Presentation to the 10th IEBC Meeting

Xiamen, CHINA, 21 May 2008

Natural U-Th series radio-nuclides reveal important estuarine biogeochemical processes in the Delaware and Chesapeake Bays, USA

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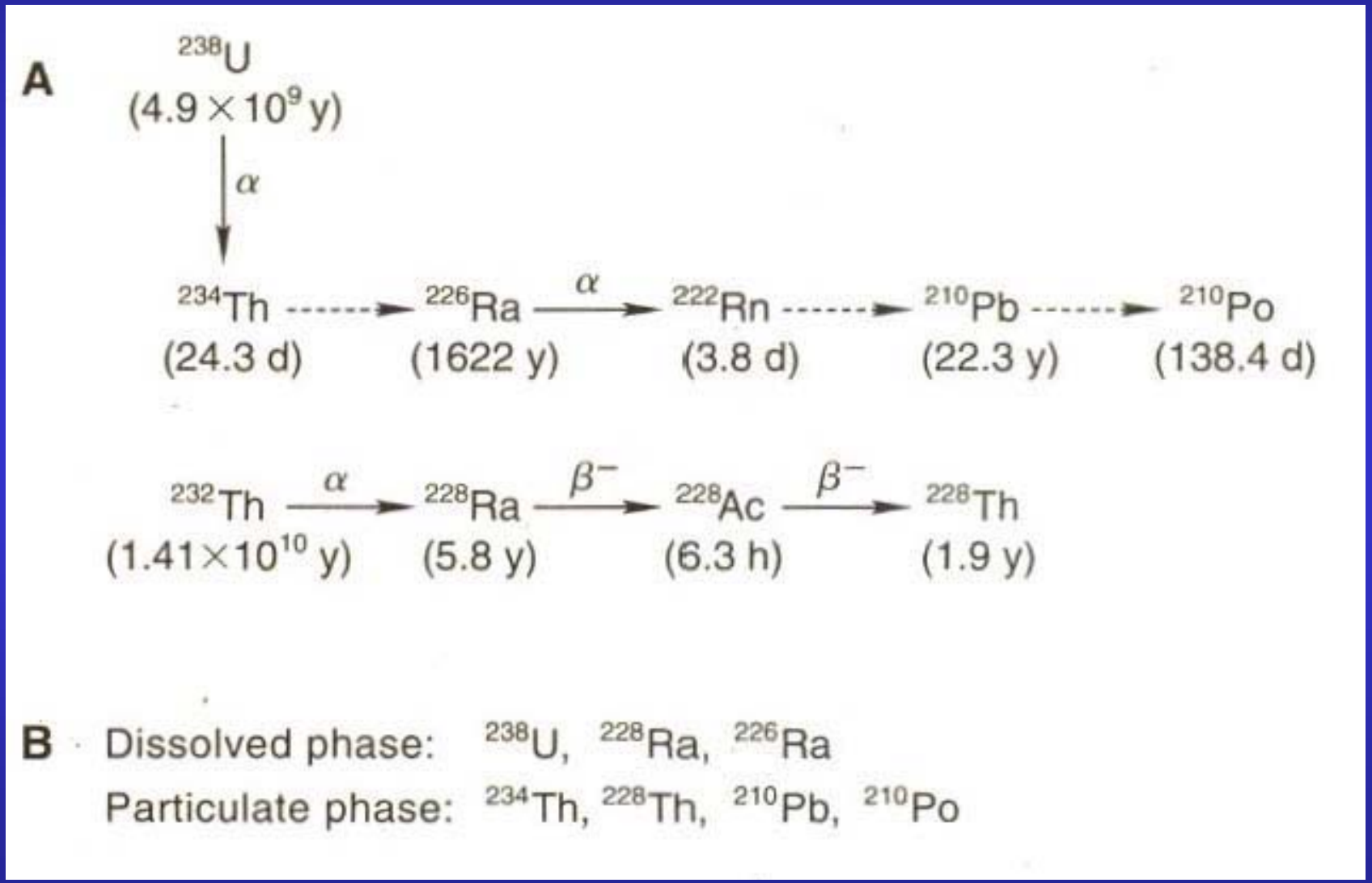
U-Th Series Nuclides for Estuarine Studies



Background to U-Th Series

- *Range of U-Th physical chemical properties*
- *Diverse U-Th biogeochemical properties*
- *Estuaries represent biogeochemical filters*
- *Resulting inter-, sub-tidal and shelf regions*

Recent papers on estuarine U-Th

Recent Review:

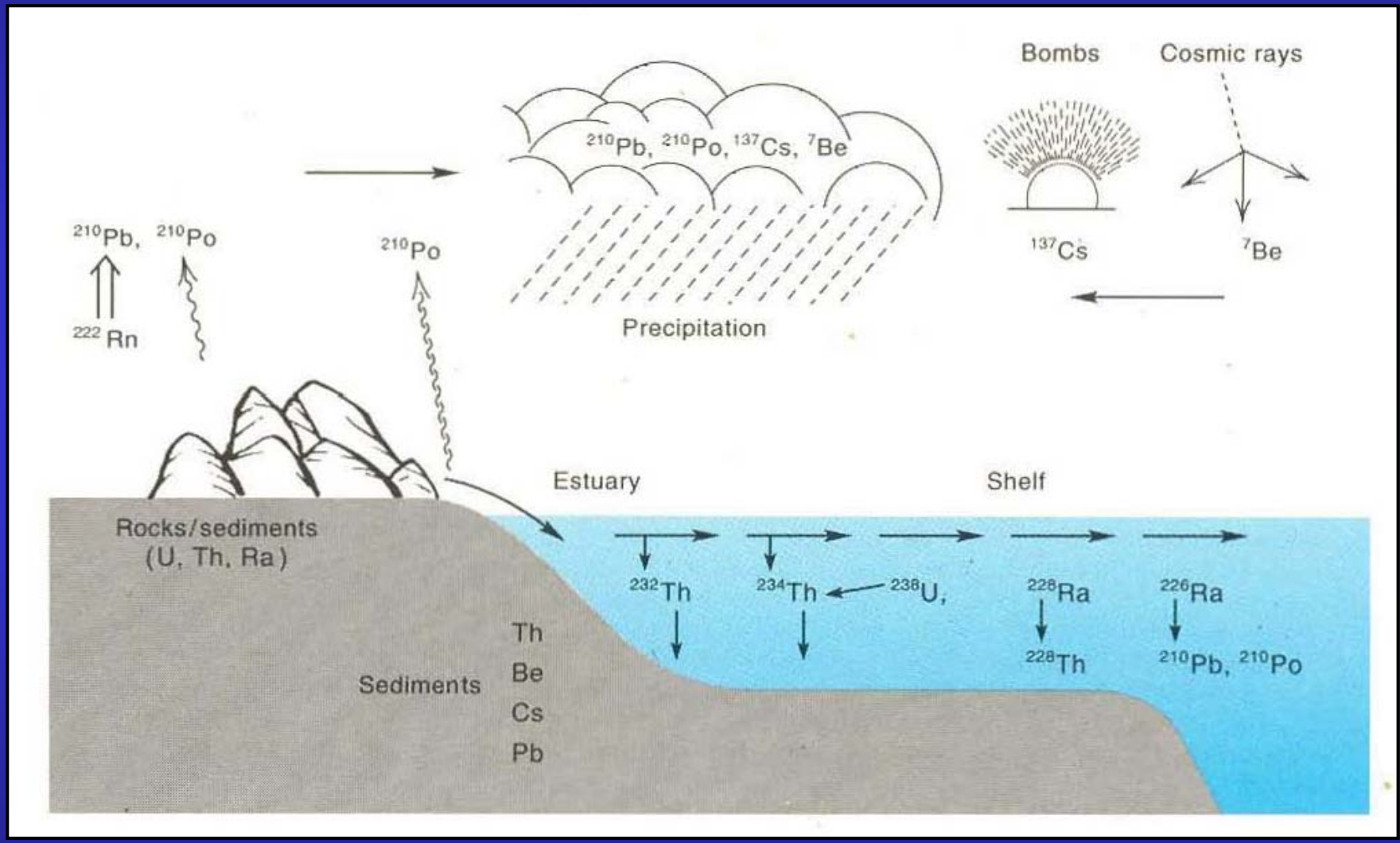
McKee, B. A. (2008)
"U-Th series nuclides in estuarine environments"
Chpt. 6 (in) Radioactivity in the Environment. Vol. 13.
S. Krishnaswami and J.K. Cochran (eds.), Elsevier

10th IEBC Meeting Posters:

Saari, H.-K. Sl Schmidt, J. Schafer, P. Castaing and B. Sautour "Short-lived radioisotopes (234-Th, 7-Be, 210Pb) as tracers for particle transport in the Gironde fluvial-estuarine system (France)

Su, N., Y. Zhang and J. Du "The distribution characteristics of radium isotope in the east coast of Hainan"

Sources and behavior of estuarine nuclides



OBJECTIVES

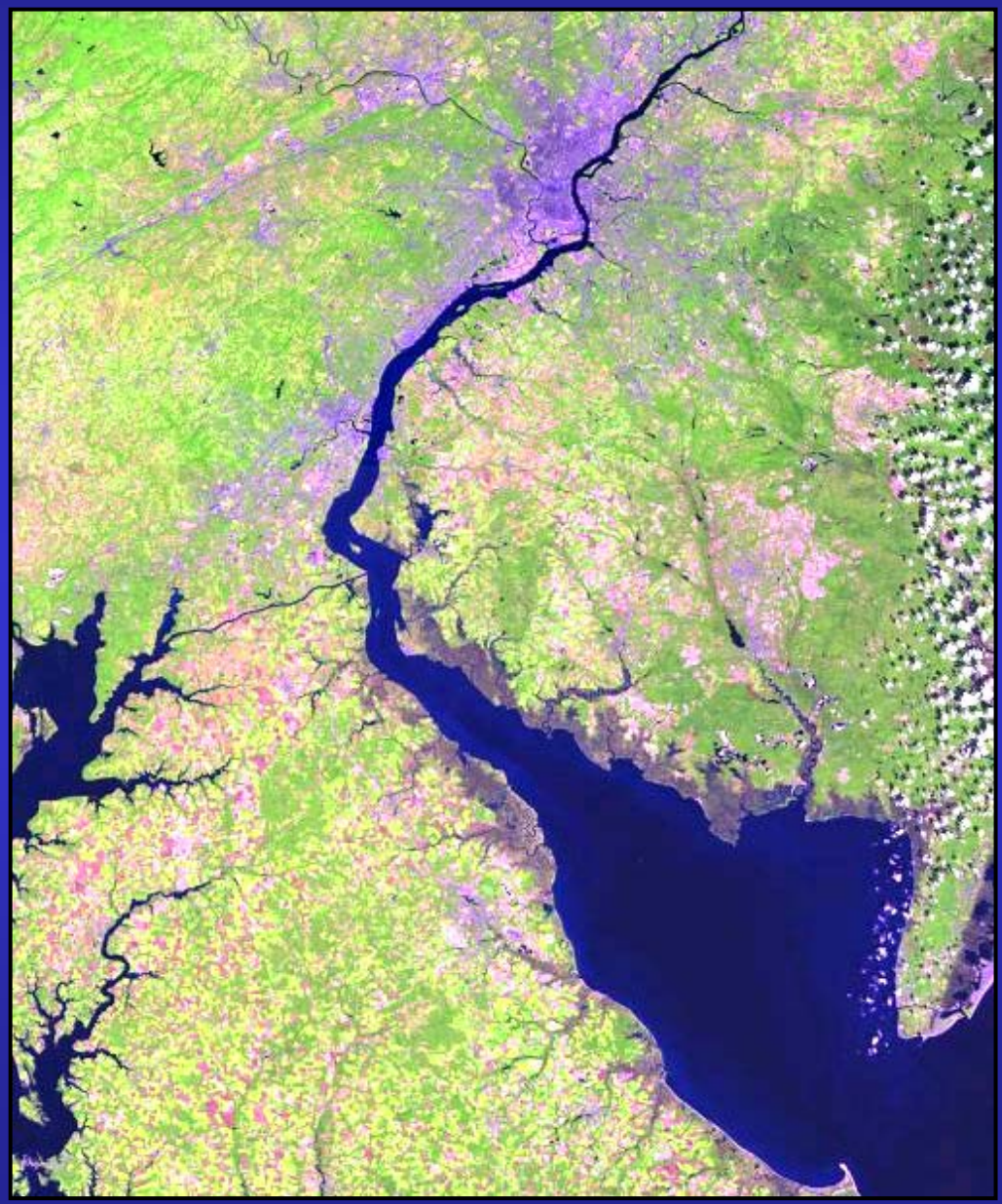
- ***What U-Th series reveal estuarine processes?***
  - Soluble: U (238,234),Ra (226, 224, 228)
  - Particle scavenging: Th (234,228), Pb 210)
  - Biogenic and gases: 210-Po, 222-Rn

- ***How do estuarine processes impose disequilibrium?***
  - Physical chemistry of estuarine scavenging
  - Hydrogeology of suspended and permeable sediments

- ***Why do U-Th disequlibria provide qualitative tracers and quantitative rates of estuarine process?***
  - Scavenging residence times, biological C cycling, ground water flux, biogeochemical modeling

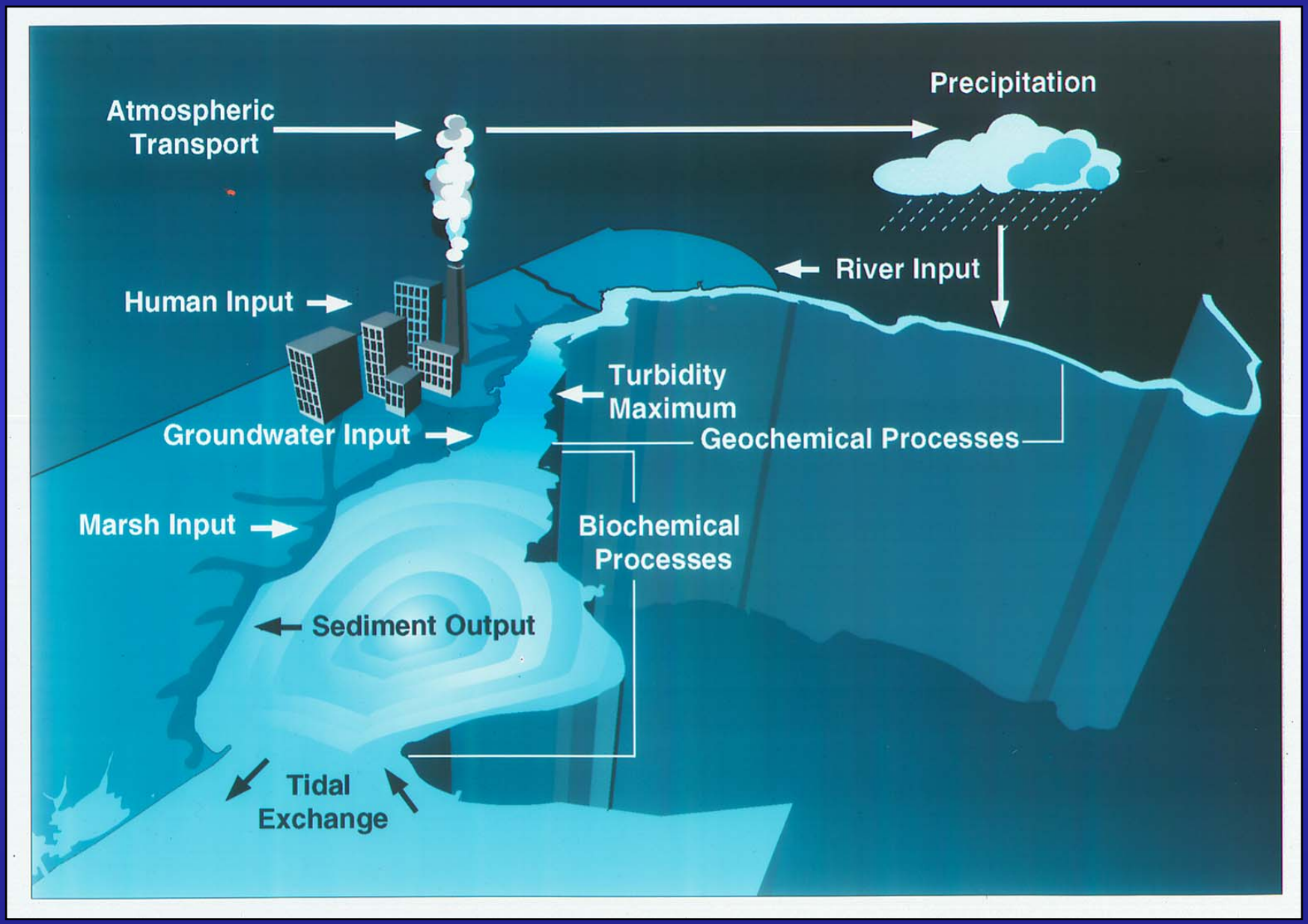
Delaware Bay Estuary

The Delaware Estuary and Land Use Patterns

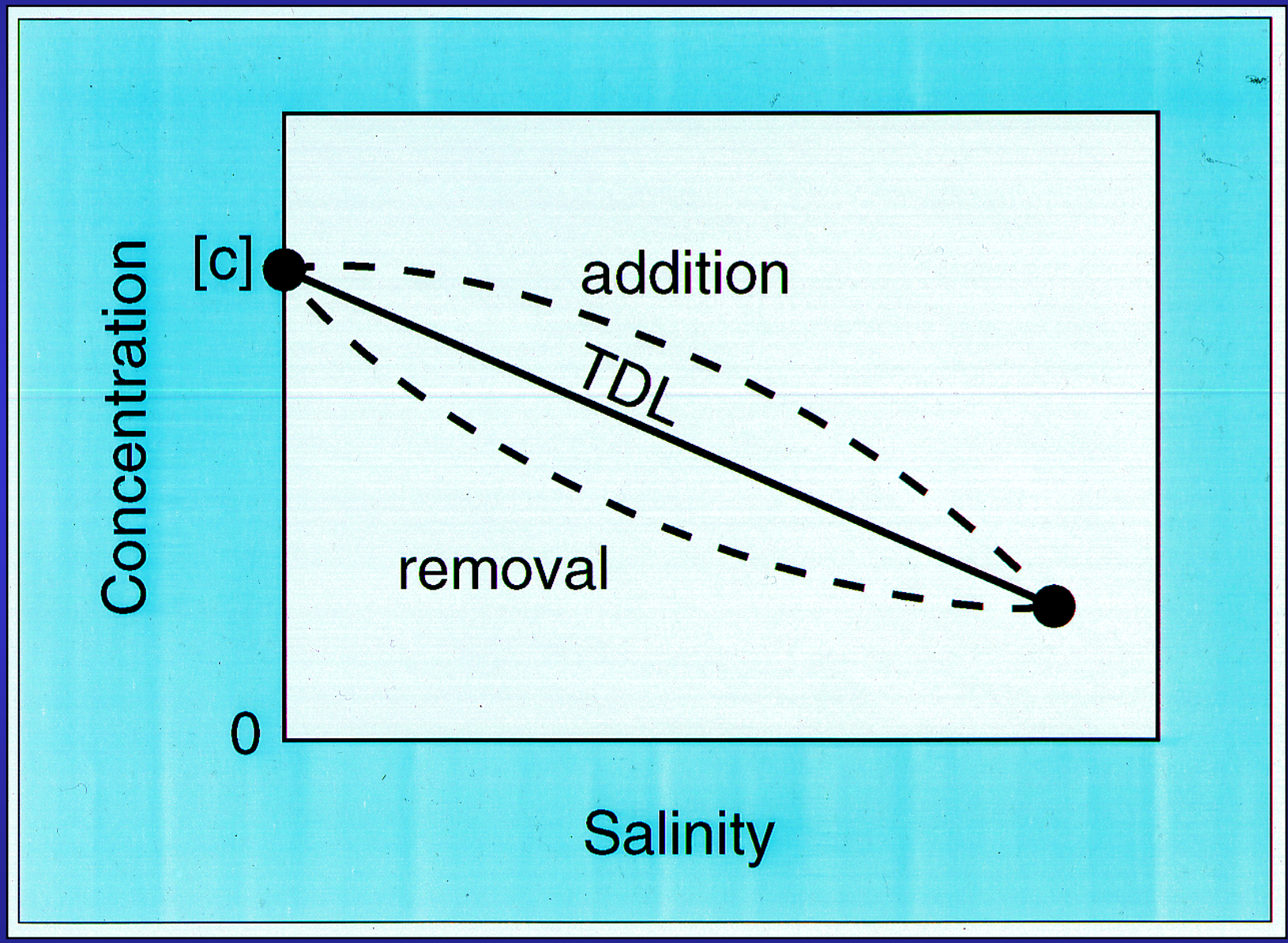


Satellite Image of a Delaware Salt Marsh

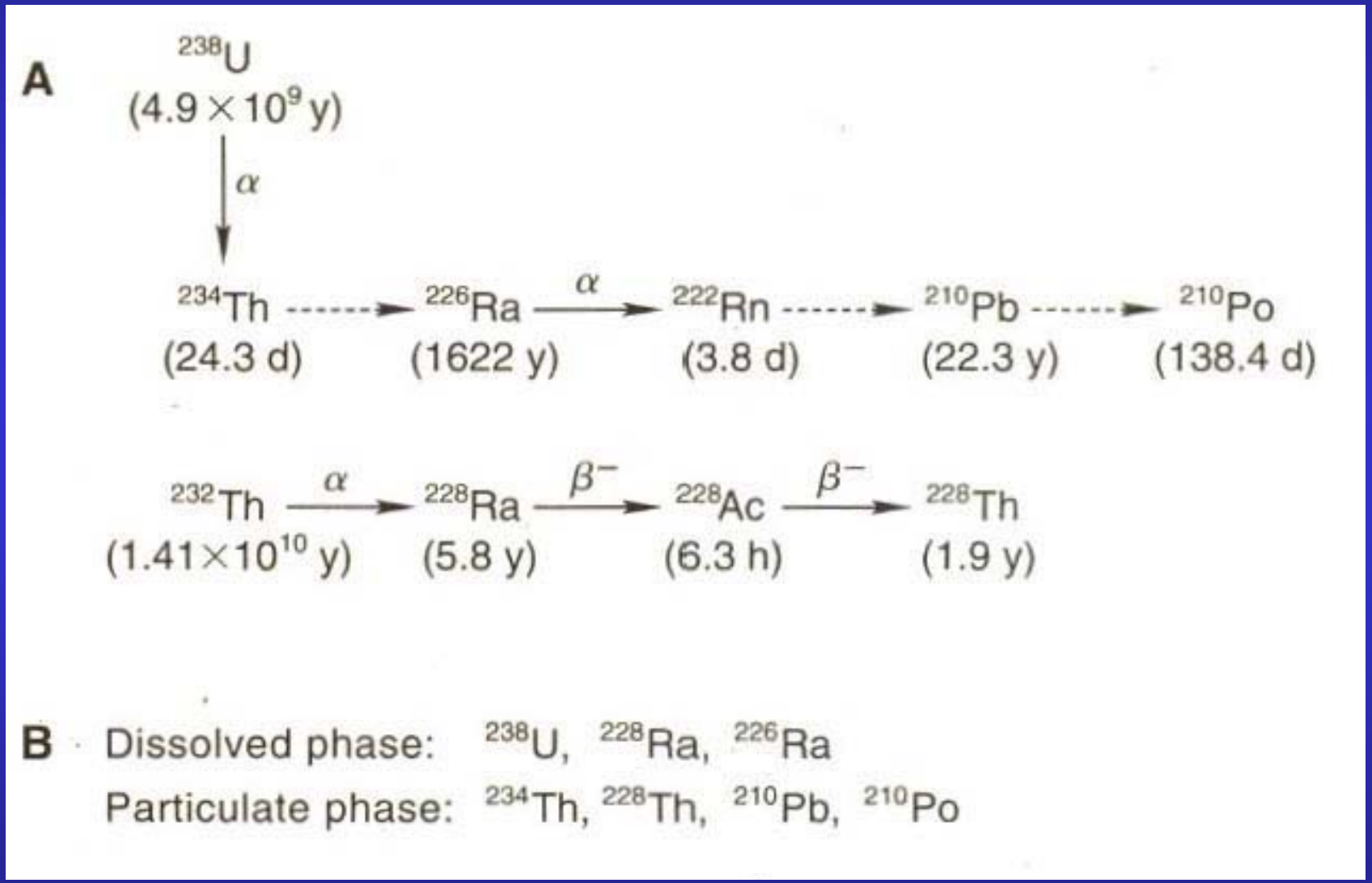
Delaware Bay Estuarine Processes



Estuarine Concentration vs Salinity Systematic



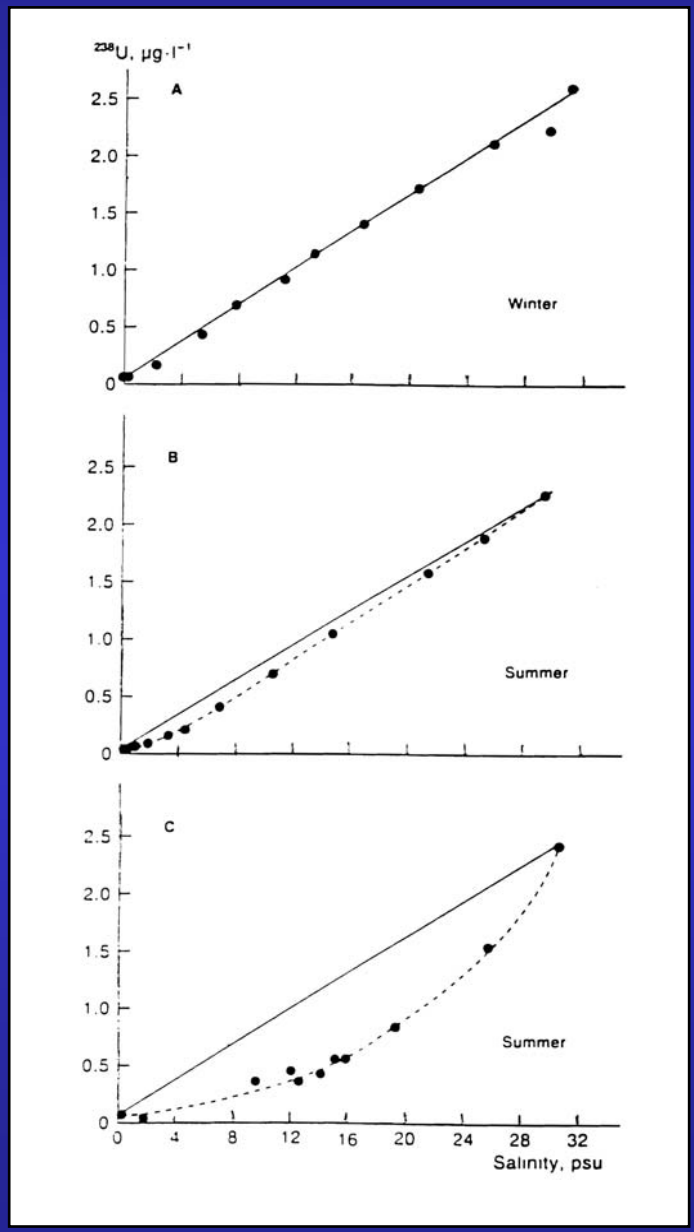
U-Th Series Nuclides for Estuarine Studies



Uranium 238 in Delaware estuaries

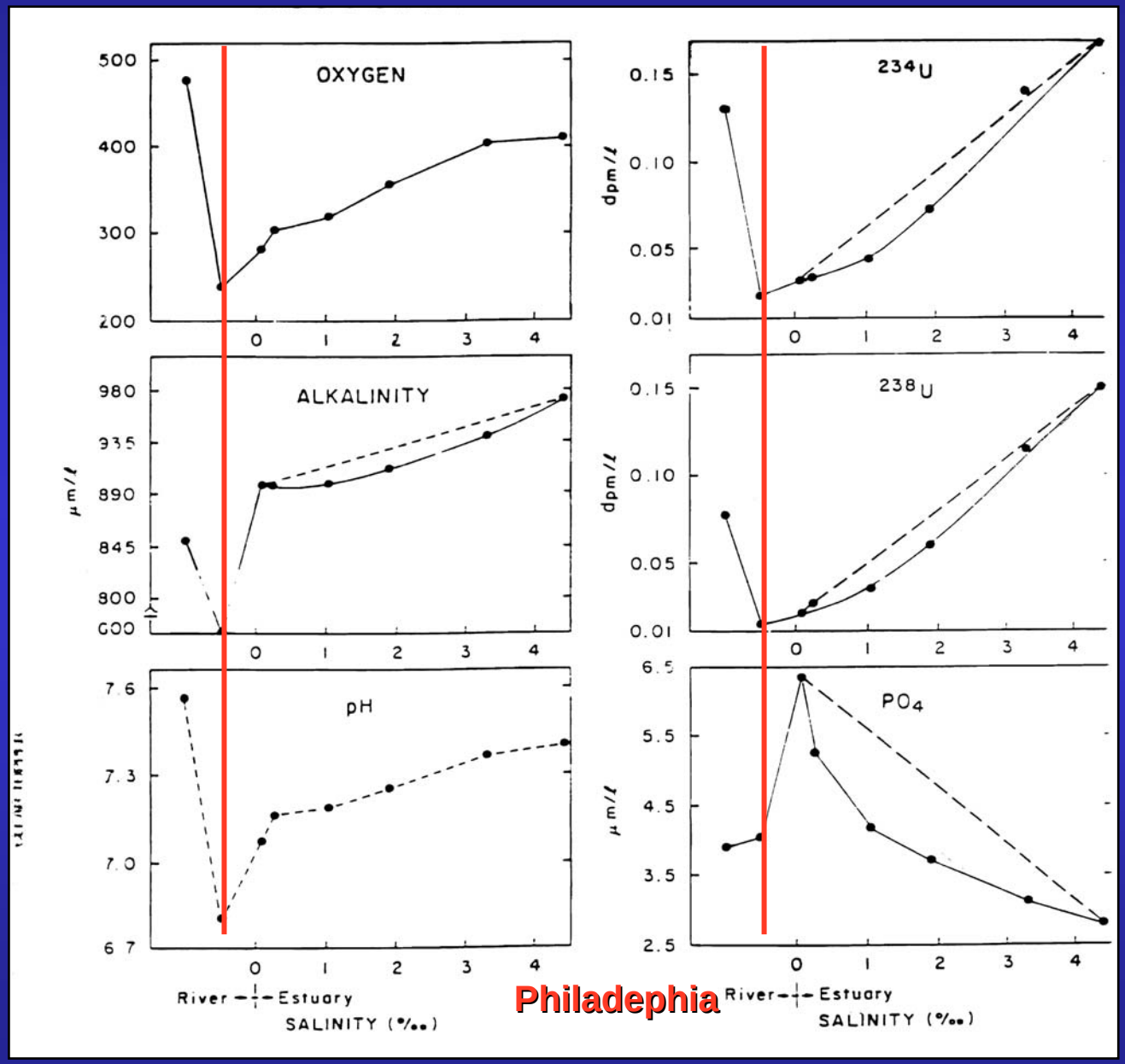
Estuarine Bay

Salt Marsh

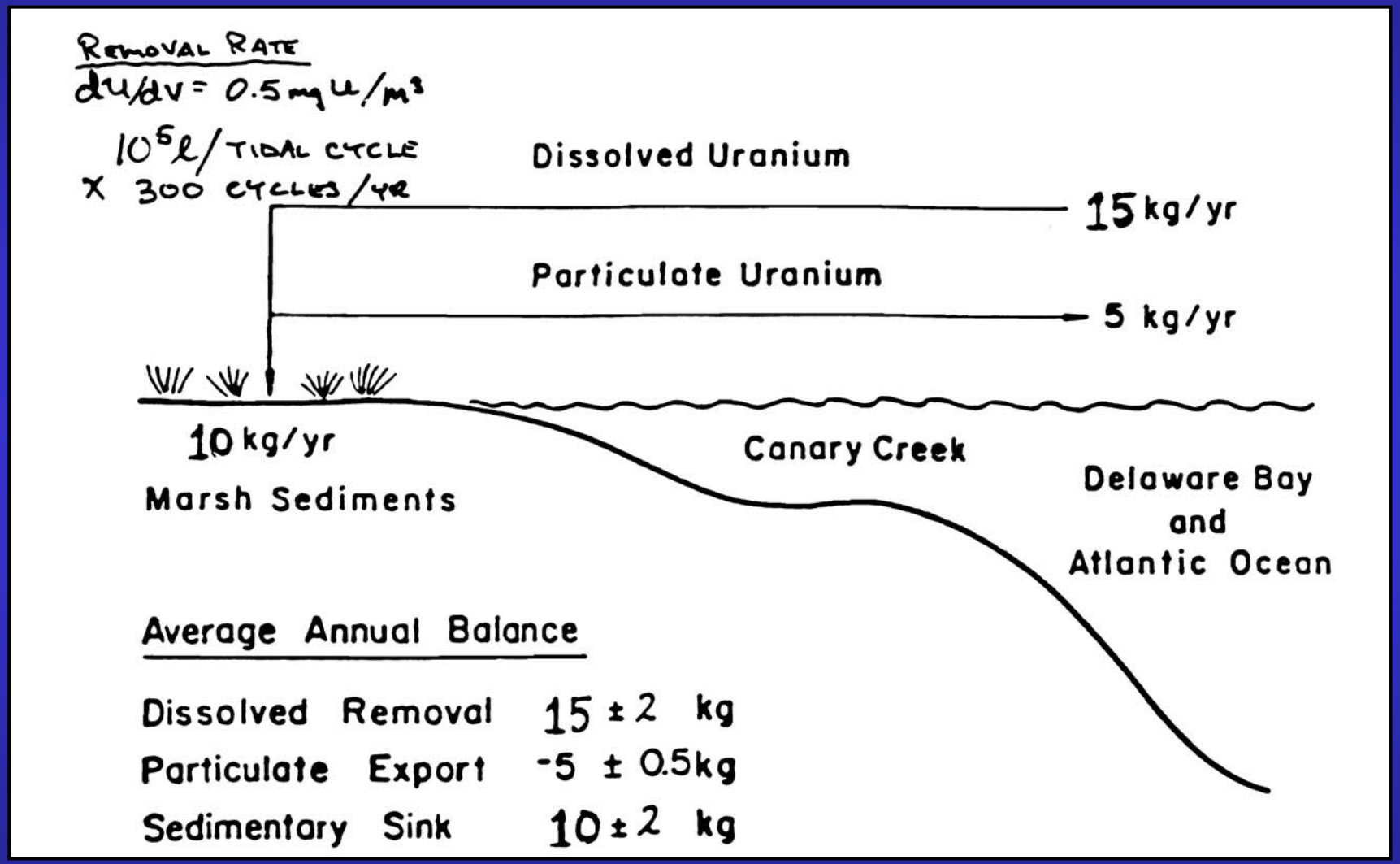


Sarin and Church, 1994

U associated chemical parameters

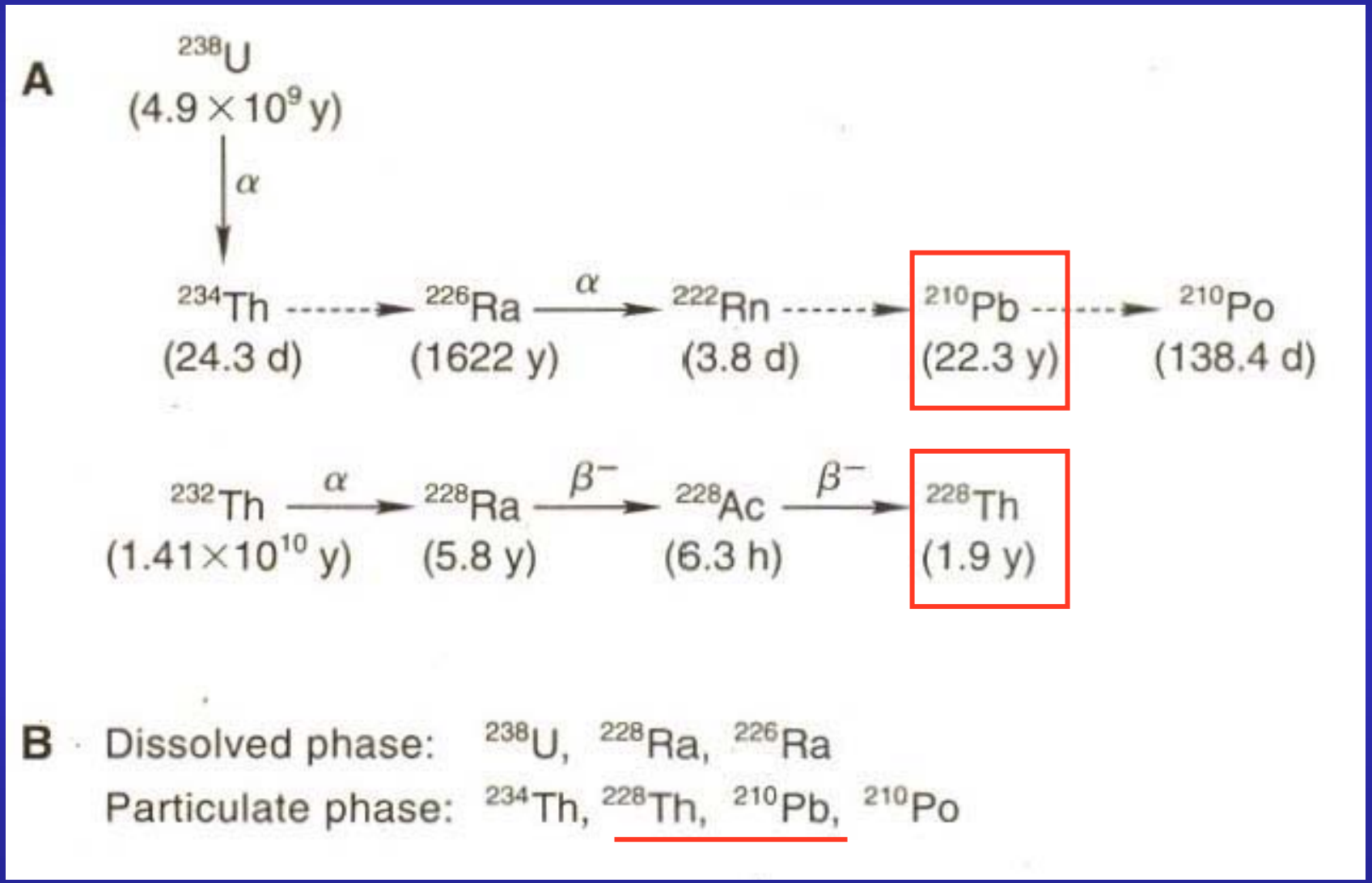


Uranium budget in De salt marsh

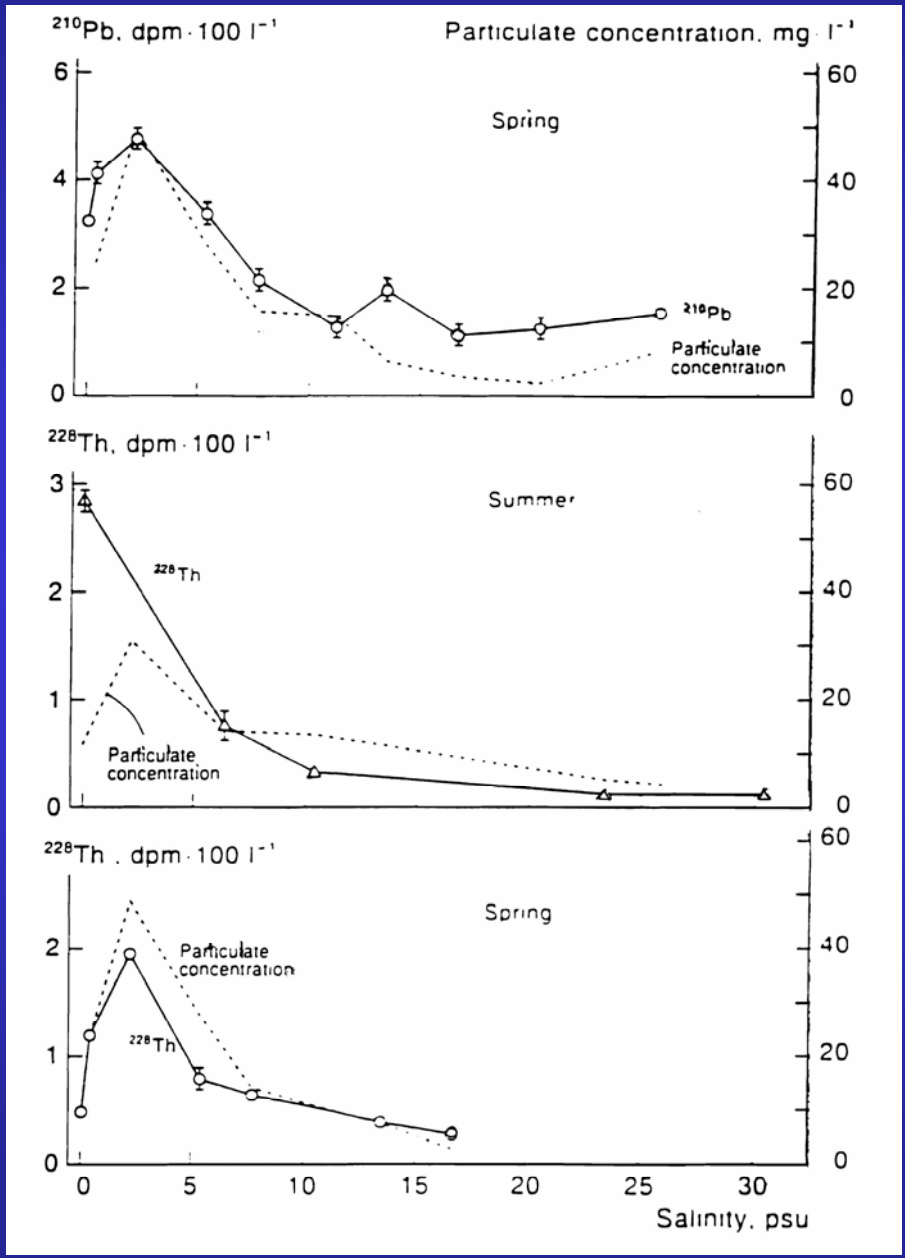


Church, et al. 1996

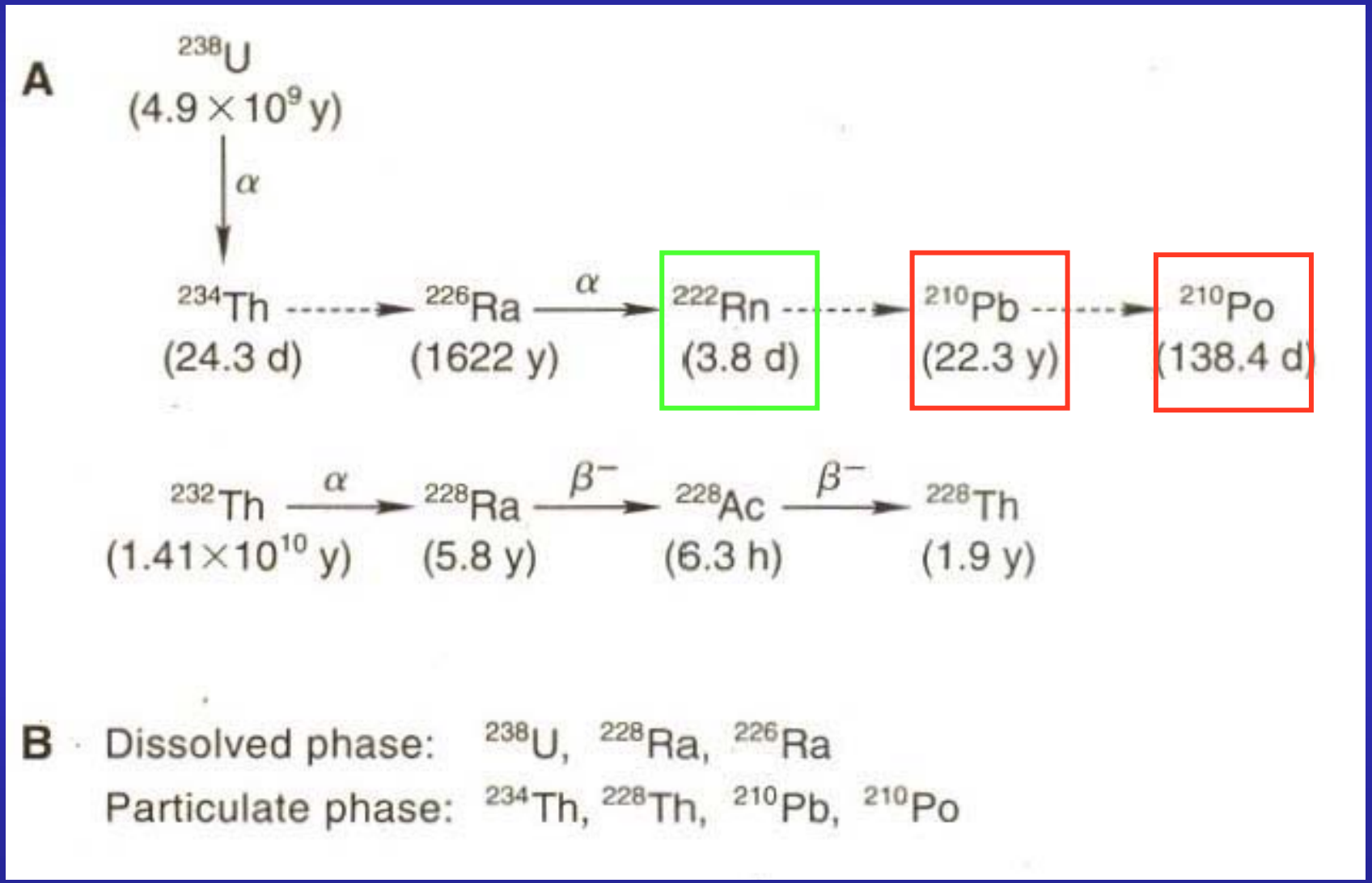
U-Th Series Nuclides for Estuarine Studies



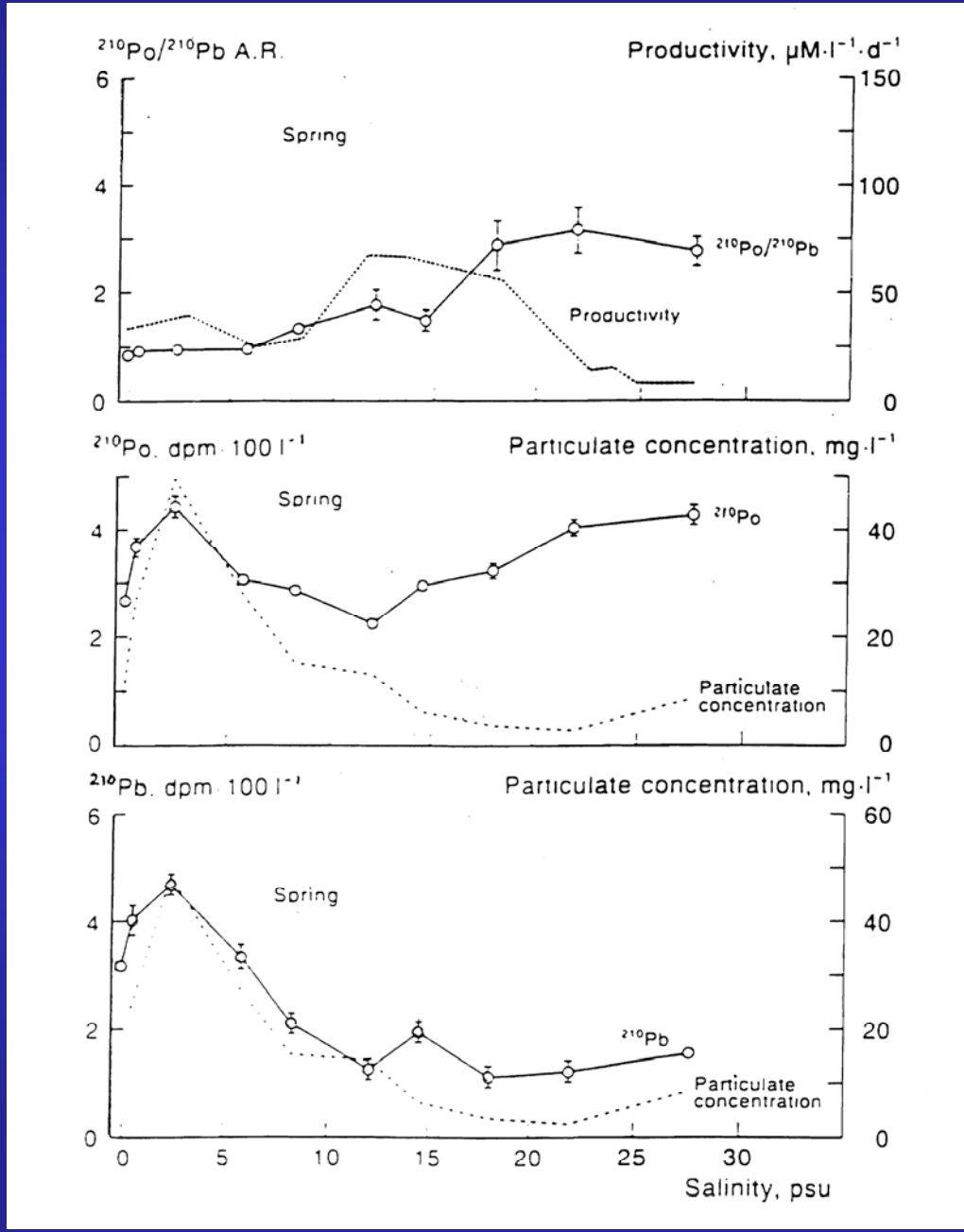
Thorium and lead isotopes in De Bay



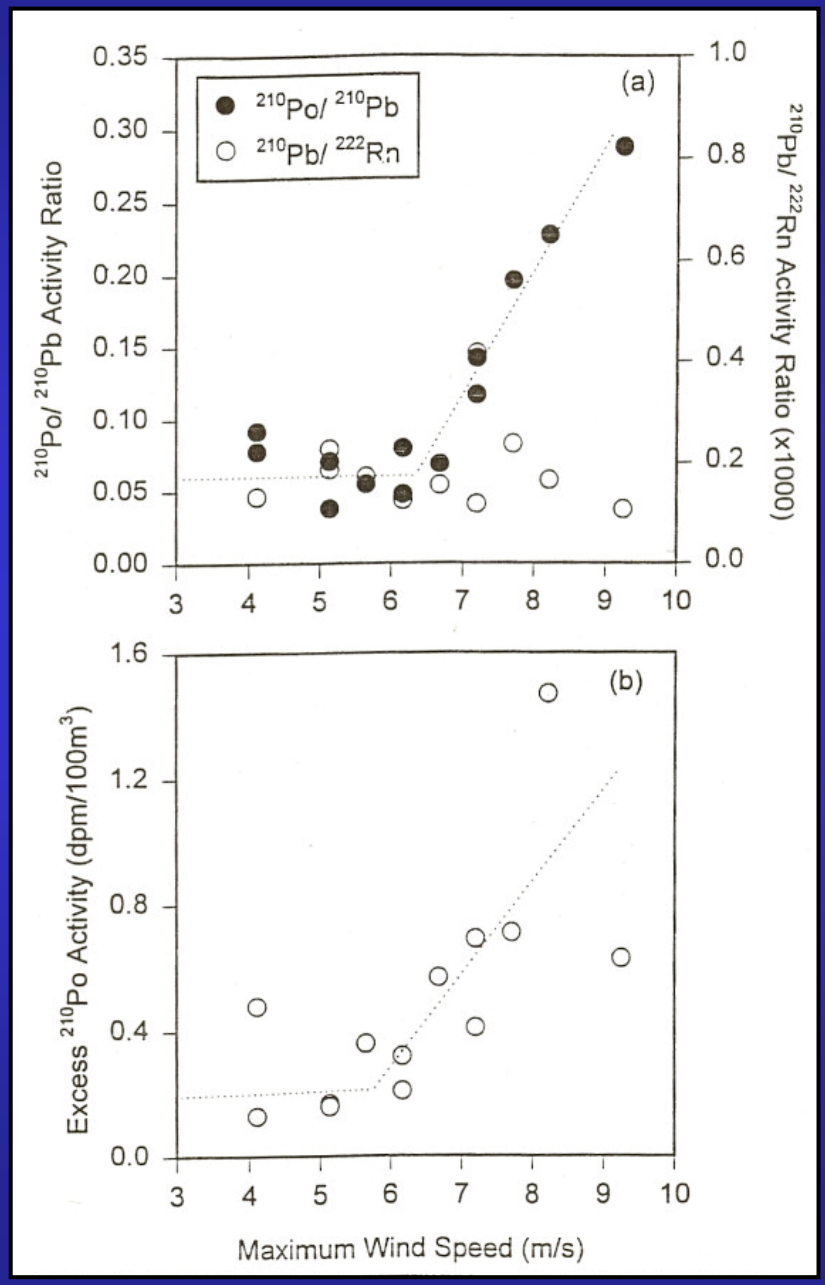
U-Th Series Nuclides for Estuarine Studies



210-Pb and 210-Po isotopes in De Bay

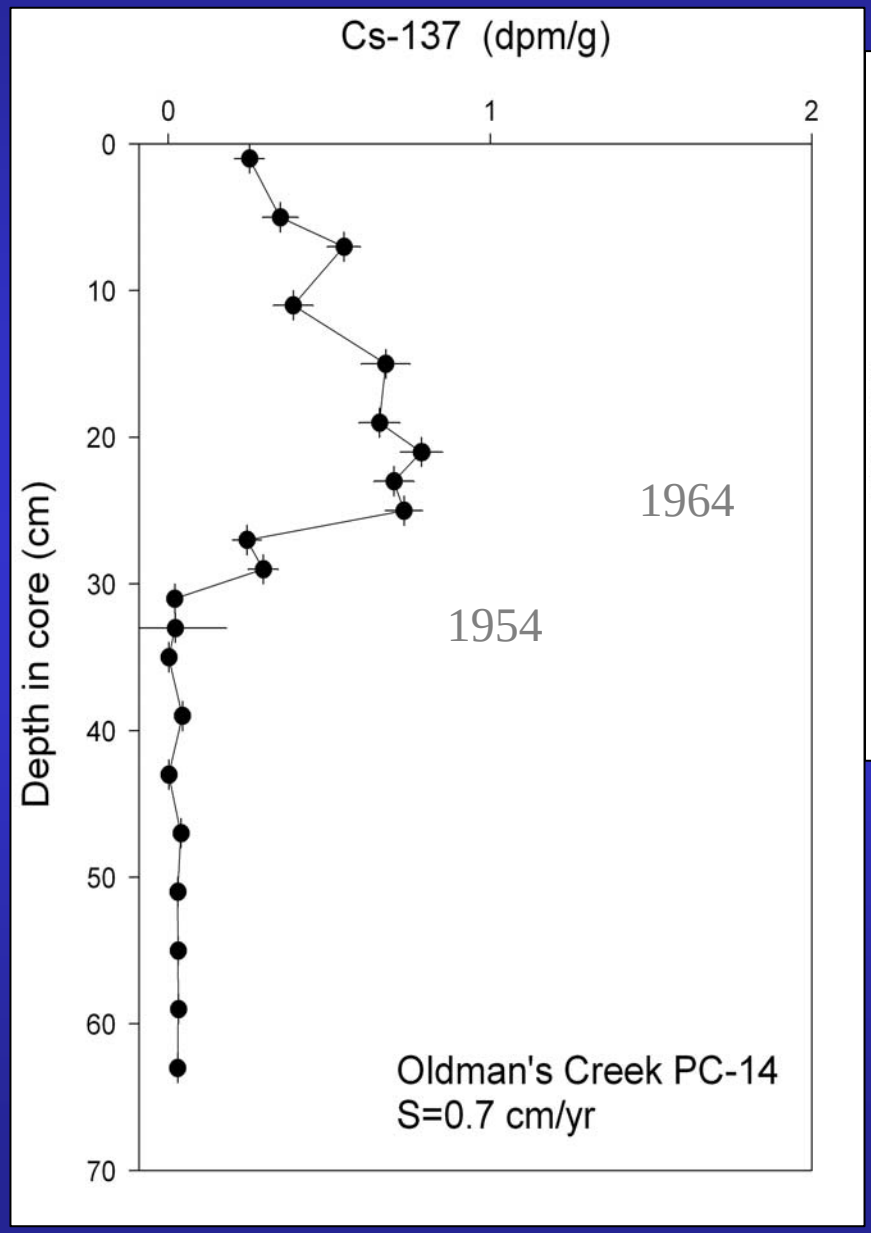


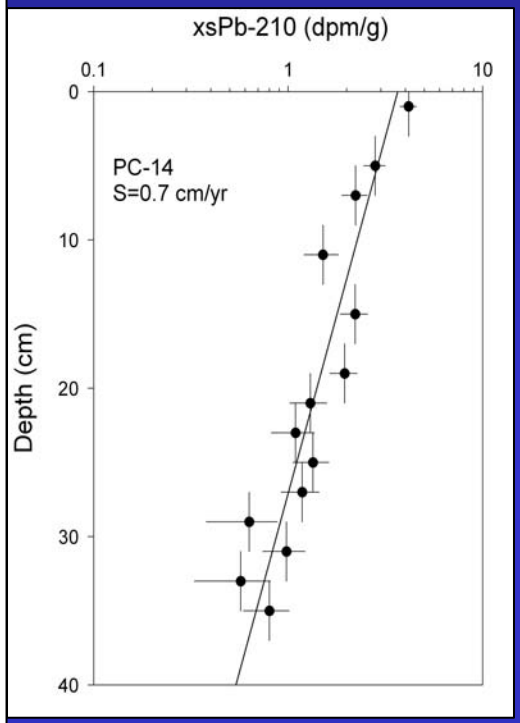
210-Po volatile exchange in MAB coastal waters



Kim et al. 2000

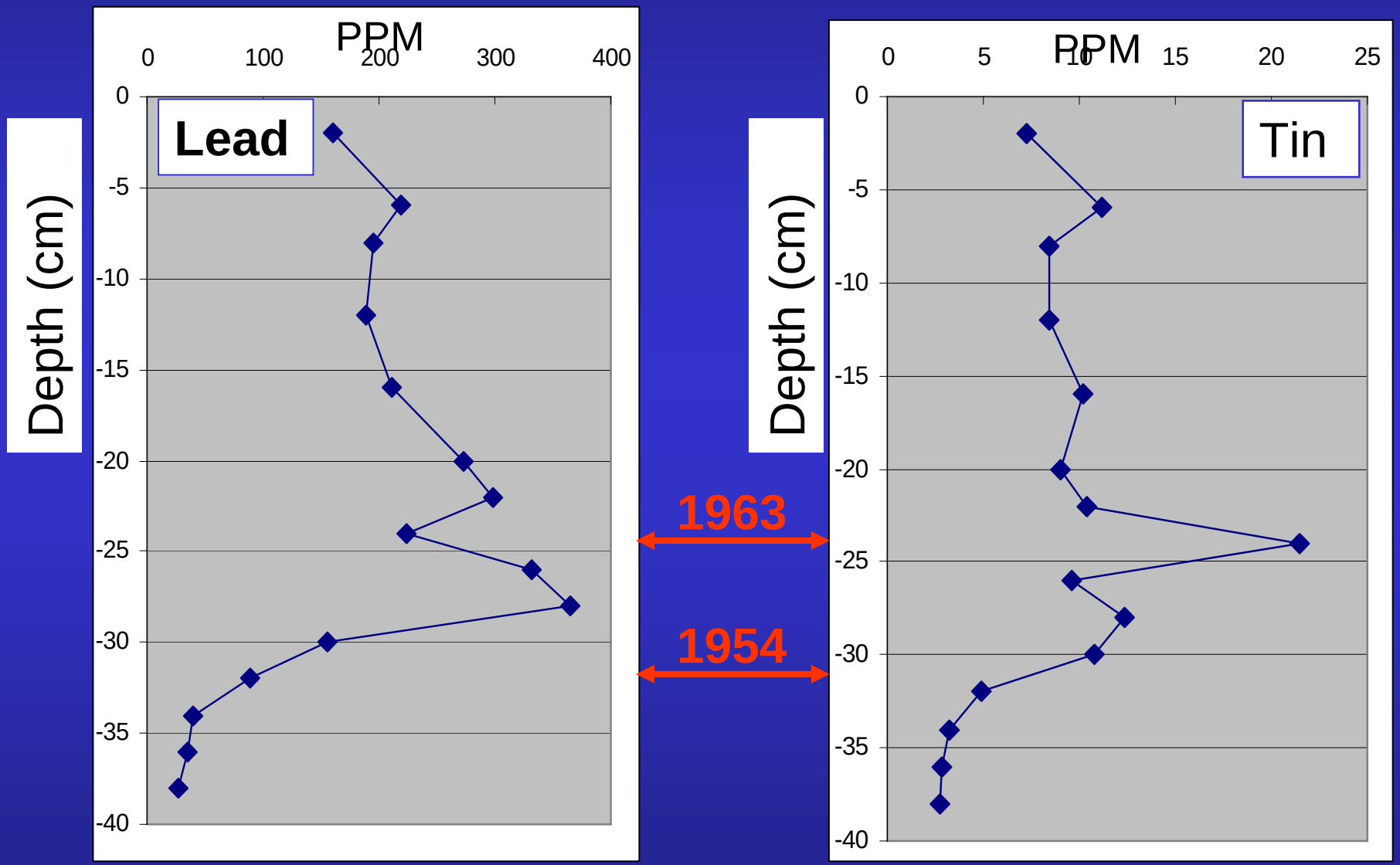
Cs-137 and Pb-210 Geochronology for PC-14



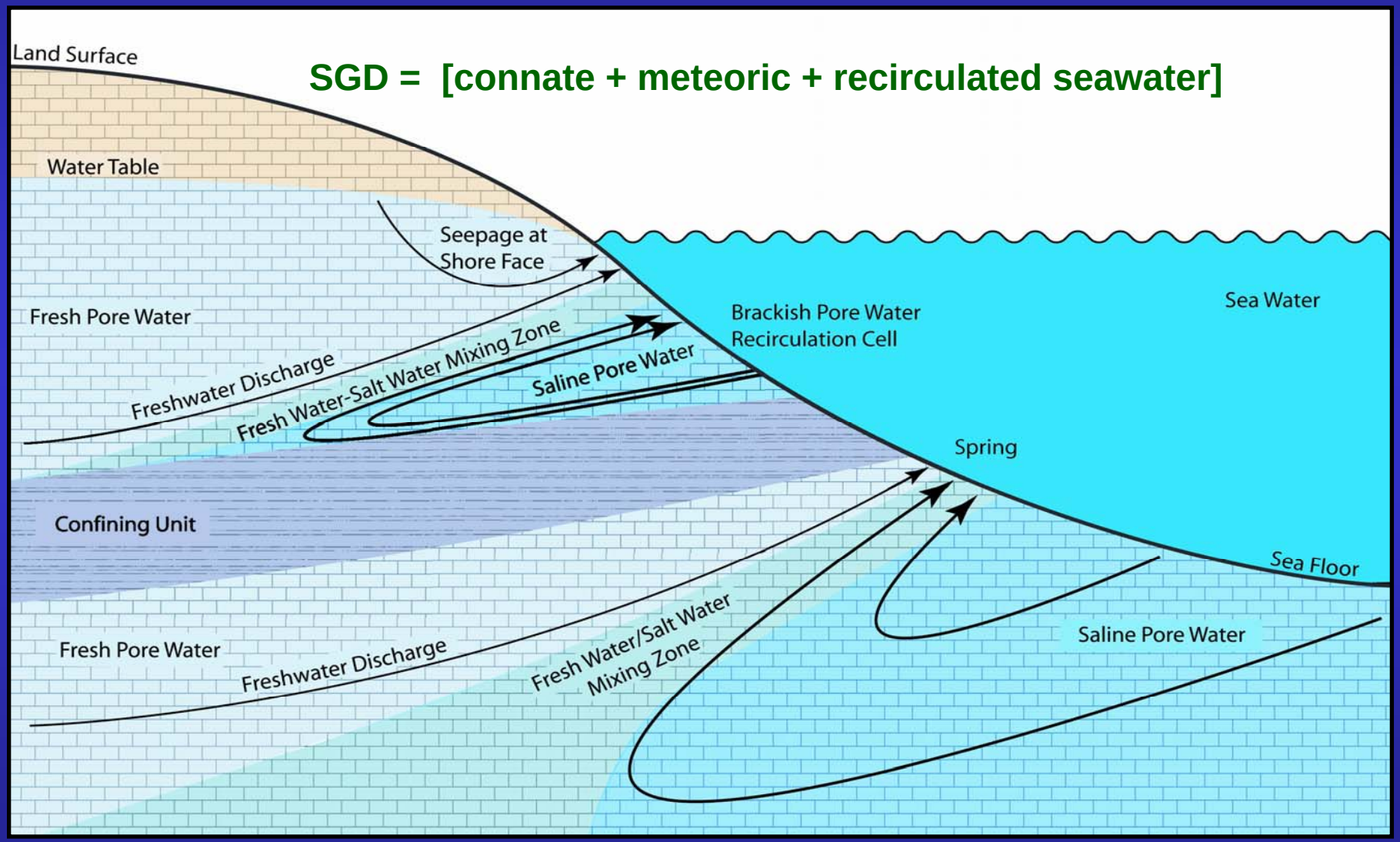


Church et al. 2006

Organo-Trace Metal Profiles for PC-14



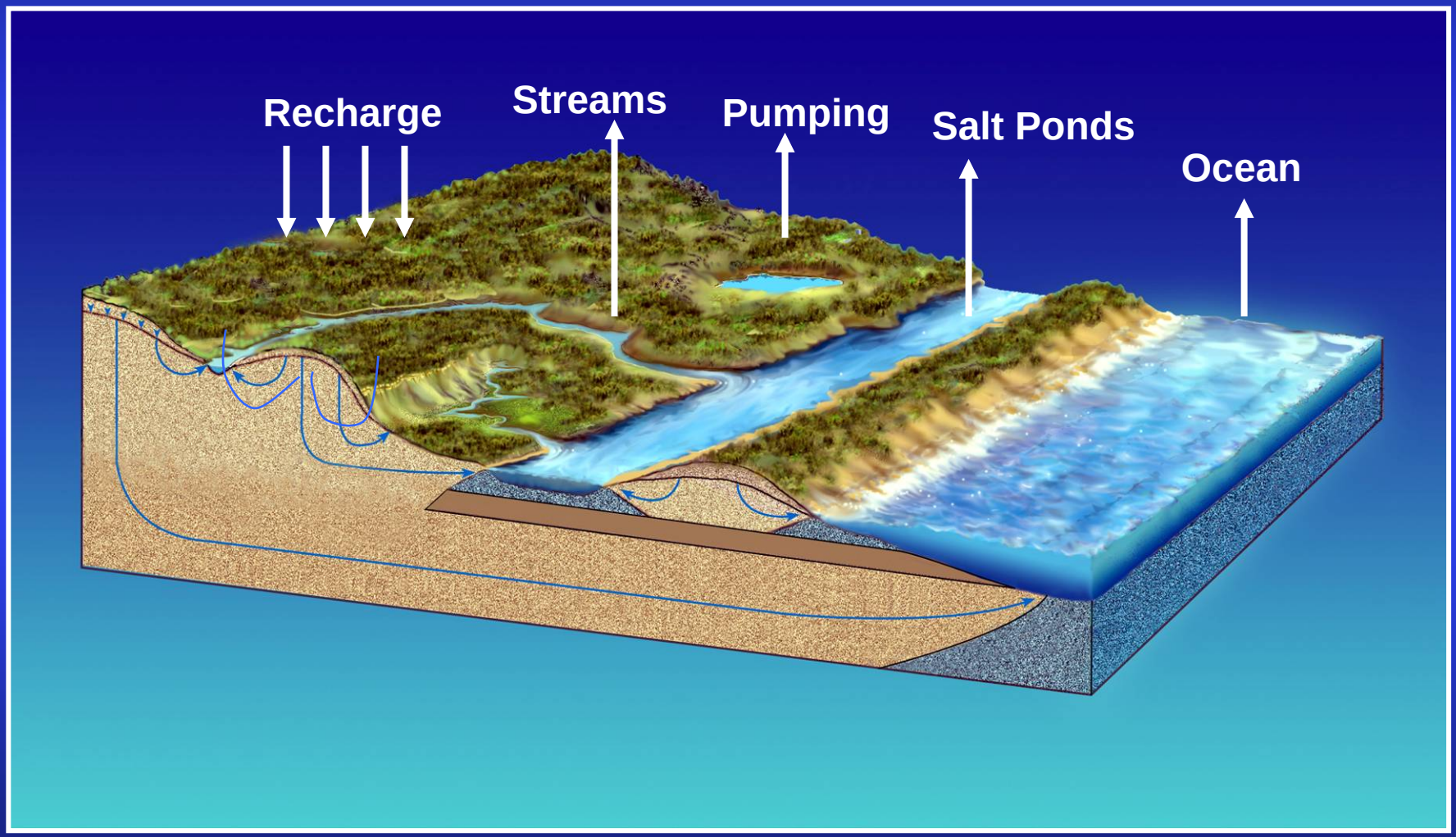
Processes at the fresh water / saltwater interface



Potential significance of SGD

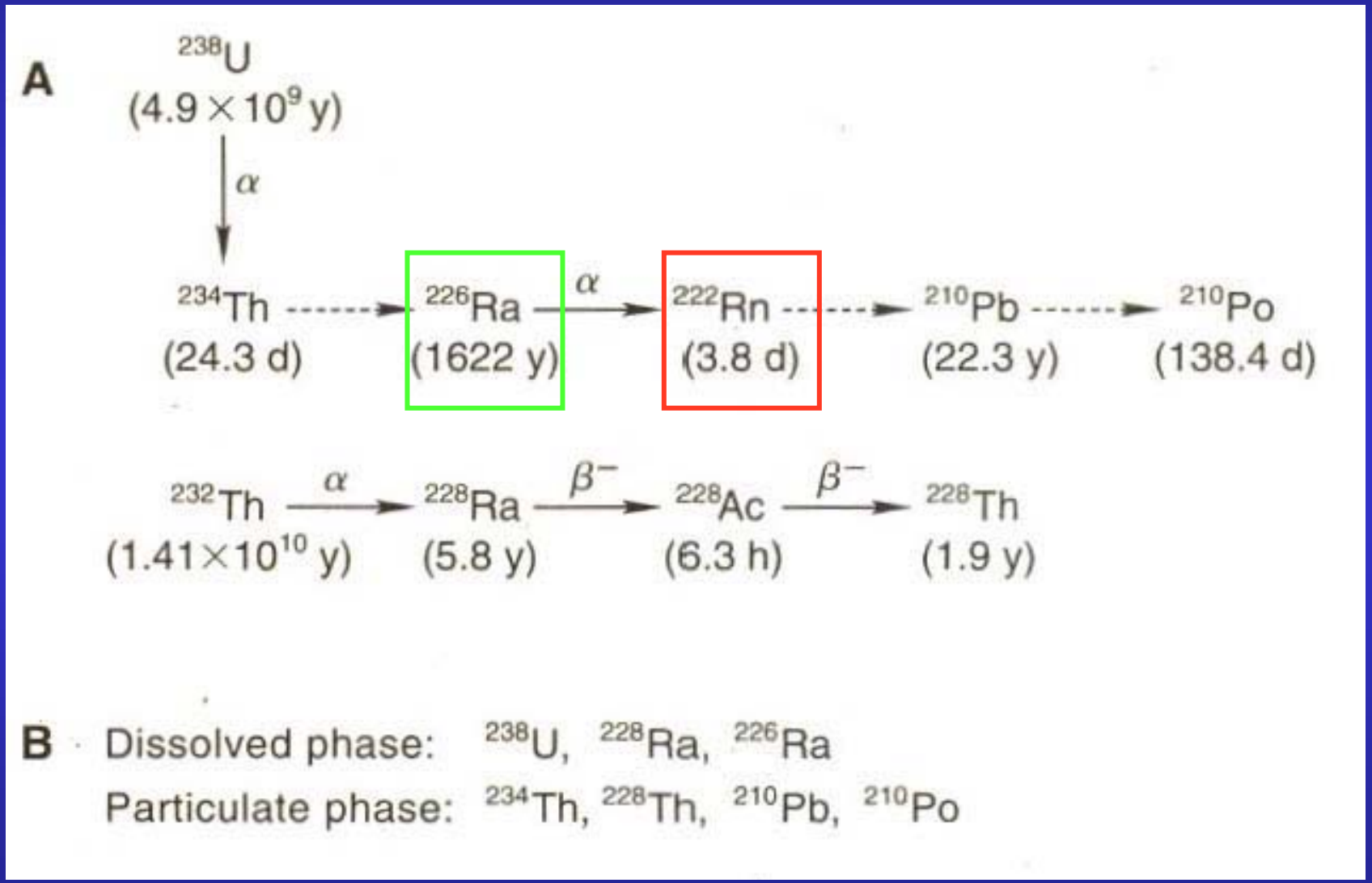
1. Solute pathway between land and sea
2. Underground estuaries and rivers
3. Nutrients for benthic ecosystems
4. Contributions to coastal eutrophication
5. Saltwater intrusion to potable GW

Submarine ground water estuarine inputs

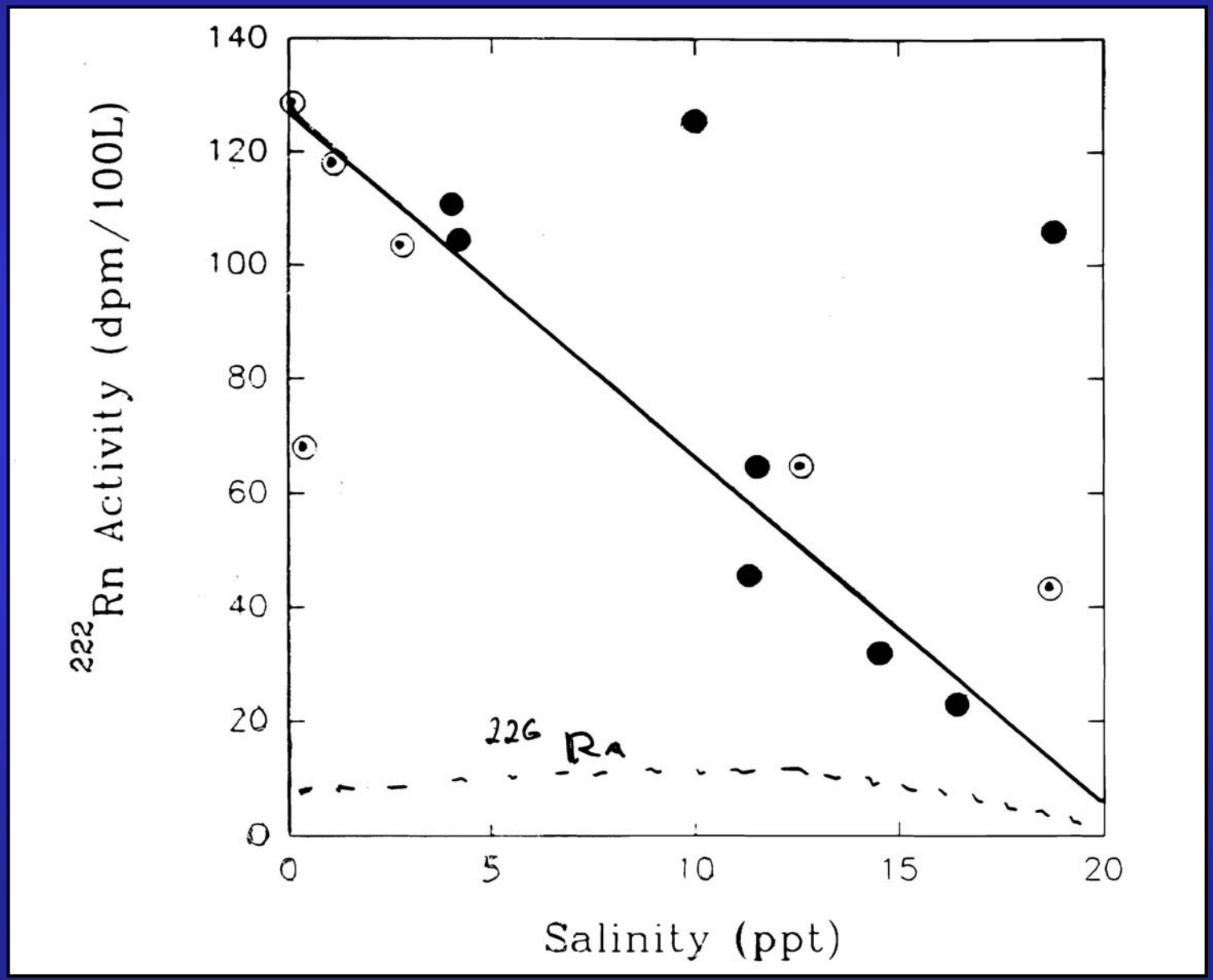


Courtesy J.P. Masterson, USGS

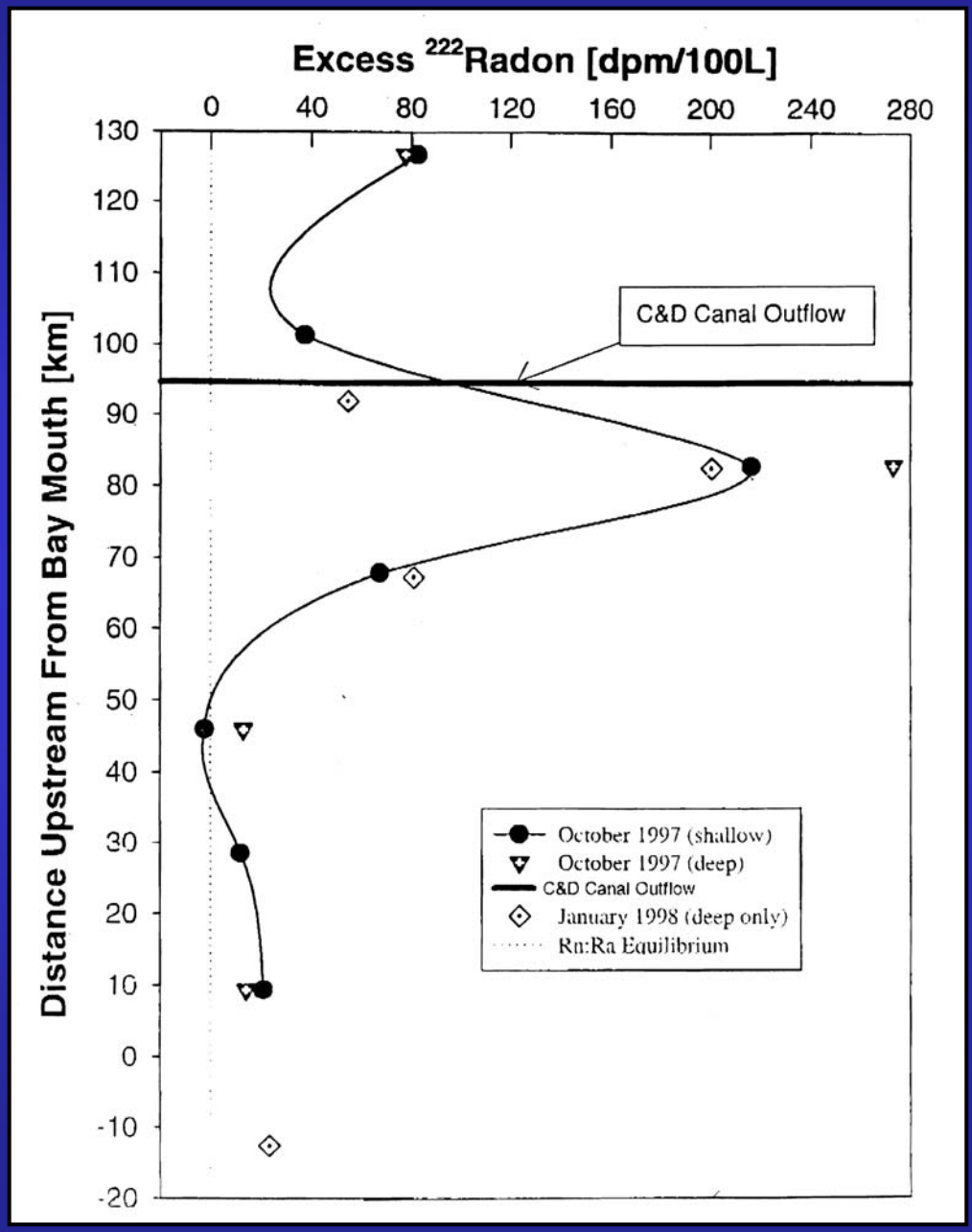
U-Th Series Nuclides for Estuarine Studies



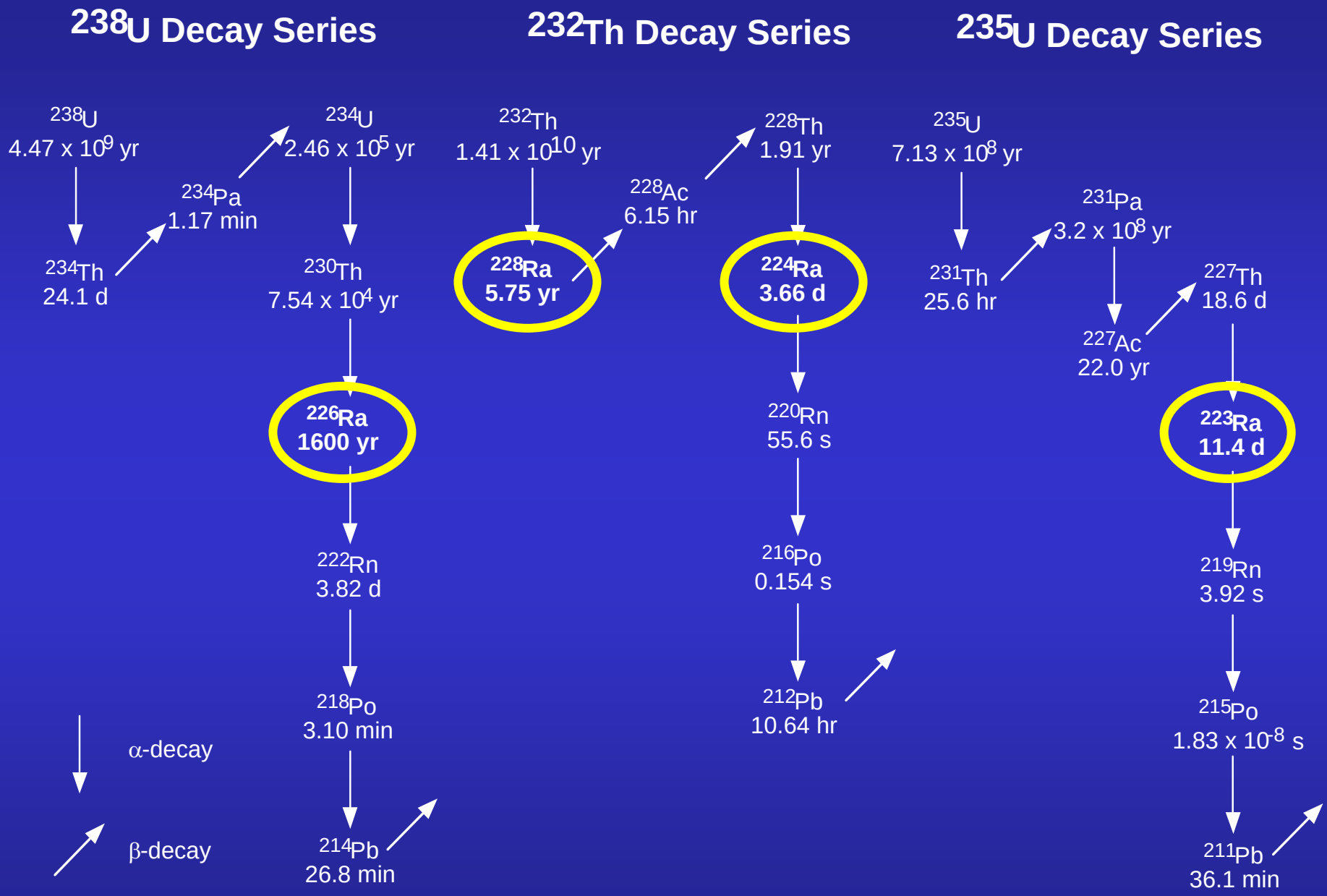
222-Rn & 226-Ra vs Salinity in Ches. Bay



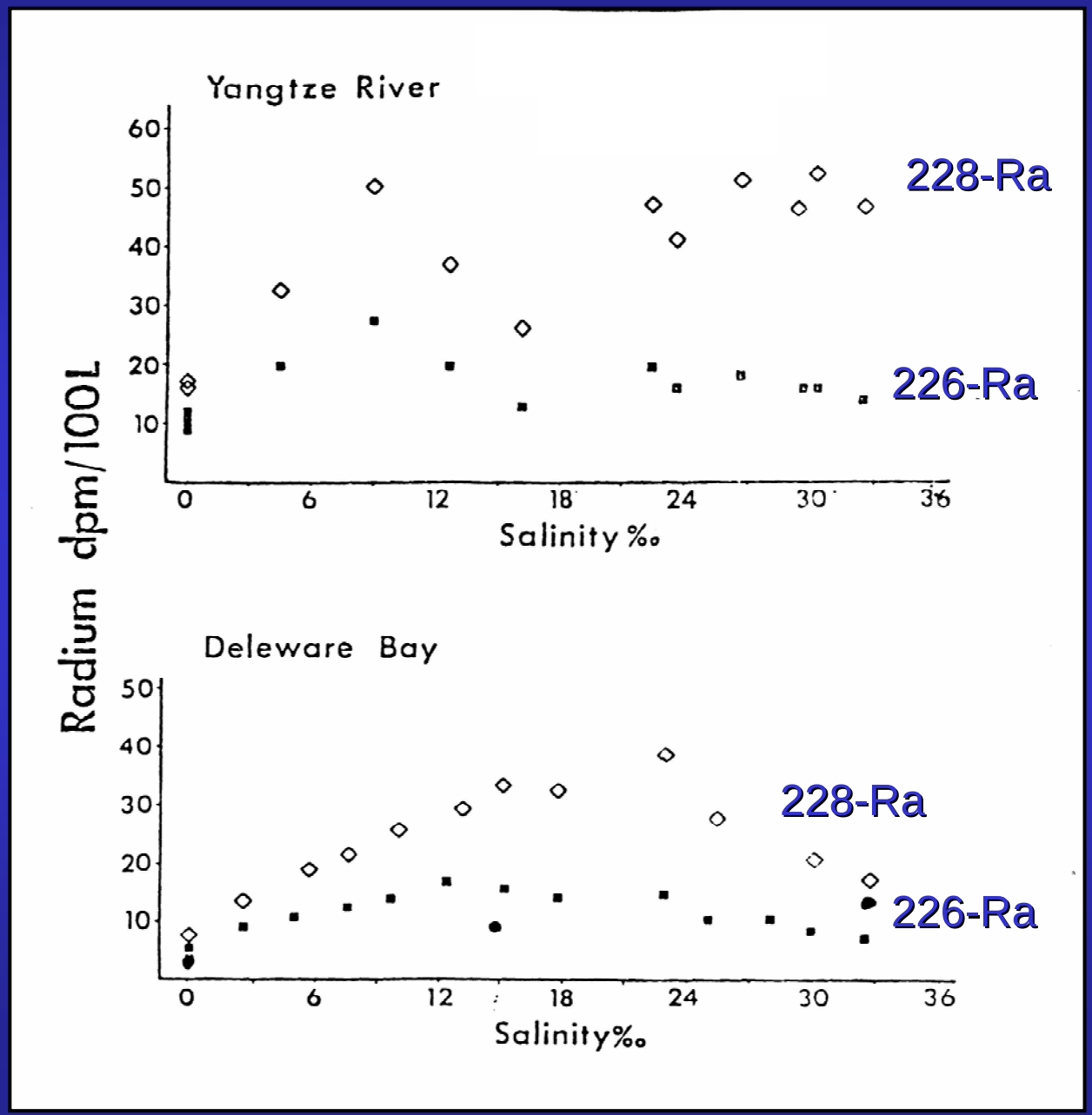
Excess 222-Rn SGD profile in De Bay



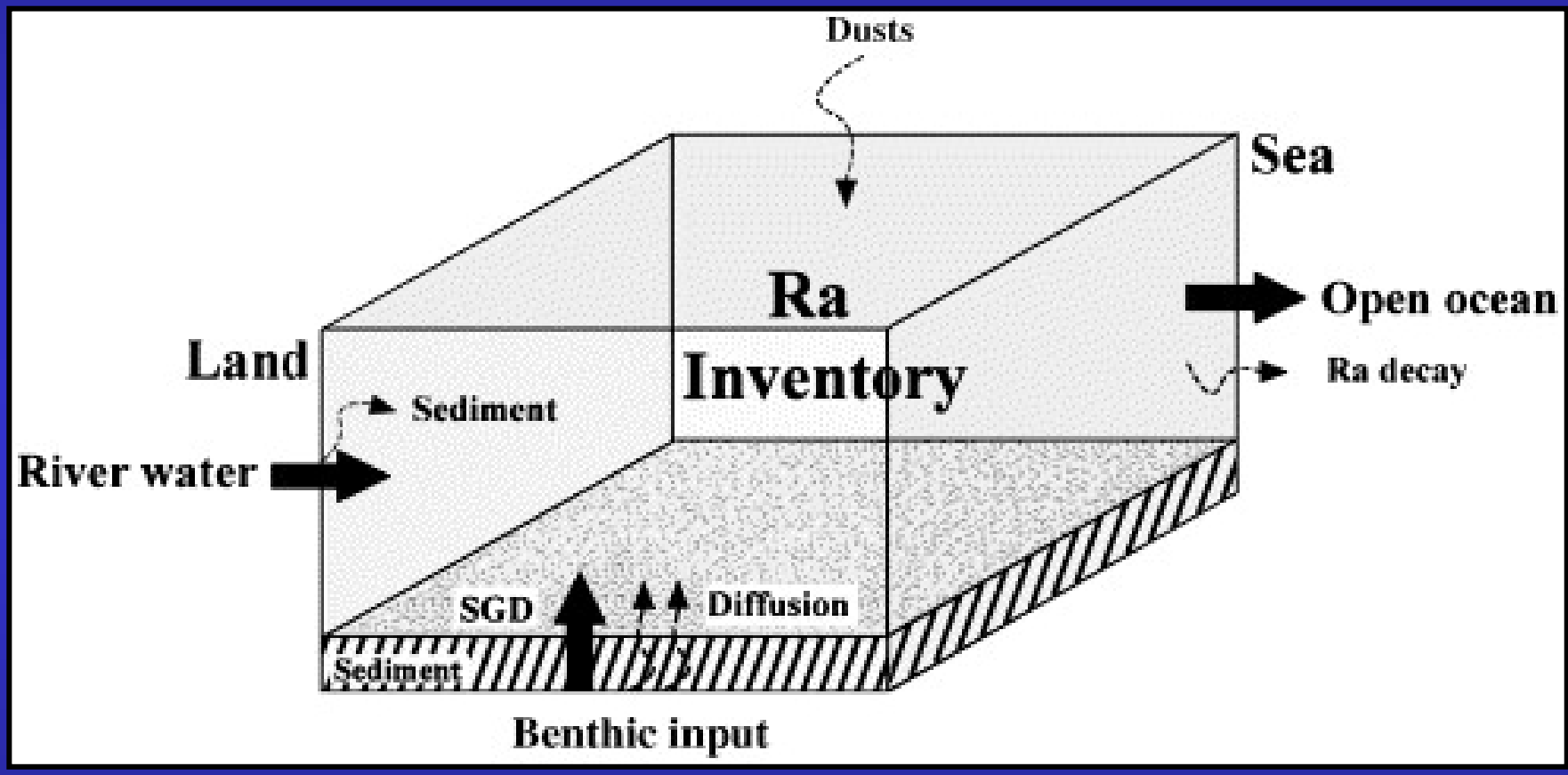
Schwartz, et al. 1999


238U Decay Series
238U
4.47 x 10^9 yr
234Pa
1.17 min
234U
2.46 x 10^5 yr
234Th
24.1 d
230Th
7.54 x 10^4 yr
226Ra
1600 yr
222Rn
3.82 d
218Po
3.10 min
214Pb
26.8 min
α-decay
β-decay
232Th Decay Series
232Th
1.41 x 10^10 yr
228Ac
6.15 hr
228Th
1.91 yr
228Ra
5.75 yr
224Ra
3.66 d
220Rn
55.6 s
216Po
0.154 s
212Pb
10.64 hr
235U Decay Series
235U
7.13 x 10^8 yr
231Pa
3.2 x 10^8 yr
231Th
25.6 hr
227Ac
22.0 yr
227Th
18.6 d
223Ra
11.4 d
219Rn
3.92 s
215Po
1.83 x 10^-8 s
211Pb
36.1 min

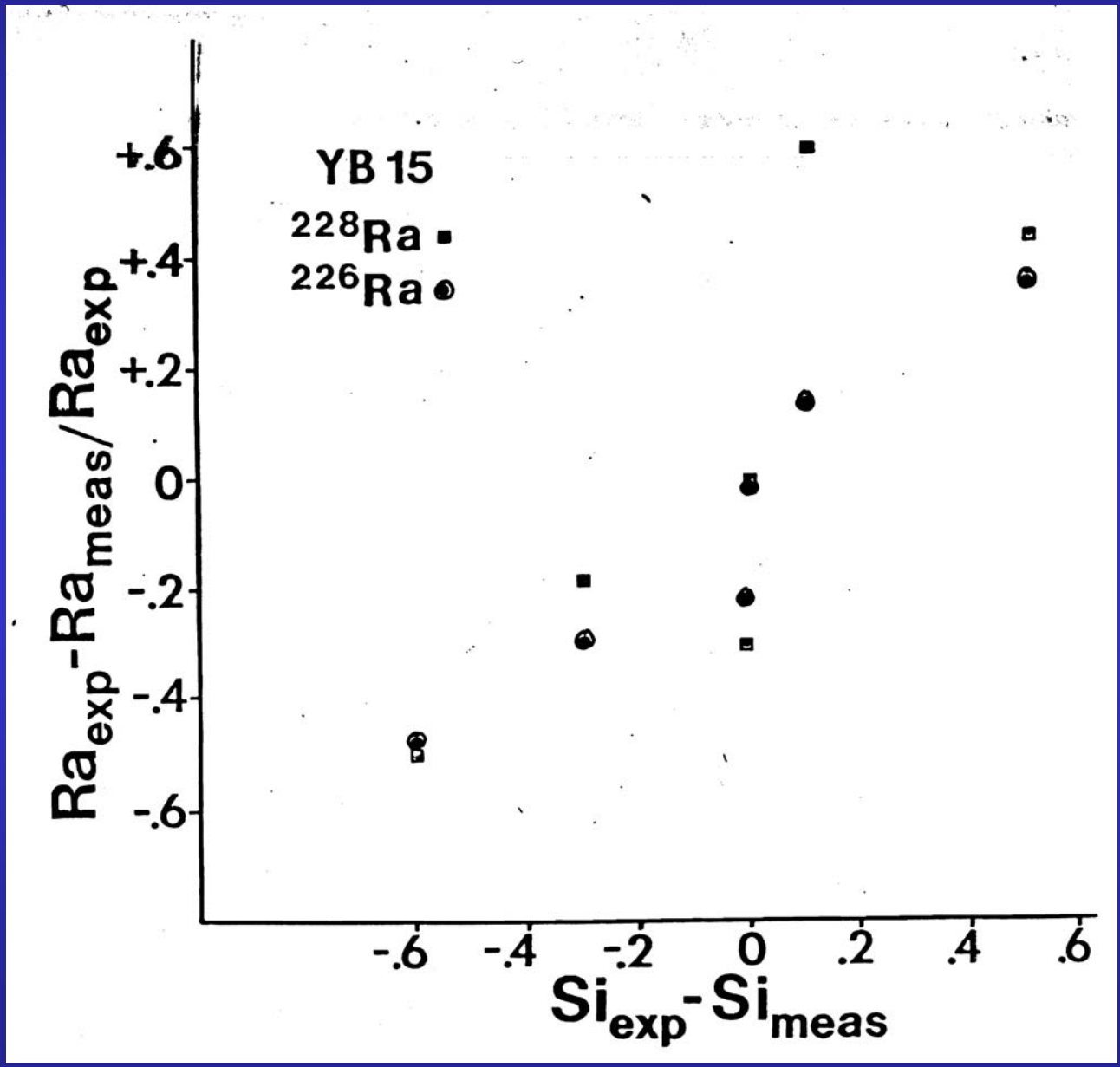
Ra (226&228) desorption & sediment inputs



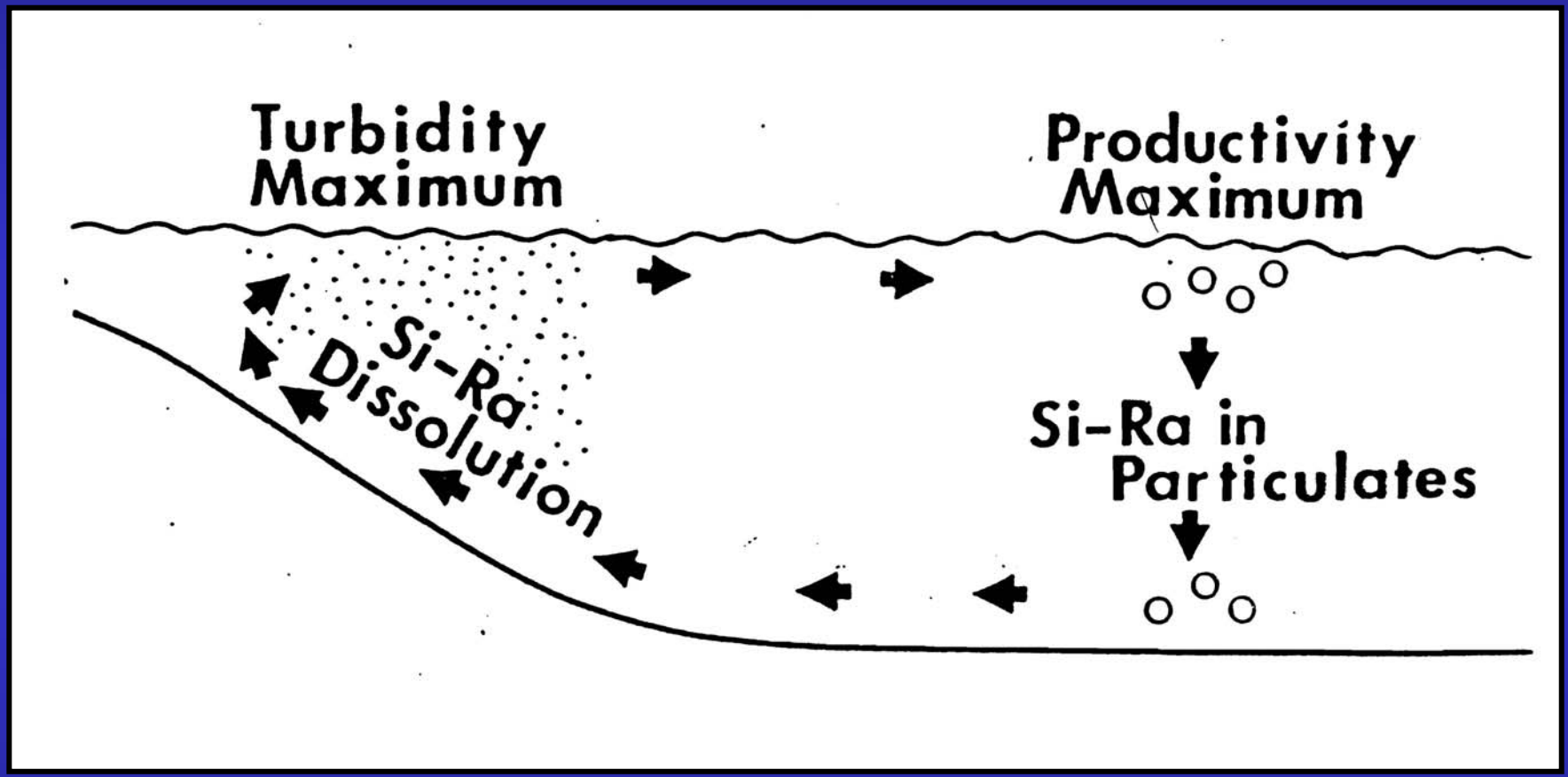
Radium (228-224) estuarine box model



Radium (226-228) in Si cycle of De Bay



Coupled Ra and Si cycles in De Bay



U-Th Quantitative model: Sources, sinks and radioactive decay

Sources

- Riverine input
- Desorption from suspended particles
- Ocean input
- Groundwater input and diffusion from sediments

Sinks

- Tidal flushing
- Radioactive decay
- Porewater burial
- Biological uptake

Conclusions

U-Th Processes in Estuaries

- U-Th series reveal sources and fate of chemical and biological substances in estuaries
- Radionuclide (U, Th, Ra, Rn, Pb, Po) tracers are useful for studying particulate scavenging and water residence times in estuaries.
- Development of isotopic tracer observations into useful models to be refined at GEOTRACES coastal/estuarine interface