与智慧渔业需求，研发海洋生物原位成像技术及设备，并研发基于水下生物视频的数据增加、生物识别、行为分析等深度学习技术。


广角高清低生物附着水下成像仪（东山站仪器研发实验室）

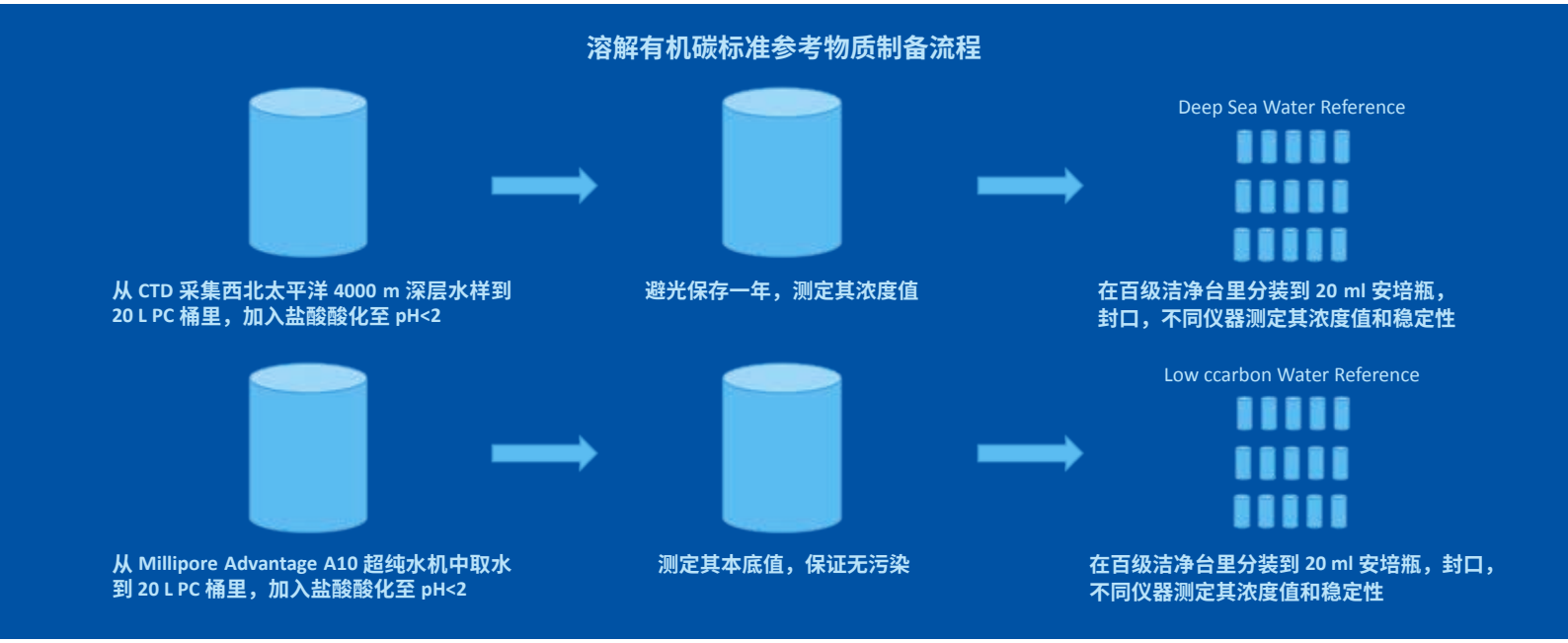

鱼类目标检测与行为分析

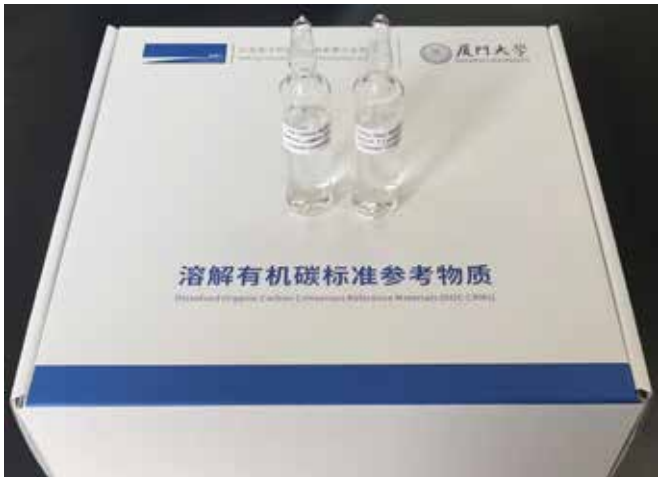
溶解有机碳标准参考物质

溶解有机碳（Dissolved organic carbon）是海洋中最大的还原性碳库，其碳储量约为 662 Pg C，与大气二氧化碳相当，是全球碳循环和气候变化的重要调解者。大洋 DOC 的浓度整体较低（35 – 90 μmol C/L），对其循环过程和机制的研究高度依赖于高精度的 DOC 浓度分析。国际比对结果表明，采用统一的参考物质（Consensus Reference Material, CRM）可以大幅降低不同研究组在分析同一样品时的相对偏差，有利于同行之间 DOC 数据的比较研究。从 1999 年开始，迈阿密大学为海洋 DOC 的研究提供了高质量的 CRM，但从 2017 年起，因 CRM 容器的更换，导致 CRM 在保存和运输中容易出现变化，稳定性下降。因此，研发我国自己的 CRM 变得十分紧迫。

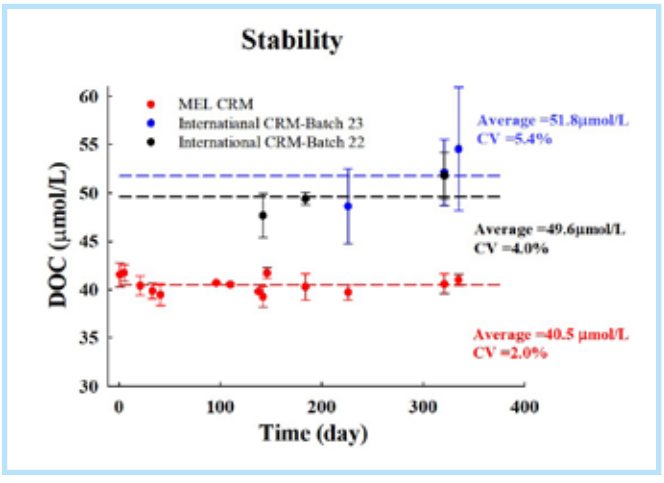
MEL 经过多次尝试，成功制备了 DOC 天然海水参考物质，并已应用于日常分析工作中。将采集到的西北太平洋 4000 m 深层水样酸化至 pH≈2, 并在室温下陈化两年后于百级洁净台内进行分装，制备了一批深层海水参考物质。随机抽取 12 个深层海水参考物质进行均一性测试，其平均值为 40.0 μmol C/L, 相对标准偏差（RSD）为 1.3%，均一性符合要求。在为期近一年的稳定性测试中，MEL CRM 的平均值为 40.5 μmol C/L，相对标准偏差为 2.0%，与国际参考物质对比，MEL 制备的深层海水参考物质在稳定性方面表现更优。目前，国内多家科研单位受邀开展这批参考物质的比对验证工作，后续将进一步邀请国际知名科研院所实施国际比对工作。

目前，MEL 建立了 DOC 标准参考物质从样品采集、制备至分析测试等完整的标准流程，有利于其他浓度 DOC 标准参考物质的研制。此外，MEL 还将探索溶解有机氮和溶解有机磷标准品的研制，希望能为国内外同行提供高质量的标准参考物质。





MEL 天然海水参考物质



MEL 和国际参考物质的稳定性比较

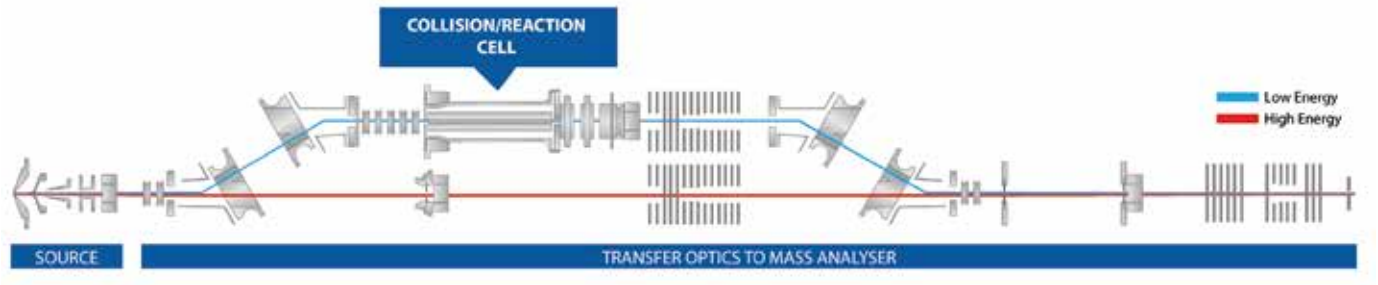
多接收器电感耦合等离子体质谱仪

过去 20 年中，多接收器电感耦合等离子体质谱仪（MC-ICP-MS）的进步推动了非传统稳定同位素系统（如 Li、Mg、Si、S、K、Ca、Ti、V、Cr、Fe、Ni、Cu、Zn、Se、Sr、Nb、Cd、Ba，Hg 和 Pb）在古海洋学和海洋生物地球化学中的应用。

新购置的的高分辨率 MC-ICP-MS（Sapphire）带有双通道，包含“高能量”离子路径（传统 MC-ICP-MS）和独立的“低能量”离子路径（碰撞 / 反应池）。“双通道”设计既可在较低分辨率下消除氩离子源产生的同质量多原子离子干扰，也为与反应池相关的射频多极器件可能引起的质量歧视问题提供了有效解决方案。因此，该仪器能够在完成精确和准确的同位素分析的同时，满足更高灵敏度的需求。

立足于西北太平洋生物泵固碳和储碳机理及碳汇演变趋势这一重大科学问题，MEL 将利用 Sapphire 完善现有的同位素体系（如 Si、Sr、Nb、Ba、Th、Pa、U）以及开发新的痕量元素同位素体系（如 Fe、Ni、Cu、Zn、Pb 等）分析方法，揭示西太平洋海水和颗粒物痕量元素同位素组成特征，提升对这片海洋“荒漠”中痕量元素的生物地球化学过程及其与全球气候变化紧密联系的认识。该设备已加入 COMET 预约共享系统。

多接收器电感耦合等离子体质谱仪



Sapphire 的“双通道”设计

时间序列沉积物捕获器

时间序列沉积物捕获器平台以时间序列方式长期原位采集水体中自然沉降的颗粒物质，用于生物地球化学研究，包括放射性核素、古海洋指标和碳循环研究，是海洋沉降输出通量及其相关生物地球化学过程研究的重要手段之一，也可应用于环境和污染监测。

COMET 仪器研发中心与海洋观测技术与数据中心两大技术团队成员和国家重点研发计划项目“西北太平洋生物碳泵的氮磷铁调控及演变趋势（PIN-Pump）”项目成员合作，于 8 月 5 日在北太平洋公海海域成功布放时间序列沉积物捕获器锚系一套，下放了长达 5800 m 的缆绳，在三个深度（500 m、1000 m 和 5000 m）收集沉降颗粒物，装备了 17 台 / 套声学多普勒海流剖面仪、单点海流计和温盐深仪等设备，实现对水文动力特征的长时间定点连续观测。通过测定沉降颗粒物的生物、化学组成，并结合水文动力特征分析，可系统揭示研究海区生物泵碳输出通量的时空变化规律，评估生物泵的固碳、储碳效率并阐明其机制。这是实验室布放的首套深海沉积物捕获器锚系，极大推进了对海洋固碳、储碳及其机制的研究工作。

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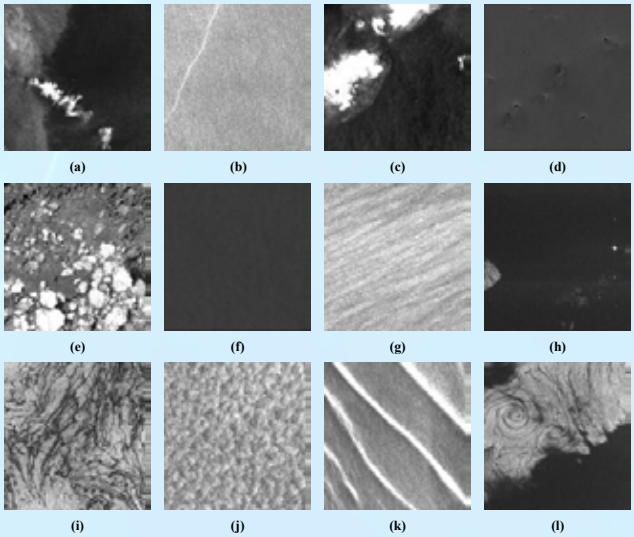
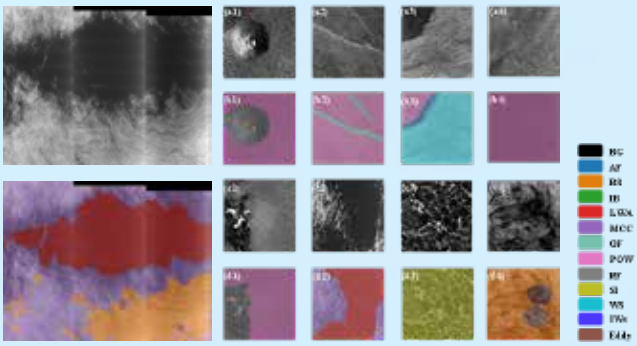
海丝卫星

◉ 海丝一号

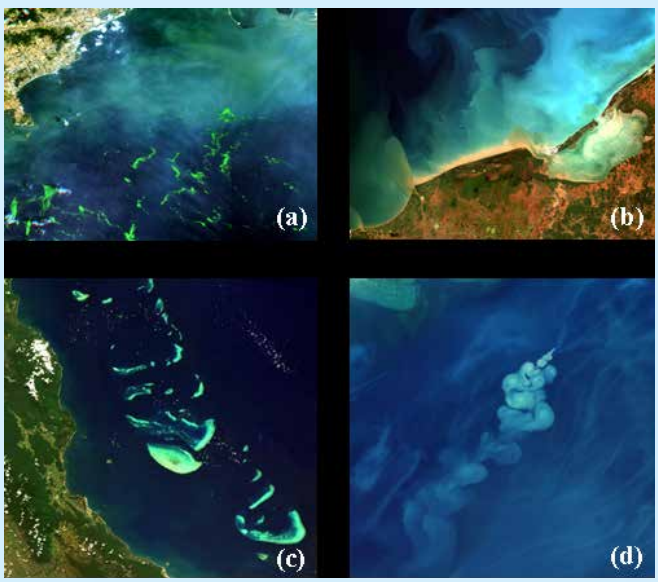
2024 年度，海丝一号（以下简称 SAR 卫星）重点观测典型海洋与大气现象。SAR 卫星对海面粗糙度十分敏感，各种海洋和大气现象可能显著影响海面粗糙度，从而在 SAR 图像中呈现出不同的亮暗特征。研究团队应用海丝一号和哨兵一号的图像，构建了一个涵盖 12 种典型海洋和大气现象的 SAR 语义分割数据集。这些现象包括大气锋面（AF）、海洋锋面（OF）、降雨（RF）、冰山（IB）、海冰（SI）、纯海浪（POW）、风条纹（WS）、低风速区（LWA）、生物油膜（BS）、微对流单元（MCC）、海洋内波（IWs）和海洋涡旋（Eddy）。此外，团队提出了一种改进的 Segformer 模型，用于自动检测和分割 SAR 海面图像中的这些典型现象。



SAR 图像中典型的海洋与大气现象
（a）大气锋面；（b）海洋锋面；（c）降雨；（d）冰山；（e）海冰；（f）纯海浪；（g）风条纹；（h）低风速区；（i）生物油膜；（j）蜂窝对流；（k）海洋内波；（l）海洋涡旋



SAR 图像的识别效果



◉ 海丝二号

2024 年度，海丝二号监测沿海和内陆水域水生生态系统，捕捉到更多近岸水体特性和细节。通过 20 米空间分辨率，团队更准确地计算了黄海浒苔分布面积，如图（a）；研究了在径流输入和再悬浮泥沙的作用下，墨西哥湾内复杂和多变的水质状况，如图（b）；解析了大堡礁及其邻近海域丰富多变的水质和底质情况，如图（c）。除了传统的水色研究，海丝二号也展现出与其空间分辨率相适应的涡旋捕捉探测能力，如图（d）。

中国、墨西哥和澳大利亚上空拍摄的四幅图像
(a) 中国黄海浒苔的成片分布；(b) 墨西哥卡门市附近近海水域的不同水质；(c) 澳大利亚大堡礁的部分珊瑚礁；(d) 北部湾，船体航行导致的对称卡门涡街

福建台湾海峡海洋生态系统国家野外科学观测研究站

福建台湾海峡海洋生态系统
国家野外科学观测研究站
National Observation and Research Station for the Taiwan Strait Marine Ecosystem

2024 年，福建台湾海峡海洋生态系统国家野外科学观测研究站 (简称台海站）组织开展台湾海峡上升流、东山湾、漳江口三个观测区航次共 11 次，完成漳江口红树林样方观测各 1 次，滨海湿地鸟类、鱼类和底栖动物观测各 2 次，结合 14 套自动观测设施获取观测数据约 18GB，海底有缆珊瑚在线观测系统获取东山造礁珊瑚视频超过 1300 小时。

台海站积极开展示范服务和科普传播，2024 年共举办科普活动 10 场，其中东山实验场围绕珊瑚保护与保育、海龟研究、河口 - 海湾生态等主题开设“苏峰讲坛”系列活动 3 讲。

与太古集团开启海洋生态保护和教育新篇章

太古集团委托旗下厦门太古飞机工程有限公司捐资人民币 546 万元用于“厦门大学东山太古海洋观测与实验站（东山站）海洋生态保护及教育计划”，支持东山站在东山湾地区开展长期监测和科研实验、区域内珊瑚物种的保护和修复，旨在加强海洋科学领域的沟通与合作，并深化海洋保护公众科普教育。

召开台海站第二届国际咨询委员会第一次会议，制定 2024-2030 战略发展规划 © 陈蕾

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科研人员

2 名
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5 名
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14 名
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5 名
行政人员

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◉ 戴民汉当选美国地球物理联合会会士并获地球与空间科学大使奖
◉ 吕永龙获俄罗斯科学院 300 周年禧年奖章
◉ 焦念志、戴民汉入选中国生态学会初始会士；吕永龙入选中国生态学学会会士
◉ 焦念志获生态环境保护产业创新发展杰出贡献奖
◉ “海洋新陈代谢与元素循环”研究群体获批国家自然科学基金创新研究群体项目
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获“2023 年度中国海洋与湖沼十大科技进展”与“2023 年度中国海洋科技十大进展”

◉ 王克坚团队成果“海洋动物新型抗菌肽的发现及其产品创制与应用”
获 2022 年度福建省科学技术奖一等奖

◉ 高树基、杨进宇、万显会团队成果“海洋硝化过程的驱动因子与全球变化”
获 2022 年度福建省科学技术奖二等奖

◉ 袁东星团队参与合作成果“高基底水样中低浓度生源要素的检测策略研究”
获 2023 年度广西科学技术奖三等奖

◉ 林森杰团队参与合作成果“基于环境适应性理论创新的珊瑚礁生态修复技术体系与示范”
获 2023 年度海南科学技术奖三等奖

科研人员

万显会 博士 教授

2017 年获厦门大学博士学位，曾在厦门大学、美国普林斯顿大学从事助理研究员和博士后工作（2018-2024），于 2024 年 6 月入职厦门大学。主要研究方向为海洋生物地球化学，以稳定同位素示踪为主要技术手段，探索海洋氮循环的主要过程及其控制机理。

温作柱 博士 副教授

2019 年获厦门大学博士学位，曾在厦门大学、德国亥姆霍兹基尔海洋科学研究中心从事博士后研究（2020-2024），于 2024 年 5 月入职厦门大学。重点聚焦海洋氮循环中的生物固氮作用，研究固氮生物多样性及固氮机理，探究生物固氮在海洋生物碳泵中的关键作用及对全球变化的响应。

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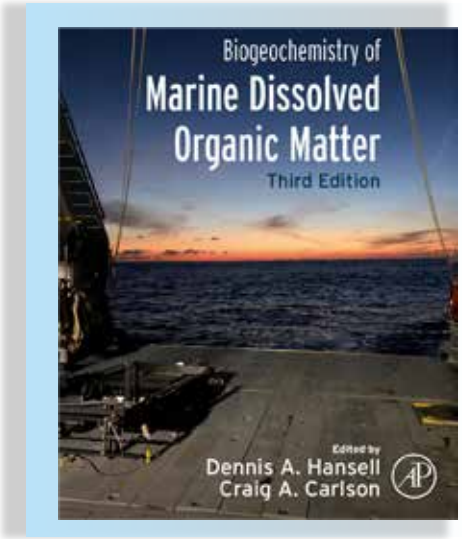

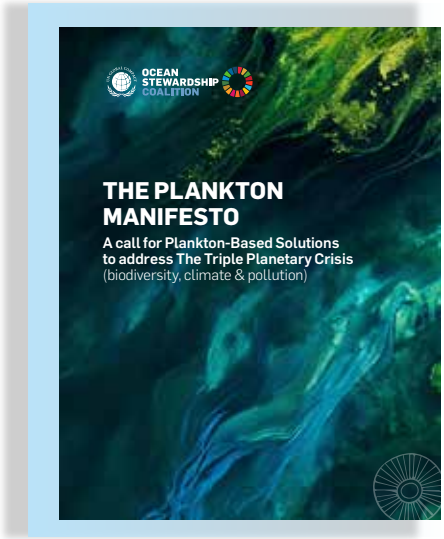

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