EPA United States Environmental Protection Agency

The New Bedford Harbor Superfund Site Long-Term Monitoring Program

William G. Nelson, Barbara J. Bergen
NHEERL, Atlantic Ecology Division, Narragansett, RI 02882

Presentation Overview

- Informal – *Please ask questions when you have them!*
- Background
- Site Characteristics
- Sampling Design
- Selected Results:
  - Chemical (PCBs, Copper)
  - Biological (Sediment - Benthic Diversity & Condition, Water Column Mussel PCB Bioaccumulation)
- Present Assessment & Conclusions

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

Background

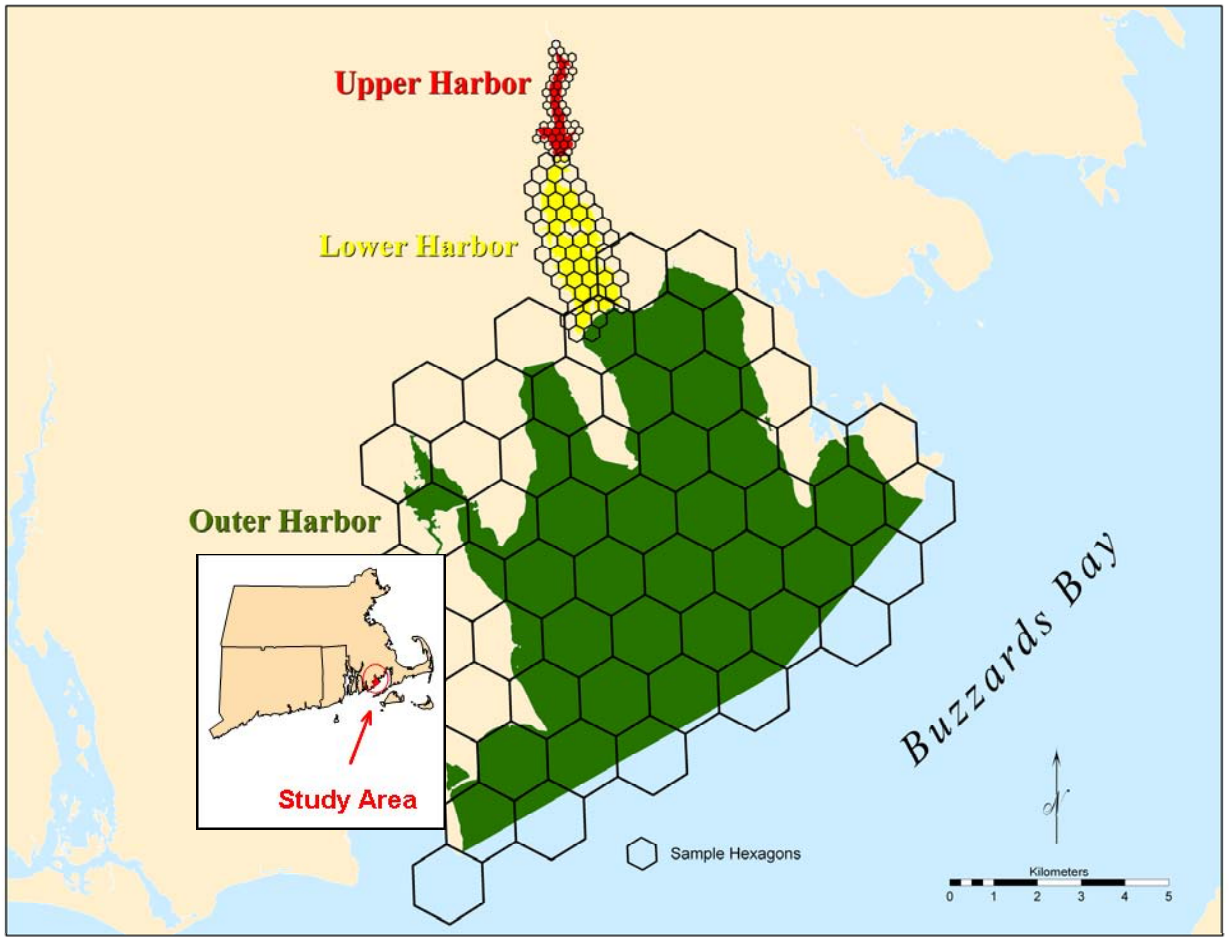
- New Bedford Harbor (NBH) Long-Term Monitoring (LTM) Program designed in 1993 by the Atlantic Ecology Division, Narragansett, RI, in conjunction with EPA Region I, ACE-NED, State of Massachusetts
- Overall Goal: Assess remedial effectiveness by quantifying spatial and temporal chemical and biological changes at the NBH Superfund site.
- Key components for the NBH LTM Program:
  - Link **spatial** and **temporal** changes in sediment endpoints throughout the site (broad coverage) to goals and remedial activities (localized effects)
  - Unbiased sampling design to allow for statistically rigorous analyses
  - Present results in multiple formats; informative to both technical and non-technical users
  - Performance based analytical/testing procedures: 1) consistency over time, 2) adaptable to incorporate new technologies

New Bedford Harbor (NBH) Superfund Site Characteristics

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH Superfund Site Characteristics

- Superfund Site due to high sediment PCB concentrations:
  - Upper Harbor (Red):
    - Almost entire area to be remediated
  - Lower Harbor (Yellow):
    - Depositional areas only
  - Outer Harbor (Green):
    - Isolated areas



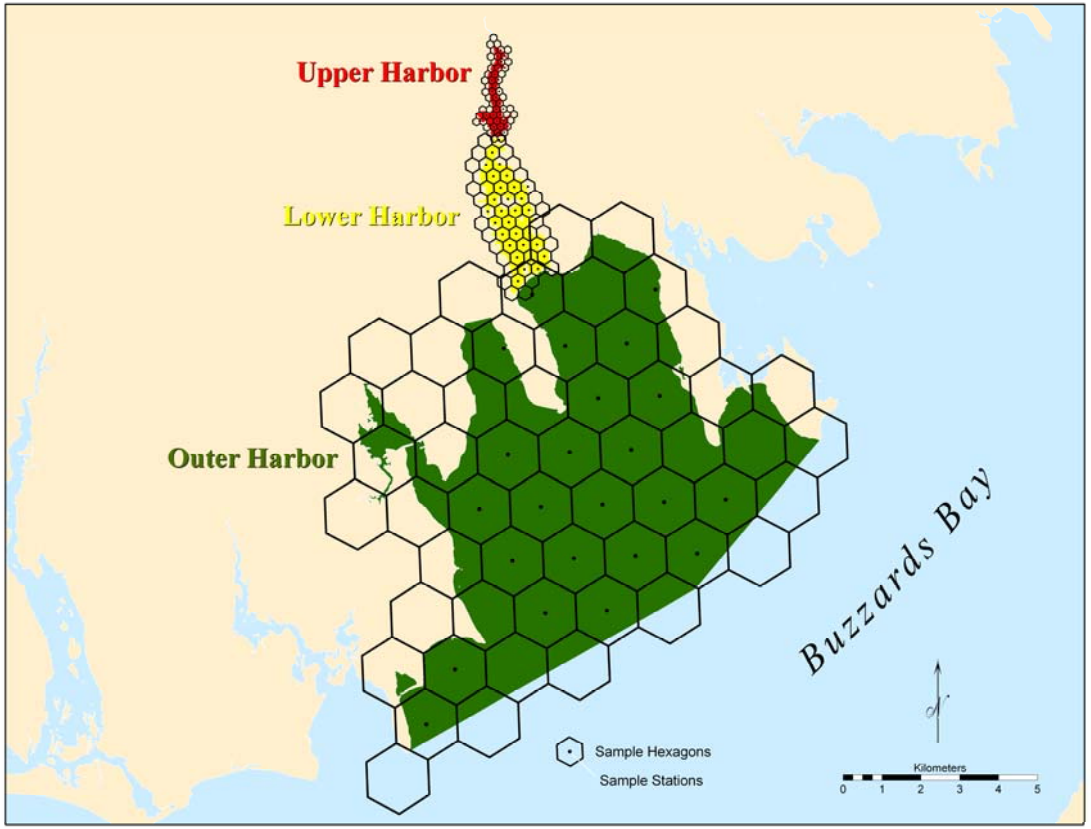
Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH Long-Term Monitoring (LTM) Program: Sampling Design

- Overall Goal: Assess remedial effectiveness by quantifying spatial and temporal chemical and biological changes in the Upper, Lower, and Outer Harbor
- Human Health Endpoints (Beyond the scope of this presentation):
  - Seafood consumption, dermal contact
- Ecological Endpoints:
  - Chemical: PCBs (18 congeners), 8 metals (Cu, Cd, Pb, Cr, Ni, Zn, Hg, Se, As), TOC, AVS
  - Physical: Grain Size, Temperature, Salinity
  - Biological: Sediment toxicity, Benthic community (diversity & condition), Water column PCB bioaccumulation in blue mussels

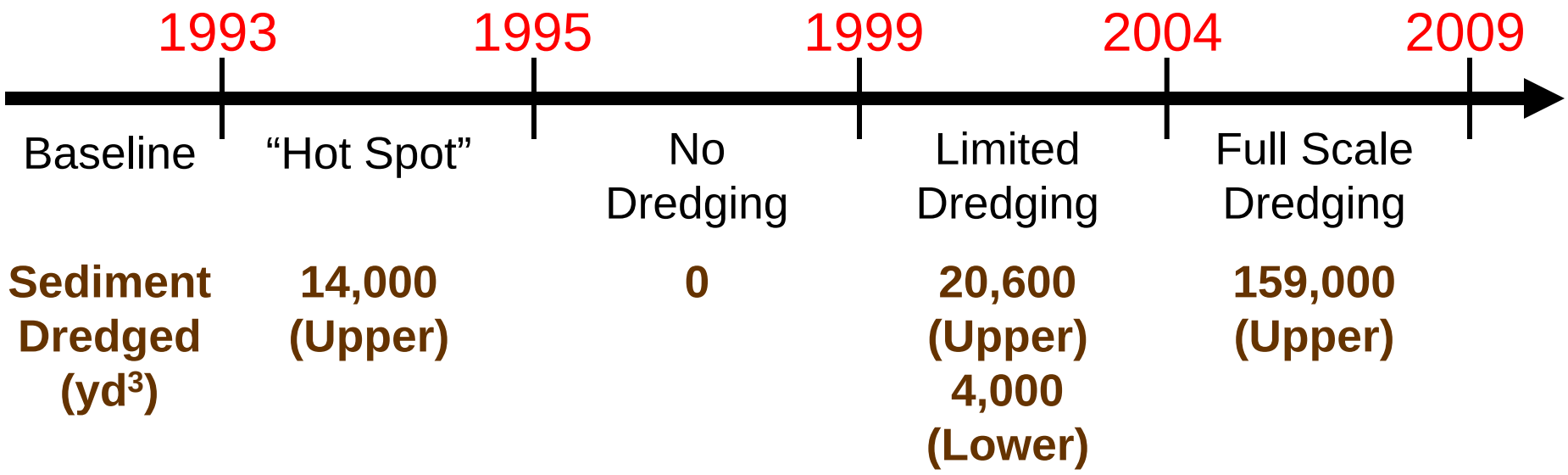
NBH LTM Program: Ecological Sampling Design (cont.)

- Spatial Considerations:
  - Probabilistic design
  - Coverage of entire area (74 stations)
- Temporal Considerations:
  - Before/after each remedial phase (or ~ every 5 years)
- Five collections to date:
  - Baseline -1993
  - Post Hot Spot -1995
  - Pre Upper Harbor remediation -1999
  - Limited dredging – 2004
  - Full scale dredging – 2009



Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

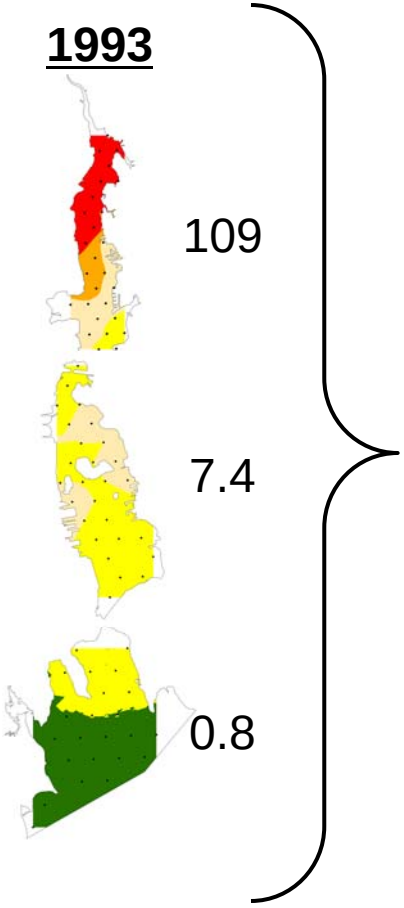
NBH LTM Program: Relationship Between LTM Collections and Remedial Activities

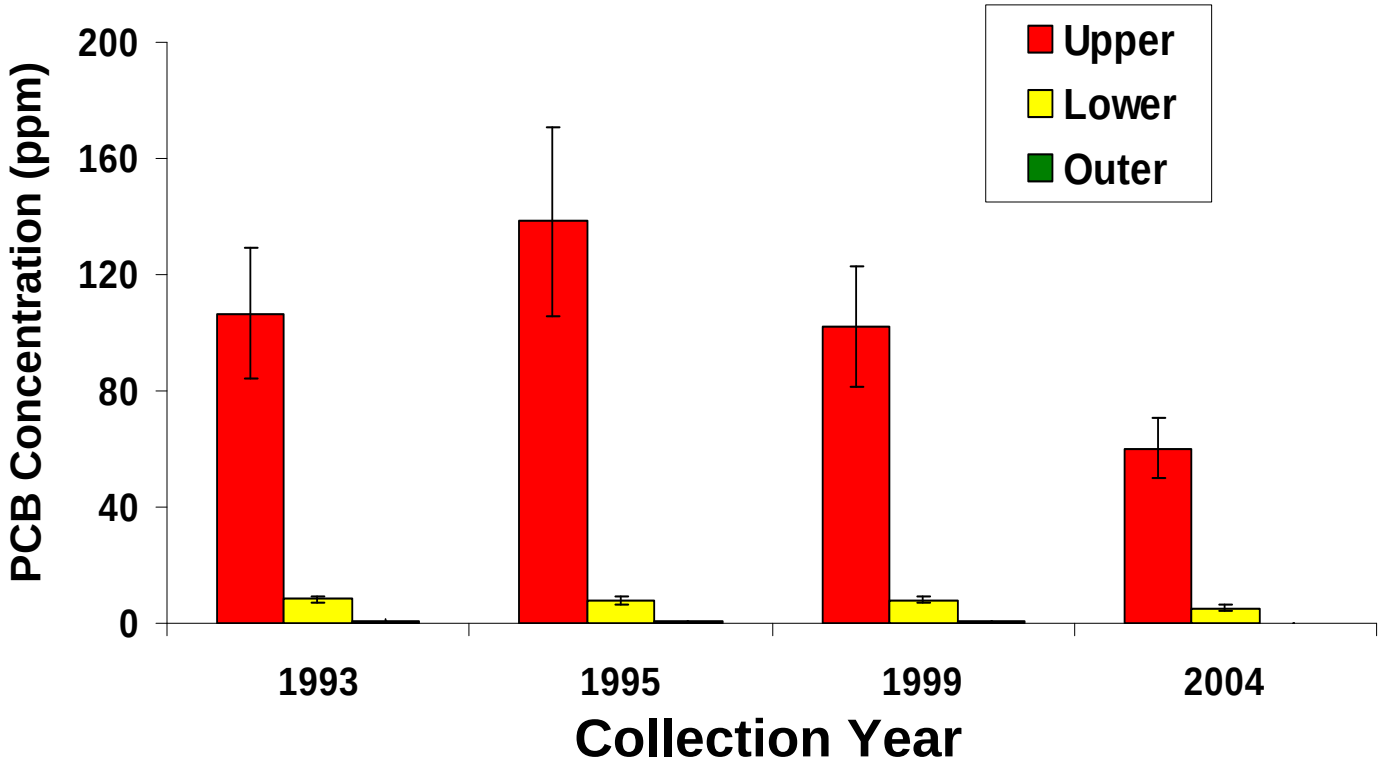


Approximately 700,000 cubic yards remain to be remediated

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Comparison of GIS and Bar Graph Presentation Formats





(Displays Spatial Patterns, SWACs, etc.)

(Displays Magnitude, Statistical Differences, etc.)

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

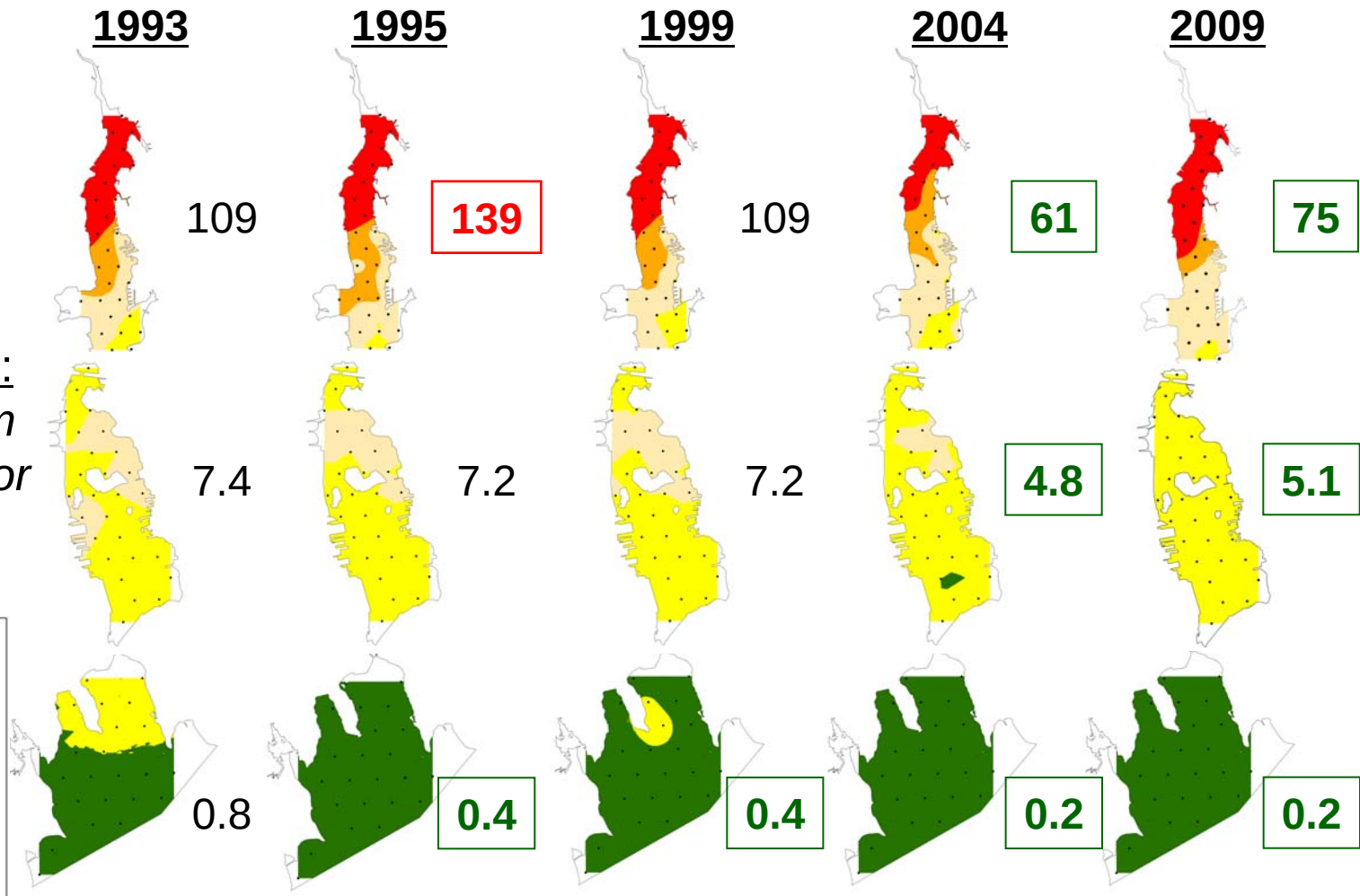
NBH LTM Program: Surficial Sediment (2 cm) PCB Conc. (ppm) – Broad View

Spatial Trends:

- *Upper, Lower, and Outer segments statistically different each year.*

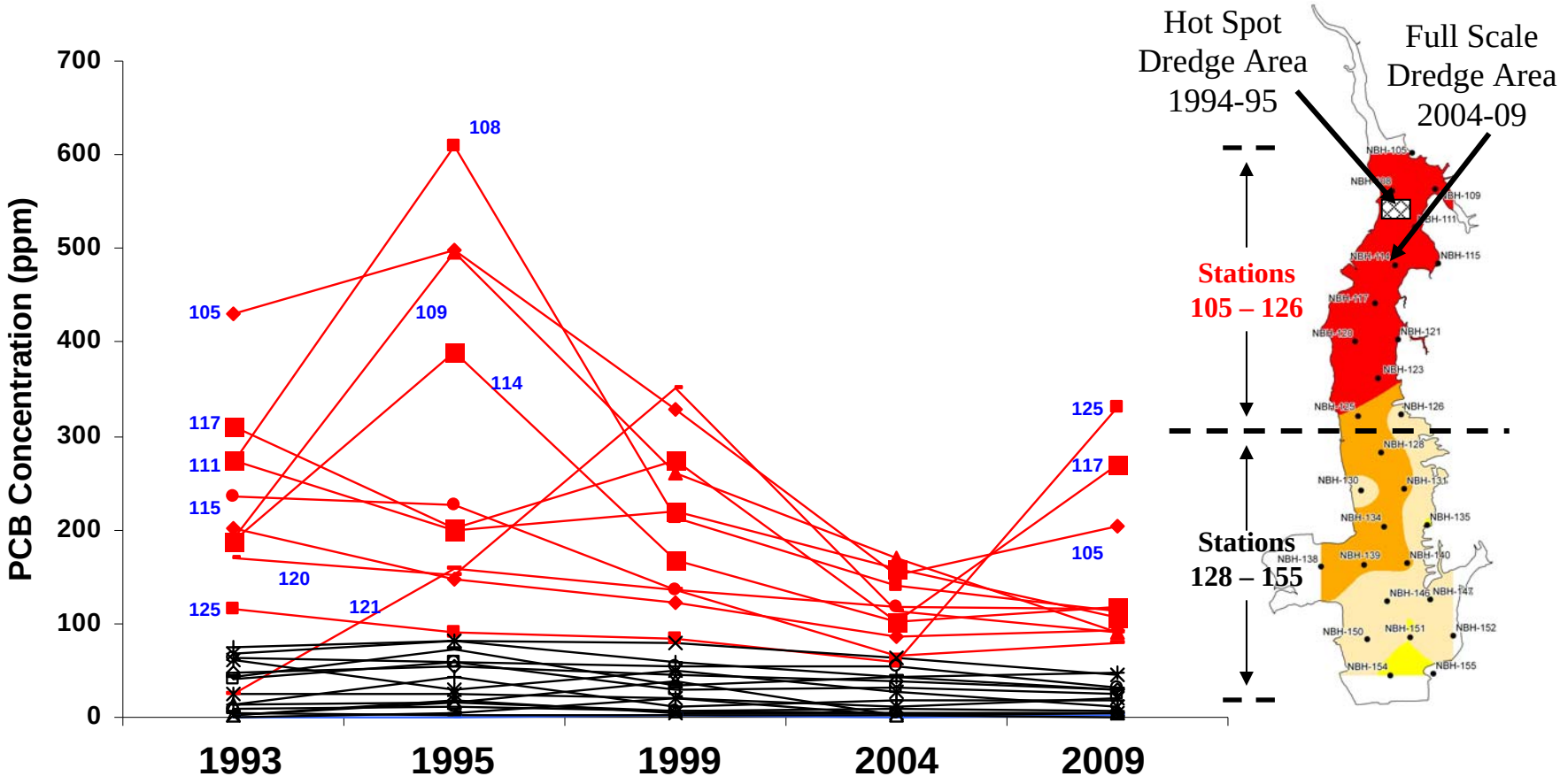
Temporal Trends:

- *Differences from '93 shown by color (Red = higher, Green = lower).*



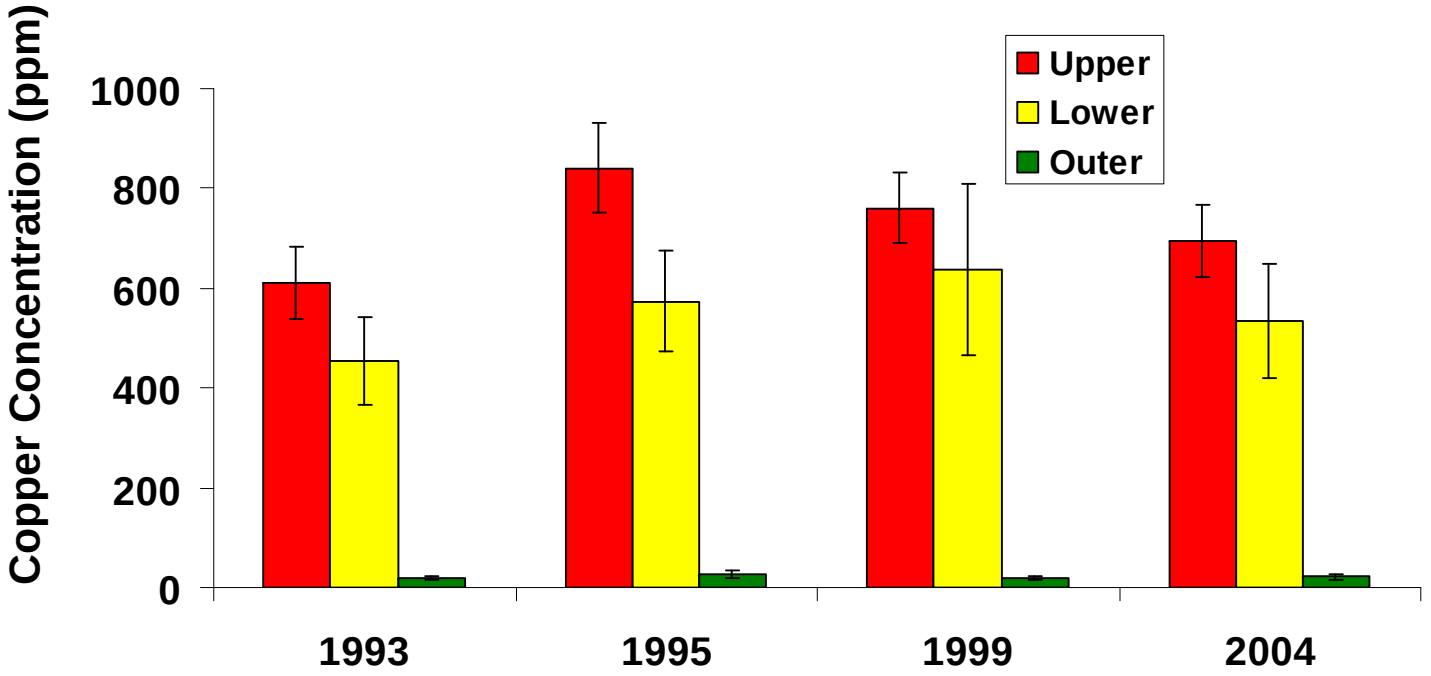
Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Upper Harbor Surficial Sediment (2 cm) PCB Conc. (ppm) – Localized View



Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Sediment Copper Concentrations (ppm)



Spatial Trends:

- *Upper and Lower Harbor not different from each other all years.*
- *Outer Harbor significantly lower each year*

Temporal Trends:

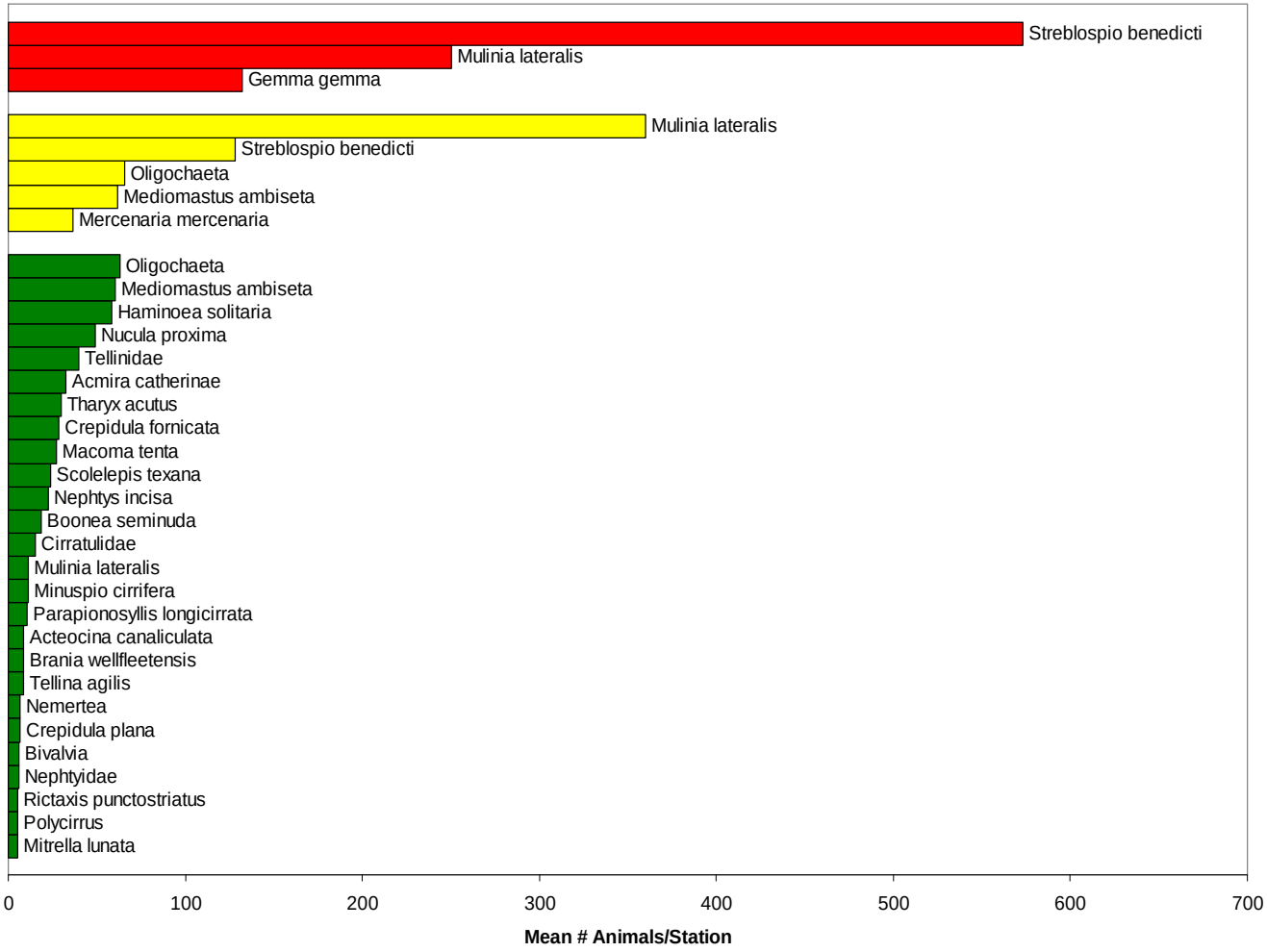
- *Upper Harbor - '95, '99, and '04 significantly higher than '93*
- *Lower Harbor higher than '93 only in '95*
- *Outer Harbor same each year*

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Benthic Community 1993 (Dominance/Abundance)

Biological Diversity:
What animals are present and how many of each?

- Upper Harbor (Red):
  Large numbers of a few smaller, short-lived species (3)
- Lower Harbor (Yellow):
  More species, including some larger ones (5)
- Outer Harbor (Green):
  Fewer numbers of more long-lived species, good diversity (26)



Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Benthic Animals

United States Environmental Protection Agency

Upper Harbor

Streblospio

Mulinia

Gemma

Lower Harbor

Cirratulidae

Tharyx

Mercenaria

Outer Harbor

Crepidula

Nucula

Macoma

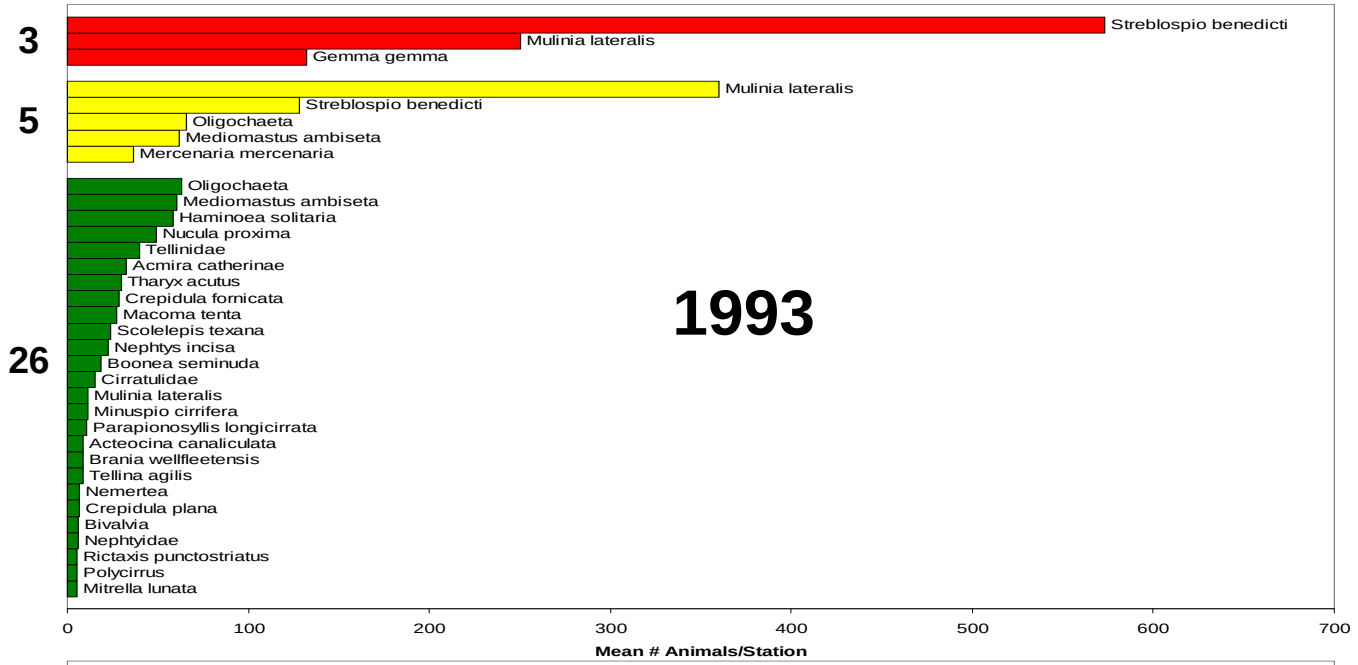
Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

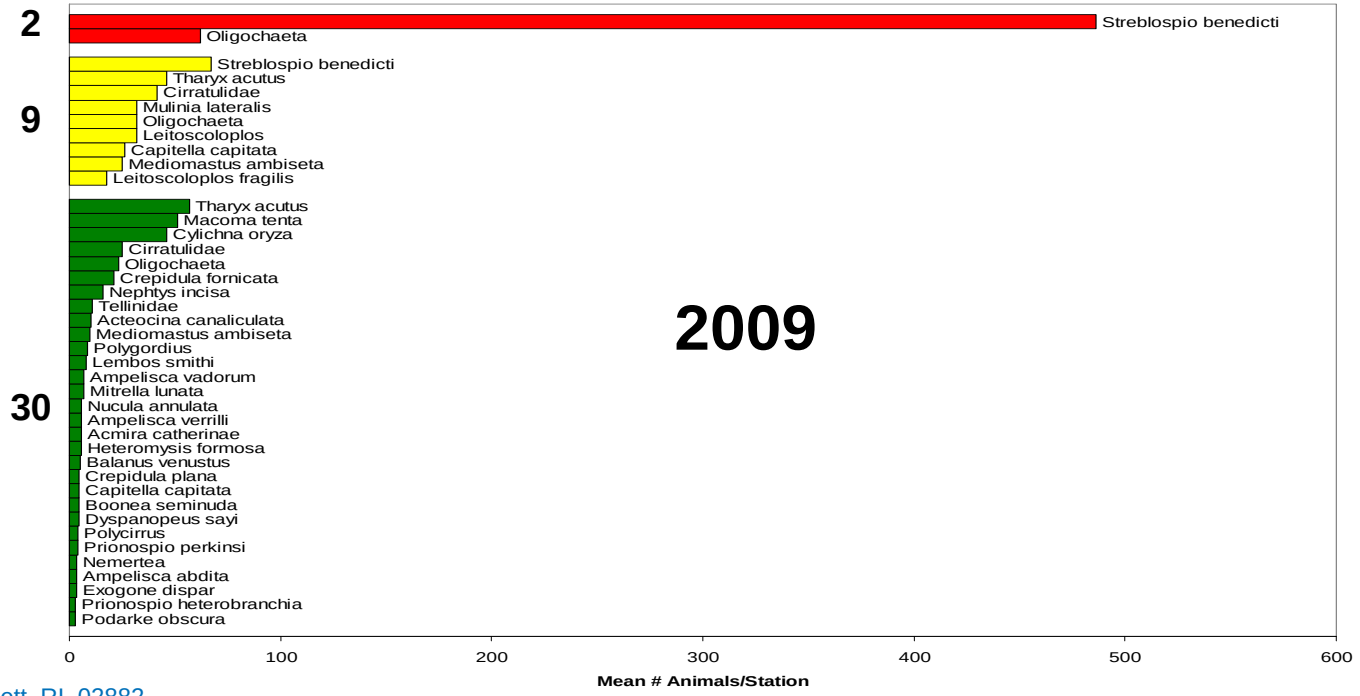
United States Environmental Protection Agency

Benthic Community Comparison (1993/2009)

Biological Diversity: What animals are present and how many of each?

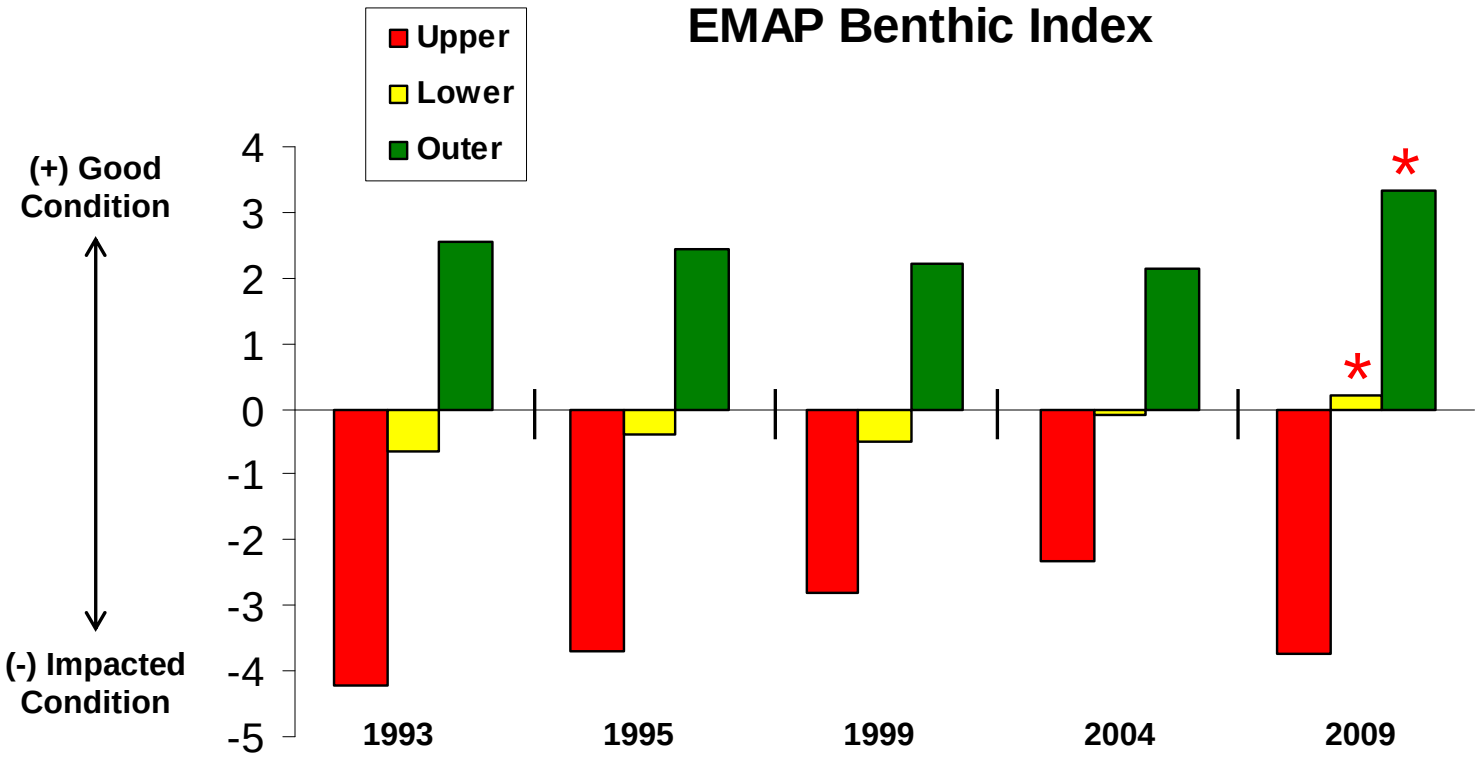
- Similar spatial and temporal patterns between 1993 and 2009





Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Benthic Community Condition Index



Other New England Coastal System Values:

1.6	Ipswich Bay, MA
0.9	Menemsha, MA
0.3	Pt Judith, RI
-0.1	Gloucester, MA
-1.5	Boston Harbor, MA
-1.5	NY/NJ Harbor
-2.0	New Haven, CT
-5.4	Providence, RI

Spatial Trends:

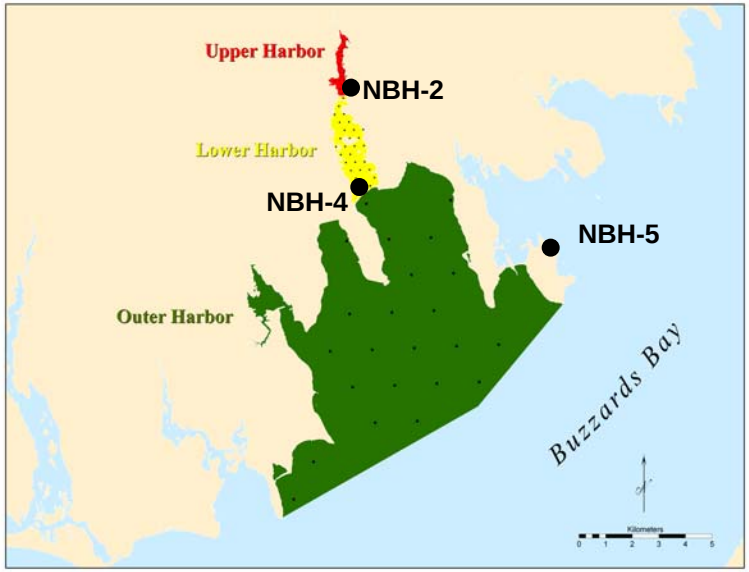
- *For each year, significant differences between Upper, Lower, and Outer Harbor*

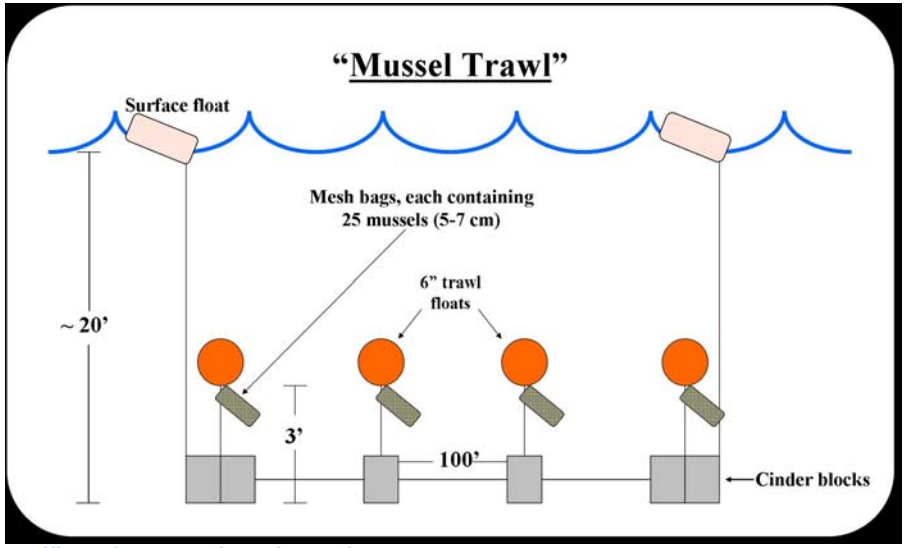
Temporal Trends:

- *Significantly higher benthic condition in 2009 for the Lower and Outer Harbor compared to 1993*

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

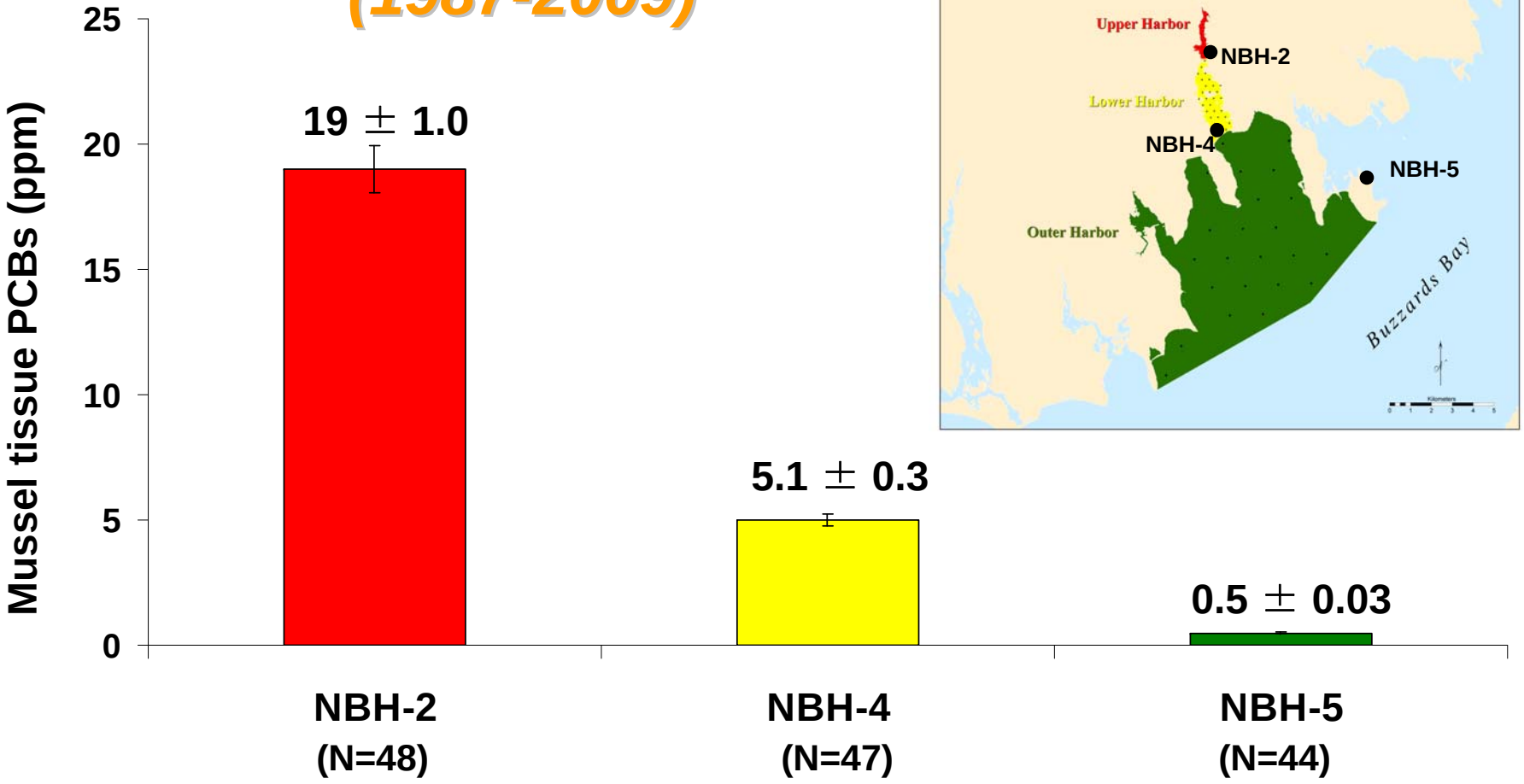
NBH LTM Program: Mussel PCB Bioaccumulation (1987-2009)





Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Mussel PCB Bioaccumulation - Spatial Pattern (1987-2009)

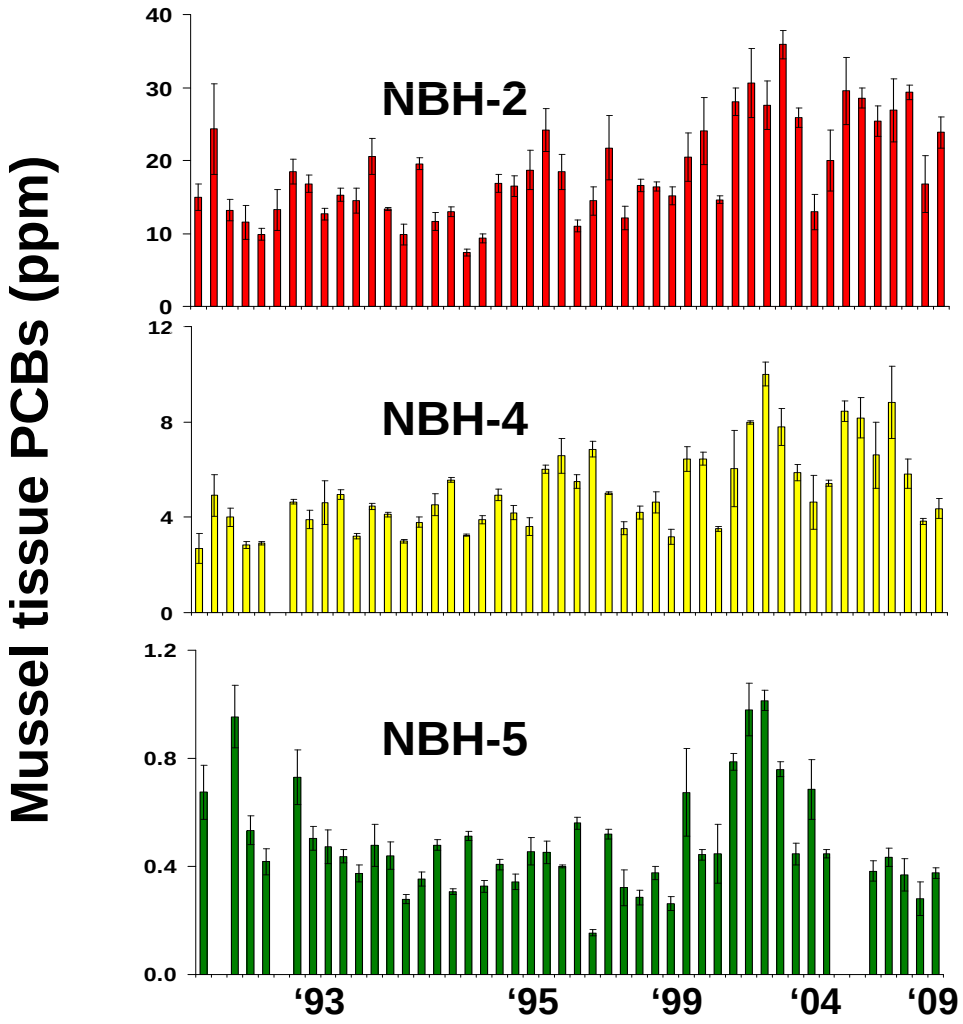


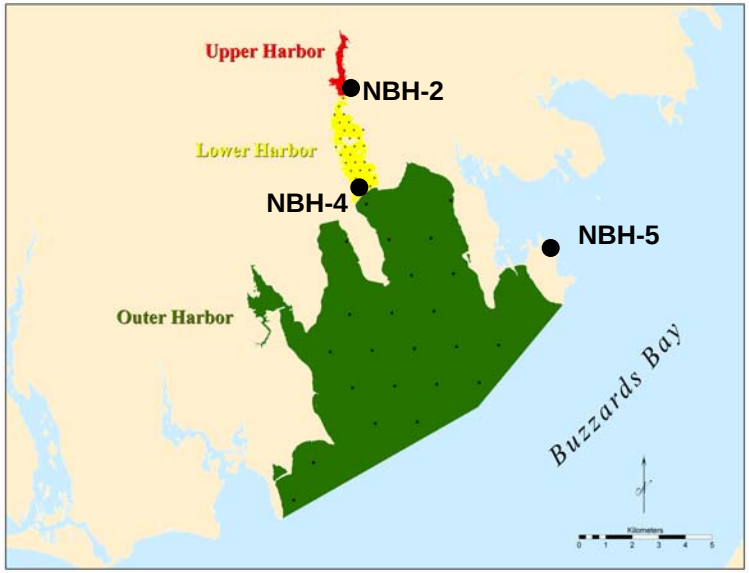
Spatial Trend:

- *Significant differences between the Upper, Lower, and Outer Harbor*

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Mussel PCB Bioaccumulation Temporal Pattern (1987-2009)





Temporal Trends:

- *PCB concentrations similar over time at a station*
- *PCB differences between stations similar over time*
- *Natural variability (e.g., spawning patterns) is comparable among stations*

Office of Research and Development
NHEERL. Atlantic Ecology Division, Narragansett, RI 02882

NBH LTM Program: Present Assessment

- *Overall goal is to assess remedial effects/effectiveness by quantifying spatial and temporal chemical and biological changes*
  - Spatial Results:
    - Significant decreasing PCB gradient present from Upper to Lower to Outer Harbor
    - Hot Spot dredging in Upper Harbor (‘94-’95) appears to have localized impact in ’95, similar localized effect in ’09; however, remedial dredging has not transported PCBs to the Lower and Outer Harbor
    - Higher contaminant concentrations (PCBs and metals) are associated with lower biological diversity and impacted benthic community

NBH LTM Program: Present Assessment (cont.)

- Temporal Results:
  - Dredging between ‘99 and ‘09 has significantly reduced PCBs in Upper Harbor compared to ’93; similar decrease in Lower and Outer Harbor in ’04 and ‘09
  - Biological differences maintained over time in benthic community and mussel bioaccumulation, with statistically significant increase in benthic condition in 2009 in the Lower and Outer Harbor
    - Biological variability does occur between sampling events; however, this doesn’t mask contaminant effects
      - Mussel PCB concentrations demonstrate natural variability due to things like spawning, but are still different between stations
- Overall Results:
  - Current NBH-LTM Program has been able to quantify spatial & temporal changes, as well as effects and effectiveness of the remedial activities to date

NBH LTM Program: Conclusions

- Baseline sampling is crucial to assess spatial and temporal changes
- Spatial coverage must be unbiased, large enough to assess the entire site, but still have adequate fine-scale coverage to explain localized effects
- Temporal coverage must link chemical and biological variables at appropriate time scales
  - Chemical: Water column concentrations typically change slower than sediments (i.e., localized mass removal vs wide spread remediation)
  - Biological: Long-term changes like benthic community don't relate with yesterday's dredging
- Overall: Full-scale dredging between 2004 and 2009 correlates with significant improvement in Lower and Outer Harbor benthic condition
- Performance based QA/QC plan is essential to: 1) maintain consistency when sampling over long time frames, and 2) be able to incorporate new techniques as technology improves (e.g., Sediment Profile Imaging (SPI) camera).