Development and Application of a Benthic Index for the NY/NJ Harbor

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Credits

This is based on the original efforts of Darvene Adams, Stephen Weisberg, Joel O'Connor, Ananda Ranasinghe, Sandi Benyi, and the entire Benthic Working Group

Goal

Estimate the area of the Harbor and its sub-basins that has degraded benthos

- Need a probabilistic sampling design
- Define "degraded"
- Convert characteristics that reflect "biological integrity" into one score

Objective

Develop a benthic indicator that can differentiate between impaired and unimpaired benthic communities

- Harbor-specific
- Reliable
- Easily calculated and understandable
- Minimize redundancy in metrics
- Management utility
- Defined expectations for the benthic community
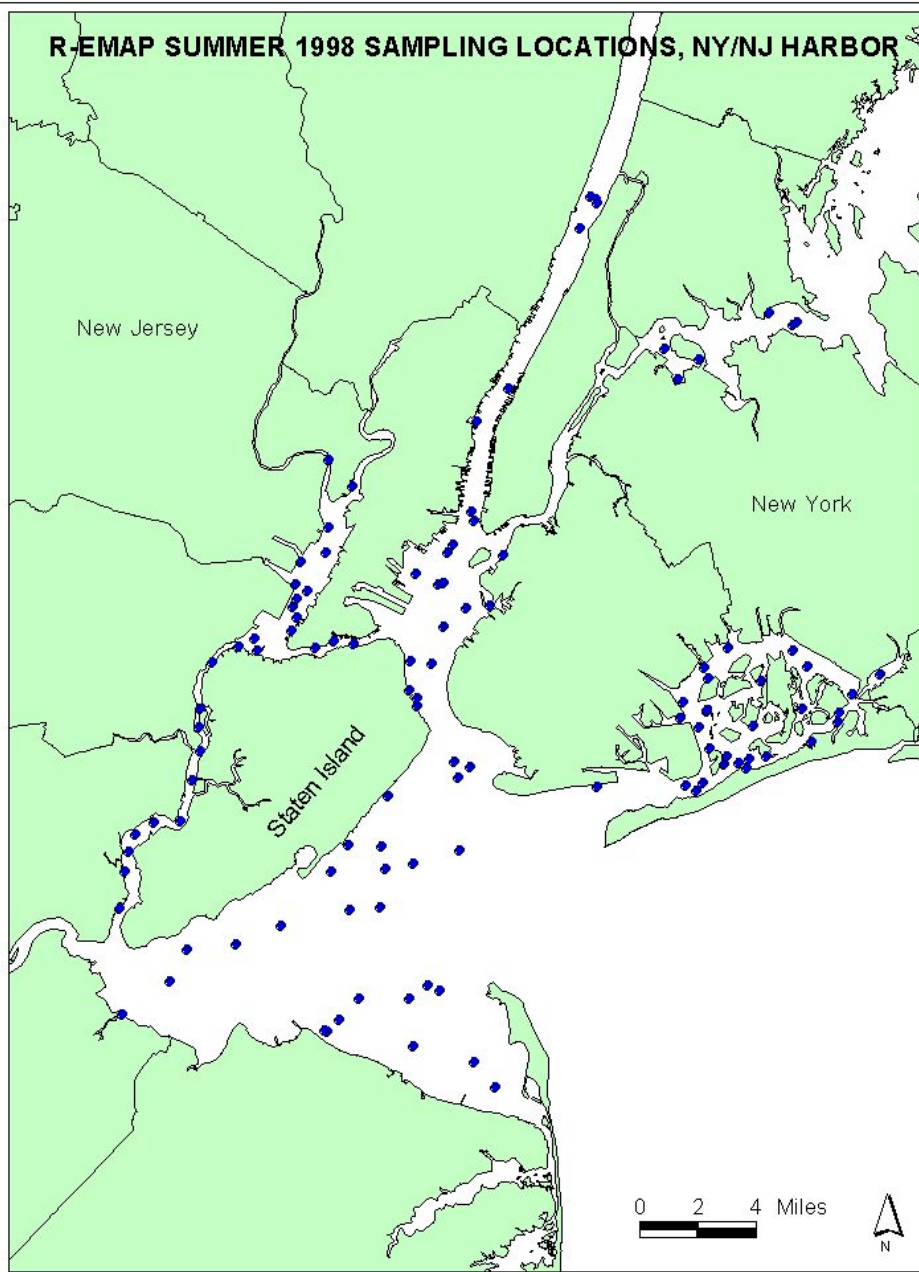- Adjust for substrate
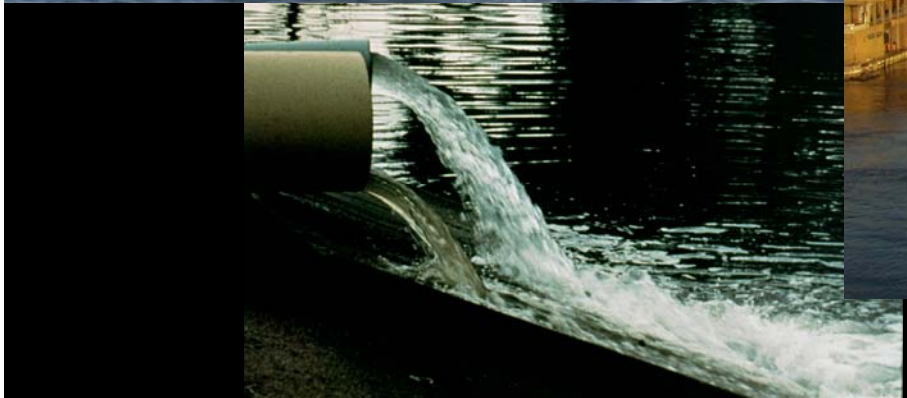
Data Sources

- EMAP – Initial 1990 -1993 survey in the Virginian Province. 525 stations from Chesapeake Bay through Cape Cod

- 1993/4 - Initial REMAP survey (168 stations, 6 sub-basins)

- 1998 - 5 year revisit (124 stations, 4 sub-basins)

- 2003 - trend assessment (124 stations, 4 sub-basins)

R-EMAP SUMMER 1998 SAMPLING LOCATIONS, NY/NJ HARBOR

Generic Index Development

- Identify a calibration (developmental) data set.
- Develop a list of candidate benthic metrics.
- Test each metric for differences between reference sites and other sites.
- Determine threshold values for each metric based on distribution at reference sites.
- Test and validate the index with an independent data set.

Benthic Working Group

- Experts in Mid-Atlantic benthic ecology
- Consensus on pollution-tolerant and pollution-intolerant species lists
- Defined four habitats to be used in the index (combinations of salinity and substrate)

Calibration Data Set

- Examine existing benthic indices
  - Chesapeake Bay restoration goals index
    - Preferred because of its simplicity and transparency
    - Suggested refinements
  - EMAP Virginian Province index
- Examine datasets for index development
  - EMAP-E data used because it included a range of environmental conditions
    - 525 stations

Existing Benthic Indices

EMAP BI = 1.389 (salinity-normailzed Gleason's D - 51.5) / 28.4
- 0.651 (salinity-normalized tubificid abundance – 28.2) / 119.5
- 0.375 (spionid abundance – 20.0) / 45.4

Chesapeake Bay B-IBI Metrics:

- Shannon-Wiener species diversity index
- Total species abundance
- Total species biomass
- Percent abundance of pollution-indicative taxa
- Percent abundance of pollution-sensitive taxa
- Percent biomass of pollution-indicative taxa
- Percent biomass of pollution-sensitive taxa
- Percent abundance of carnivore and omnivores
- Percent abundance of deep-deposit feeders
- Tolerance Score
- Tanypodinae to Chironomidae percent abundance ratio

Mean Score:

¡ 3.0   Meets restoration goal
2.7-2.9   Marginal
2.1-2.6   Degraded
¡ 2.0   Severely degraded

Proposed Refinements

- ## Refine calibration data set
  - Determine geographical limitation (excluded Chesapeake Bay and sites with < 15 ppt salinity)
  - Add TOC criterion
  - Add 1992 and 1993 EMAP data

- ## Refine metrics
  - Develop lists of pollution-intolerant and pollution-tolerant species

- ## Develop a Harbor validation data set

Reference Site Criteria

- Sediment toxicity not significantly different from controls
- All contaminants less than ER-M values and no more than 2 exceed ER-Ls
- TOC < 2.5%
- Dissolved oxygen > 5 ppm

Reference Sites

Polyhaline/mud = 11 sites

Polyhaline/sand = 28

Euhaline/mud = 26

Euhaline/sand = 60

Candidate Metrics

- 9 candidate measures selected
- 4 habitats defined by substrate and salinity
- Each metric scored as a 5, 3, or 1

Number of Taxa
Shannon-Weiner
Abundance (# / m²)
Biomass
% abundance of pollution-indicative taxa
% abundance of pollution-intolerant taxa
% abundance of carnivore/omnivores
% abundance of deposit feeders
% abundance of suspension feeders

Final Metrics

- 5 candidate measures selected
- 4 habitats defined by substrate and salinity
- Each metric scored as a 5, 3, or 1

Number of Taxa
Abundance (# / m^2)
Biomass
% abundance of pollution-indicative taxa
% abundance of pollution-intolerant taxa

Threshold values

- Threshold values were established as the 5th and 50th percentile values for reference sites in each habitat.

- For each metric; values below the 5th percentile, were scored as 1, between the 5th and 50th were scored a 3, and values above the 50th percentile, were scored a 5.

- For each station, the mean of the metric scores was calculated for a station Index score

|	5	3	1
Number of species			
Polyhaline sand	>20	15-20	<15
Abundance (#/m²)			
Polyhaline sand	2,500-10,000	1,000-2,500 or 10,000-25,000	<1,000 or >25,000
Polyhaline mud	3,000-10,000	1,500-3,000 or 10,000-20,000	<1,500 or >20,000
Euhaline sand	3,000-10,000	1,500-3,000 or 10,000-50,000	<1,500 or >30,000
Euhaline mud	3,500-10,000	2,000-3,500 or 10,000-25,000	<2,000 or >25,000
Biomass			
Polyhaline sand	2 - 8	0.8 - 2 or > 8	< 0.8
Polyhaline mud	3 - 10	1 - 3 or > 10	< 1
Euhaline sand	2 - 10	0.8 - 2 or > 10	< 0.8
Euhaline mud	4 - 10	1 - 4 or > 10	< 1
Abundance of pollution-indicative taxa (%)			
Polyhaline sand	< 10	10 - 40	> 40
Polyhaline mud	< 10	10 - 40	> 40
Euhaline sand	< 10	10 - 40	> 40
Euhaline mud	< 10	10 - 40	> 40
Abundance of pollution-sensitive taxa (%)			
Polyhaline sand	> 15	3 - 15	< 3
Polyhaline mud	> 15	3 - 15	< 3
Euhaline sand	> 15	3 - 15	< 3
Euhaline mud	> 10	2 - 10	< 2

Validation Data Set

- NY/NJ Harbor 1993/4 REMAP data
  - 72 stations
- Final index contained 5 metrics
- B-IBI 93% effective at distinguishing stressed sites from reference
  - 91% of replicates at a site classified the same

Areal Extent of Benthic Impairment in the NY/NJ Harbor
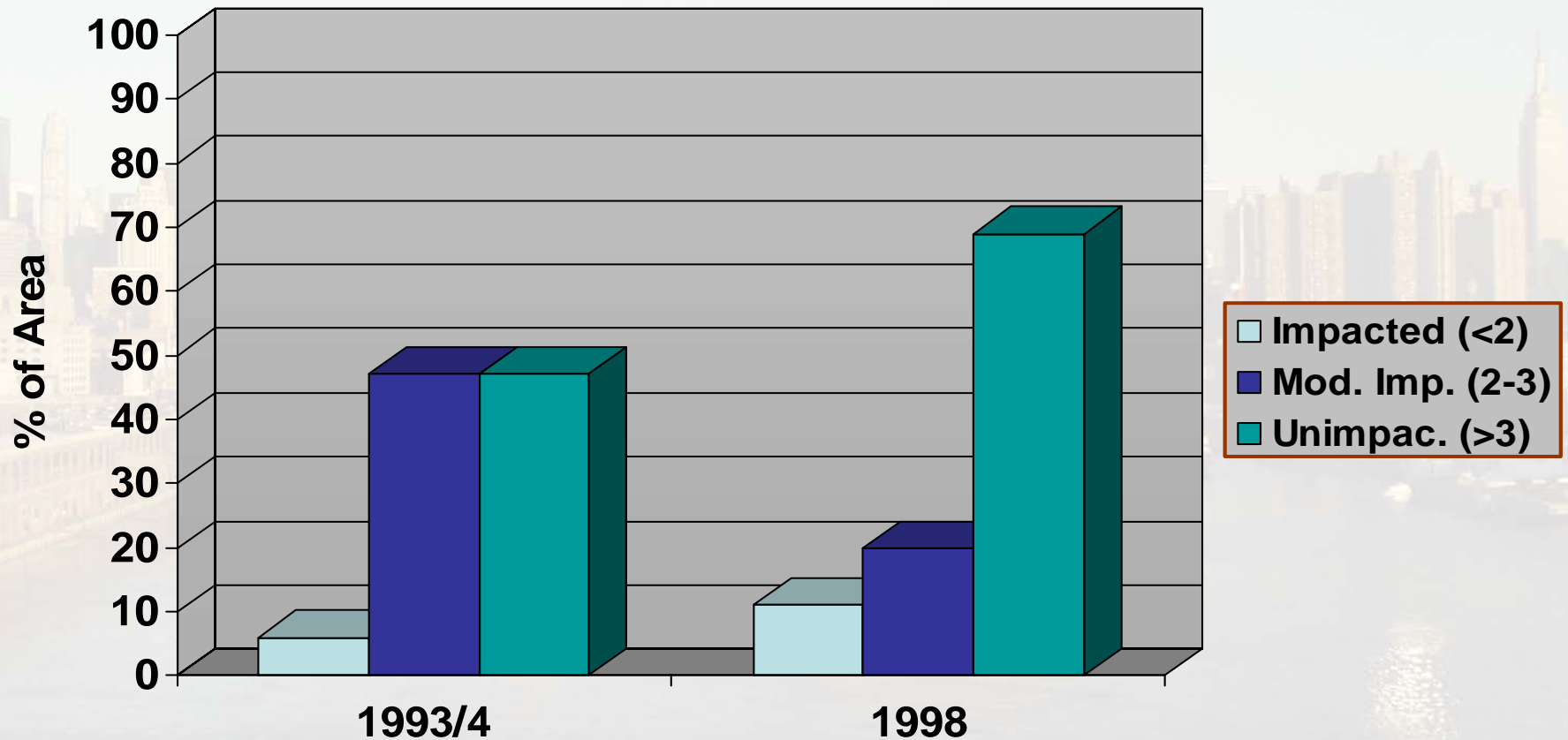
Comparison of Indices
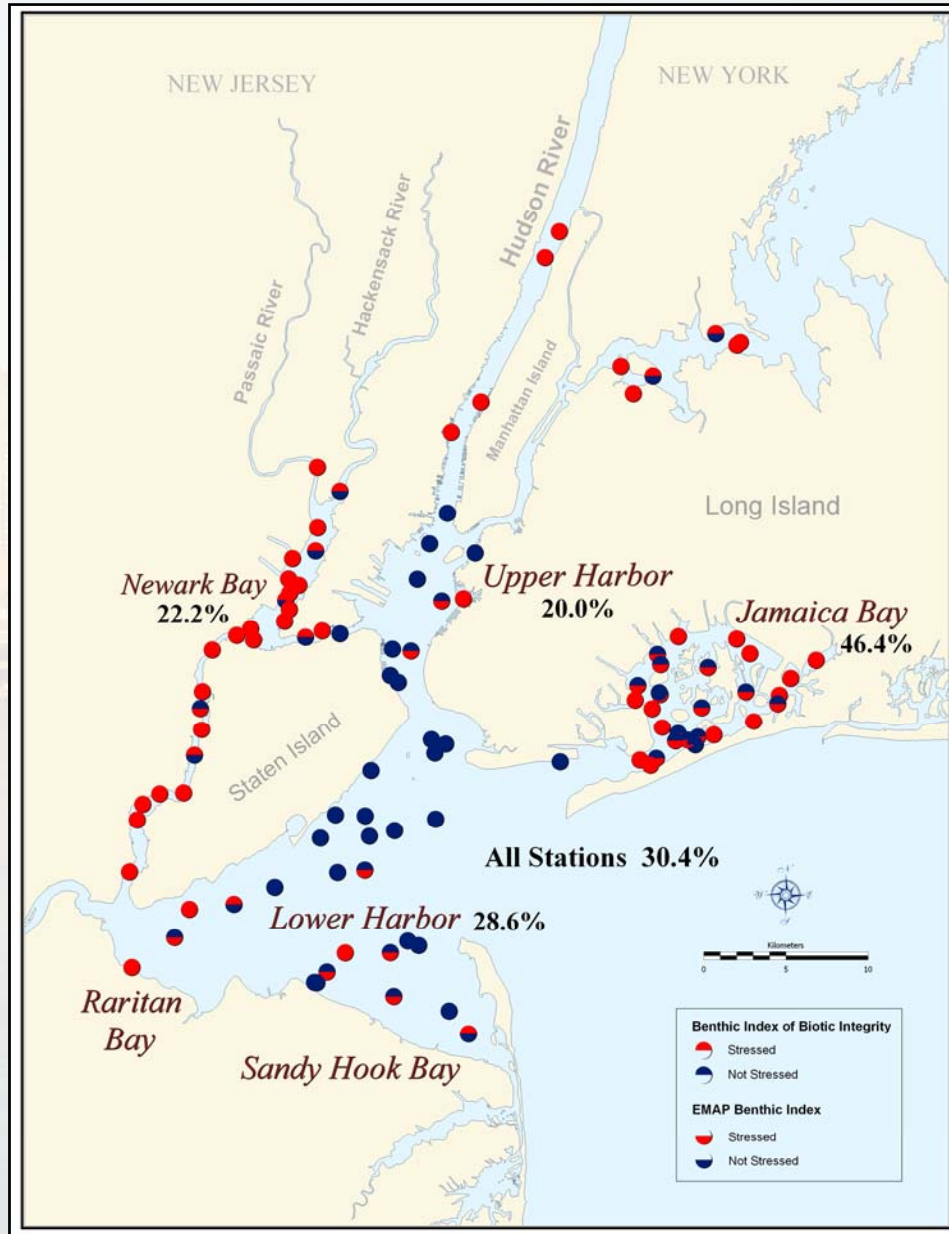
Conclusions and Recommendations

- Some improvement shown but still substantial contamination and effects
- Emphasis now on track-down, source control and pollution prevention activities
- Recommend continuing the trend assessment
  - 5 year or longer interval?
  - Evaluate the addition of emerging contaminants