TIDAL MARSHES IN THE DELAWARE ESTUARY:

HISTORICAL RECONSTRUCTION OF CHEMICAL LOADINGS

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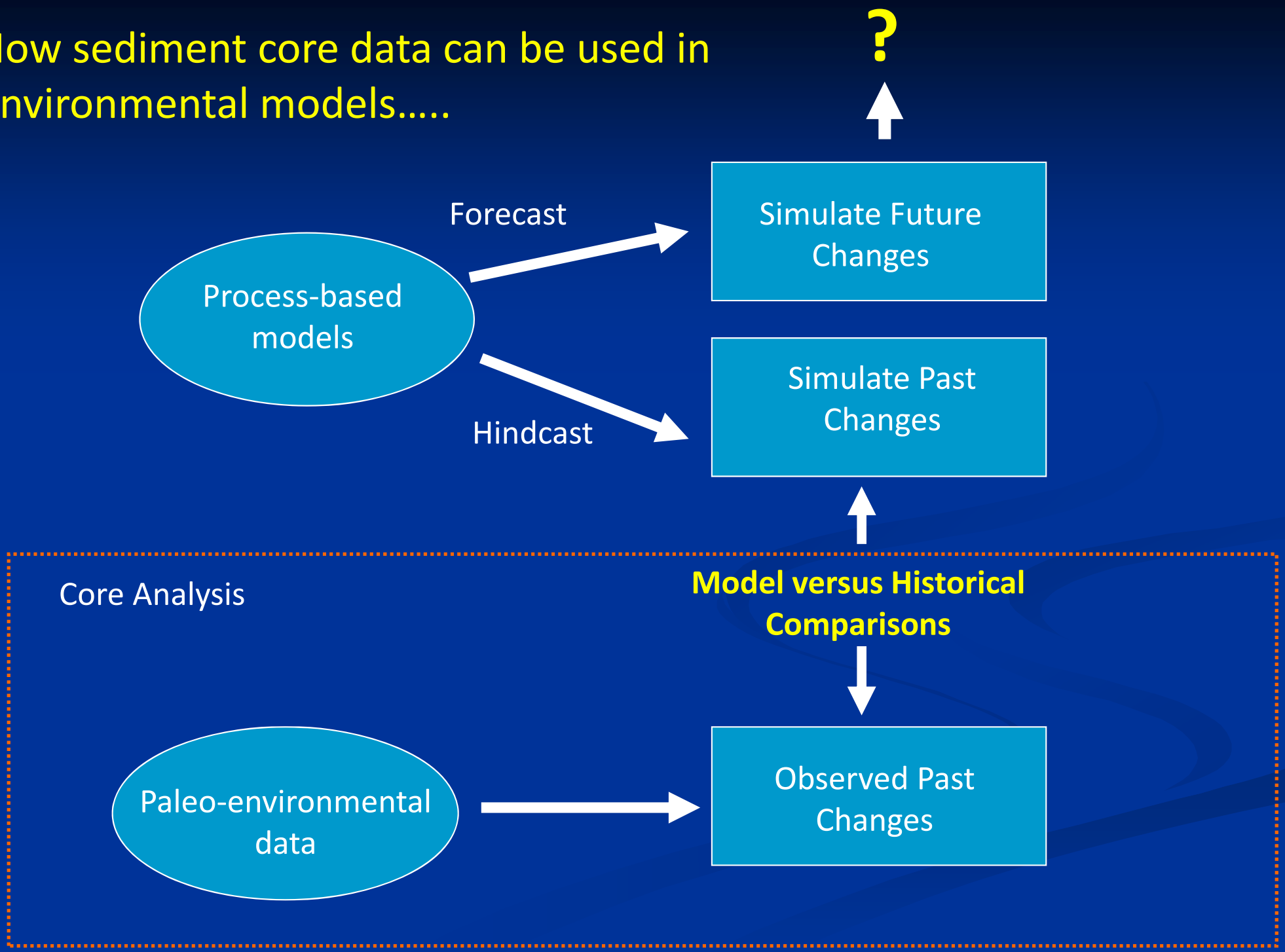
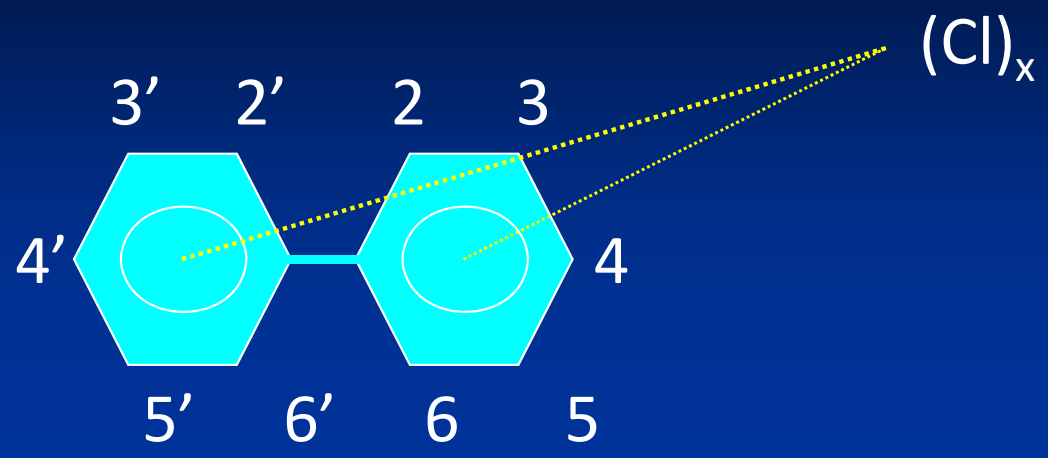
Sediments are an ecosystem's memory!!

Sediments collect and integrate global, regional and local environmental signals of ecosystem change.

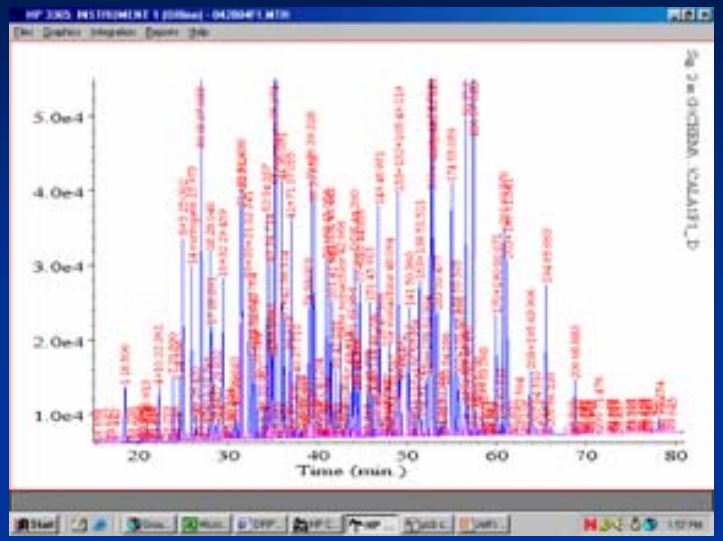
How sediment core data can be used in environmental models.....



Polychlorinated Biphenyls (PCBs)



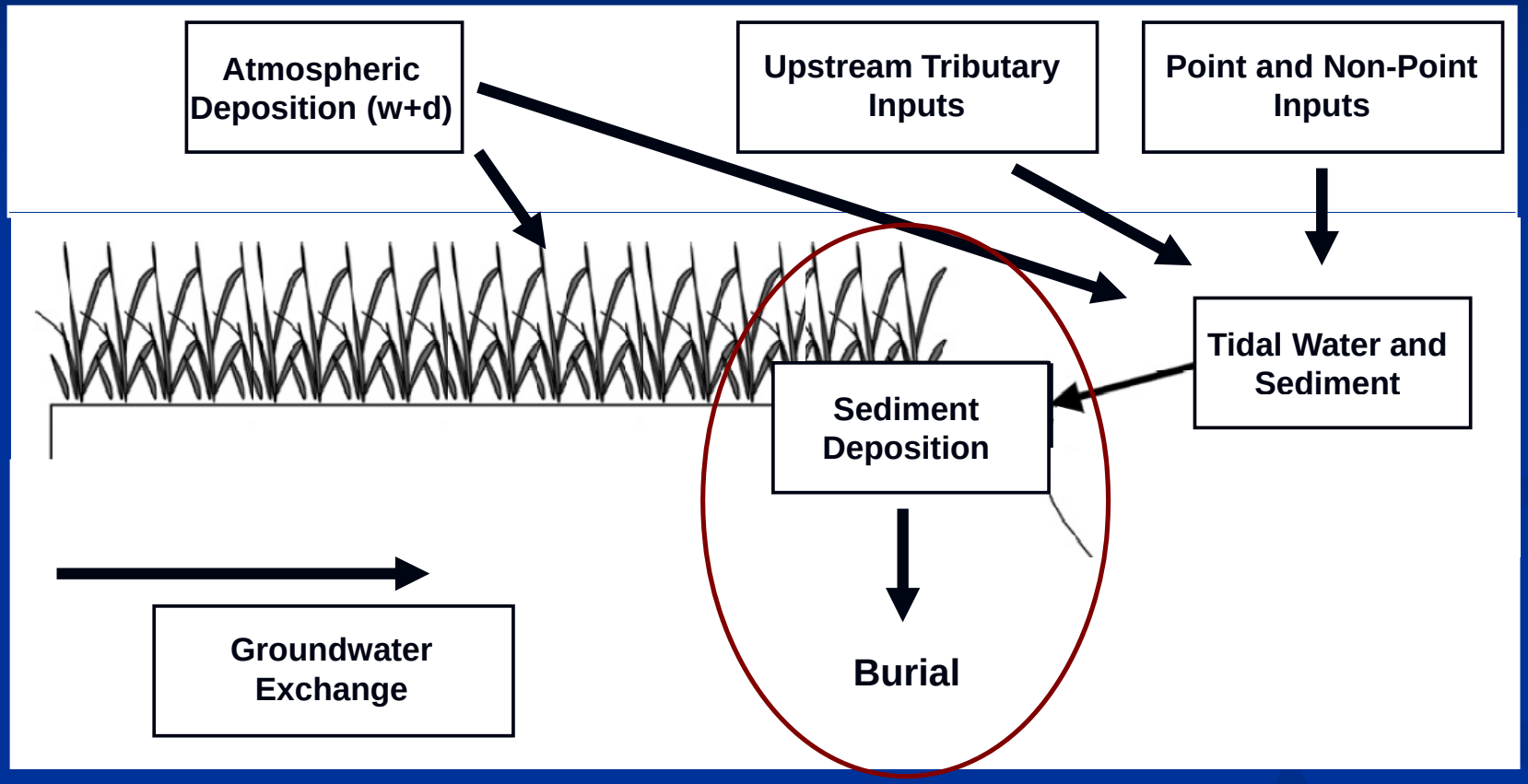
209 possible structures (congeners)



PCBs:

- coolants/insulating fluids in transformers & capacitors
- lubricants, hydraulic fluids
- ingredients in paints, varnishes, inks & pesticides
- PCBs first produced in the late1920s
- PCBs phased ban starting in the late 1970s

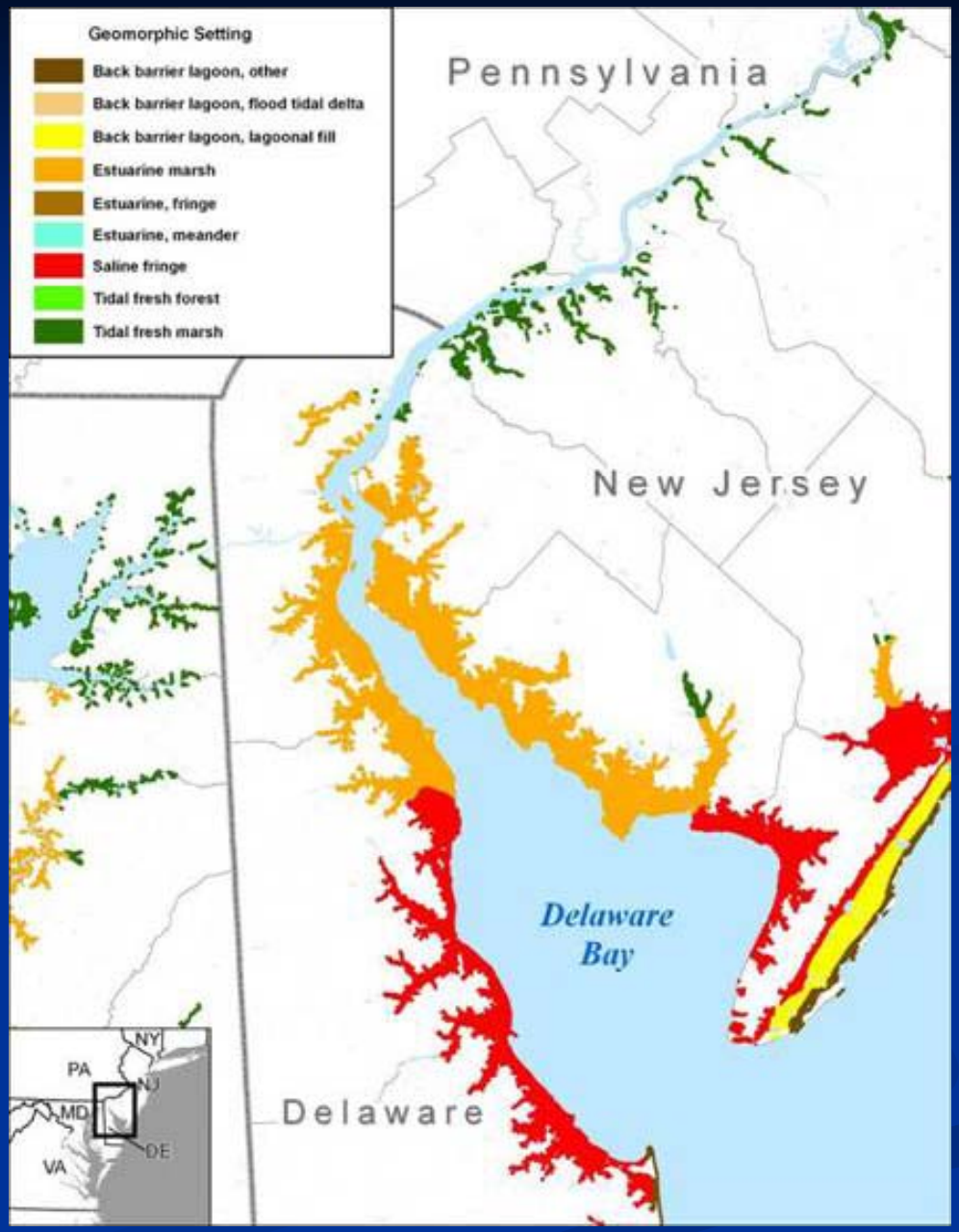
Conceptual Model of PCB Loadings to a Tidal Marsh



Project Objectives

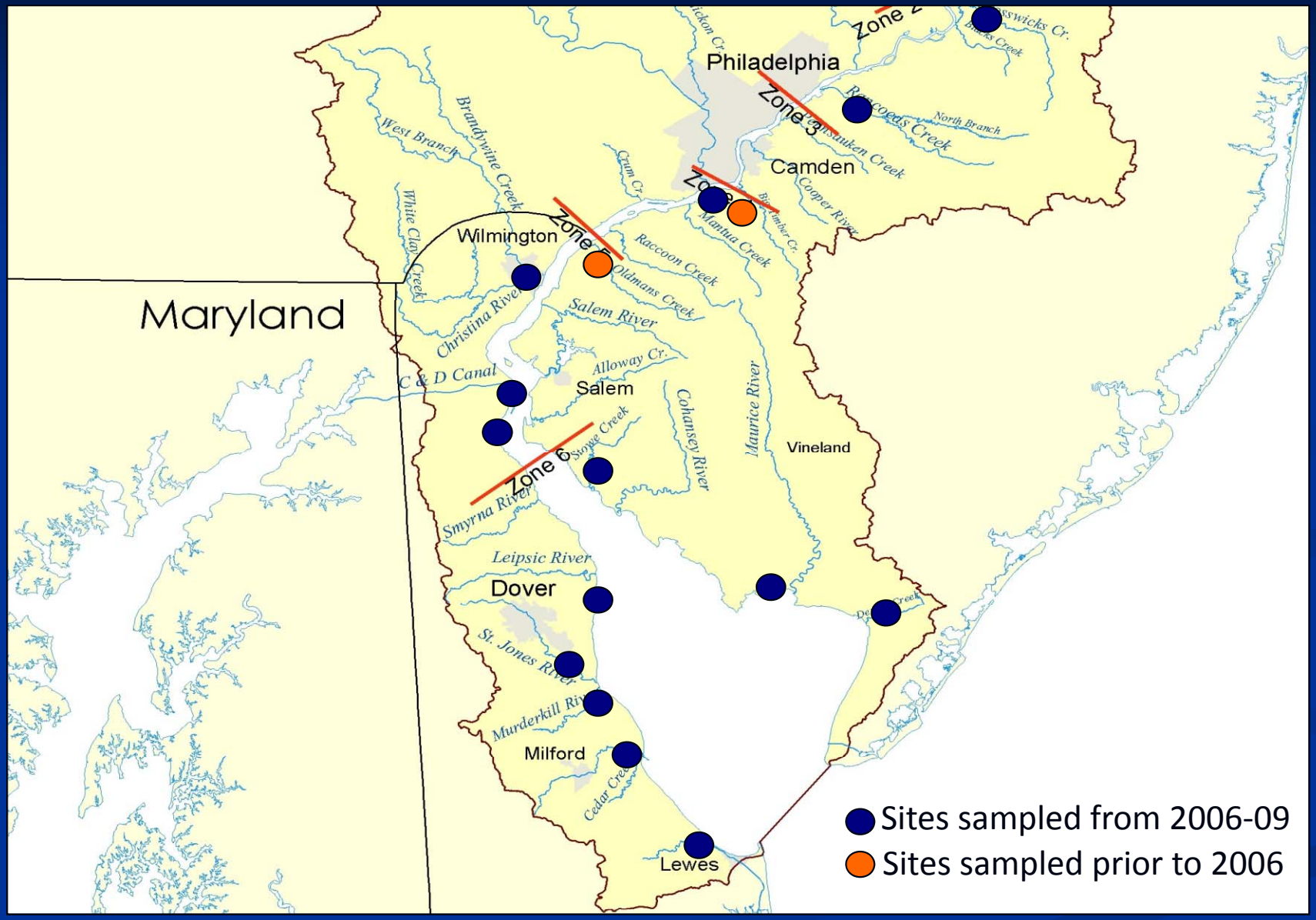
- Collect sediment cores along a salinity gradient, from tidal fresh to tidal salt marshes, within the Delaware Estuary
- Determine sediment accumulation rates using ^{210}Pb and ^{137}Cs geochronology & develop sediment-age models
- Analyze sediments for C, N, P, chemical contaminants and indicators of ecological change (diatoms, stable isotopes, etc)
- Reconstruct history of ecological changes and contaminant loading and compare to environmental management practices over time

Delaware Estuary Wetlands



D. Kreeger, E. Strange and J.G. Titus 2008. Draft Report on Climate Change and Impacts to Delaware Estuary.

Delaware Estuary Sediment Core Sites



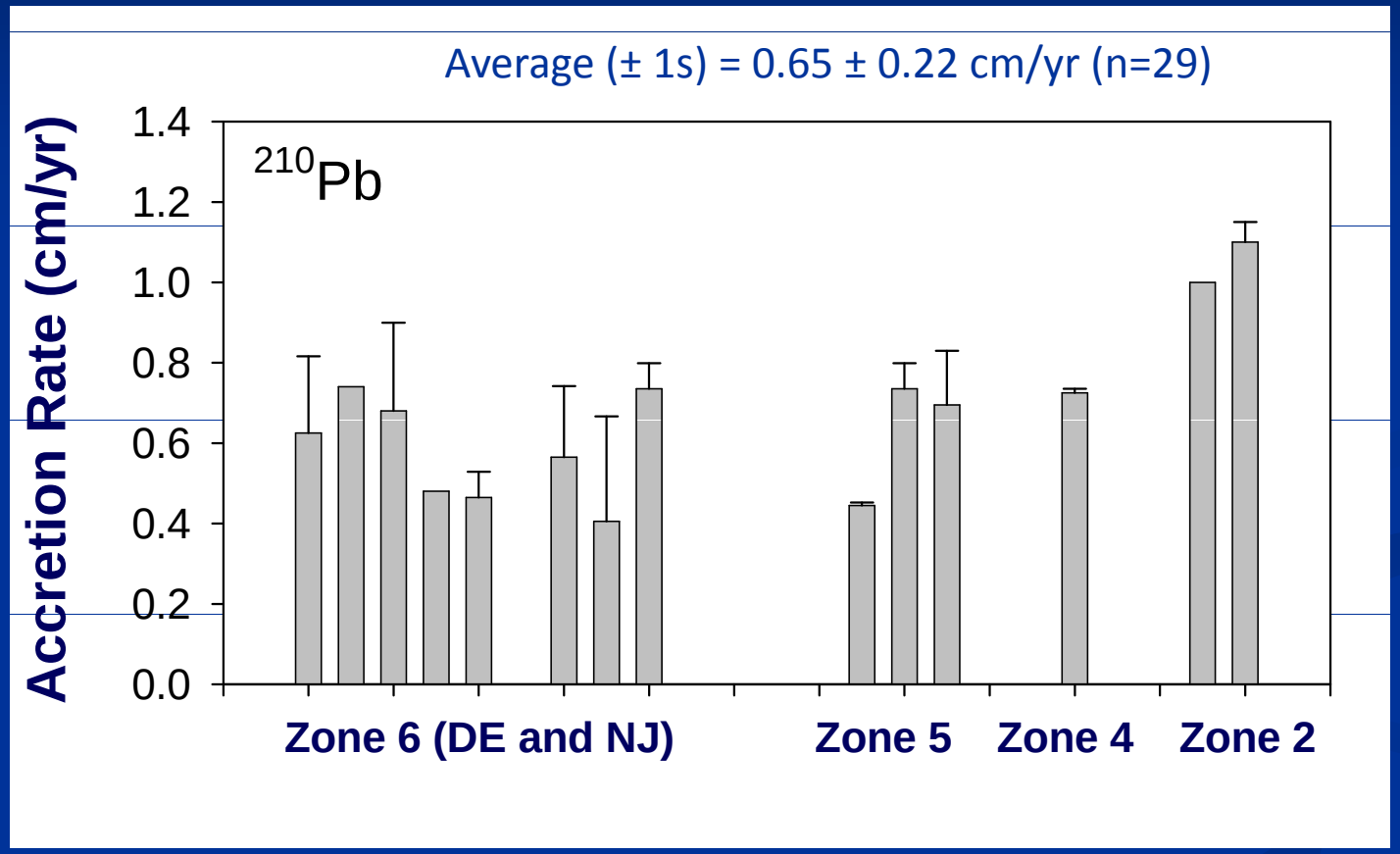
Three cores were collected at each site in mid-marsh areas.

MK-1A
10/24/08
TOP
SWANSON

Analytical Parameters

- Sediment cores were analyzed for:
  - Organic Carbon, total Nitrogen and total Phosphorus (chemical forms)
  - Polychlorinated Biphenyl (PCB, ca. 110 congener specific cmpds)
  - Polycyclic Aromatic Hydrocarbons (PAH, ca. 39 parent cmpds)
  - Organo-Chlorine Pesticides (ca. 17 cmpds like DDT and Chlordane)
  - Diatom Species Composition
  - Stable Isotopes of Carbon ($d^{13}C$) and Nitrogen ($d^{15}N$)
  - Grain size (< 63 mm; clay+silt)
  - Radioactive Isotopes: ^{210}Pb and ^{137}Cs

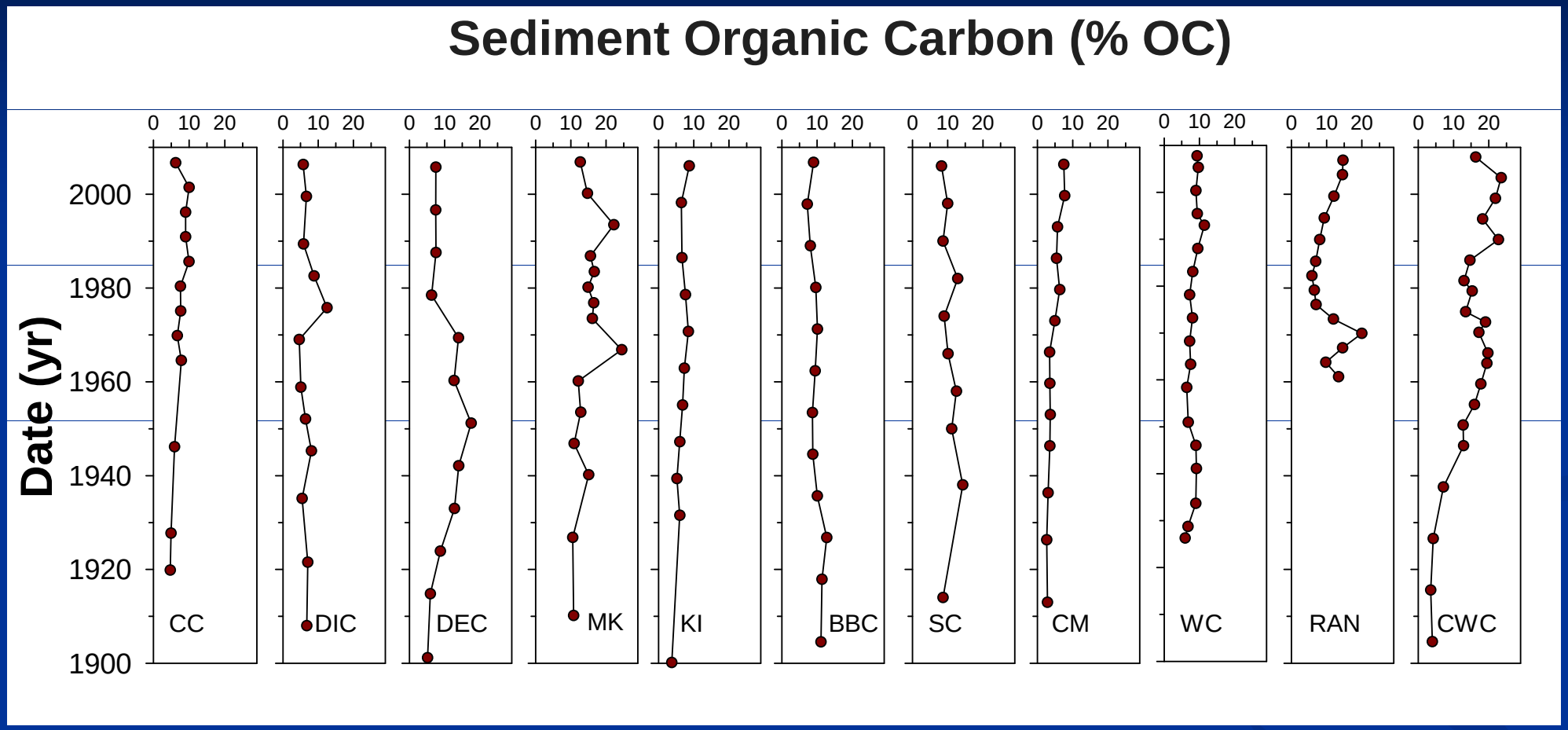
Sediment Accretion Rates



Lower Bay → Upper Bay

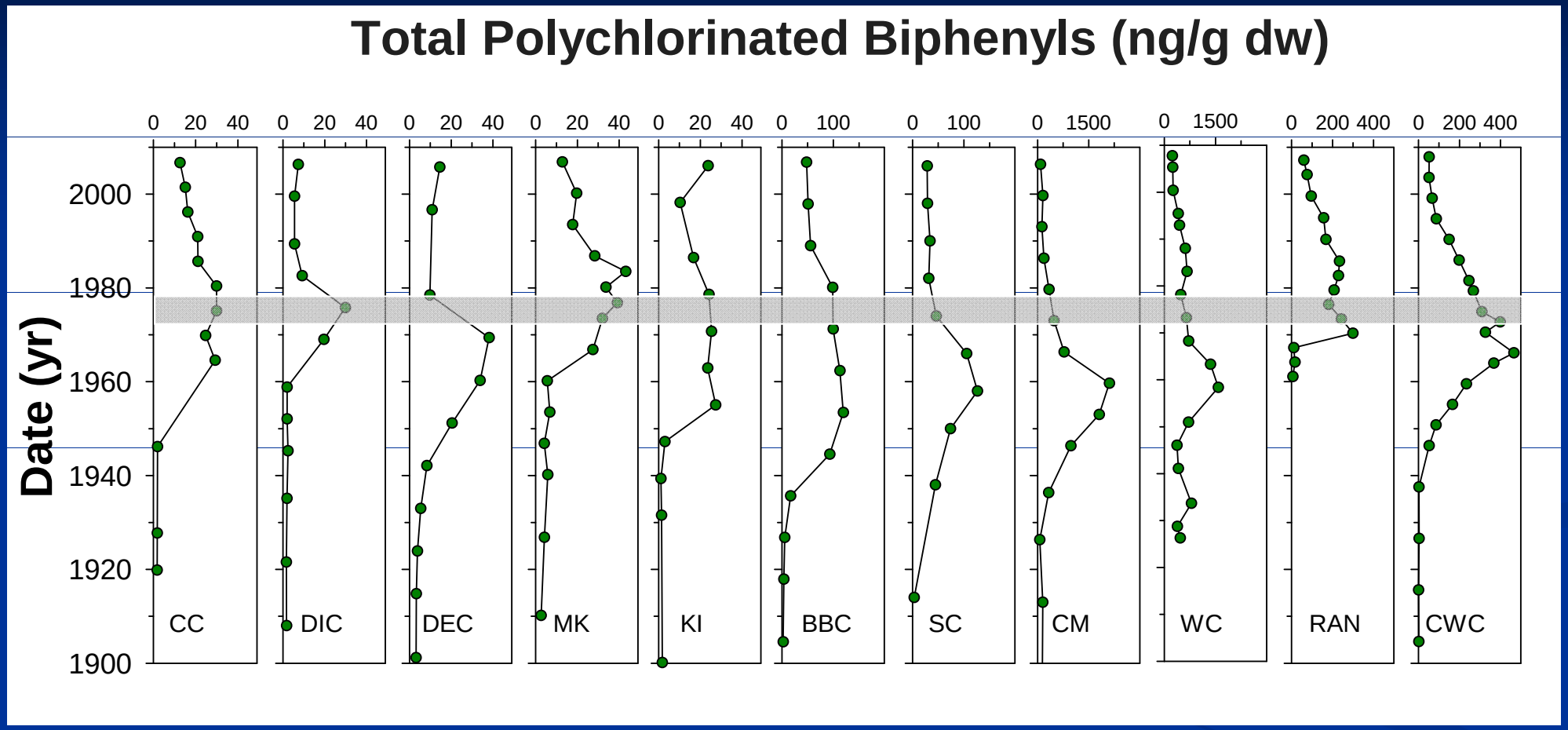
Averages of multiple cores taken from one marsh system

Organic Carbon in Marshes



Lower Delaware Bay → Upper Delaware Bay

Total PCBs in Delaware Estuary Marshes

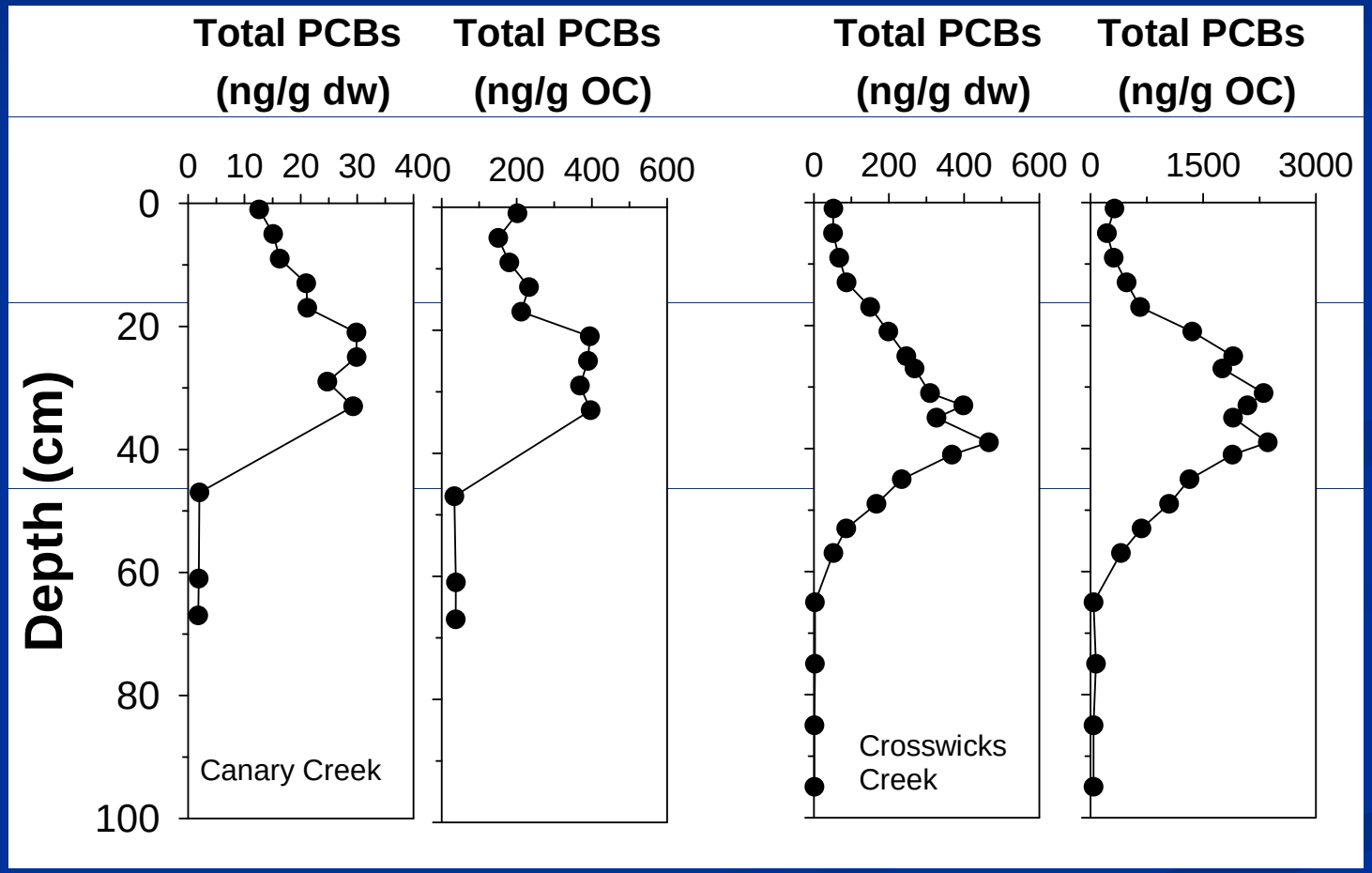


Lower Delaware Bay → Upper Delaware Bay

- PCBs first produced in 1920s
- PCBs phased ban in late 1970s

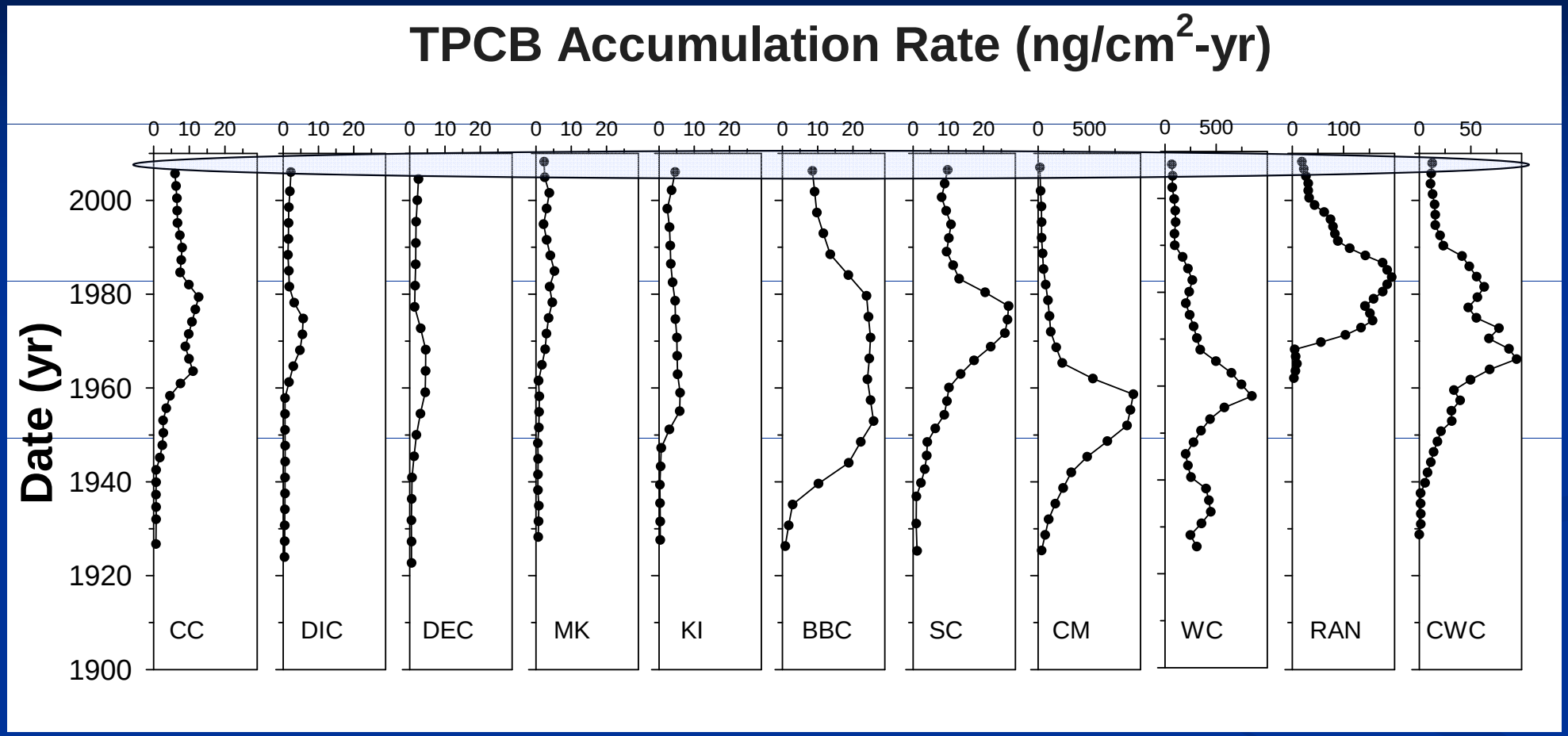
Was Organic Carbon Controlling Distribution of TPCBs?

- Organic carbon is a major carrier/sorbent for organic compounds of high K_{ow}
- Increases or decreases of organic carbon can alter the observed concentration gradient of total PCBs (i.e., is it a source distribution or related to OC gradients?)



PCB distribution in all cores reflects source changes over time

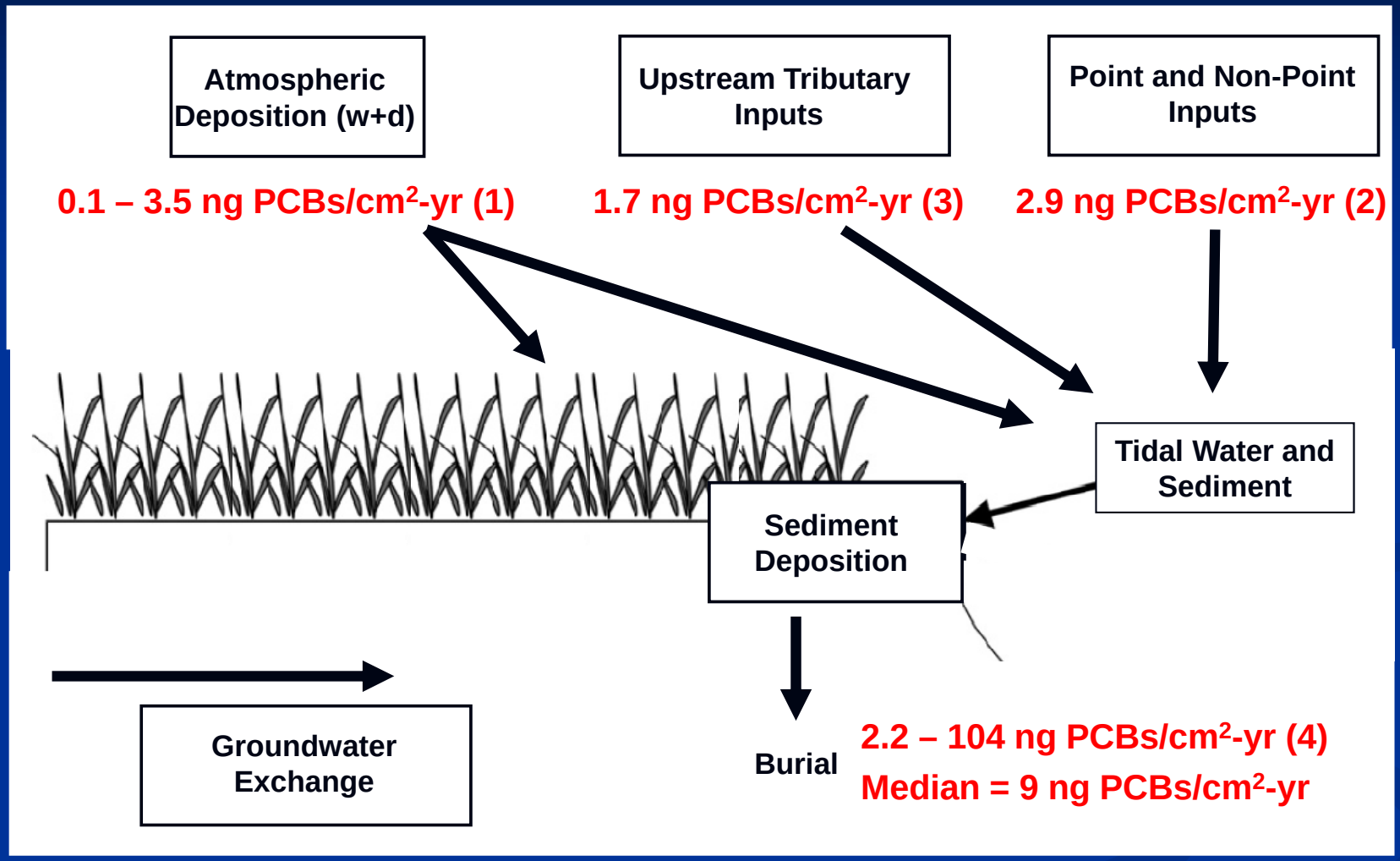
Total PCBs in Delaware Estuary Marshes



Lower Delaware Bay → Upper Delaware Bay

- **Present day rates = 2.2 to 104 ng PCB/cm^2-yr (median = 9.2 ng PCB/cm^2-yr)**

Conceptual Model of Chemical Loadings to a Tidal Marsh

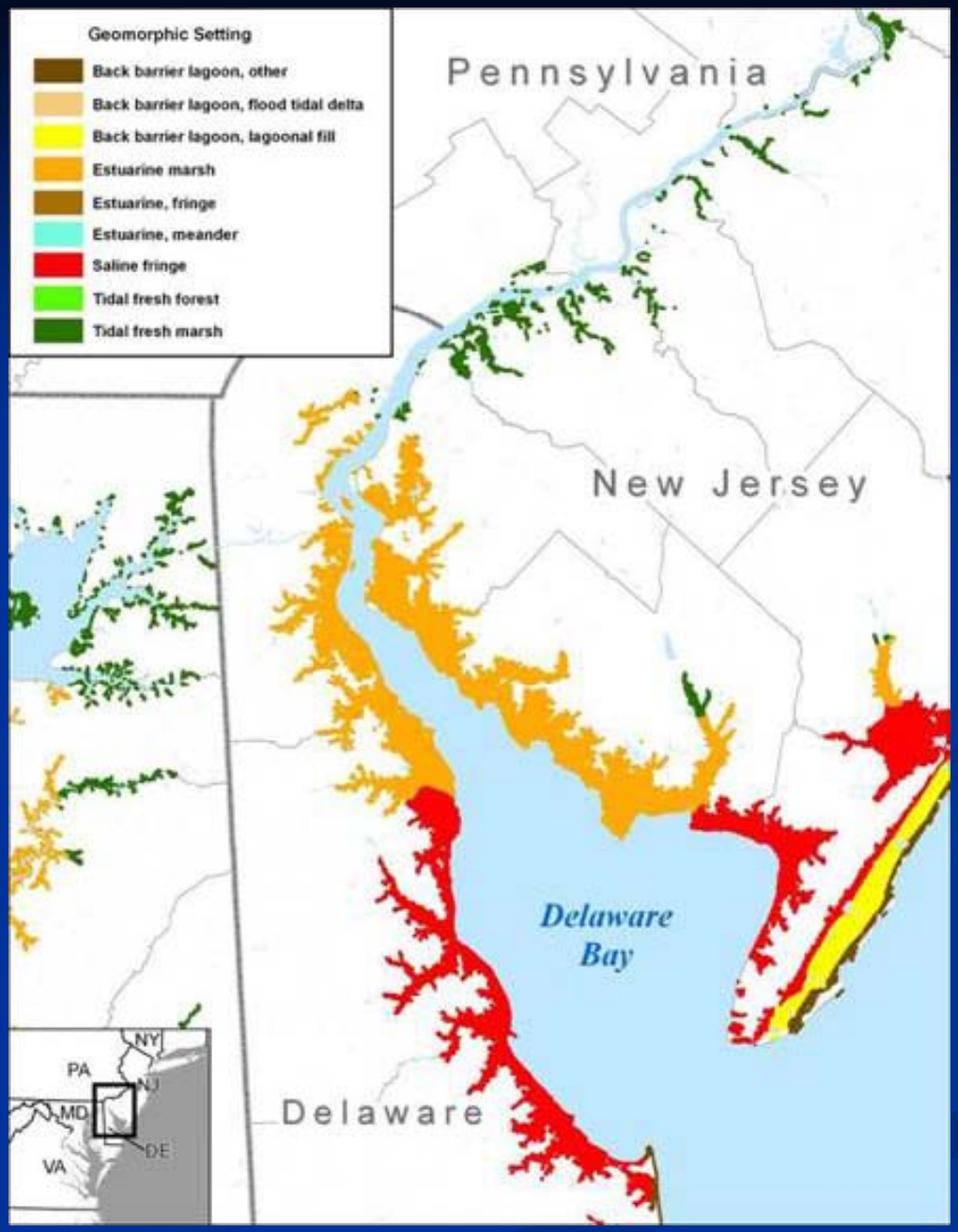


(1) - Totten et al. 2006 EST and DRBC
(2) - DRBC: Point/Non-Point direct to bay
(3) - DRBC: Tributary Loads to bay
(4) - This Study (current rates)

Being a little more specific:

- Using wetland zonation based on Kreeger, Titus (2008)
- Wetland areas from Sommerfield (unpublished data)
- PCB accumulation rates from current study

Calculate PCB accumulation in tidal marshes of Delaware Bay (in kg/yr)



Wetland types based on Kreeger, Titus (2008) and areas from Sommerfield (unpublished estimates)

PCB accumulation in tidal marshes of Delaware Bay

		Present Day Sediment Accumulation ng PCB/cm^2-yr			Total PCB Flux kg/yr		
Marsh Type	Area (km^2)	Low	High	Average	Low	High	Average
Tidal Freshwater Wetlands	73.5	12.6	104	38.1	9.3	76.4	28.0
Estuarine Marsh	469.5	4.6	9.8	7.6	21.6	46.0	35.7
Saline Fringe	268.8	2.2	6.0	3.3	5.9	16.1	8.9
Total	811.8				36.8	138.6	72.6

Current Estimate of total PCB loads to Delaware Bay = 93 kg/yr

Tidal marshes can account for ~ 80% (on average) of the total load

Wetland types based on Kreeger, Titus (2008) and areas from Sommerfield (unpublished estimates)

Summary

Sediment cores are powerful tools in evaluating long-term changes in pollution sources and ecosystem function.

- Have pollution controls for PCBs been successful?

  - Pollution controls have lowered levels of PCBs in the river over the past 40-50 years.

- How important are tidal wetlands in chemical controls in the Bay?

  - Tidal wetlands have the potential to sequester and bury approximately ¾ of the total external load of PCBs to the estuary.

Thank you

Acknowledgements

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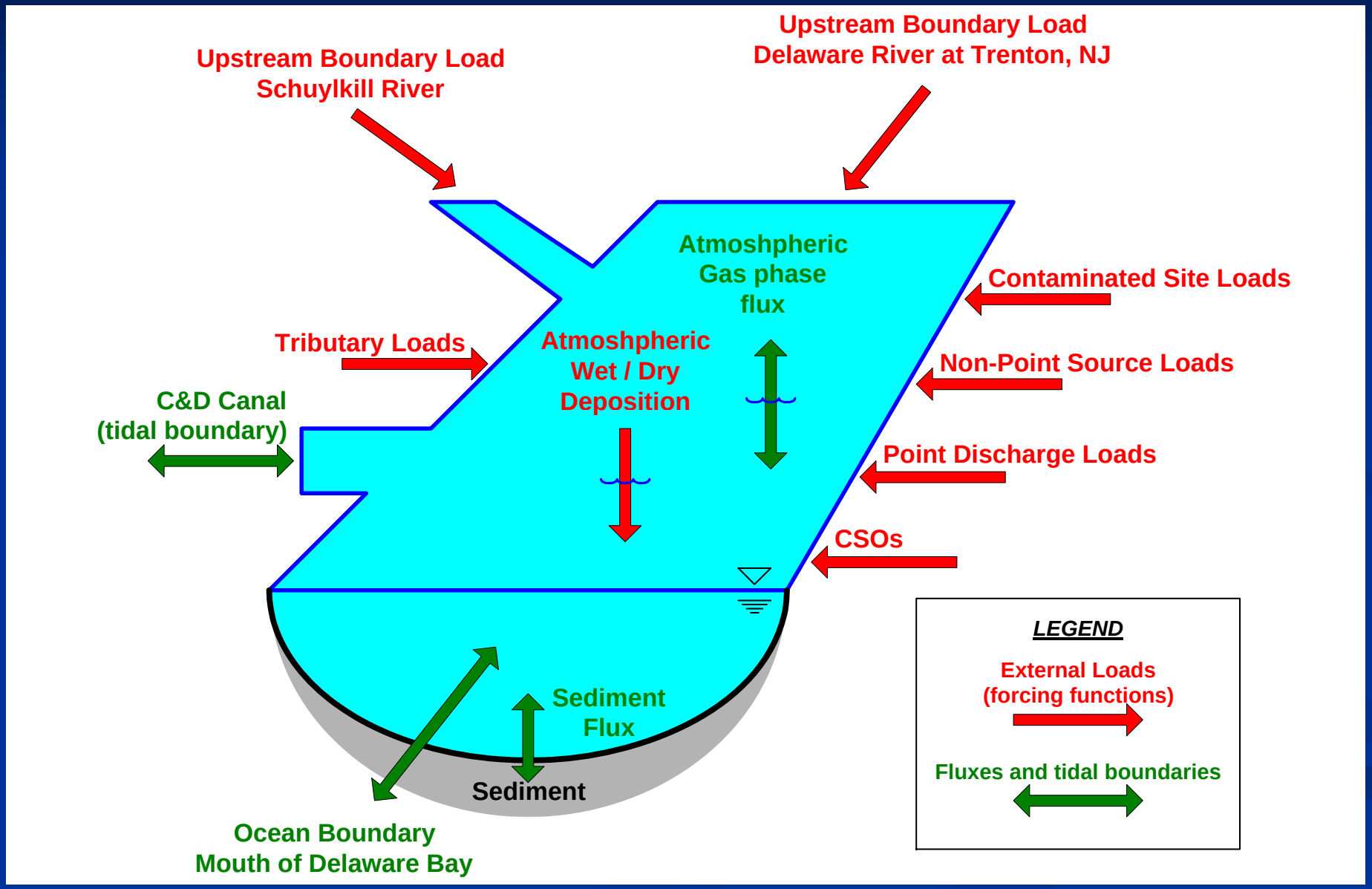
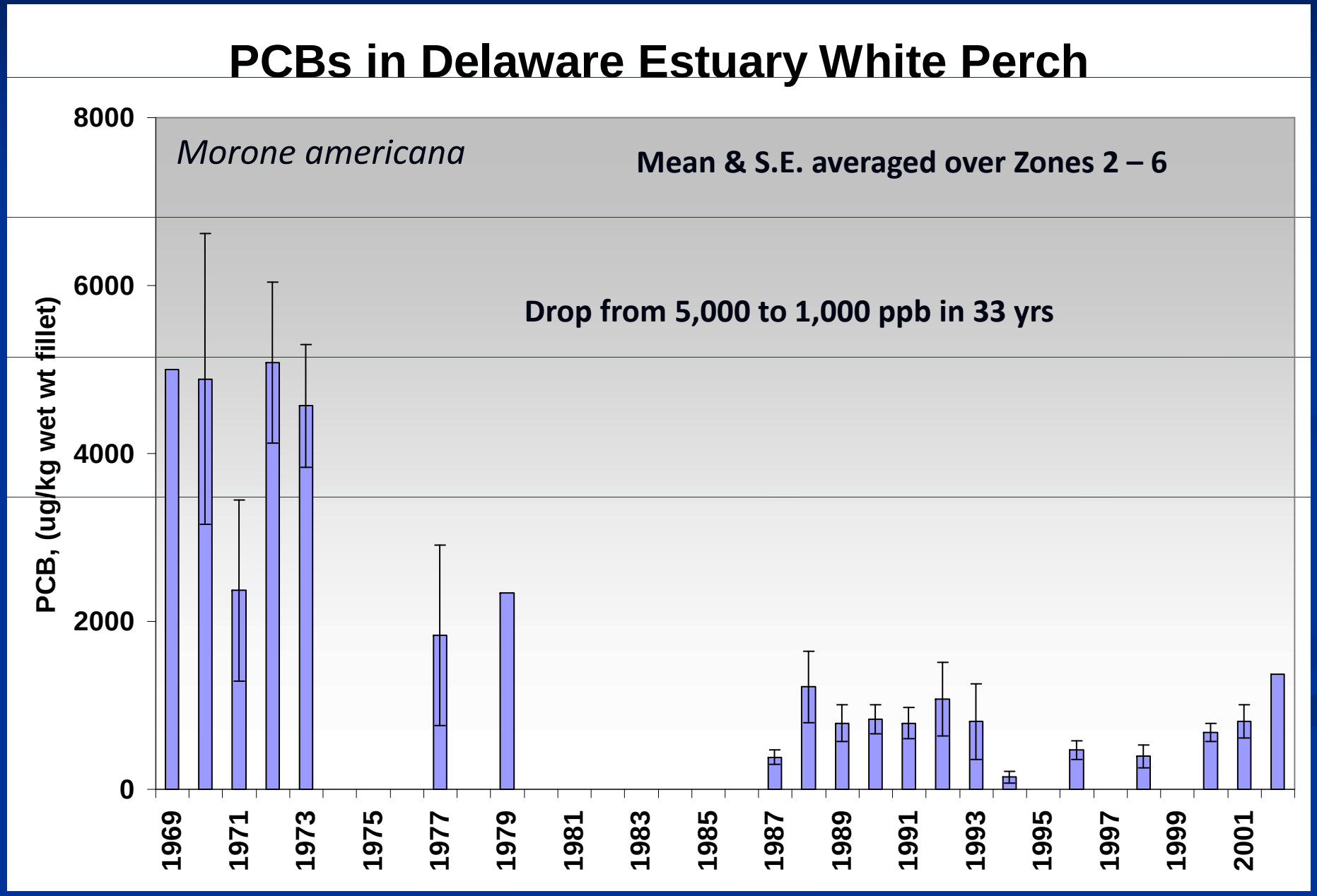
- Roger Thomas, Susanne Moskalski, Paul Kiry, Amy Farrell, Olivia Gibb, Mike Schafer, Linda Zaoudeh, Dack Stuart and others for laboratory and field assistance.

Principal Mass Loadings and Fluxes



Slide courtesy of R. Greene

Contaminants: Is the reduction in PCBs in the Estuary reflected in fish tissue concentrations?