COMPLEMENTARY MONITORING DESIGNS TO DOCUMENT REGIONAL GRADIENTS AND TEMPORAL VARIATIONS OF DISSOLVED OXYGEN IN ESTUARINE WATERS

Henry A. Walker[1], John A. Kiddon[1], Christopher F. Deacutis[2], Donald J. Cobb[1], Dana R. Kester[3], Candace A.Oviatt[3], John F. Paul[4], Gerald G. Pesch[1], Richard B. Moore[5], Keith W. Robinson[5].

[1]U.S. Environmental Protection Agency (USEPA), ORD, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, Rhode Island

[2]Univ of RI, Coastal **Institute, Narragansett, RI.**

[3]Univ of RI, Graduate School of Oceanography, Narragansett, RI

[4]U.S. Environmental Protection Agency (USEPA), ORD, National Health and Environmental Effects Research Laboratory, Research Triangle Park, North Carolina

[5]U.S. Geological Survey (USGS), New Hampshire/Vermont District, Pembroke, New Hampshire

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Research and Monitoring within an Integrated Assessment Framework

Clean Water Act
[305(b) reporting, 303(d) listing, and follow-up

- **Tier 1: Characterization of the Problem**
  - **Broad scale response properties**
  - **(surveys, automated collection and / or remote sensing)**
- **Tier 2: Diagnosis of Causes**
  - **Issue or resource specific surveys and observations**
  - **(focusing on cause and effect interactions)**
- **Tier 3: Diagnosis of Interactions and Forecasting**
  - **Intensive monitoring and research index sites with higher spatial and temporal resolution to determine specific mechanisms of interaction.**
  - **Needed to build cause and effect models**

The Future: A National Strategy NCCR 2001 – Chap. 9.

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Research and Monitoring within an Integrated Assessment Framework

"Only through a coordinated and integrated effort can coastal coastal monitoring be successful at all levels at which is is necessary to preserve, protect, manage and enhance the coastal resources of the United States"

NCCR-2001

National Coastal Assessment (NCA)
Broad scientific questions

- What are the conditions of estuarine resources in the U.S., how are they changing, and what are the causes of those changes?
  - **To document conditions, we need to systematically gather data, in addition to tapping into expert opinion.**

- How well do different coastal condition indicators and monitoring design variations work?
  - **Tier 1: broad probabilistic surveys.**
  - **Tier 2: diagnostic monitoring.**
  - **Tier 3: physical - biological interactions & forecasting.**

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

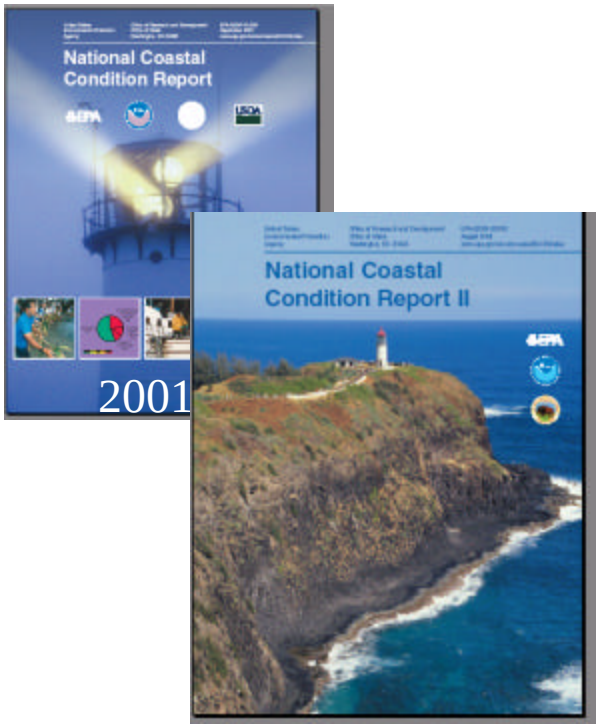
Monitoring Designs

- Stratified Random (probability) Designs
  - e.g. NCA to document “baseline conditions”
- NCA Designs include “Trend Sites”
  - about 20% of the effort for site revisits
- NCA - Hybrid Designs
  - Include sites from other monitoring programs
- Complementary Monitoring Designs
  - Issue specific, with targeted sampling
- Fixed station networks / “index sites”

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

National Coastal Condition Reports.



2004

Preliminary Findings

From summer 2000

Draft National Coastal Condition Report II, released for public comment

http://www.epa.gov/owow/oceans/nccr2/index.html

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

2004

NCCR2: Chapter 3 Northeast Coastal Conditions

Illustrates approaches that may be useful for Clean Water Act 305(b) reporting

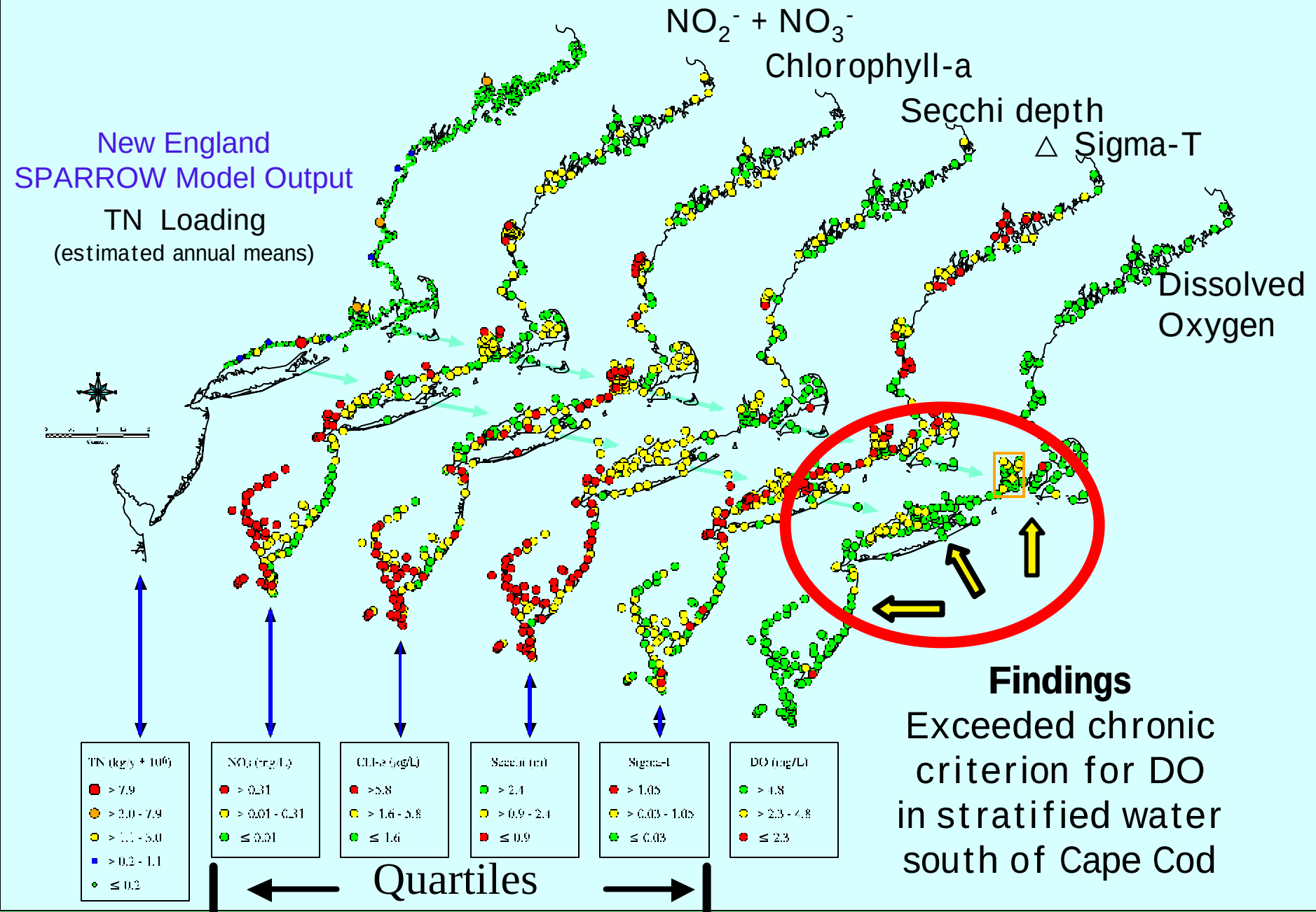
"Highlights":

- Northeast Coastal Water Quality
- Monitoring in Long Island Sound & Narragansett Bay
- New England SPARROW Model

http://www.epa.gov/owow/oceans/nccr2/index.html

National Coastal Assessment: Regional Characterization

Probabilistic sampling design / Summer 2000.



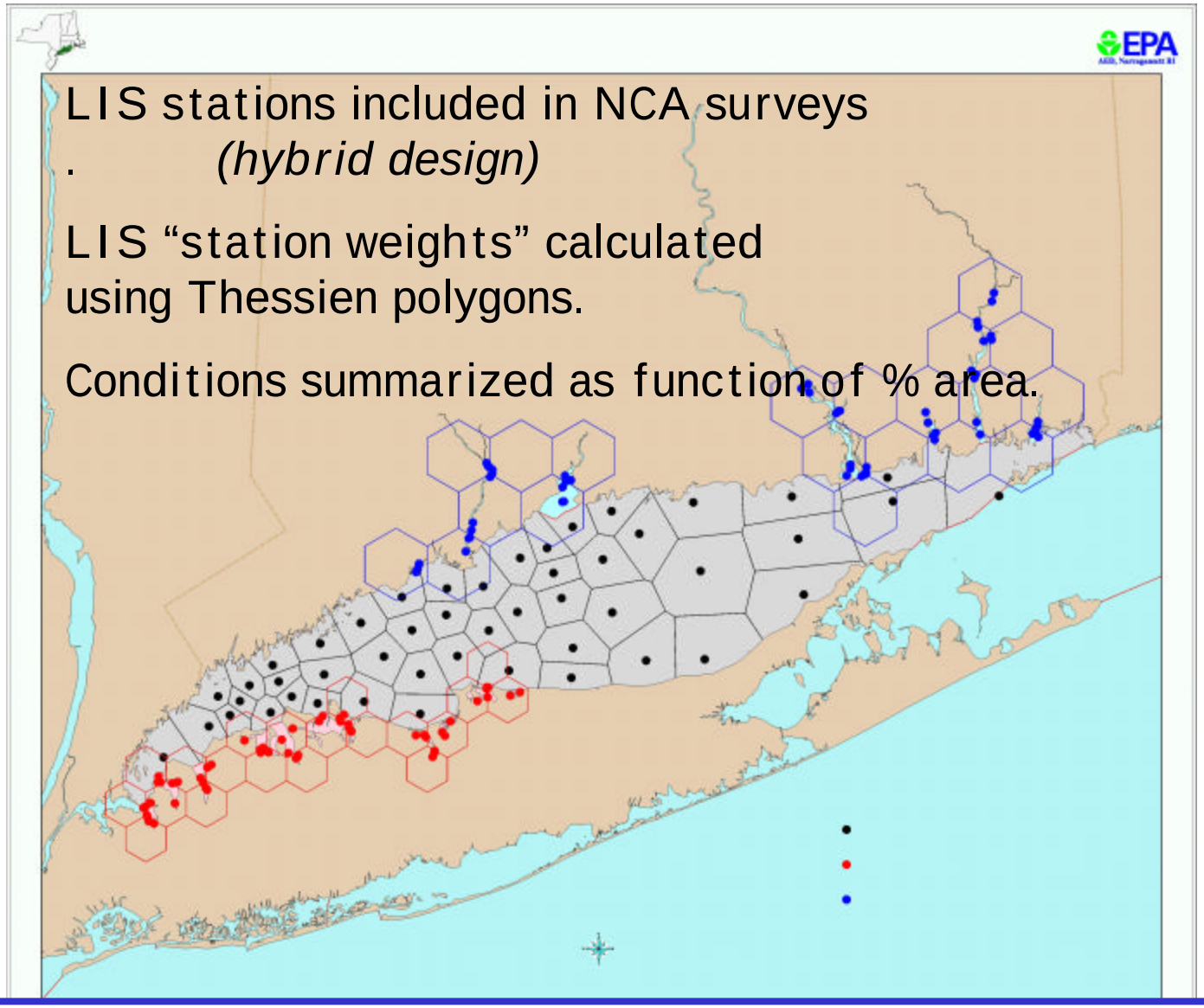
Findings

Exceeded chronic criterion for DO in stratified water south of Cape Cod

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Long Island Sound (LIS) Stations



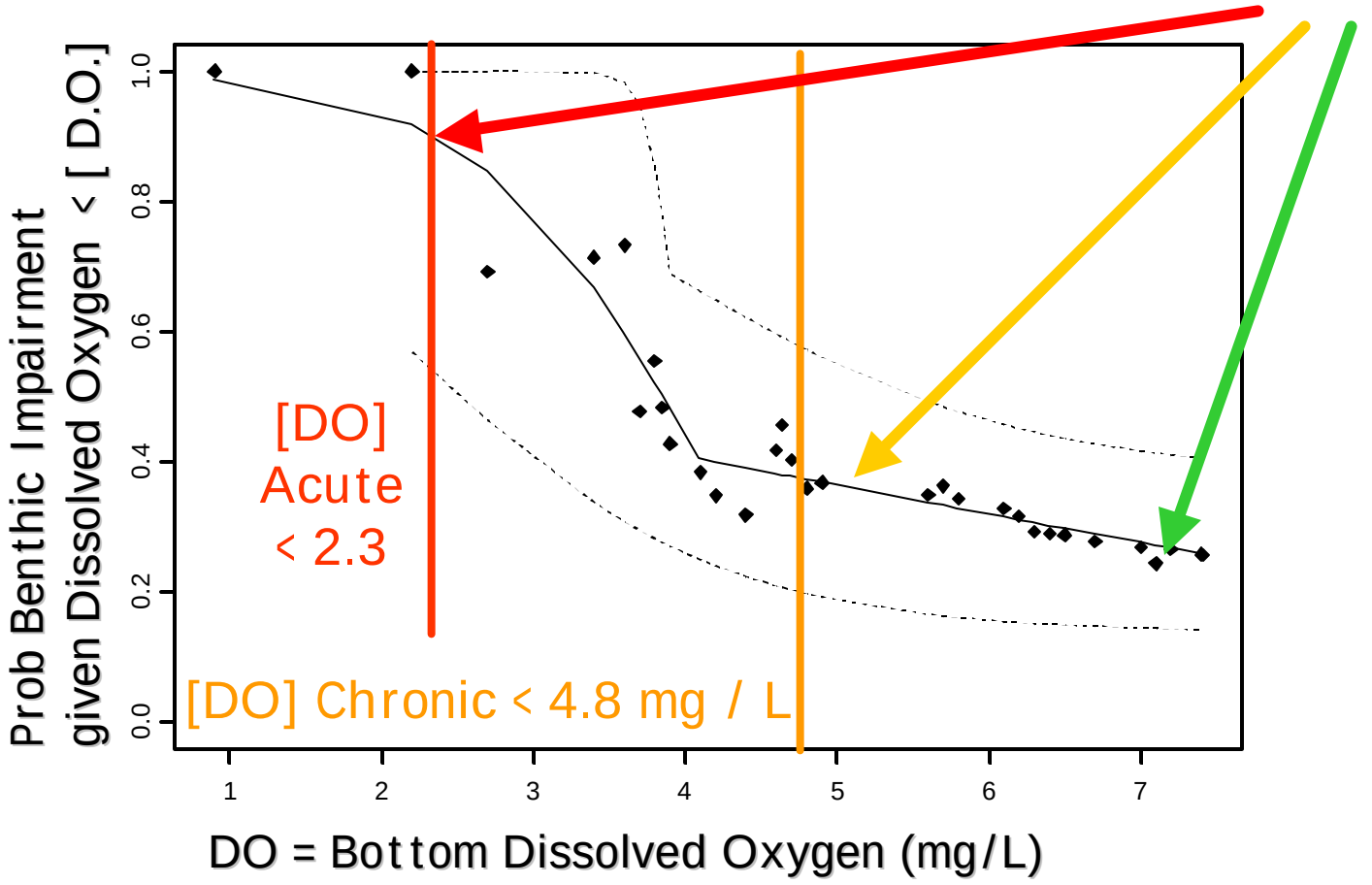
Used to estimate the percent area with impaired benthic communities, in relation to gradients in dissolved oxygen

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Open-Water (Offshore) of Long Island Sound
EMAP-Virginian Province 1990-93

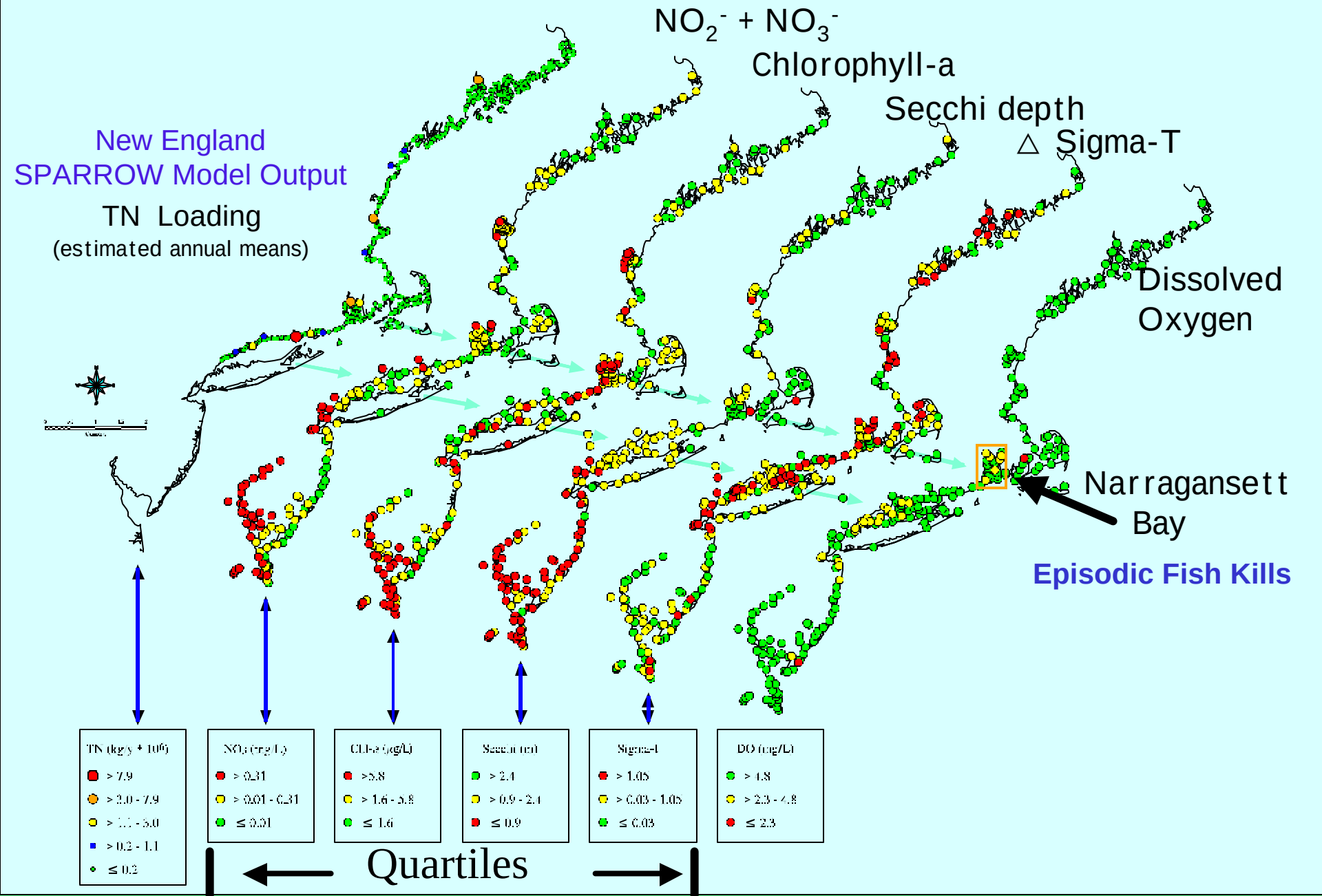
Probability of Benthic Impairment for Dissolved Oxygen < [DO]



Probability calculations weighted by station - areas

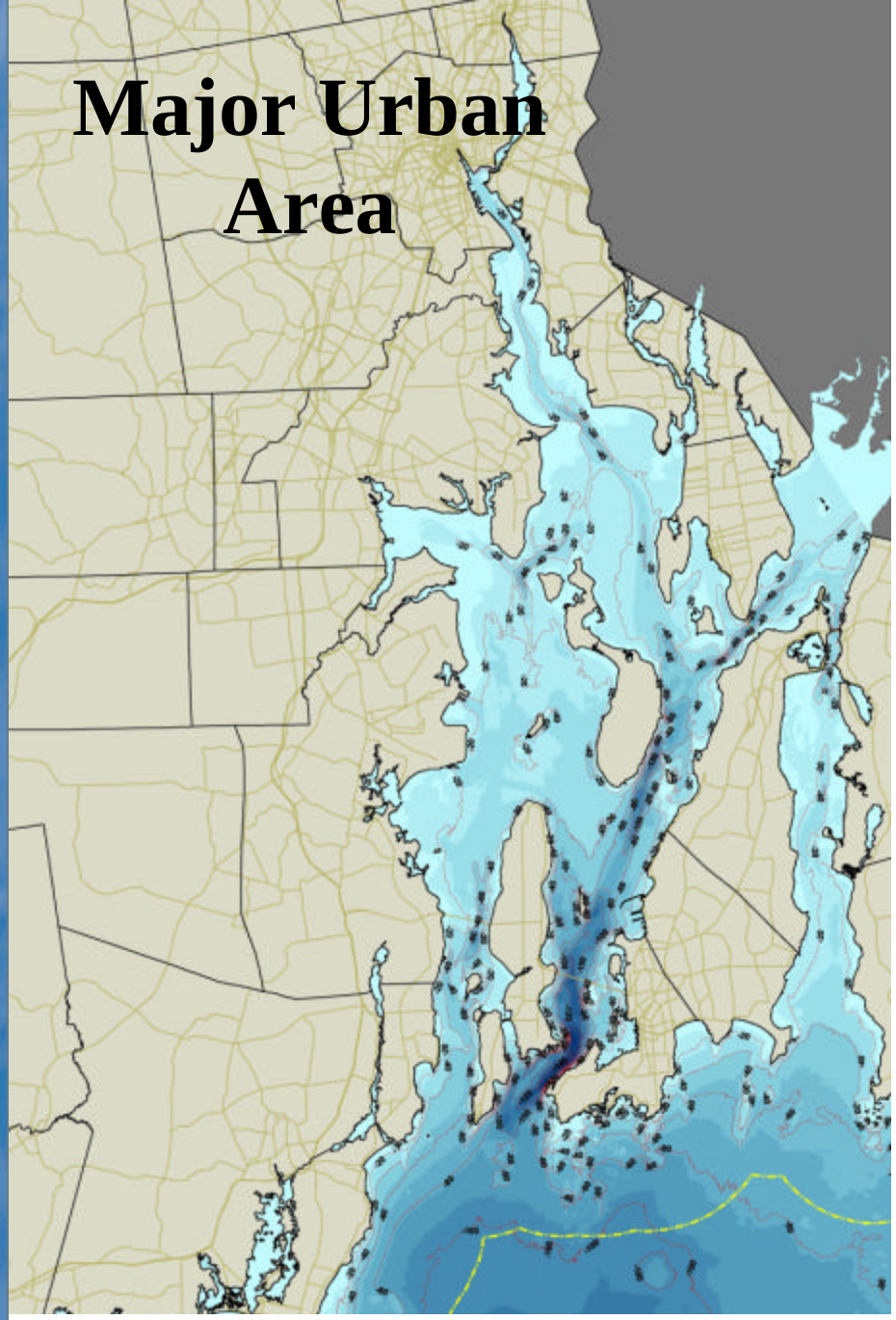
National Coastal Assessment: Regional Characterization

Probabilistic sampling design / Summer 2000.



RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions



http://www.edc.uri.edu/fish/imagemaps.html

Narragansett Bay

Nutrient Loading

- Rivers
- Several wastewater treatment facilities

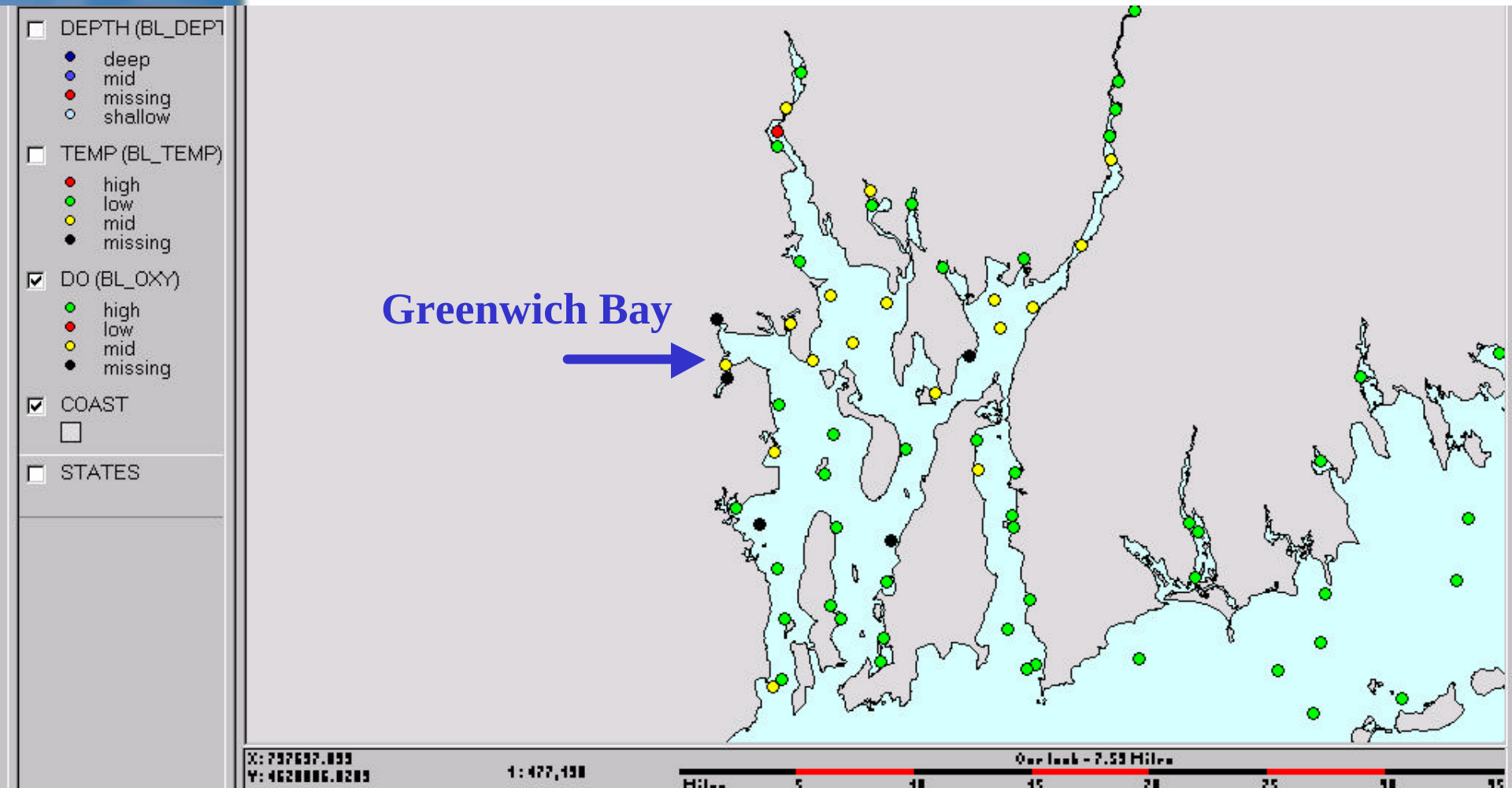
- **In summer 1997-98 found lower Dissolved Oxygen than expected in the upper Bay.**

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

NCA Bottom Water Dissolved Oxygen

NCA samples from summer of 2000, & 2001
Illustrate [DO] < 5.0 mg / l in upper Bay,
but rarely capture “acute” events [DO] < 2.3 mg / l,
and didn’t document duration of hypoxic events.



In Upper Narragansett Bay, RI
Episodic Fish Kills

Fish Kill 6 / 28 / 01 – Greenwich Bay

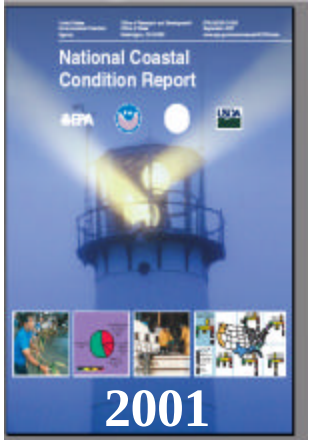
Surface D.O. : 3.8 mg/l inshore; 6.0 mg/L offshore

Bottom D.O. : < .05 mg/L near shore @ 1.8 m ;

0.6 mg/L offshore @ 3 m

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions



Research and Monitoring within an Integrated Assessment Framework

- **Tier 1: Characterization of the Problem**
  - **Broad scale response properties**
  - **(surveys, automated collection and / or remote sensing)**

- **Tier 2: Diagnosis of Causes**
  - **Issue or resource specific surveys and observations**
  - **(focusing on cause and effect interactions)**

- **Tier 3: Diagnosis of Interactions and Forecasting**
  - **Intensive monitoring and research index sites with higher spatial and temporal resolution to determine specific mechanisms of interaction.**
  - **Needed to build cause and effect models**

RESEARCH & DEVELOPMENT

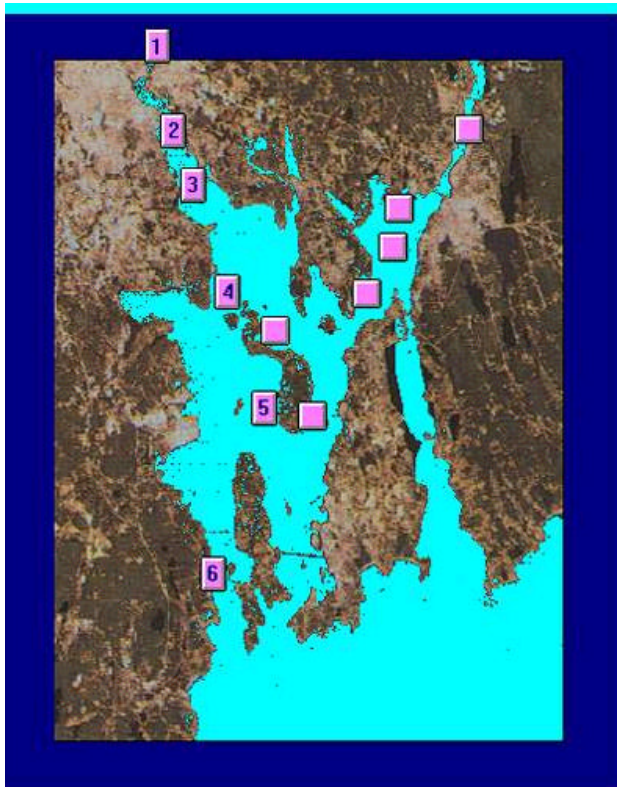
Building a scientific foundation for sound environmental decisions

Narragansett Bay

Temporal variability in surface and bottom DO studies using automated time-series measurement systems.

Dana Kester et al,
Detailed diagnostic studies at fixed station network

Narragansett & Mt Hope Bay: Automated Instrumentation at 12 sites
sensors 0.5 m below the surface and 1.0 m above the bottom :
T, S, O_2 , Chl Fluorescence, & Water level



University of Rhode Island, Graduate School of Oceanography (stations 1 thru 6)

RI DEM

Roger Williams Univ.,

University of Mass
(Boston and Dartmouth)

Mass. Coastal Zone Management Office.

http://www.gso.uri.edu/~dkester/nbay/obsnet.htm

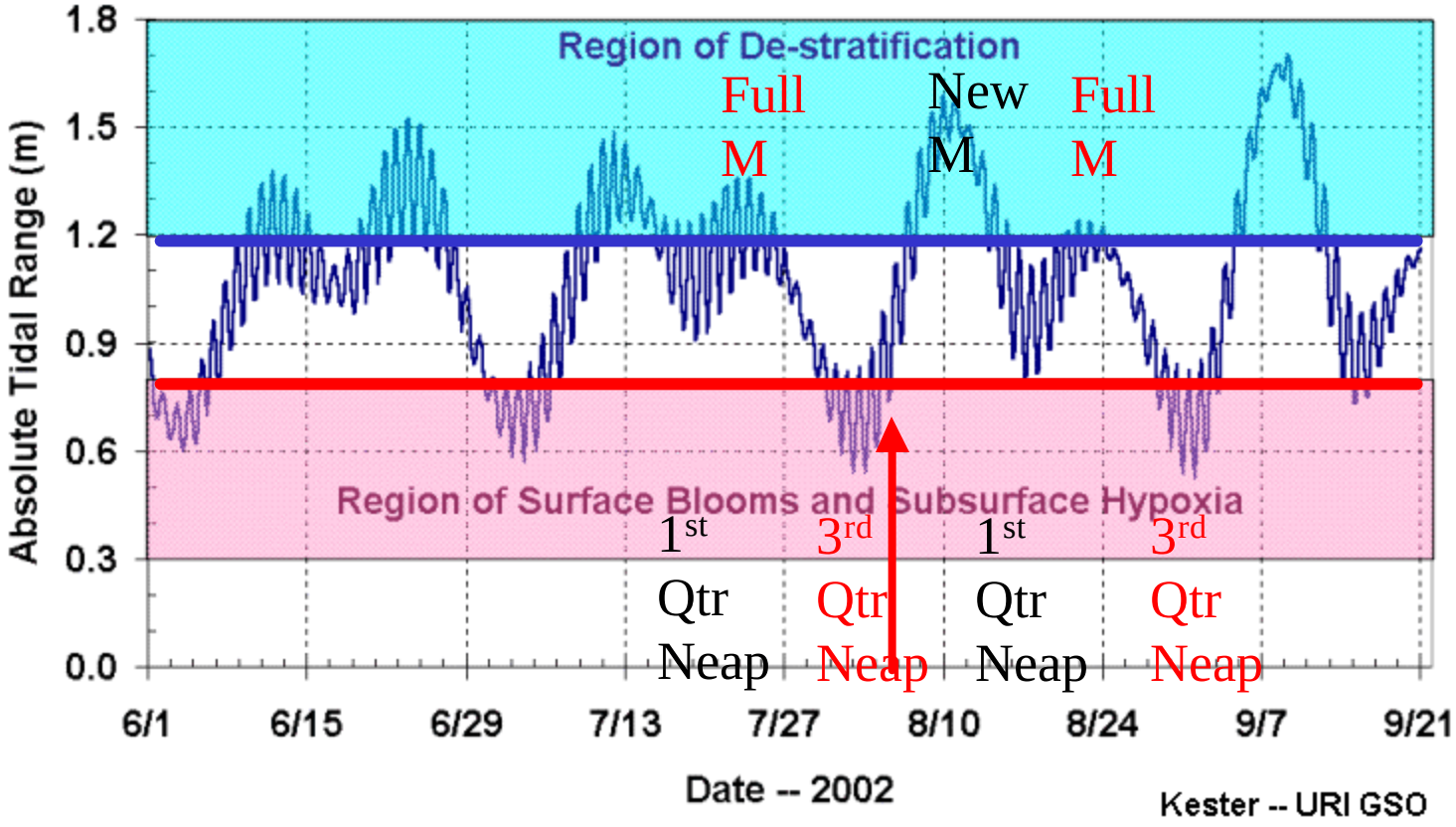
RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Chap. 3 Report Highlight:
Highlight on Narragansett Bay

Influence of tidal range variations on stratification in the upper Bay

2004



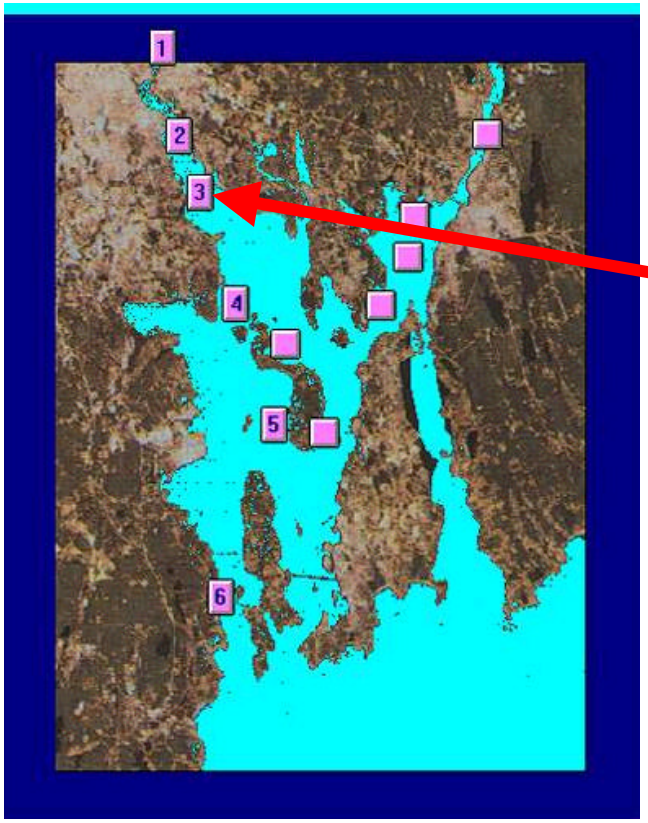
http://www.gso.uri.edu/~dkester/nbay/index.htm

Narragansett Bay

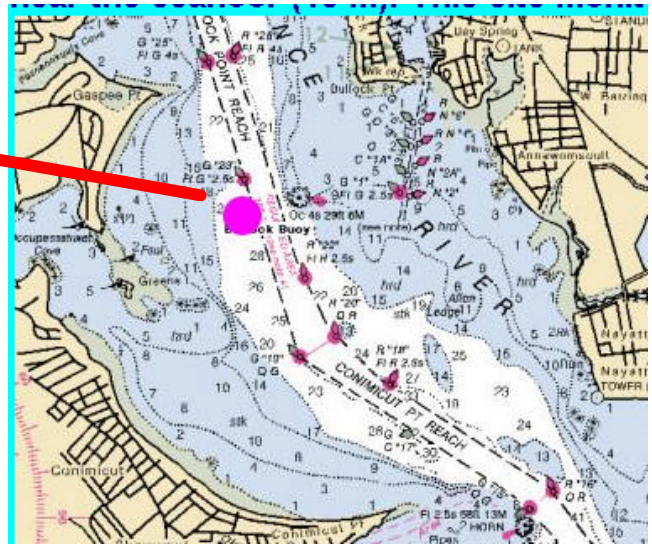
Temporal variability in surface and bottom DO studies using automated time-series measurement systems.

Dana Kester et al,
Detailed diagnostic studies at fixed station network

Narragansett & Mt Hope Bay: Automated Instrumentation at 12 sites
sensors 0.5 m below the surface and 1.0 m above the bottom :
T, S, O_2 , Chl Fluorescence, & Water level



Bullock Reach Buoy



http://www.gso.uri.edu/~dkester/nbay/bullock.htm

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

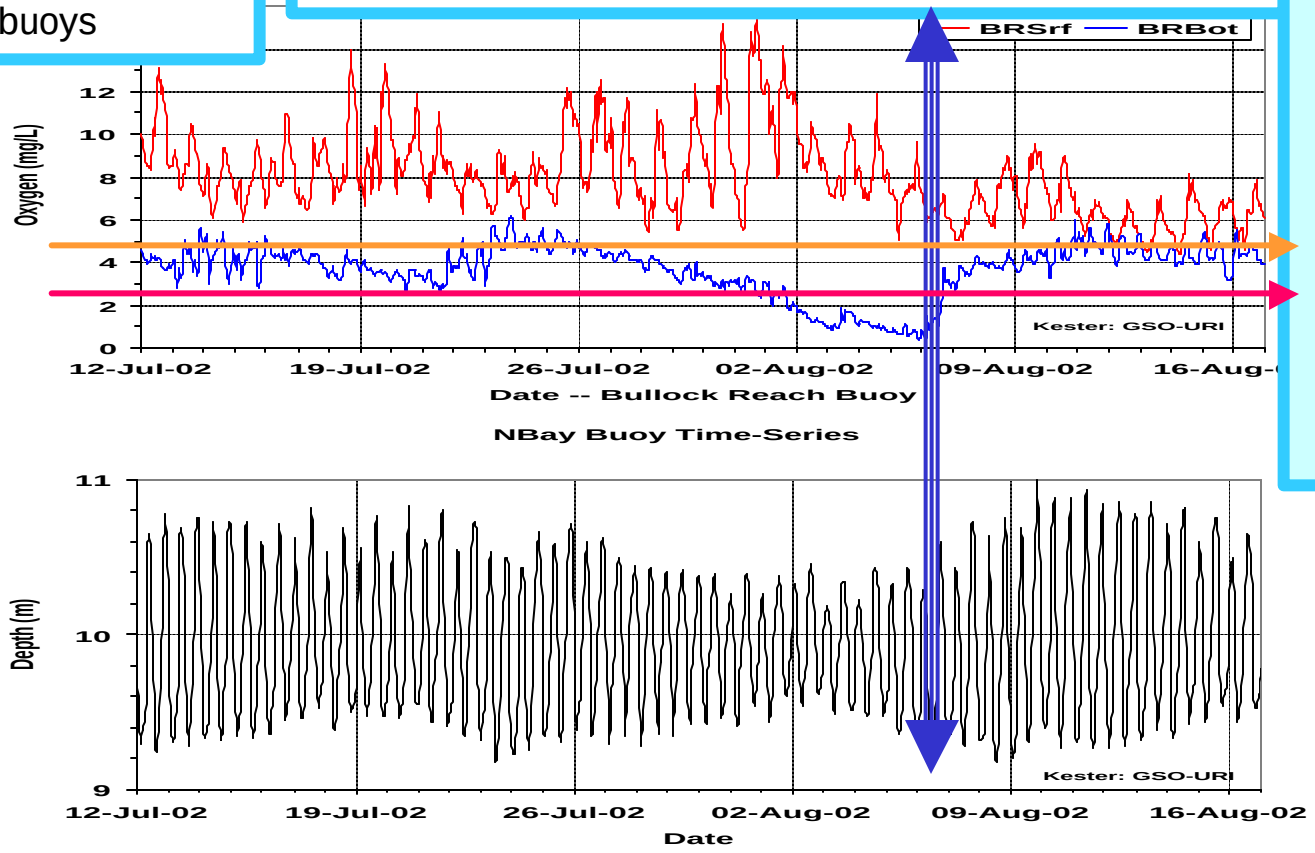
Time Series measurements

link physical & biological conditions

Saltwater DO Criteria are based on combination of dissolved oxygen concentration and duration

Data from moored buoys

Targeted Sampling for low DO on August 6,2002
5 days after the minimum neap tide on August 1st



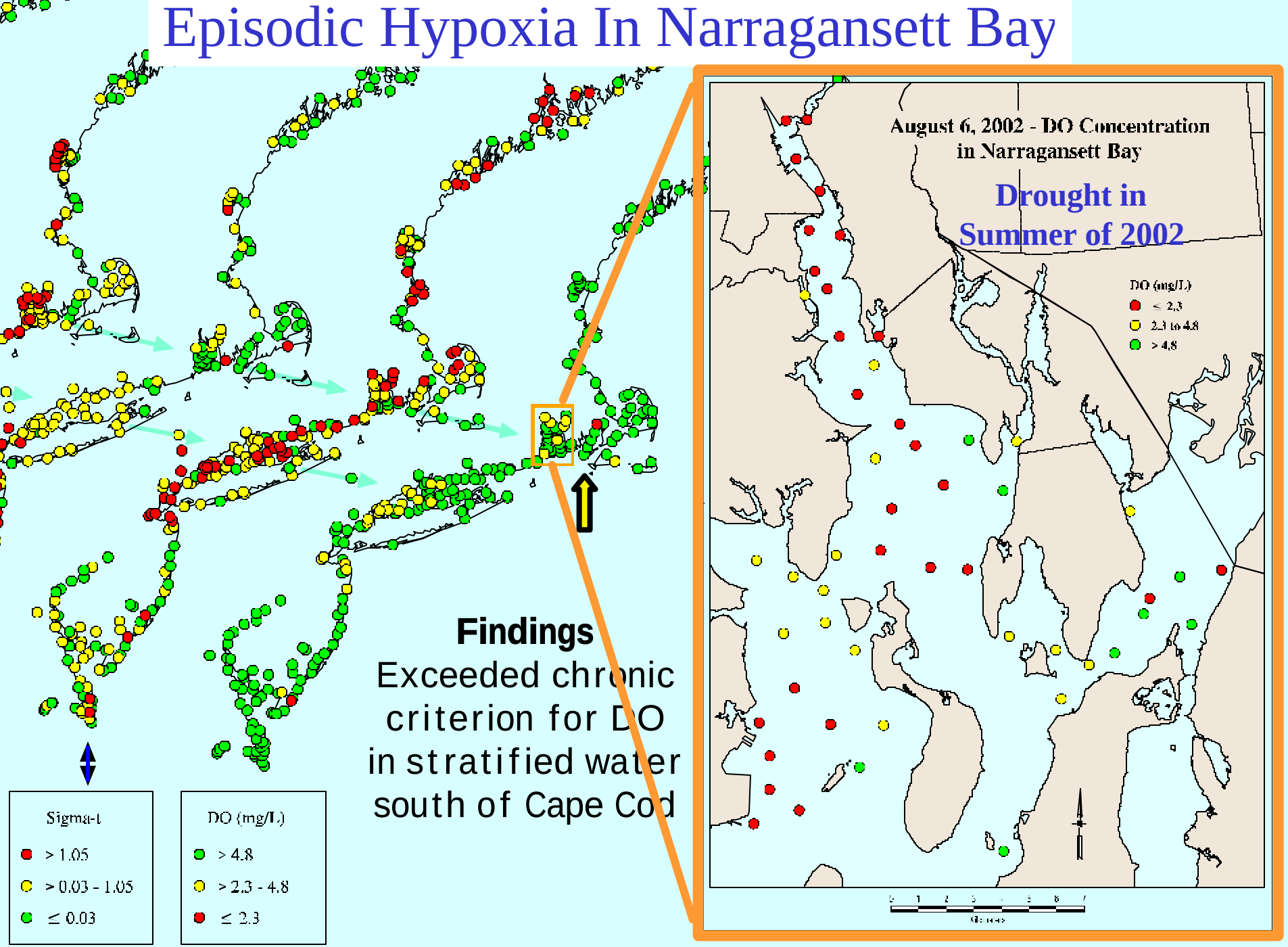
Findings

In bottom water:

Chronic DO Criterion exceeded for 10 days after July 26th

Acute DO Criterion exceeded for 5 days after Aug 1st neap tide.

Episodic Hypoxia In Narragansett Bay



Findings

Exceeded chronic criterion for DO in stratified water south of Cape Cod

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

SPATIAL AND TEMPORAL VARIATIONS OF DISSOLVED OXYGEN IN ESTUARINE BOTTOM WATERS OF THE NORTHEASTERN U.S.

SPATIAL:

- Broad scale probabilistic resource surveys

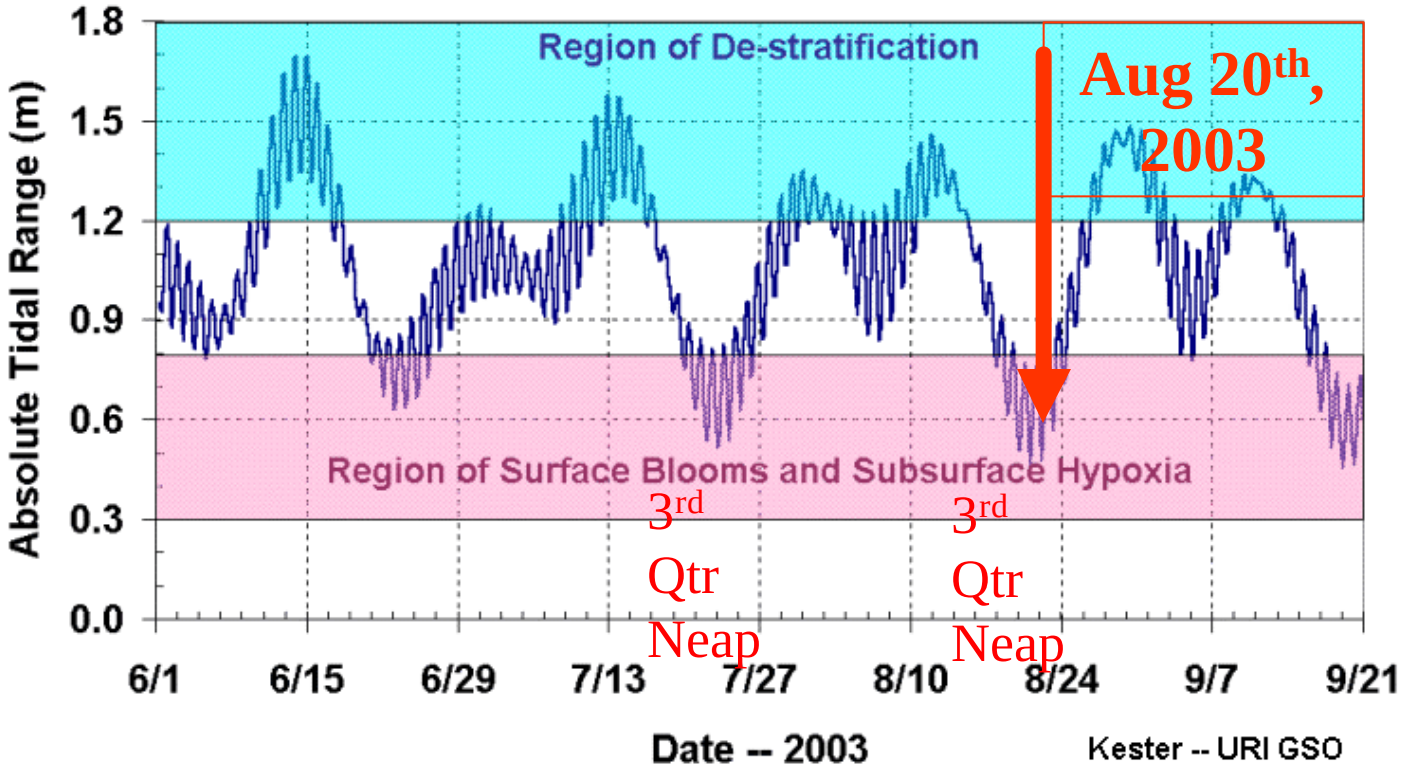
TEMPORAL:

- Moored instrumentation at specific locations
- Targeted sampling during periods of increased water column stratification (extent of acute events)

Research and Monitoring within an Integrated Assessment Framework

Tier 3: Diagnosis of Interactions and Forecasting

When is low dissolved oxygen likely in Narragansett Bay ?
Prediction: Low DO event possible in late July & late Aug 2003.
(Dana Kester, URI-GSO)

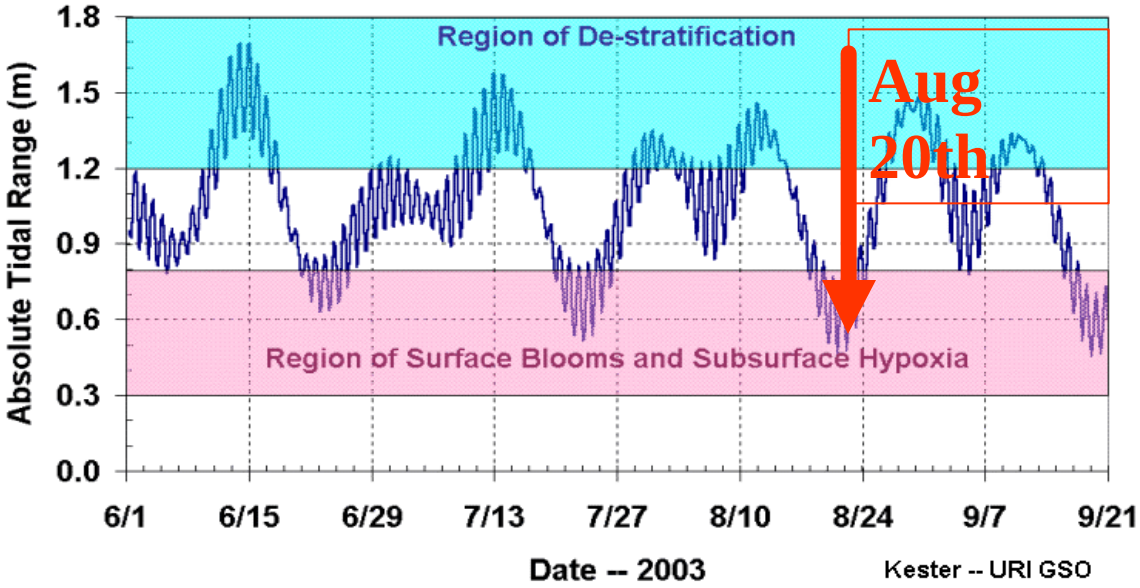


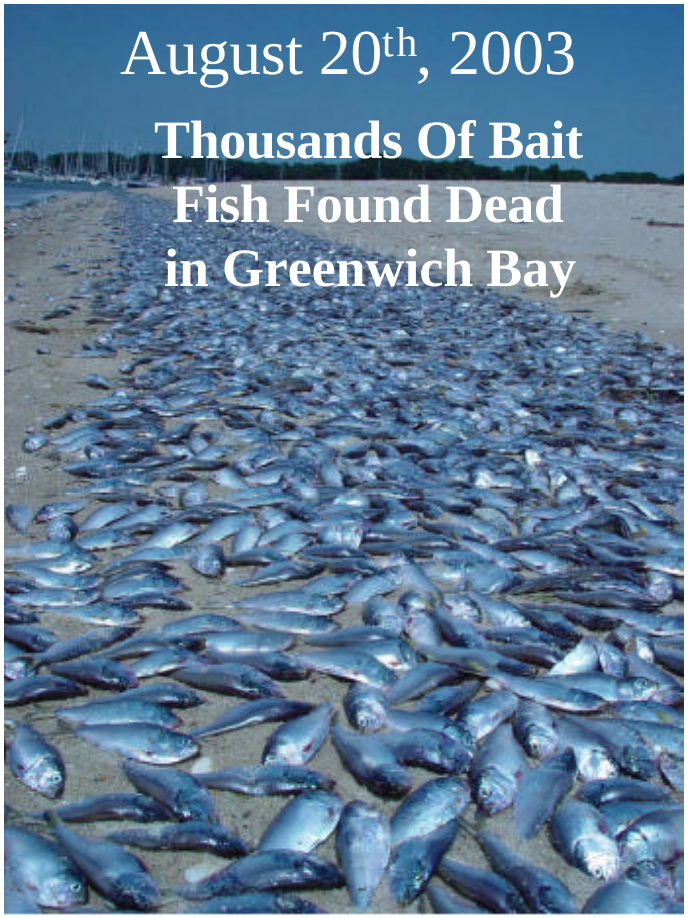
RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Dissolved Oxygen in Narragansett Bay

Summer of 2003 was wet.
Extent and persistence of low DO water was greater than in 2002.





RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Research and Monitoring within an Integrated Assessment Framework

- **Tier 1: Characterization of the Problem**
  - **Broad scale response properties**
  - **(surveys, automated collection and / or remote sensing)**
- **Tier 2: Diagnosis of Causes**
  - **Issue or resource specific surveys and observations**
  - **(focusing on cause and effect interactions)**
- **Tier 3: Diagnosis of Interactions and Forecasting**
  - **Intensive monitoring and research index sites with higher spatial and temporal resolution to document processes & determine specific mechanisms of interaction.**
  - **Needed to build physical-chemical-biotic cause and effect models**

RESEARCH & DEVELOPMENT

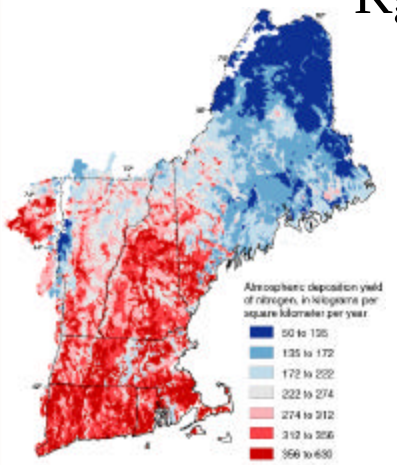
Building a scientific foundation for sound environmental decisions

Predicted Nitrogen Fluxes

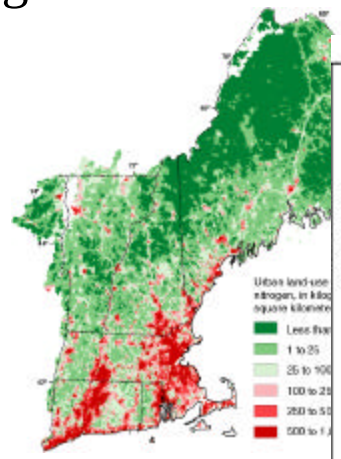
New England SPARROW Model

Estimated yield TN

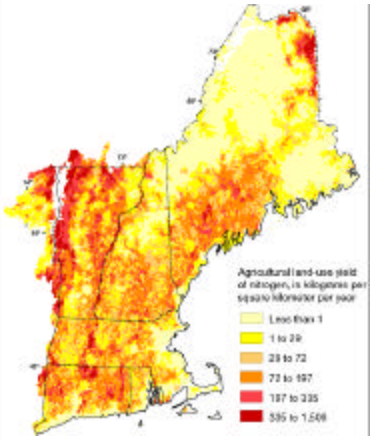
Kg / Km^2 / Yr



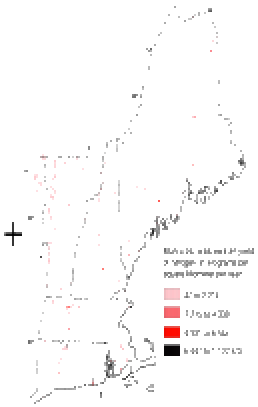
Atmospheric



Urban

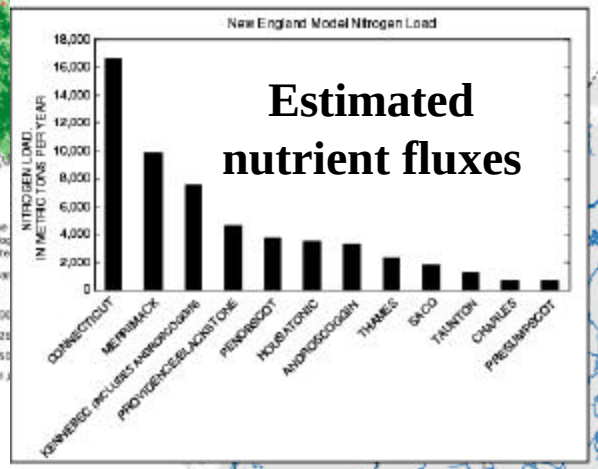


Agriculture



Point Source

Estimated fluxes at index sites



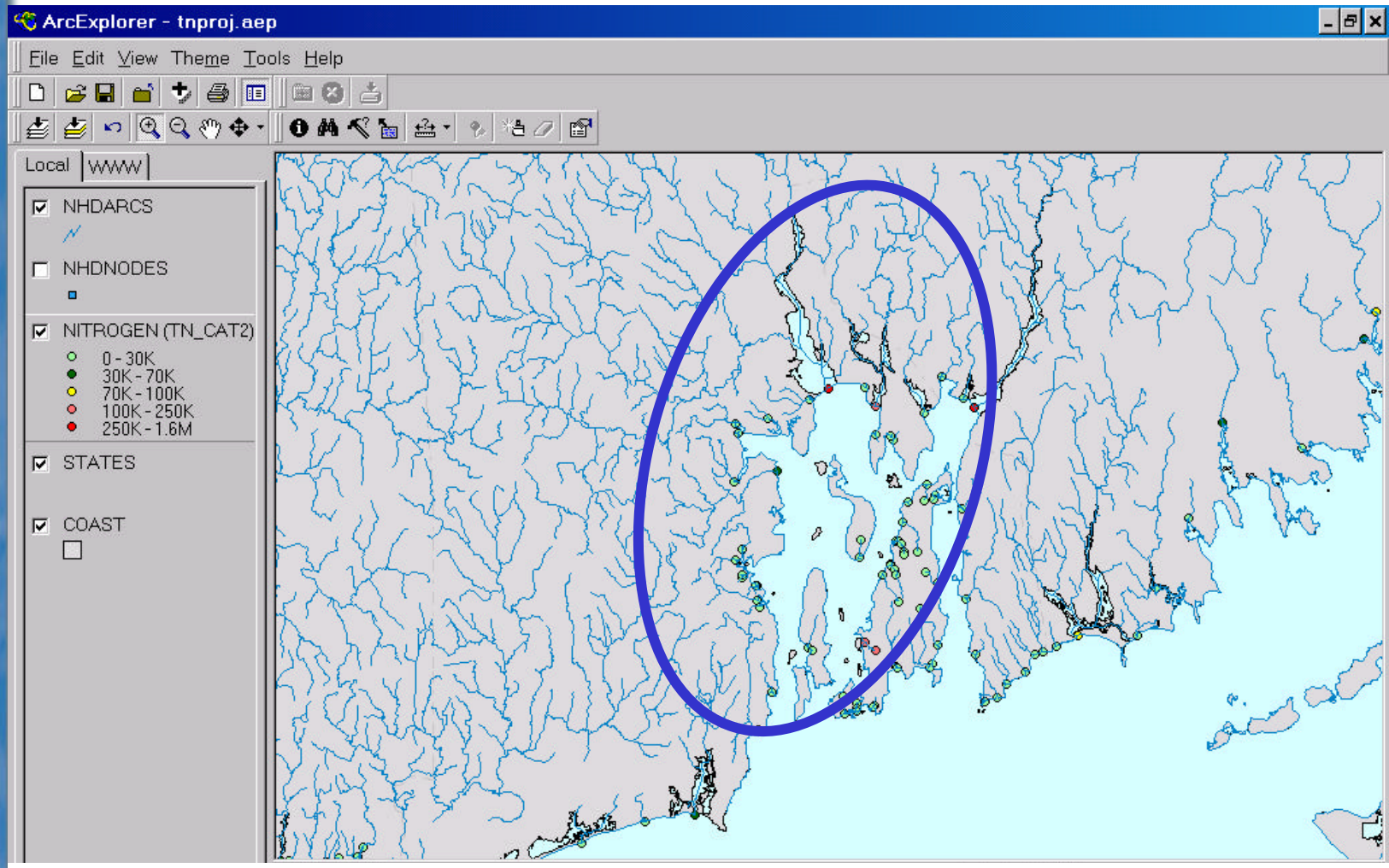
Estimated nutrient fluxes

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Landside TN Input to Narragansett Bay

Approximately 70% of the TN
estimated to be from point sources



(more detail Ed Dettmann's talk – end of this session)

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions

Methods to Integrated Monitoring and Assessment for Clean Water Act [305(b) 303(d)] Reporting

To address hypoxia in coastal waters.

- **Tier 1: Characterization of the Problem**
  - **Broad scale response properties**
  - **(surveys, automated collection and / or remote sensing)**
- **Tier 2: Diagnosis of Causes**
  - **Issue or resource specific surveys and observations**
  - **(focusing on cause and effect interactions)**
- **Tier 3: Diagnosis of Interactions and Forecasting**
  - **Intensive monitoring and research index sites with higher spatial and temporal resolution to determine specific mechanisms of interaction.**
  - **Collecting the info needed to build cause and effect models**

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions