

The New Bedford Harbor Superfund Site Long-Term Monitoring Program

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Presentation Overview

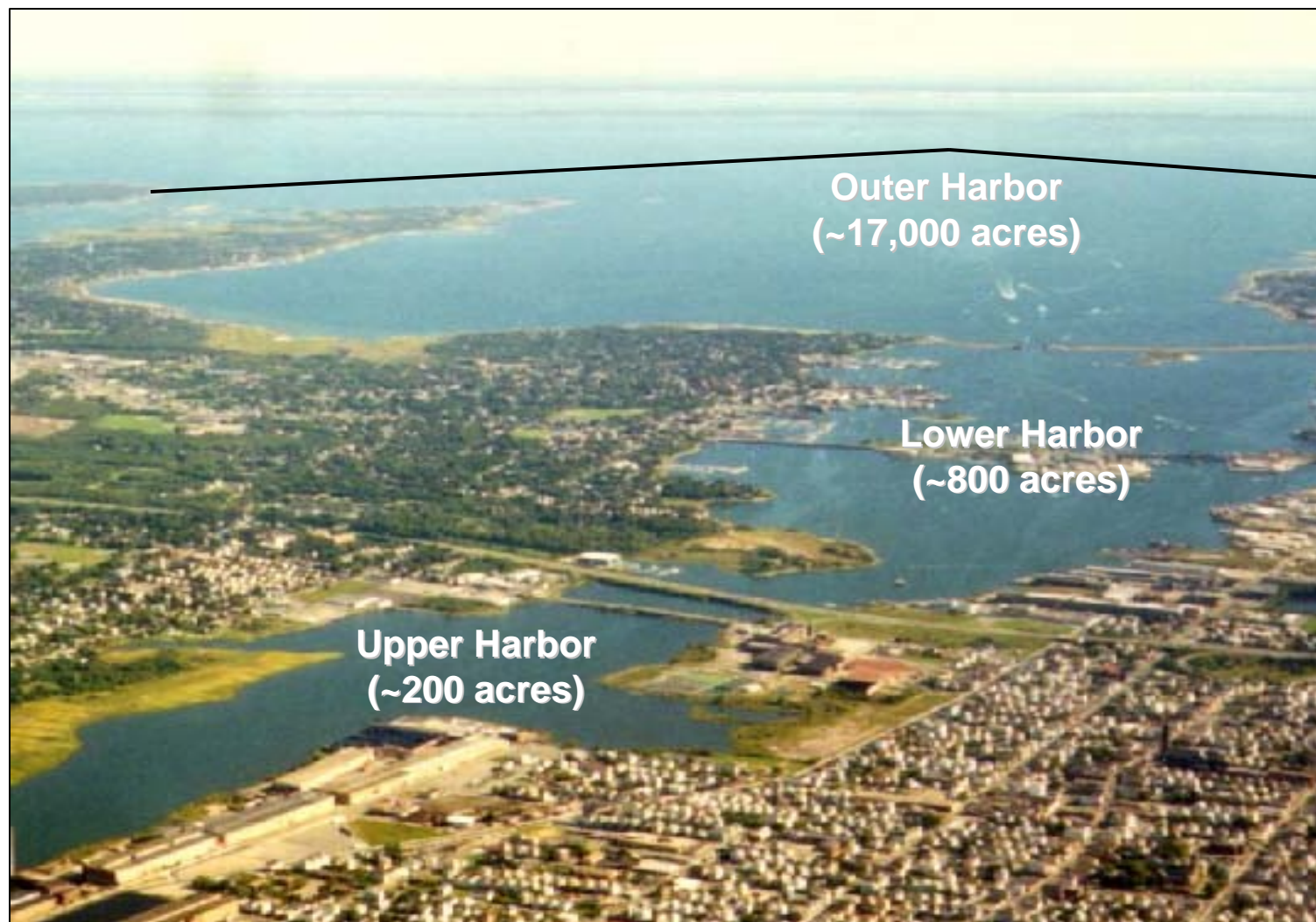
- Informal – *Please ask questions when you have them!*
- Background
- Site Characteristics
- Sampling Design
- Selected Results:
 - Chemical (PCBs, Copper)
 - Biological (Sediment - Benthic Diversity & Condition, Water Column Mussel PCB Bioaccumulation)
- Present Assessment & Conclusions



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



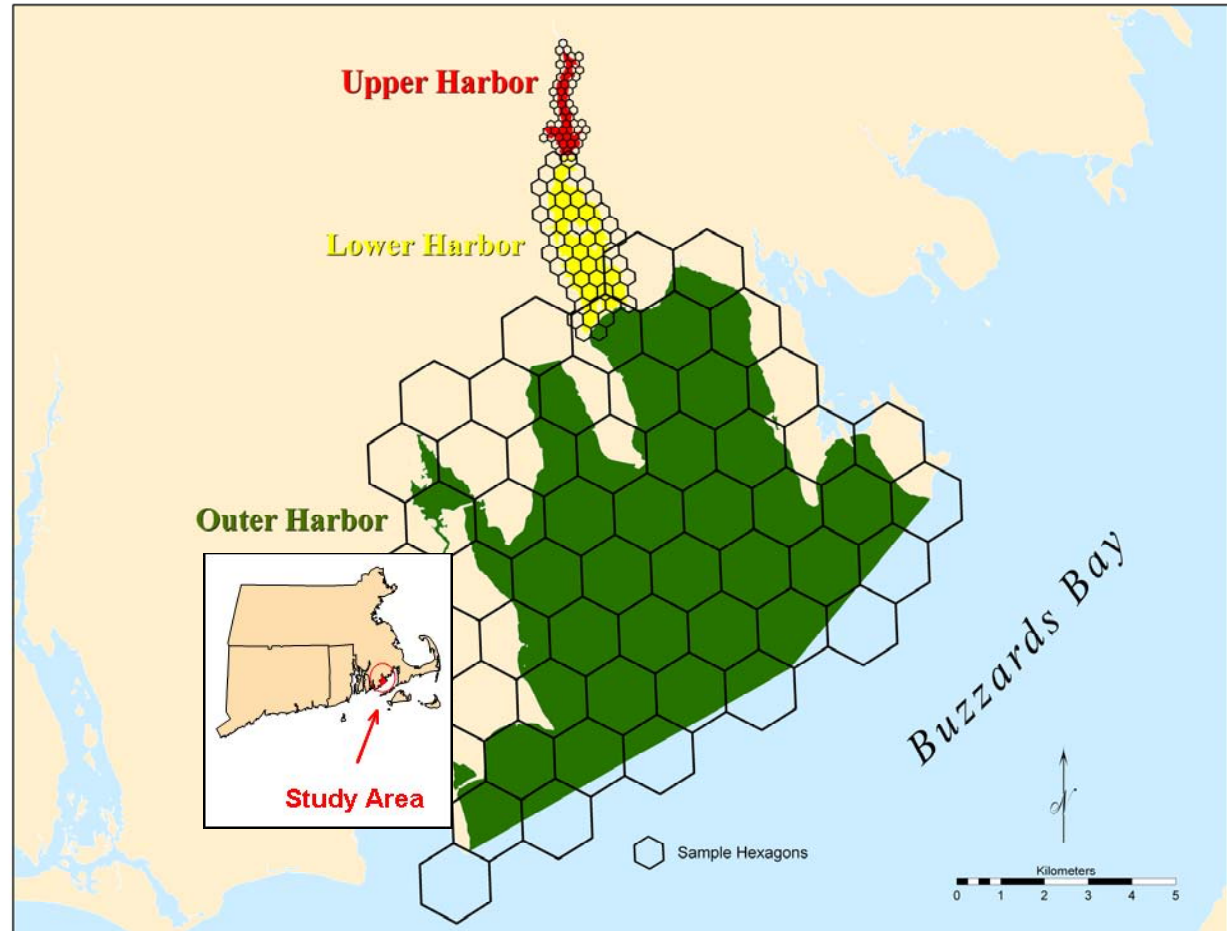
**Outer Harbor
(~17,000 acres)**

**Lower Harbor
(~800 acres)**

**Upper Harbor
(~200 acres)**

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

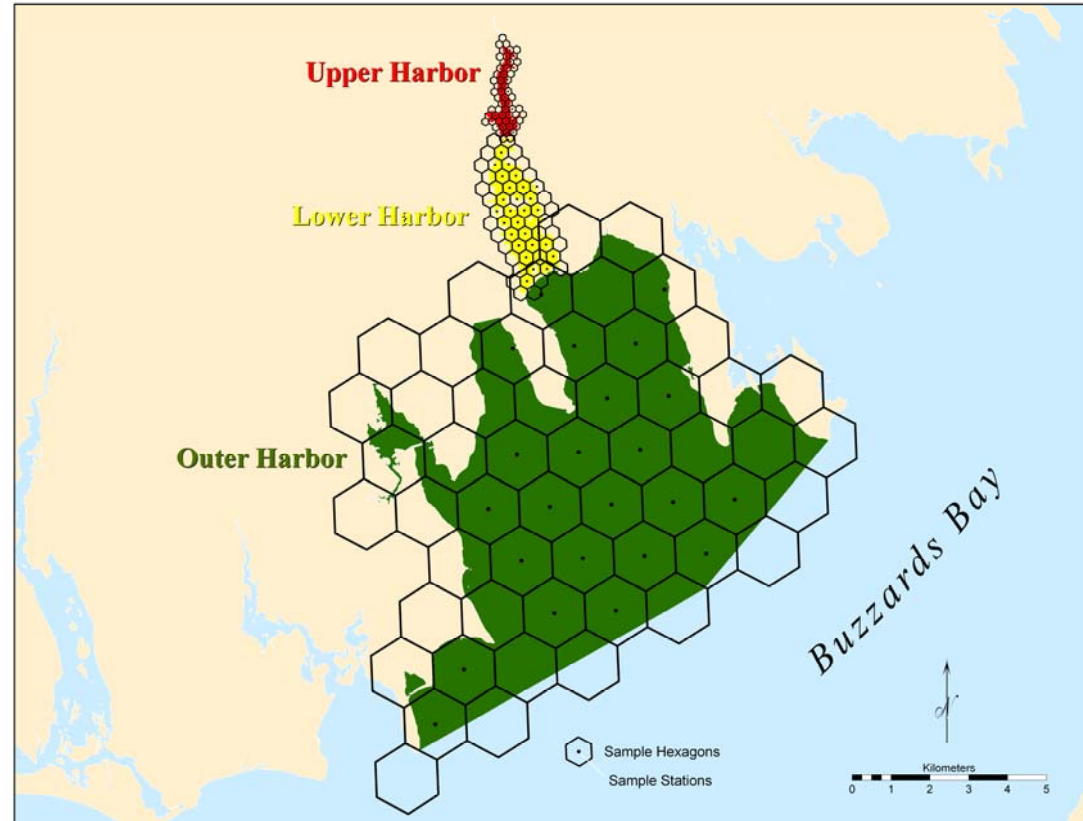


NBH Long-Term Monitoring (LTM) Program: Sampling Design

- 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



NBH LTM Program: Relationship Between LTM Collections and Remedial Activities

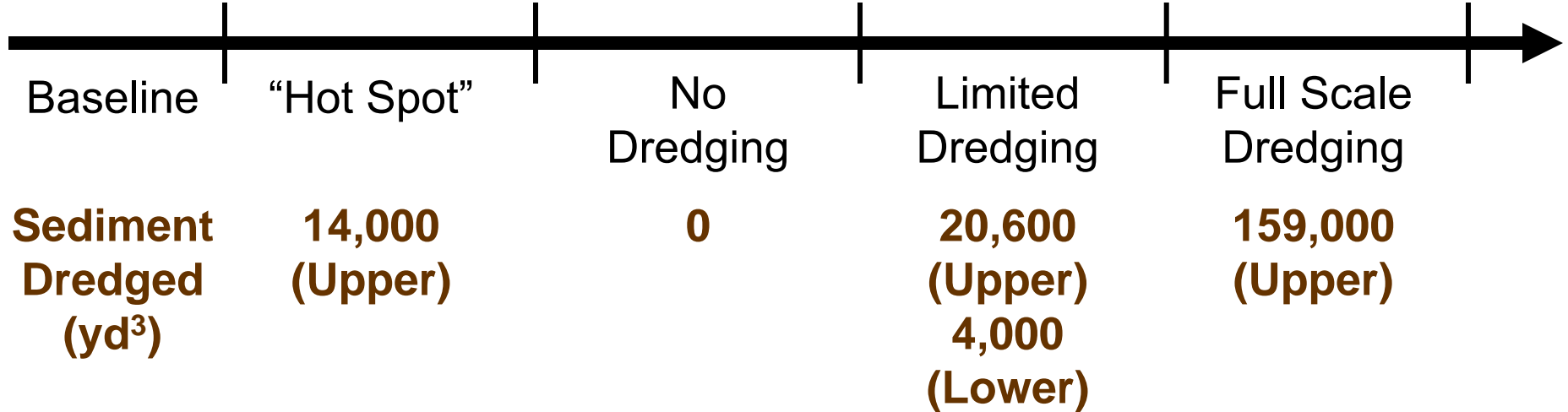
1993

1995

1999

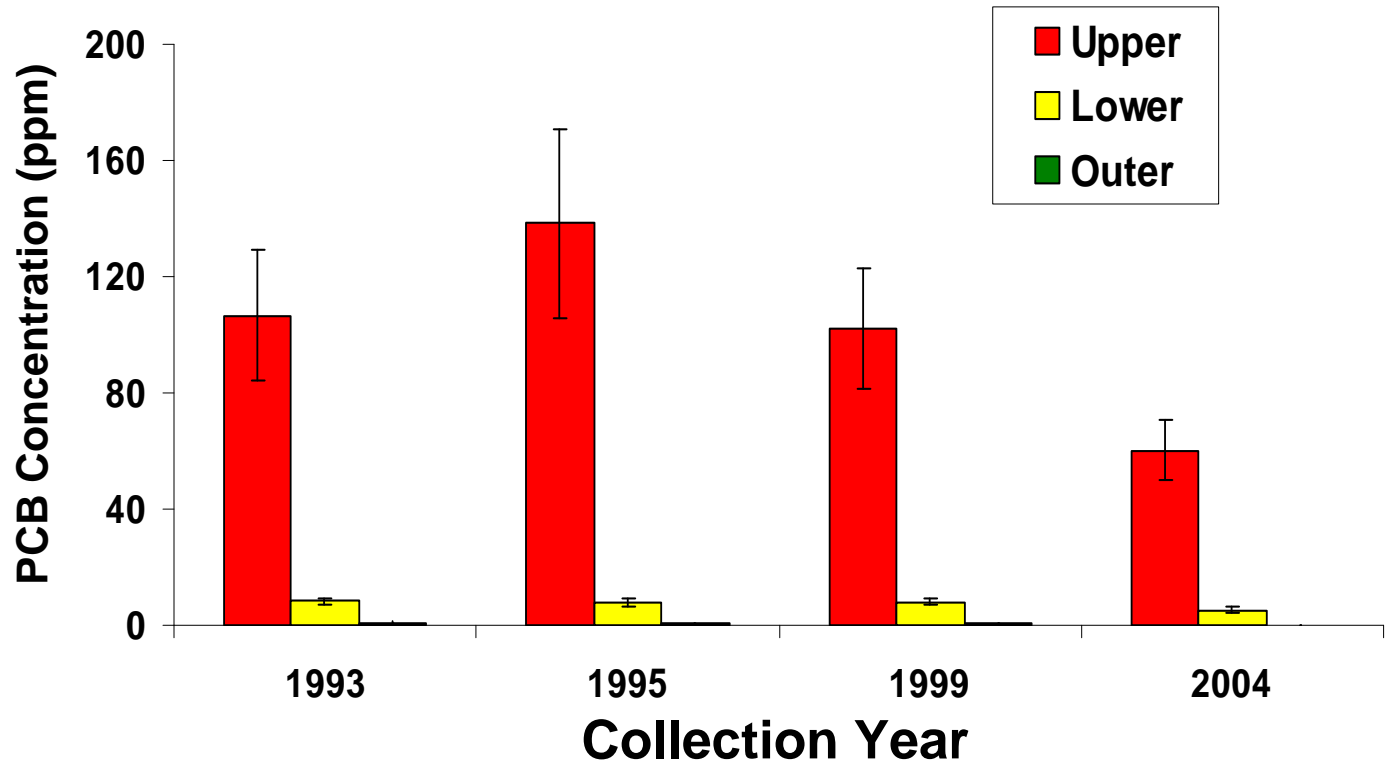
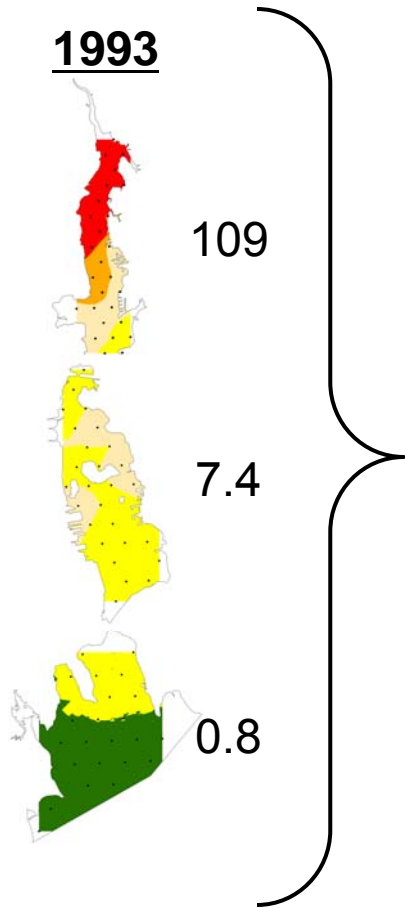
2004

2009



***Approximately 700,000 cubic yards
remain to be remediated***

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



(Displays Spatial Patterns, SWACs, etc.)

(Displays Magnitude, Statistical Differences, etc.)

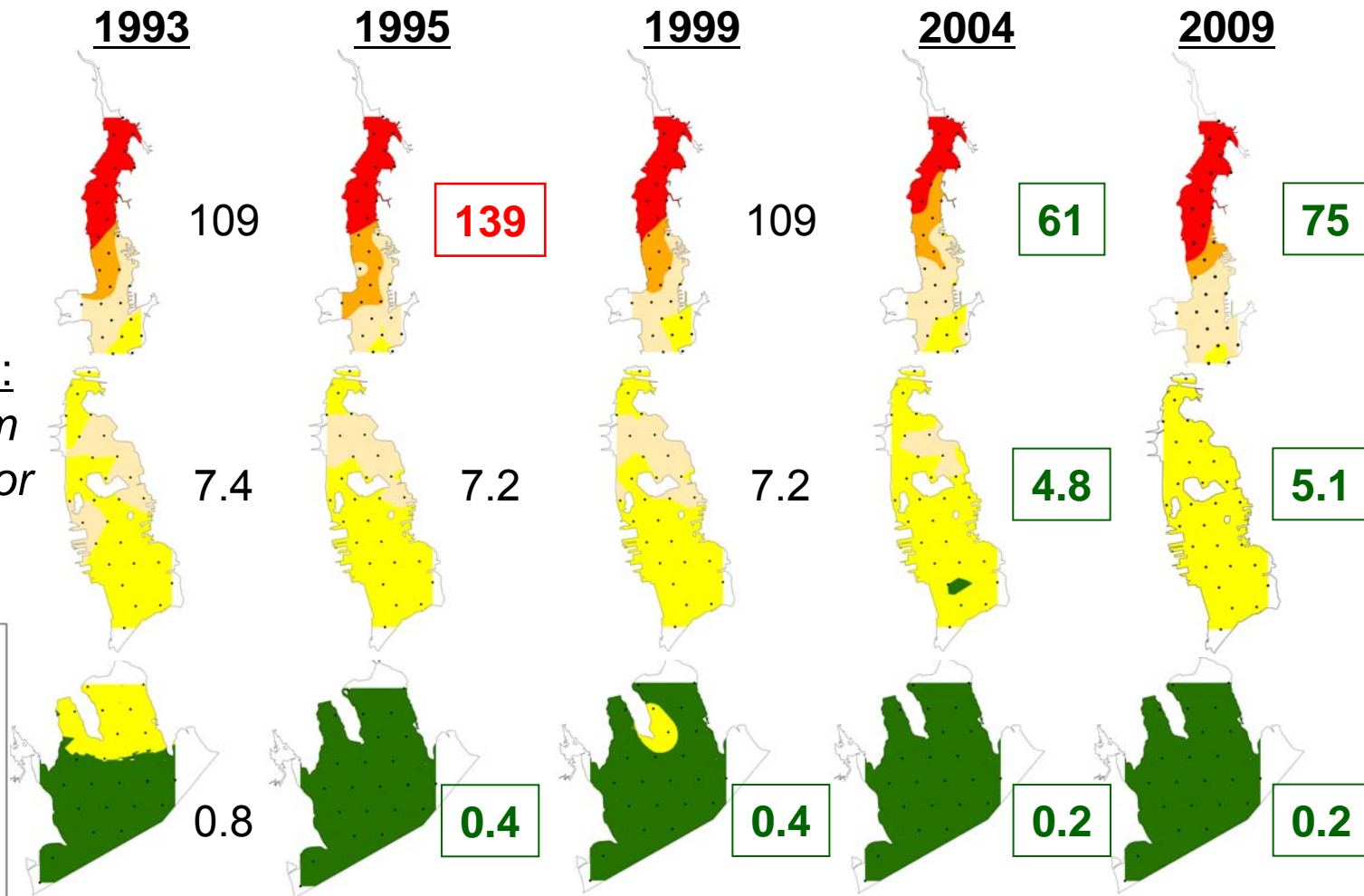
NBH LTM Program: Surficial Sediment (2 cm) PCB Conc. (ppm) – Broad View

Spatial Trends:

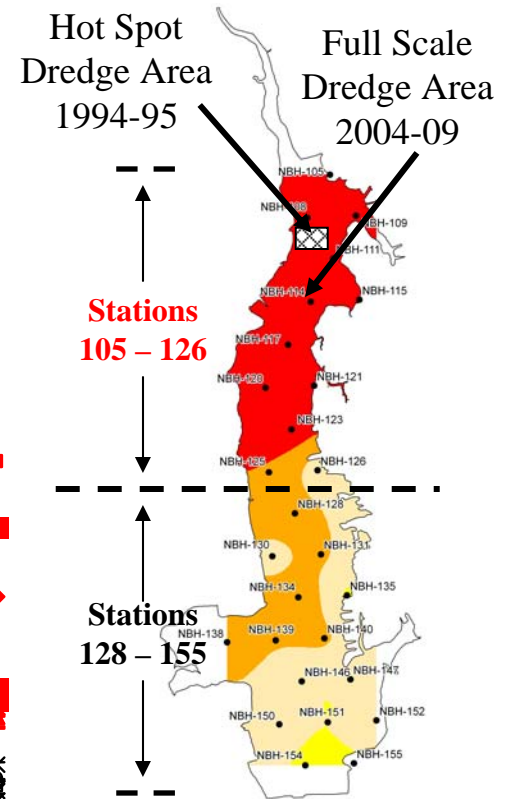
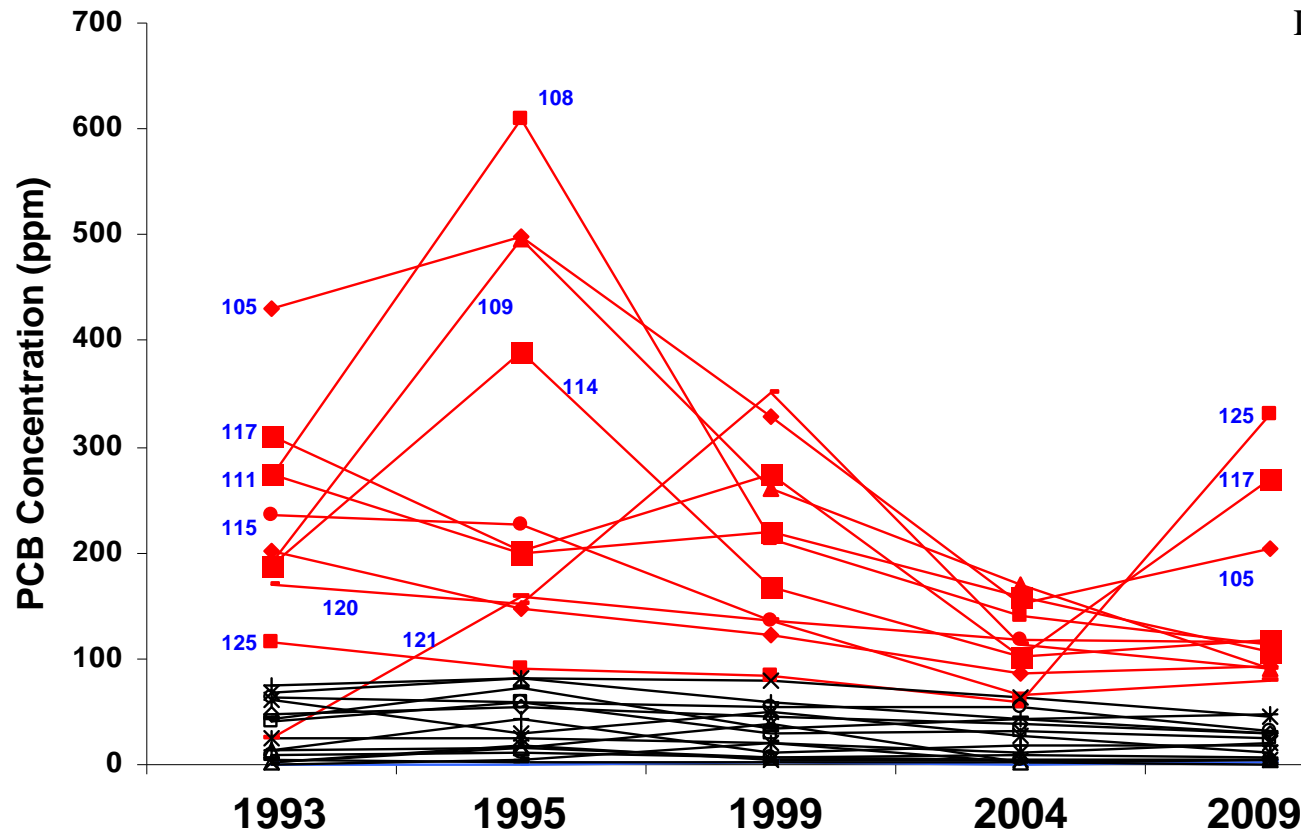
- Upper, Lower, and Outer segments statistically different each year.

Temporal Trends:

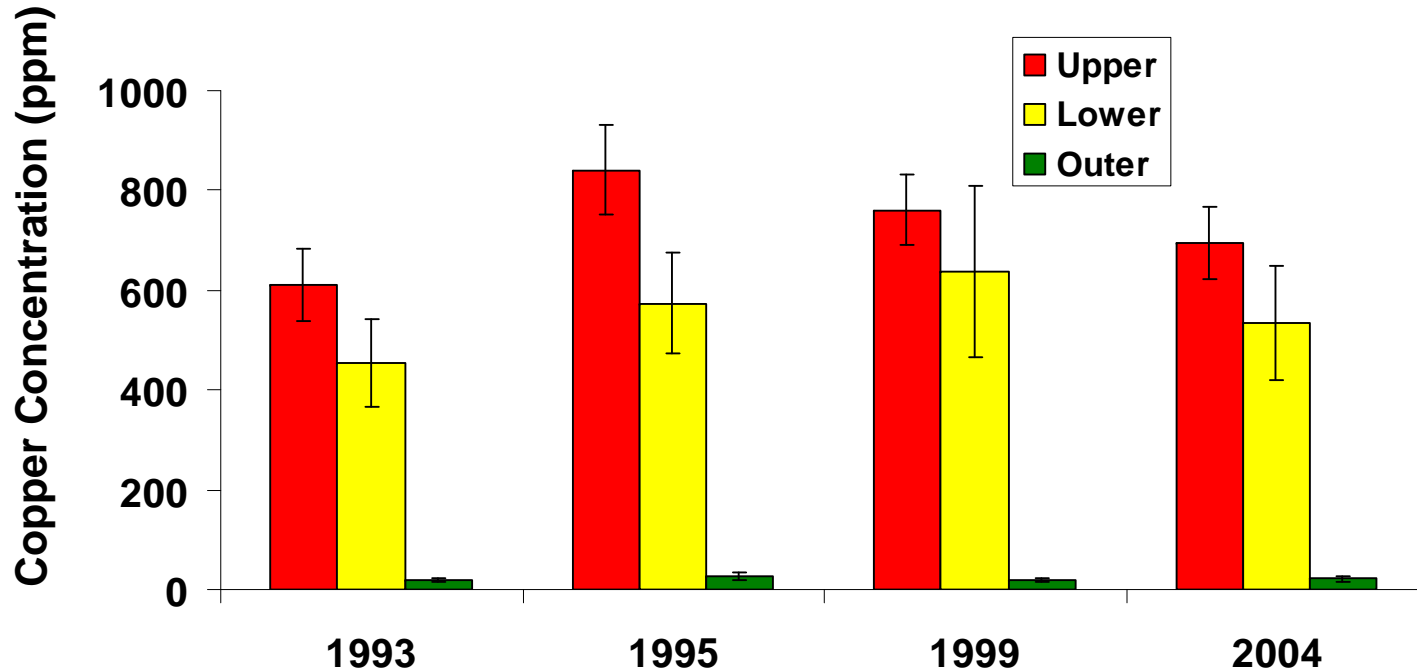
- Differences from '93 shown by color (Red = higher, Green = lower).



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



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:

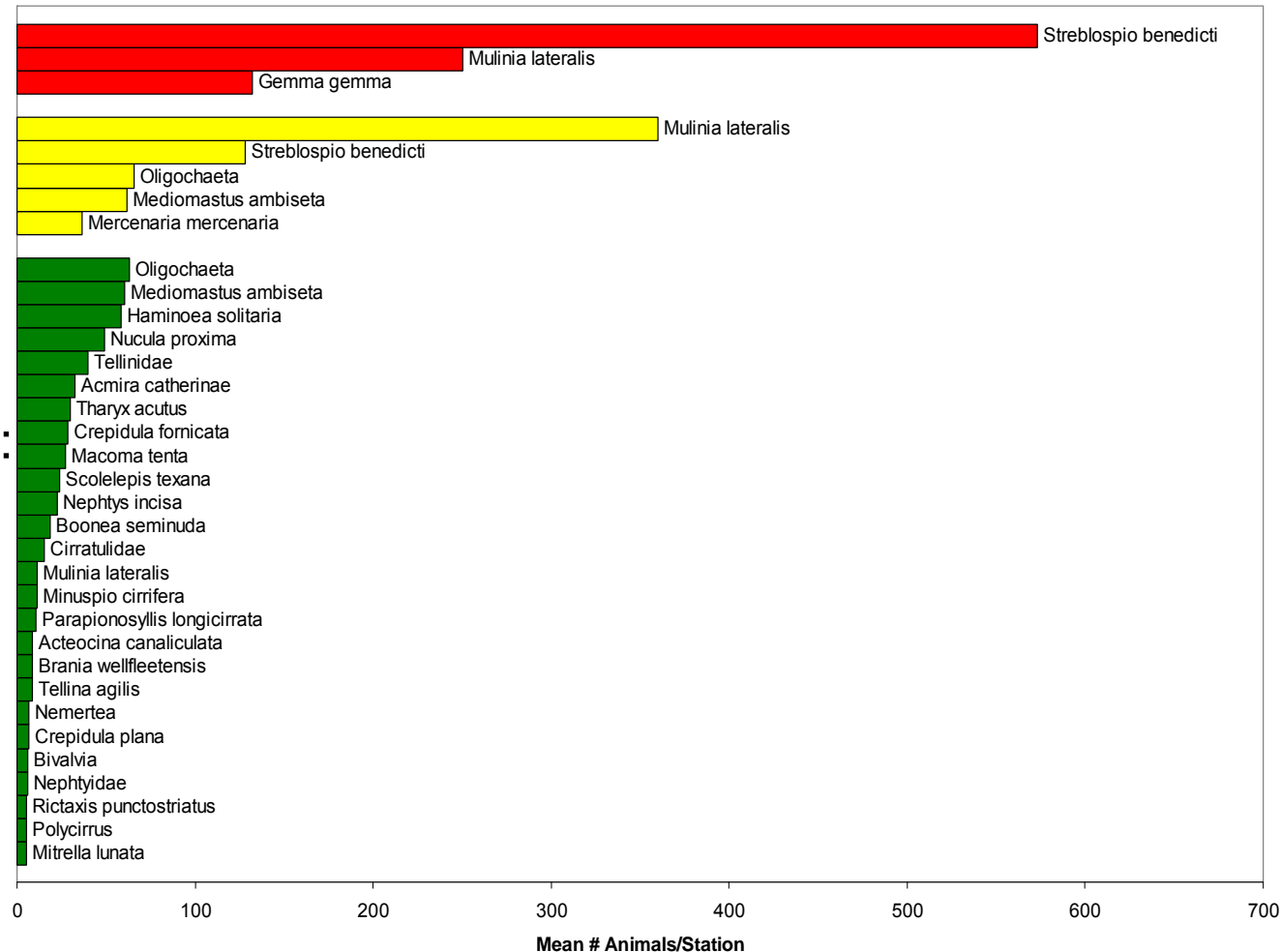
- *Upper Harbor - '95, '99, and '04 significantly higher than '93*
- *Lower Harbor higher than '93 only in '95*
- *Outer Harbor same each year*

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)



NBH LTM Program: Benthic Animals

Upper Harbor



Streblospio

Lower Harbor



Cirratulidae

Outer Harbor



Crepidula



Mulinia



Tharyx



Nucula



Gemma



Mercenaria



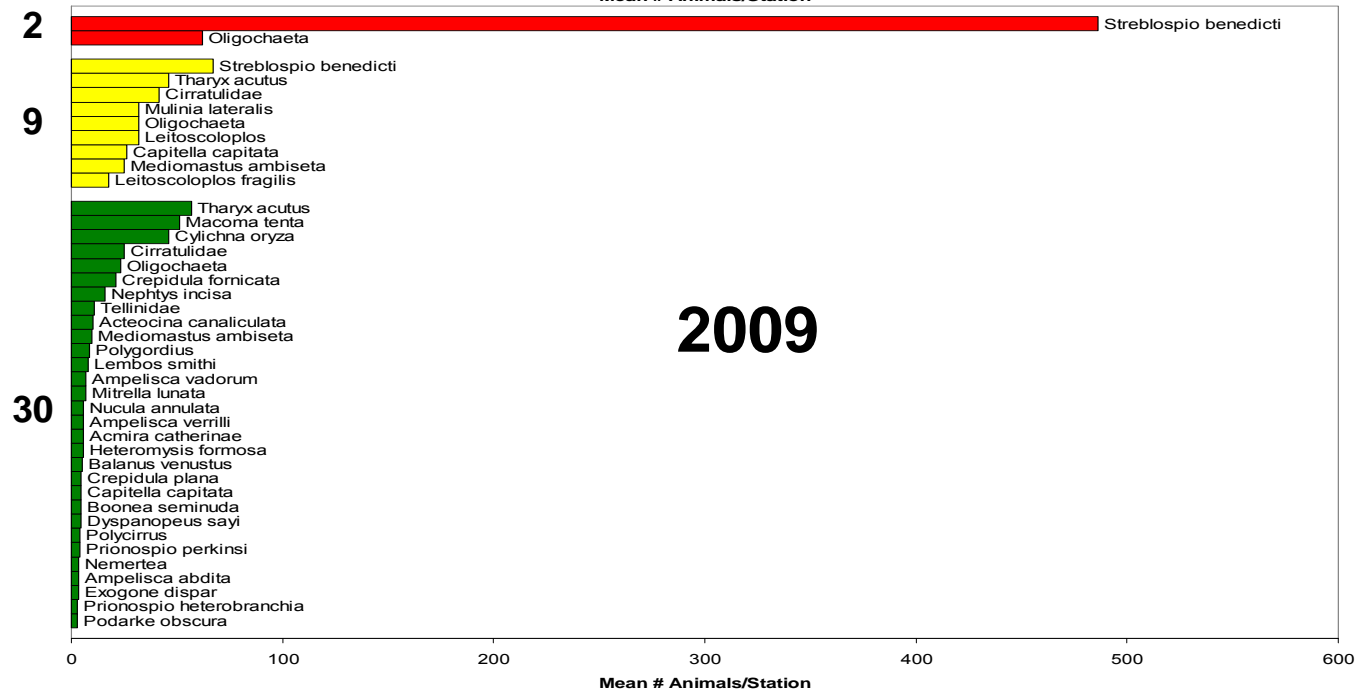
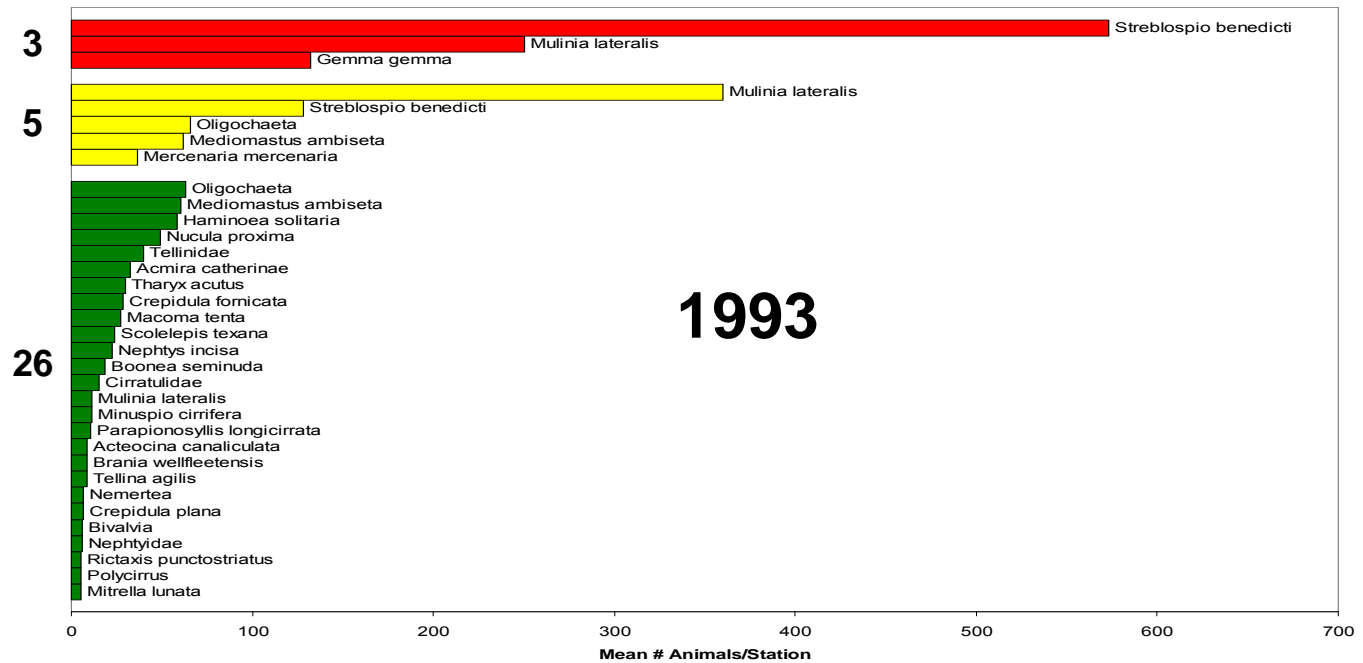
Macoma

Benthic Community Comparison (1993/2009)

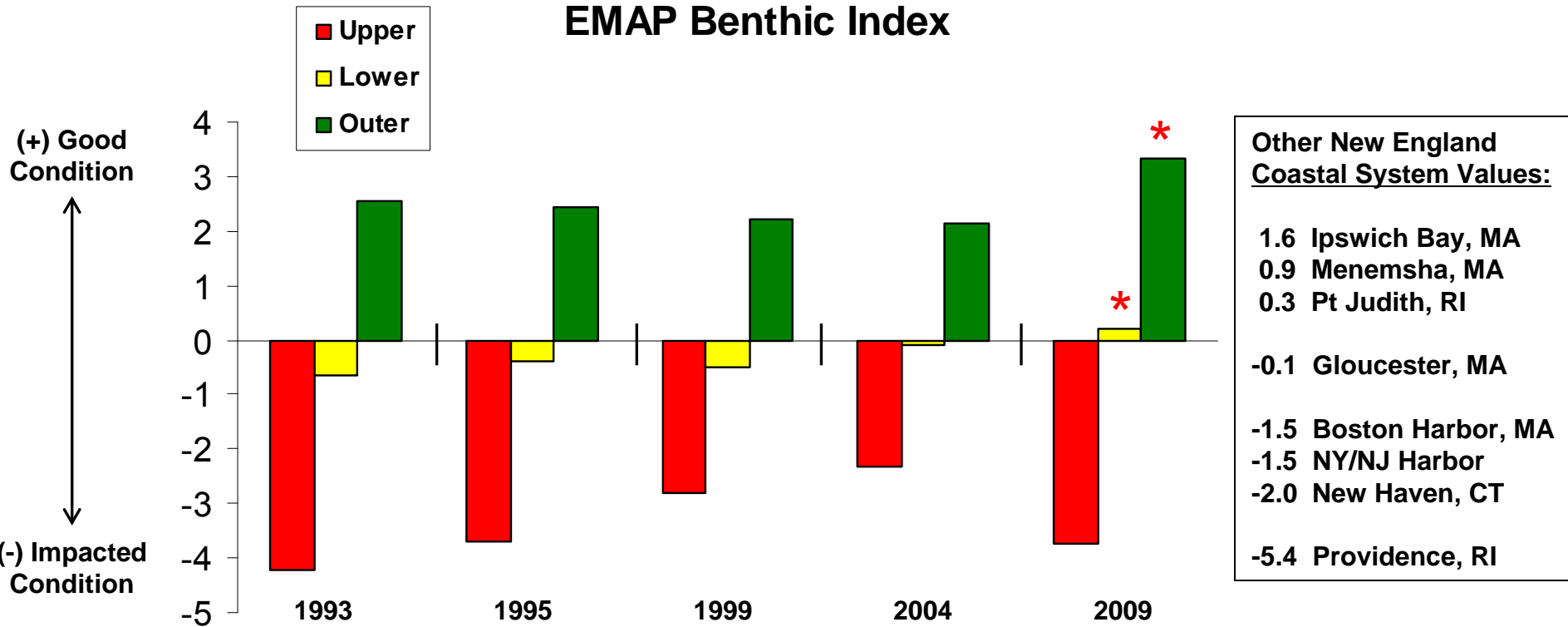
Biological Diversity:

What animals are present and how many of each?

- Similar spatial and temporal patterns between 1993 and 2009



NBH LTM Program: Benthic Community Condition Index



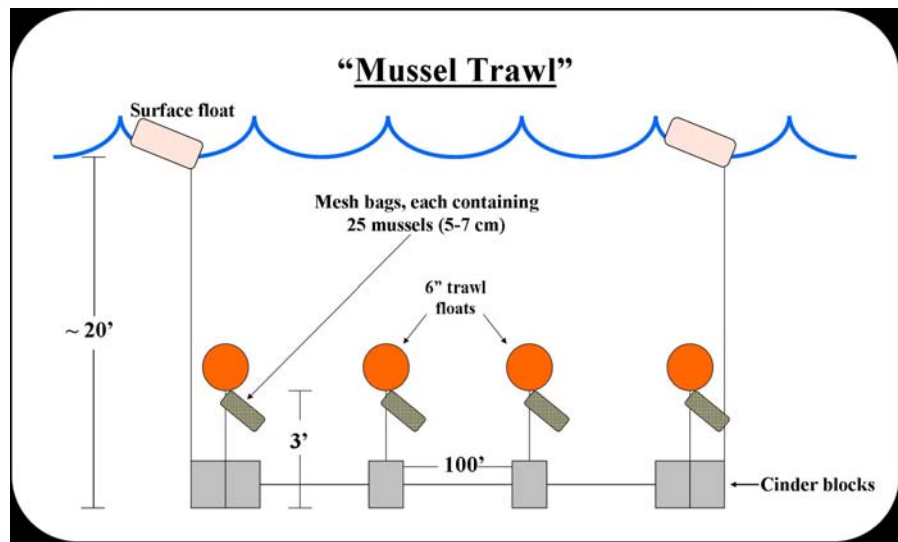
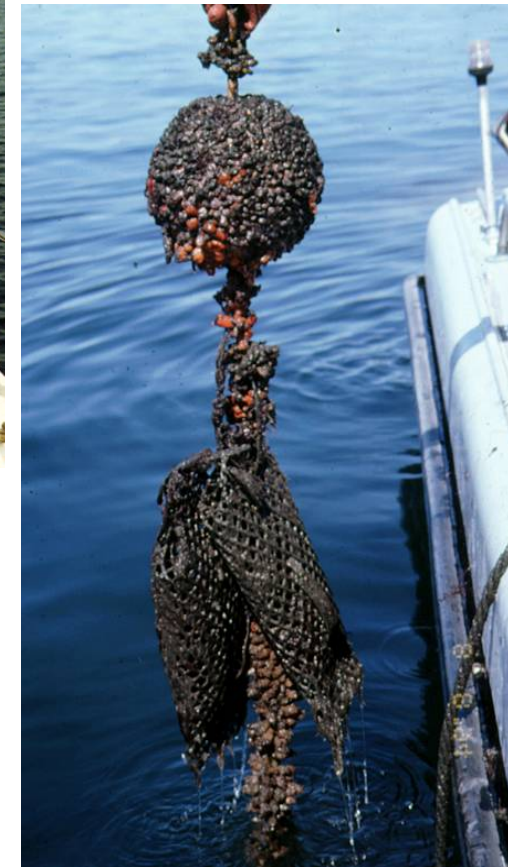
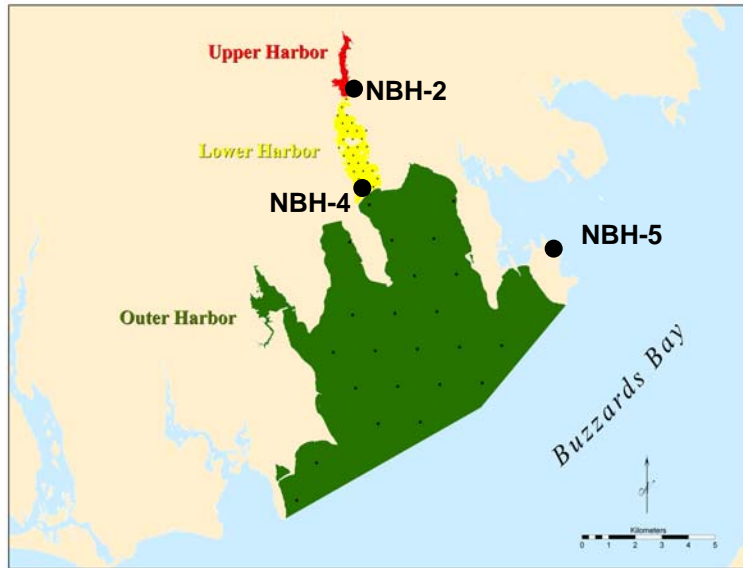
Spatial Trends:

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

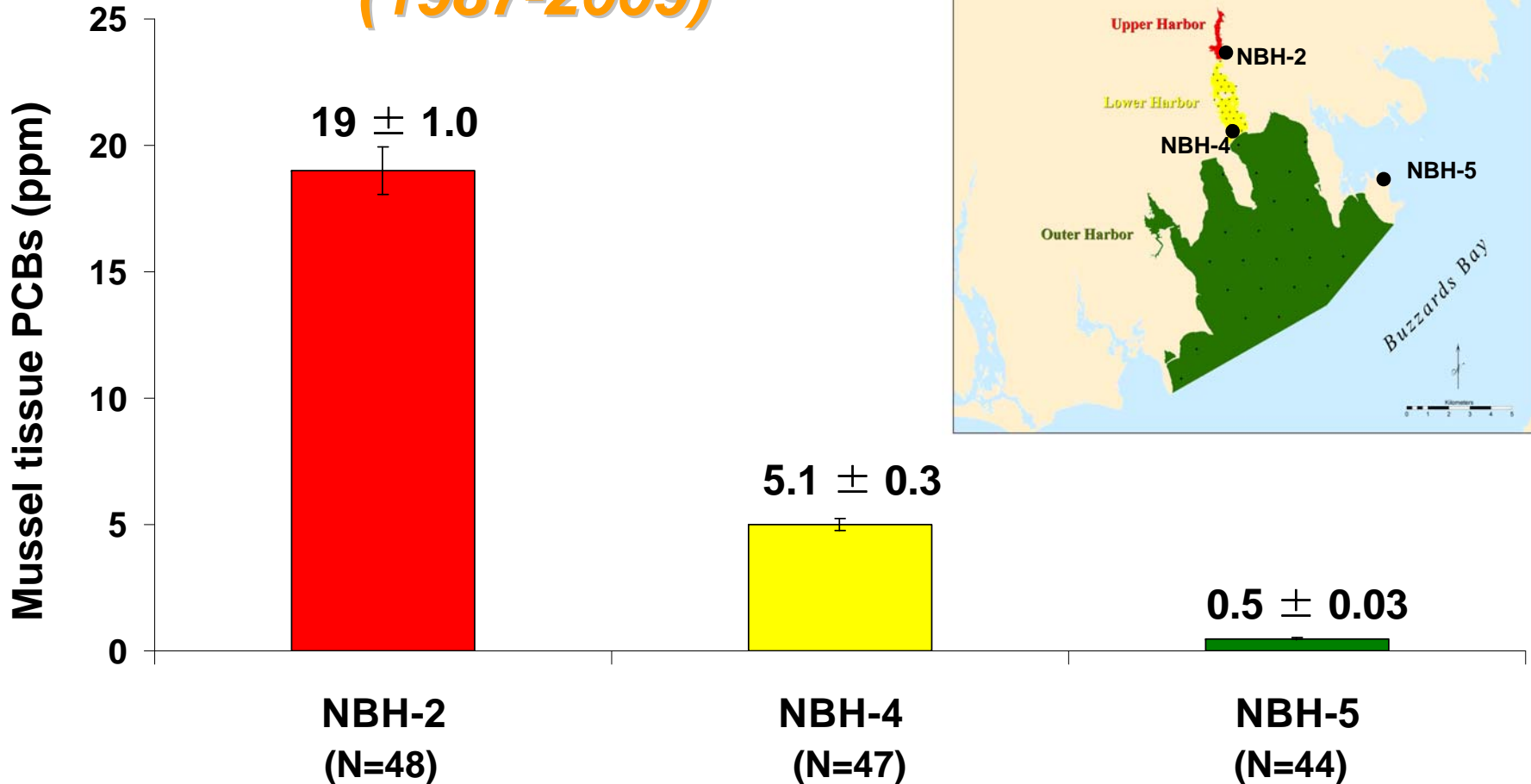
Temporal Trends:

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

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



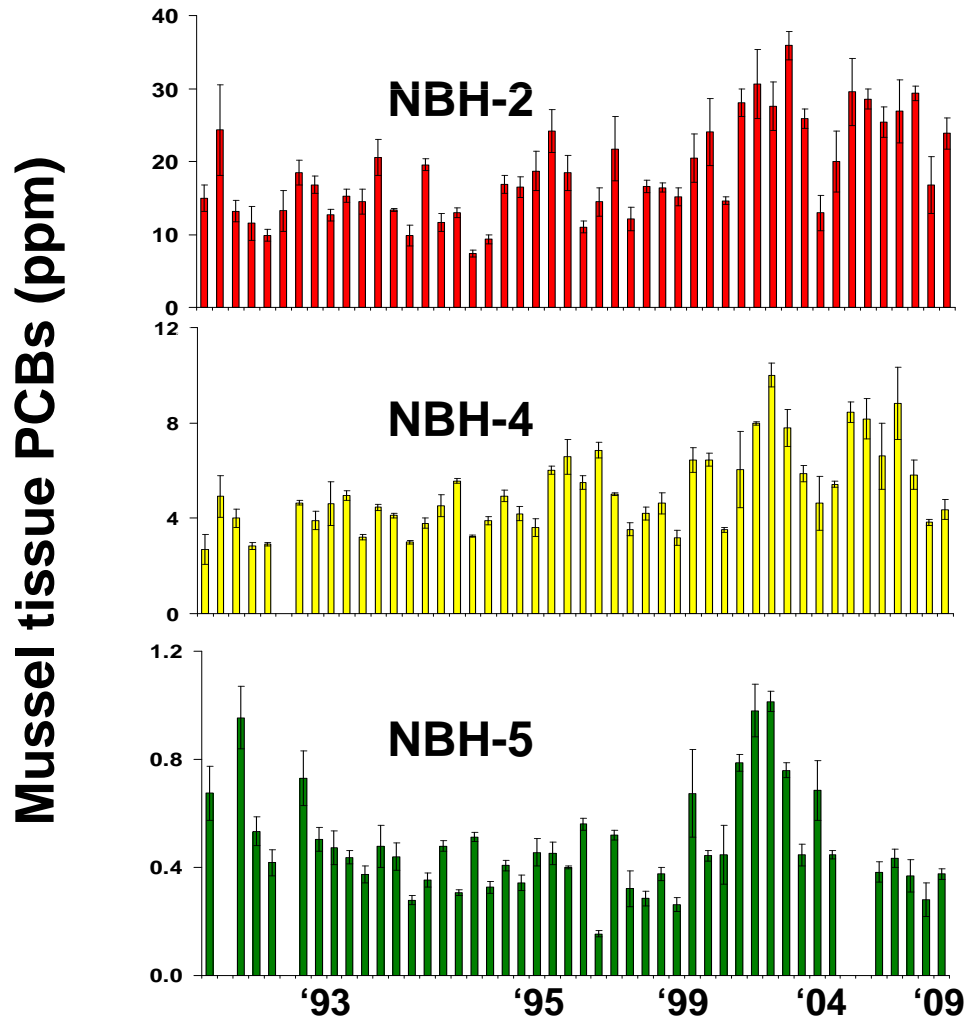
NBH LTM Program: Mussel PCB Bioaccumulation - Spatial Pattern (1987-2009)



Spatial Trend:

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

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

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).