TARGETED MONITORING FOR DISSOLVED OXYGEN : MAPPING THE EXTENT OF HYPOXIA IN NARRAGANSETT BAY, RI

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Narragansett Bay Watershed

Watershed Area =

4,714 km²

Bay Surface Area =

370 km ²

Watershed:Surface Area ~ 13: 1

3 Major River Basins :

Taunton ; Blackstone ; Pawtuxet Rivers

Annual Mean Mo. Flow =

104 m3/sec

61% of drainage basin in MA

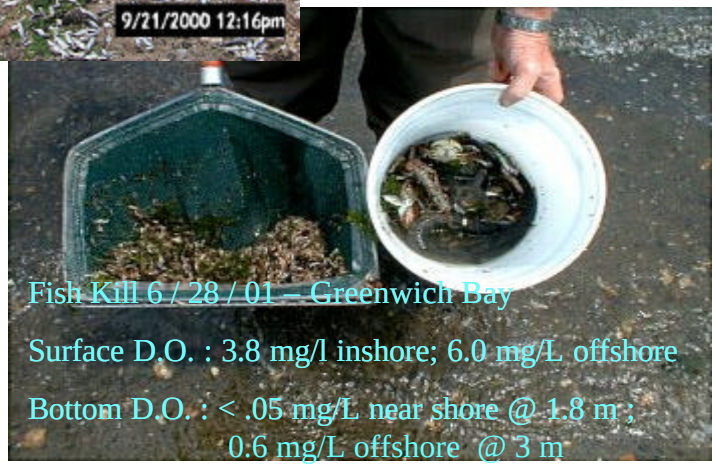
N-S Pollution Gradient ✸ STP

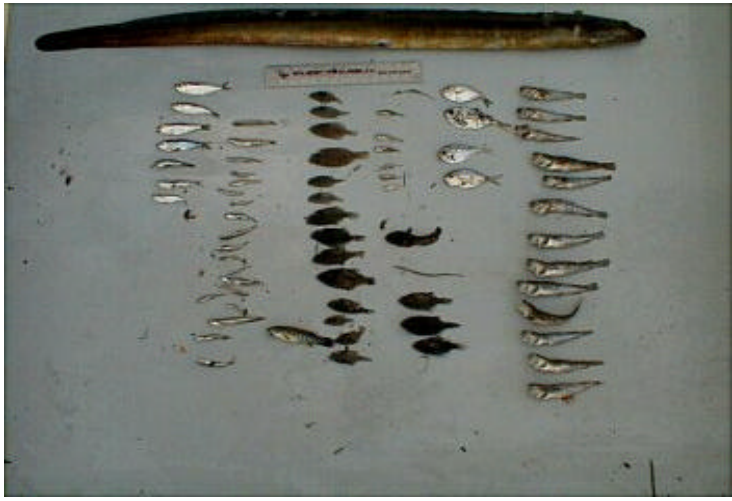
First Inklings of NE Jubilees in Narragansett Bay– Summer 1986 – *"Grey-green paint"* ***complaints***

Multi-Species Kills in Narragansett Bay

Menhaden ONLY (Bluefish Victims) –

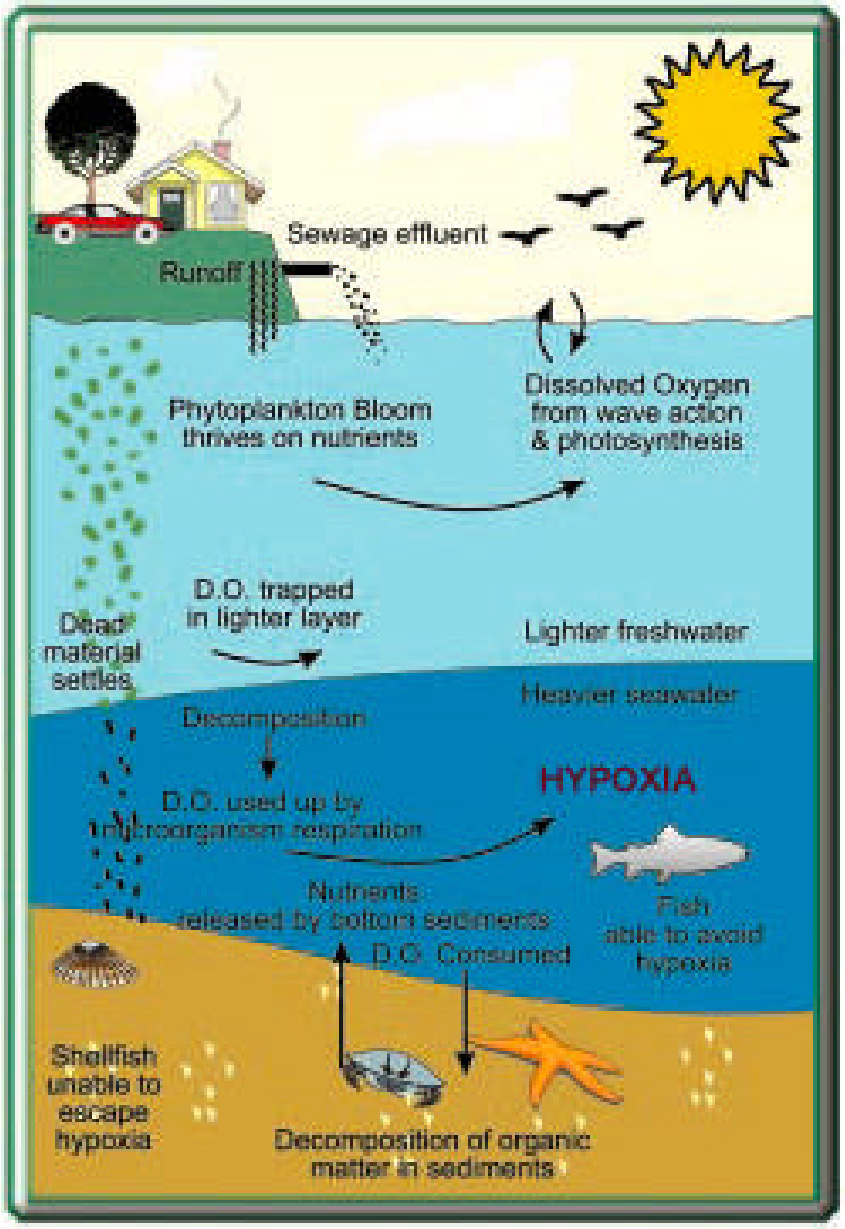
NOT anoxia





The Cause : Nutrients

(SW = NITROGEN)

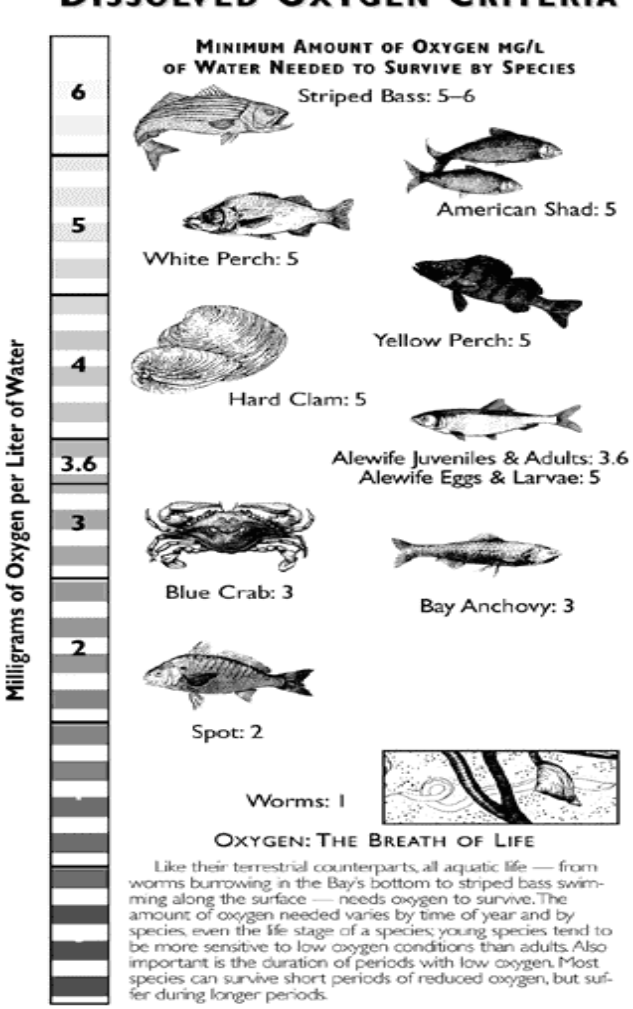


One BAD Impact:

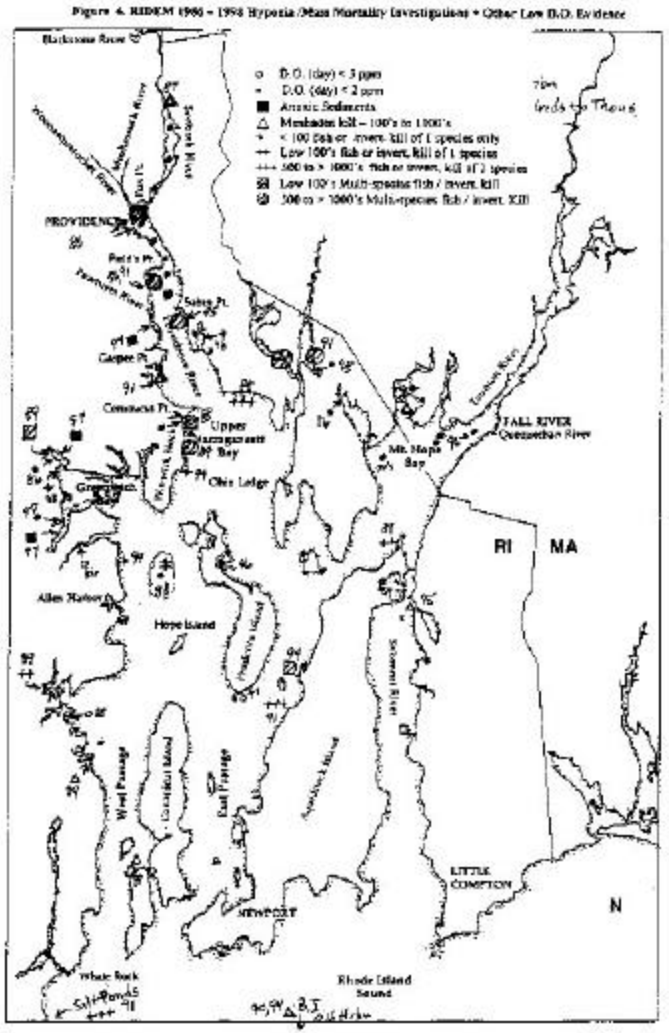
HYPOXIA / ANOXIA

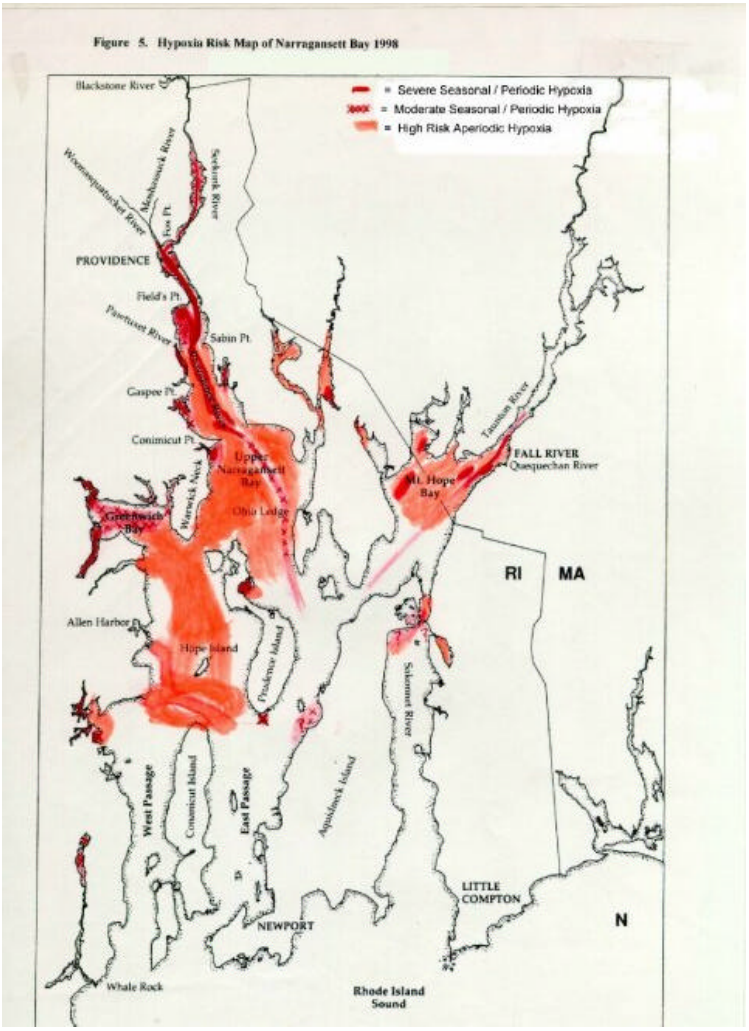
EPA Acute = 2.3 mg/L

Chronic = 4.8 mg/L



C. Deacutis (1999) . Nutrient Impacts and Signs of Problems in Narragansett Bay. pp7-23. *In*: Kerr, M. (Ed.). 1999. Nutrients and Narragansett Bay: Proceedings of a Workshop on Nutrient Removal from Wastewater Treatment facilities. RI Sea Grant. Narragansett RI 64 pp.





Targeted hypoxia monitoring design:

Use Pollution/ Nutrient N-S gradient to focus on Upper Half

What factors drive hypoxia in Narragansett Bay?

No.1 = **STRATIFICATION**

(*stratification factors?* based on D. Kester /D. Bergondo URI)

-Tidal Currents / mixing energy (late in neap)

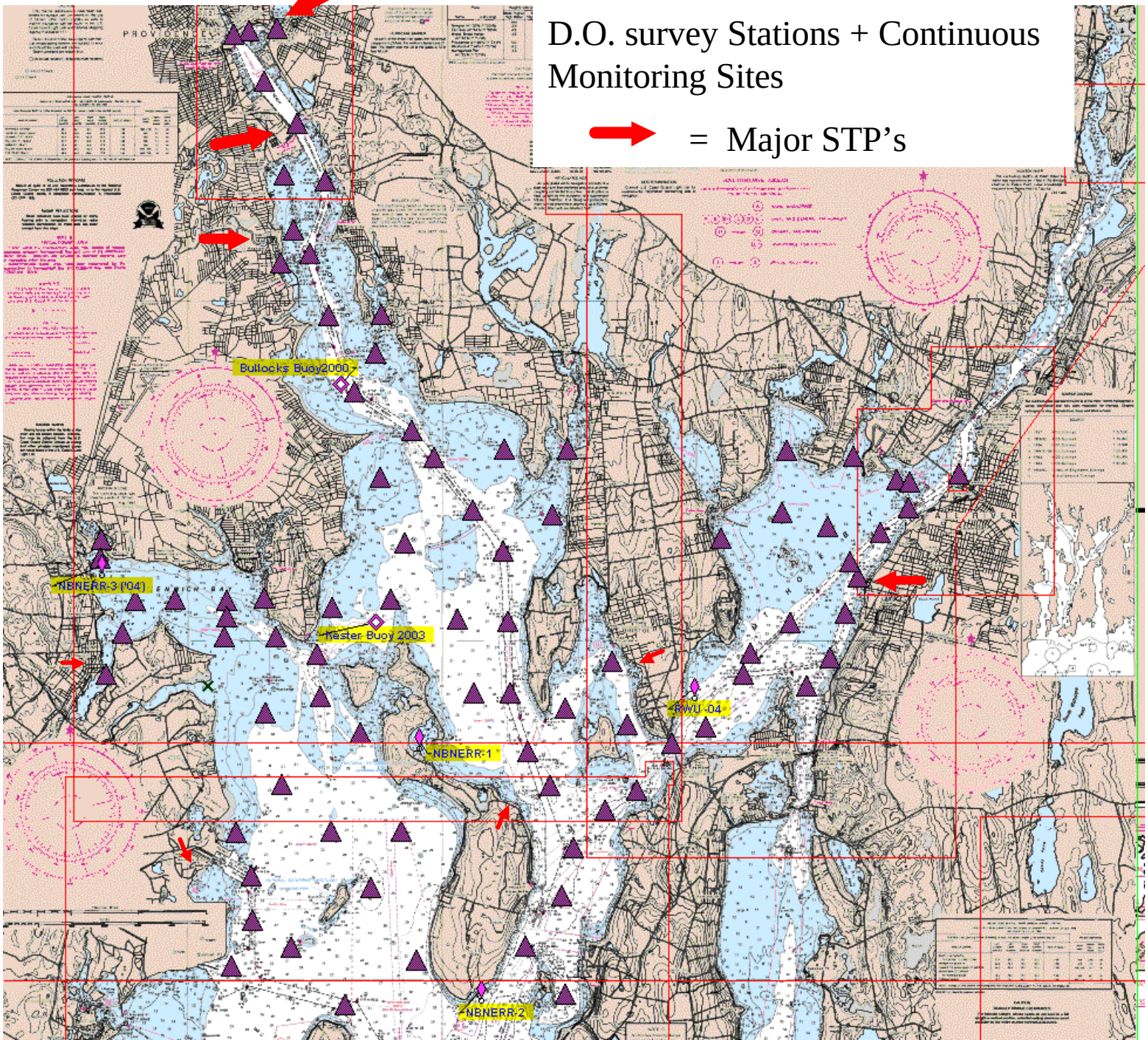
- Water Temperature (Summer)

- FW Inflow (after rainstorms ?)

- Wind (Low wind = eve.)

Original Concept – Neap tide "Strike Team" – watch buoy data

Reality : takes 3-4 days prep for successful survey
= schedule by Neap Tides "windows"


D.O. survey Stations + Continuous Monitoring Sites
= Major STP's
Bullocks Buoy2000
NBNERR-3 ('04)
Nester Buoy 2003
RWU-04
NBNERR-1
NBNERR-2

The "Insomniacs" D.O. Strike Force

Brown Univ.

MA CZM

Narr Bay Commiss.

Narr.Bay Estuary Program

Roger Williams U.

RIDEM

Save The Bay

URI & RI SeaGrant

US EPA AED

Volunteer Surveys ~ Monthly

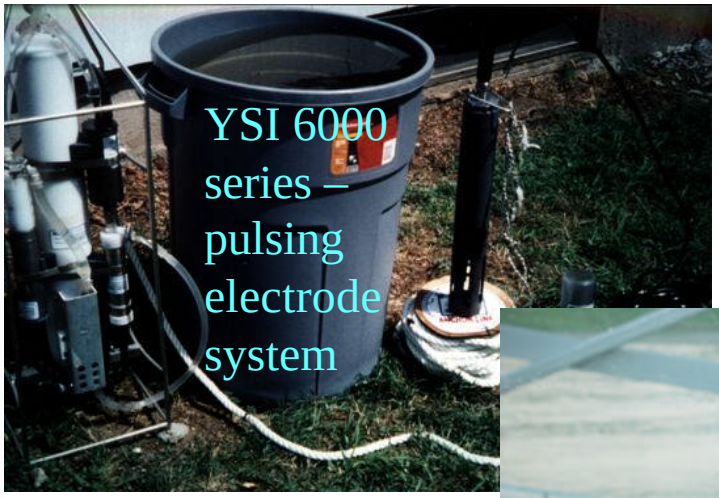
7PM to 1-2 AM (during Neap Tides)

1999 – 2003

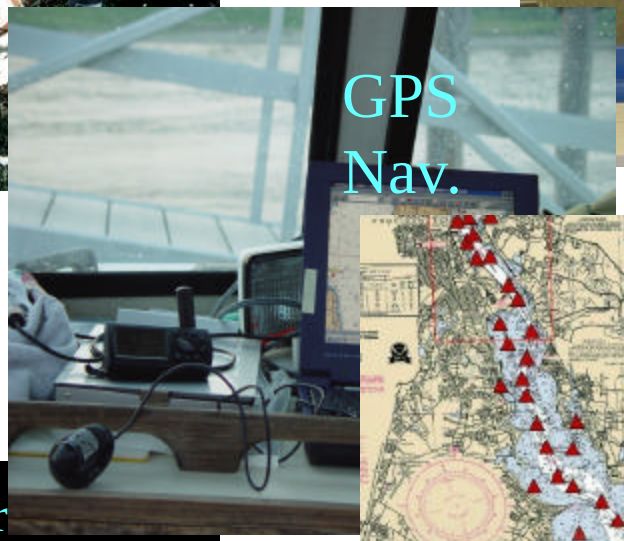
GOALS

- Provide synoptic Geogr. distribution maps of salinity, temp. & D.O.

- Use profiles to examine vertical water col. Structure & relation of D.O. to estuarine circulation



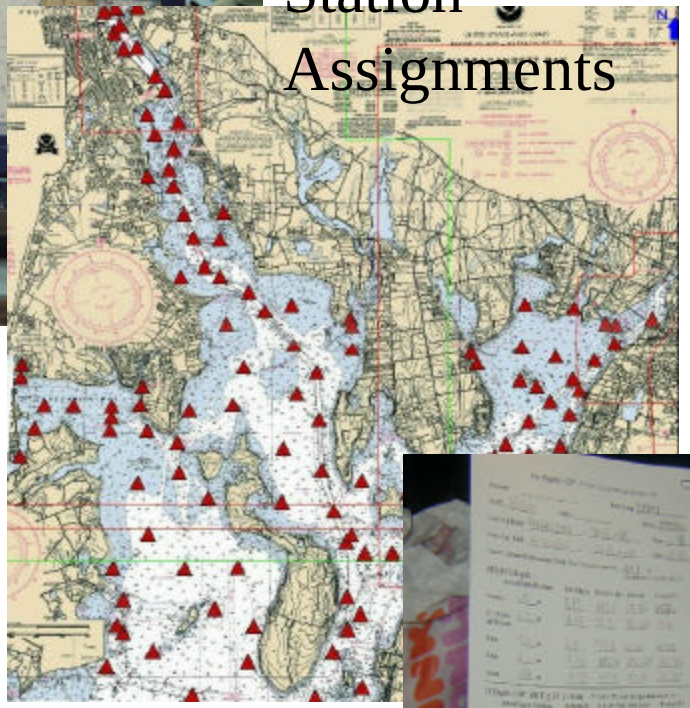
YSI 6000 series – pulsing electrode system



GPS Nav.

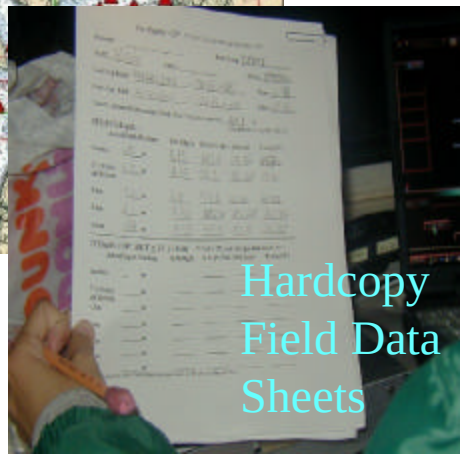
Equipment Prep

Station Assignments



Inter

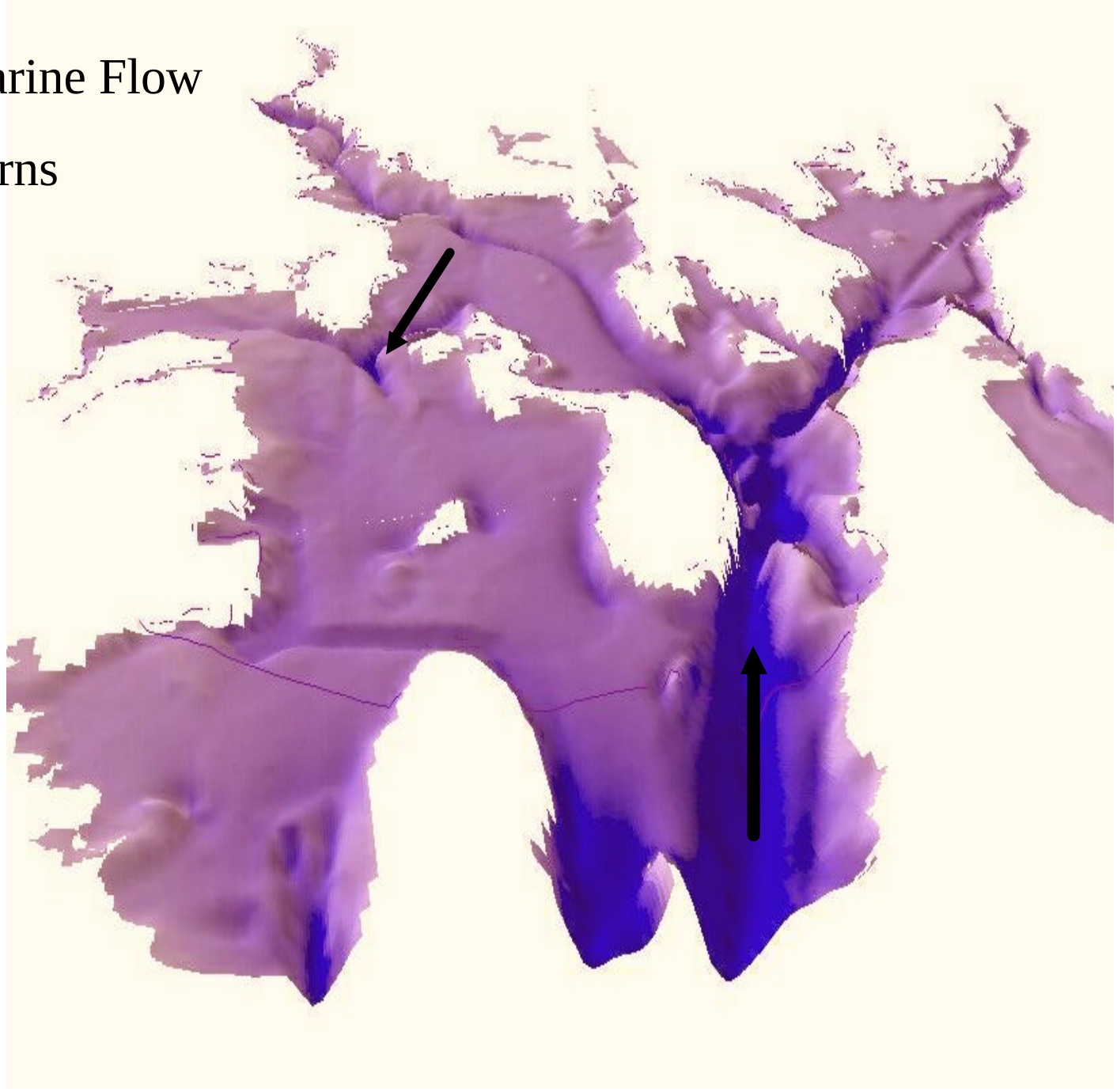
Calibration Tub

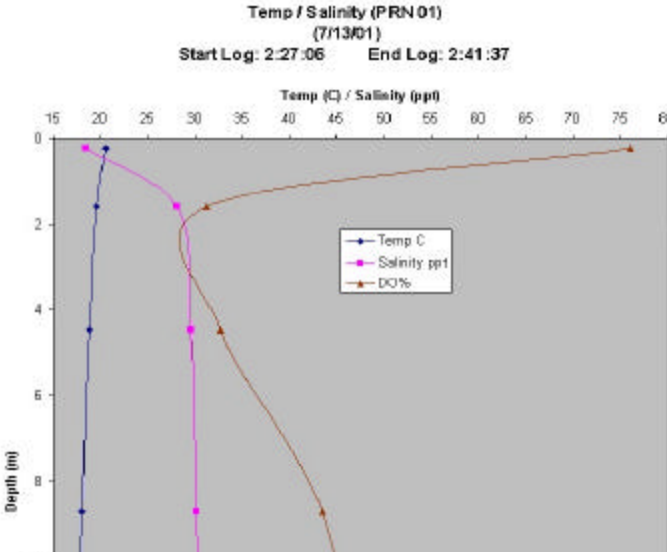


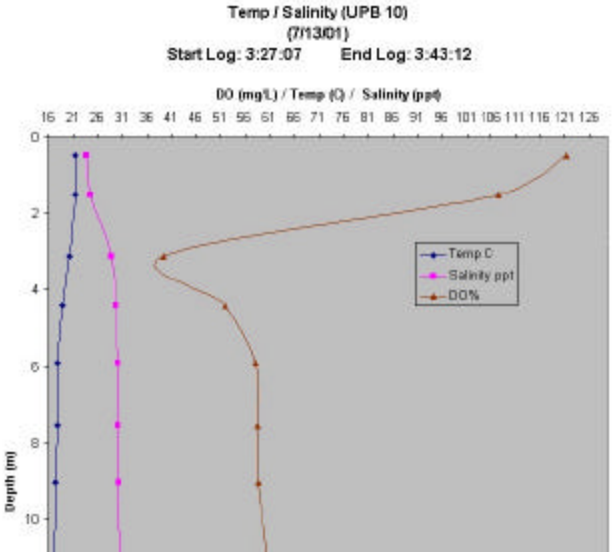
Hardcopy Field Data Sheets

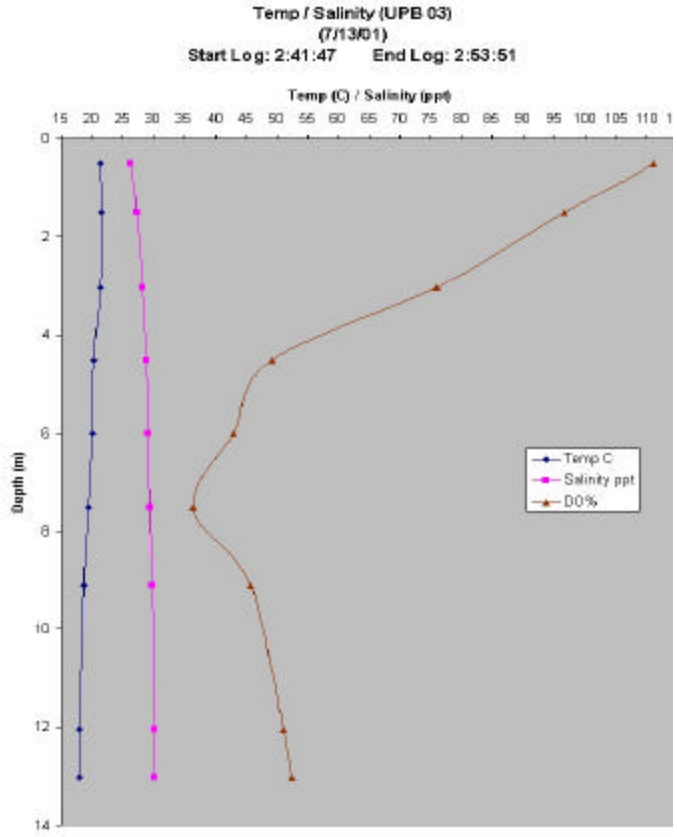
Estuarine Flow

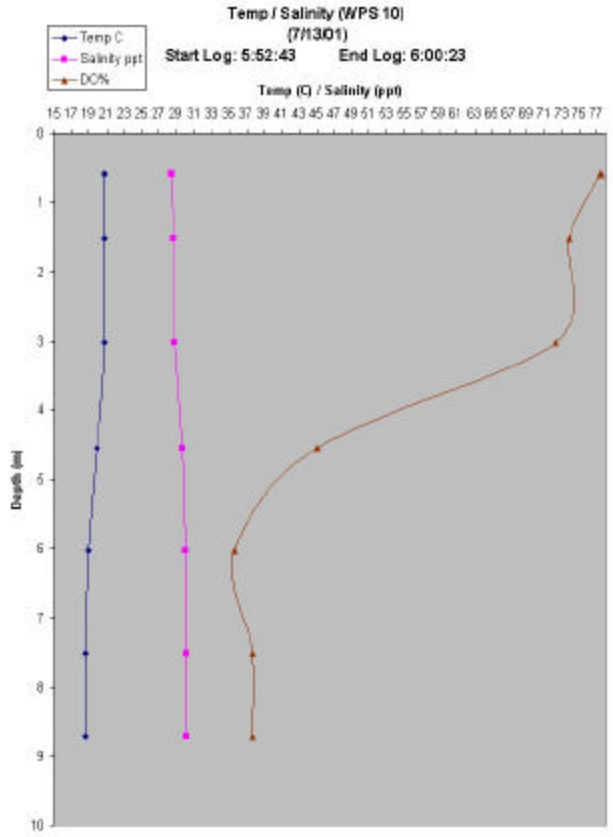
Patterns

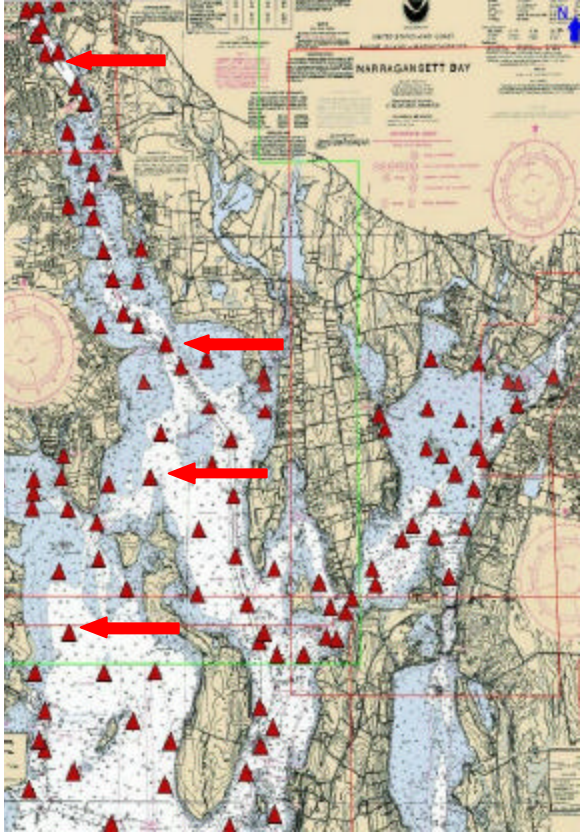












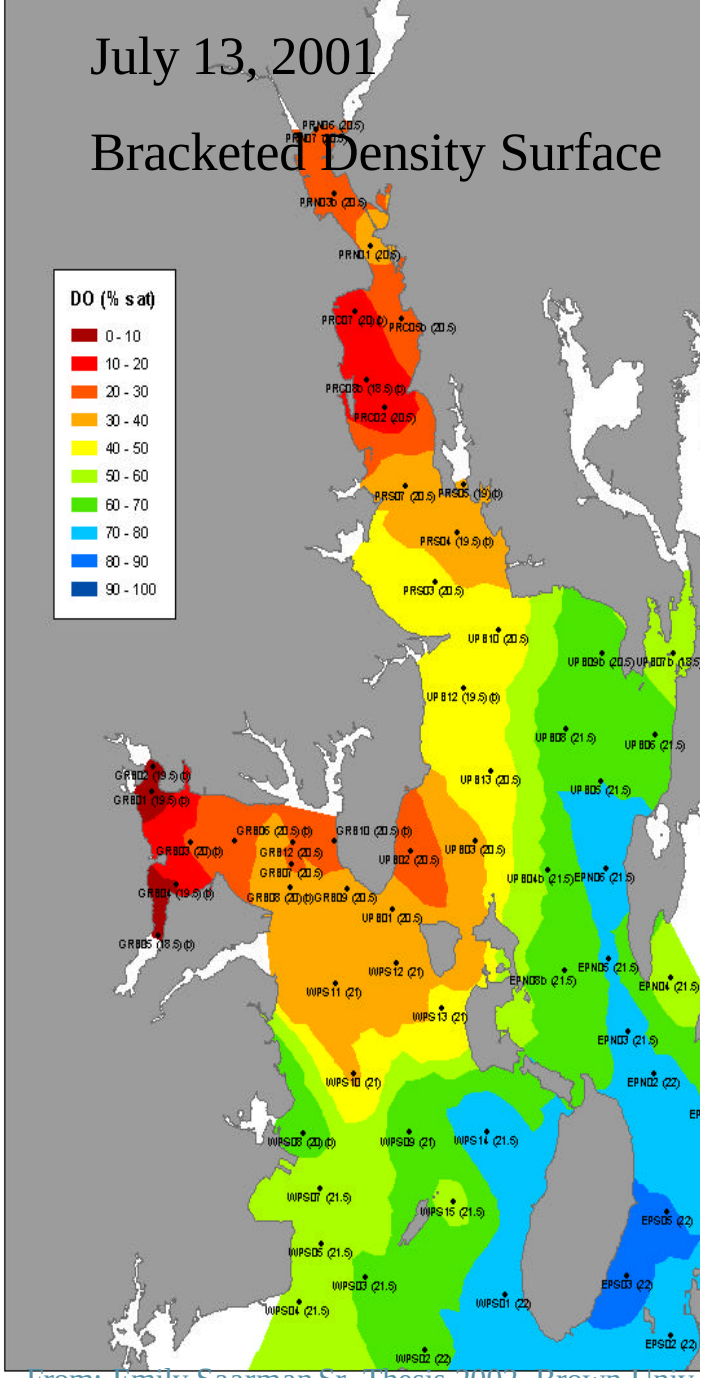
% Oxygen

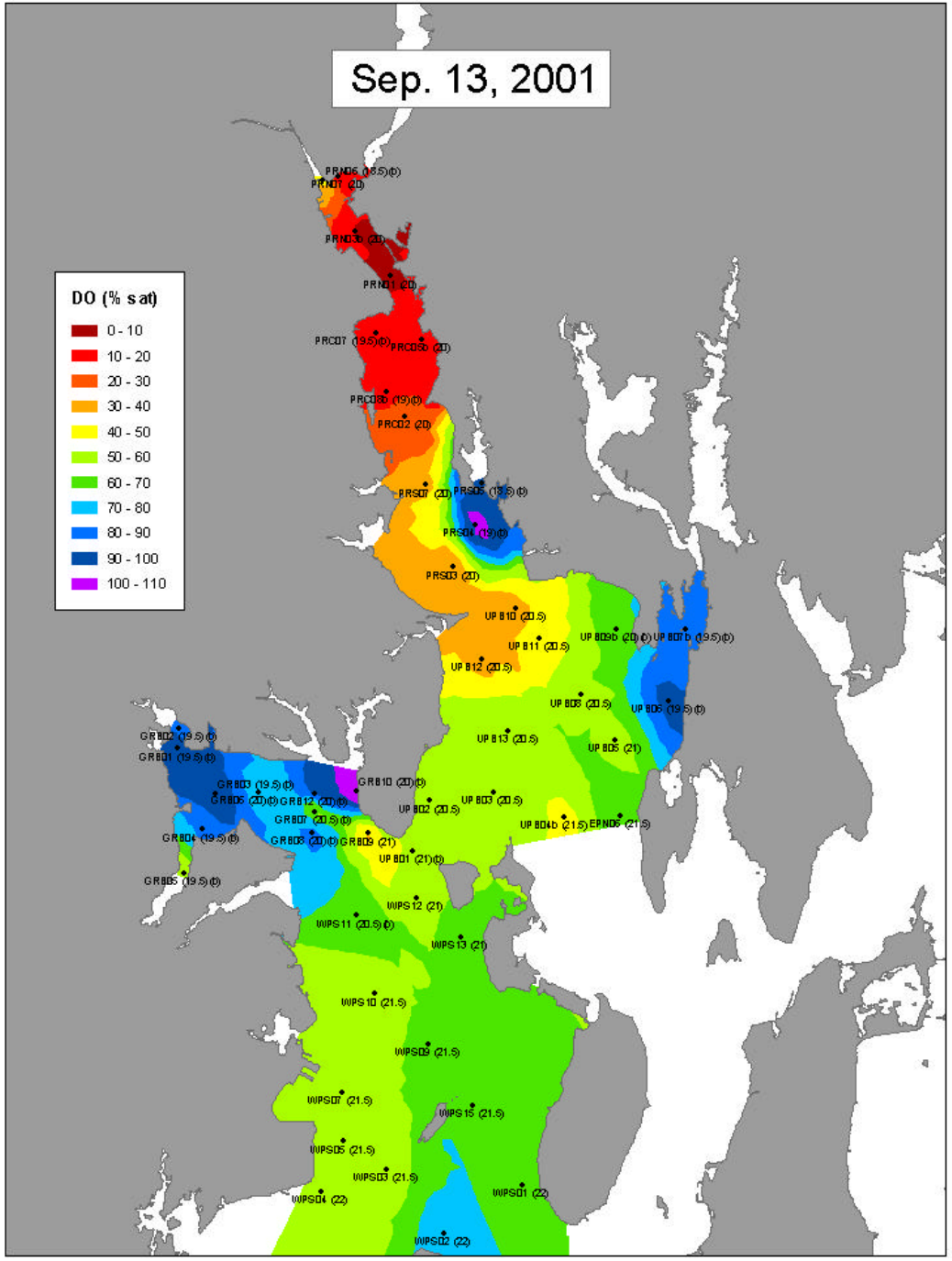
Salinity

Temp.

July 13, 2001

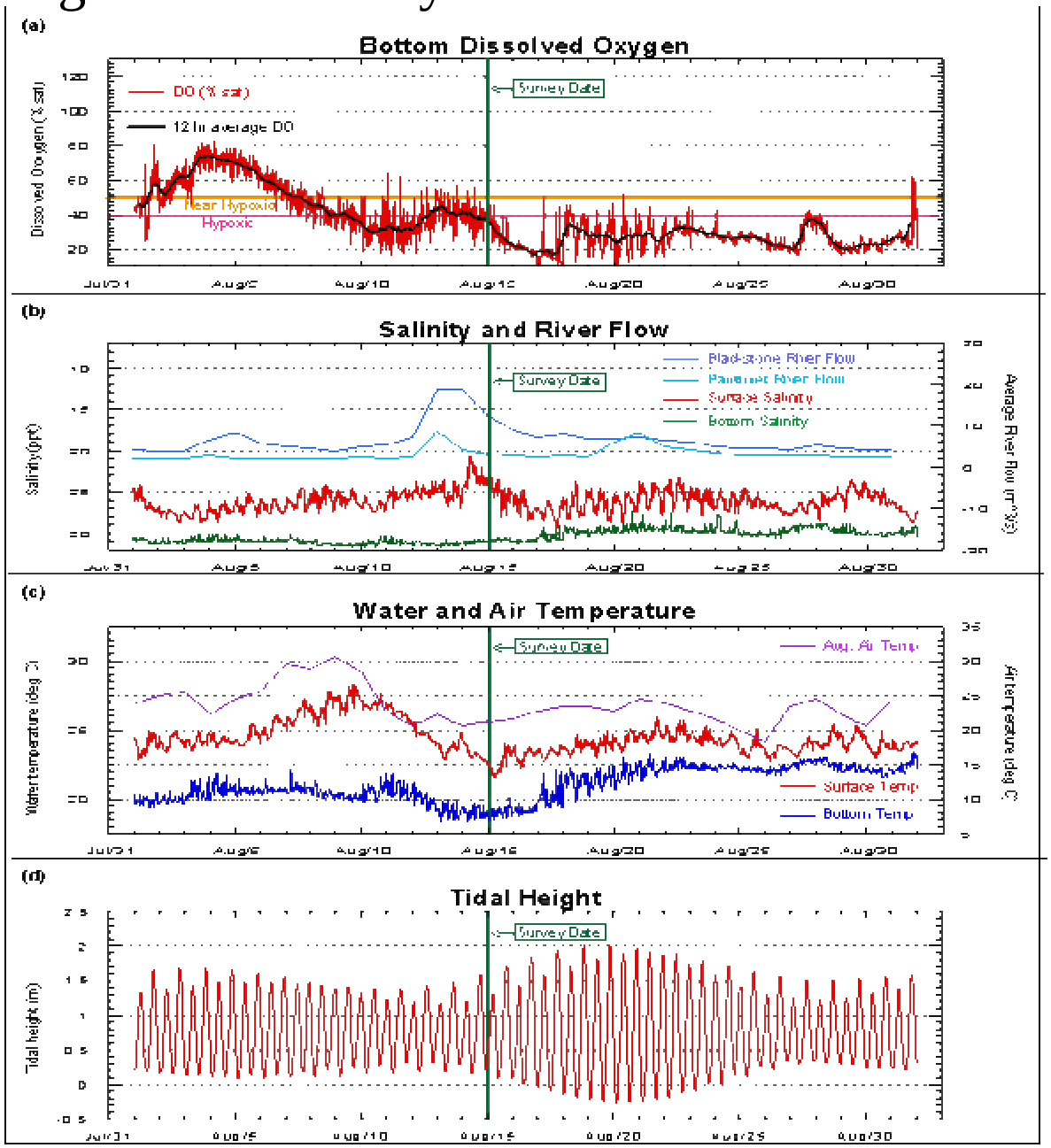
Bracketed Density Surface

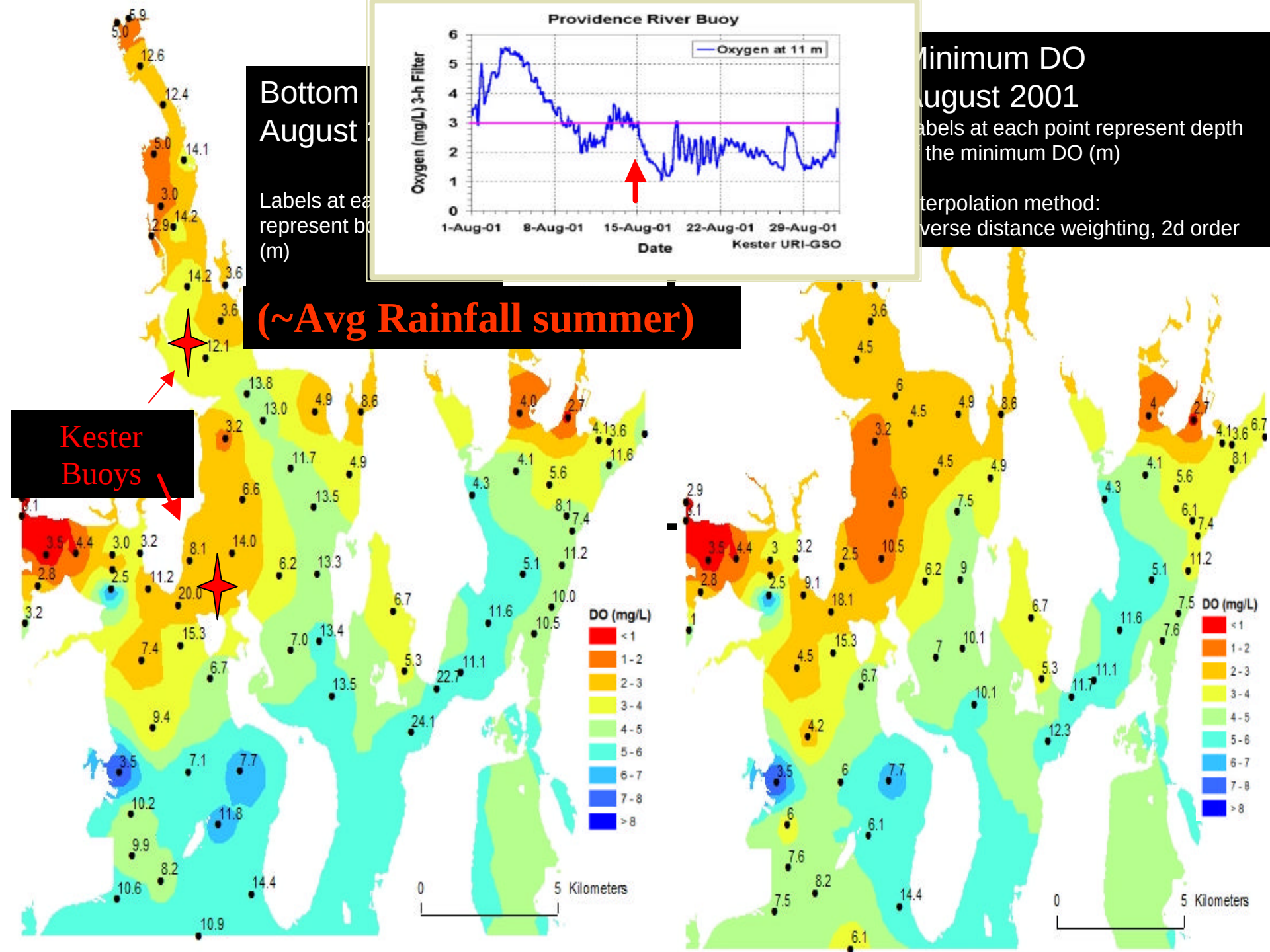


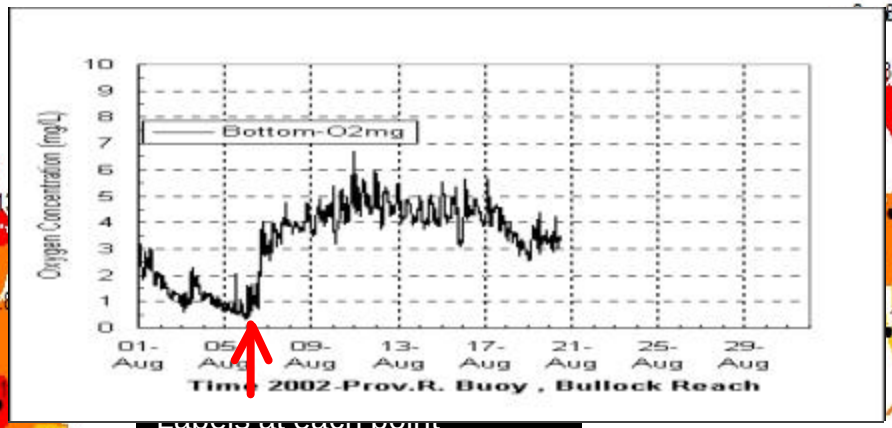


From: Emily Saarman Sr. Thesis 2002, Brown Univ.

August 2001 survey-data from Kester + Saarman




Providence River Buoy
Oxygen at 11 m
Oxygen (mg/L) 3-h Filter
0
1
2
3
4
5
6
1-Aug-01
8-Aug-01
15-Aug-01
22-Aug-01
29-Aug-01
Date
Kester URI-GSO
Bottom
August
Labels at ea
represent b
(m)
(~Avg Rainfall summer)
Kester
Buoys
inimum DO
ugust 2001
abels at each point represent depth
the minimum DO (m)
terpolation method:
verse distance weighting, 2d order
DO (mg/L)
< 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
> 8
0
5 Kilometers

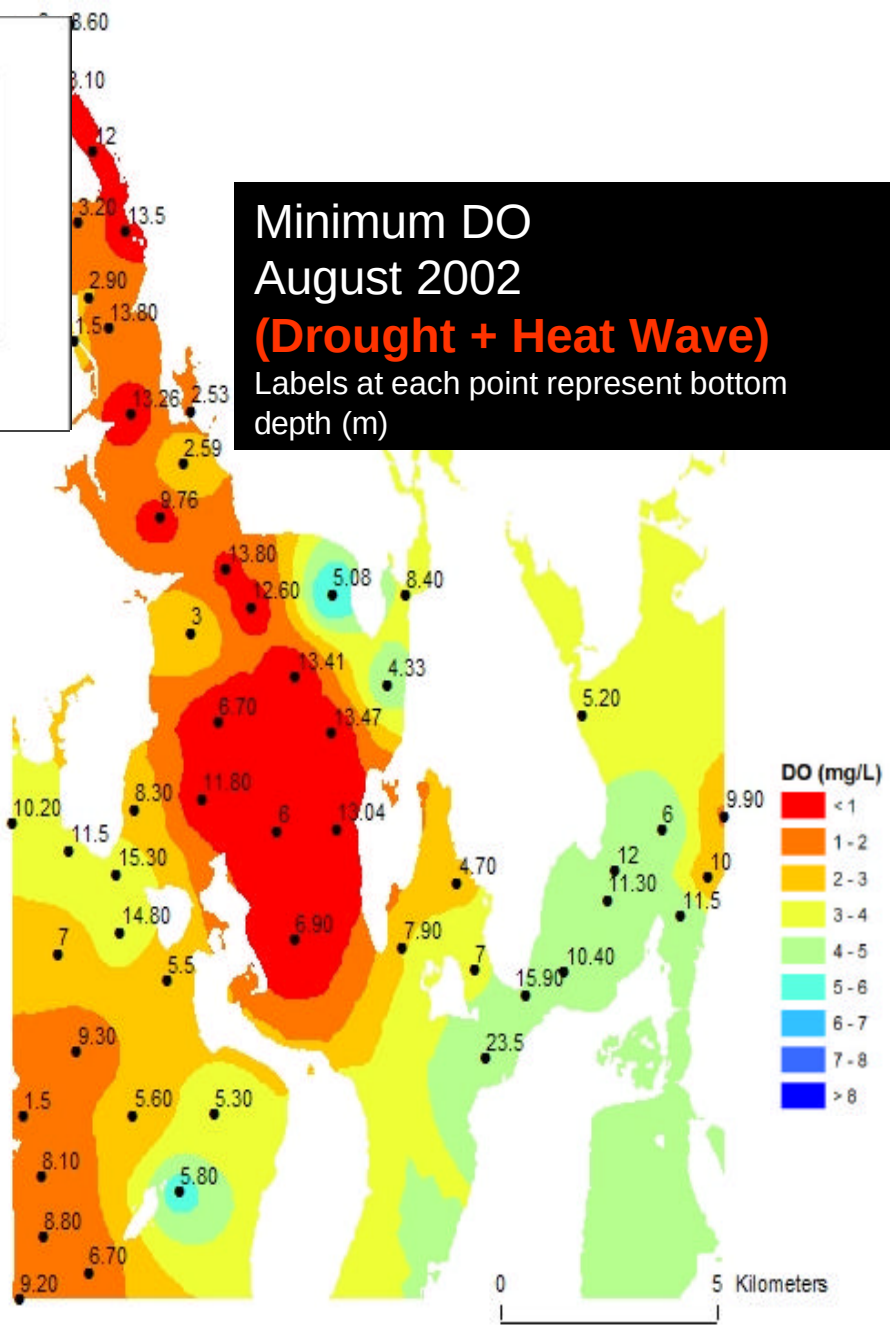


represent bottom depth (m)

Kester Buoy

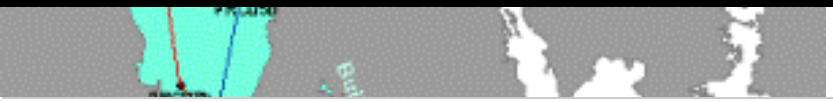
Minimum DO
August 2002
(Drought + Heat Wave)

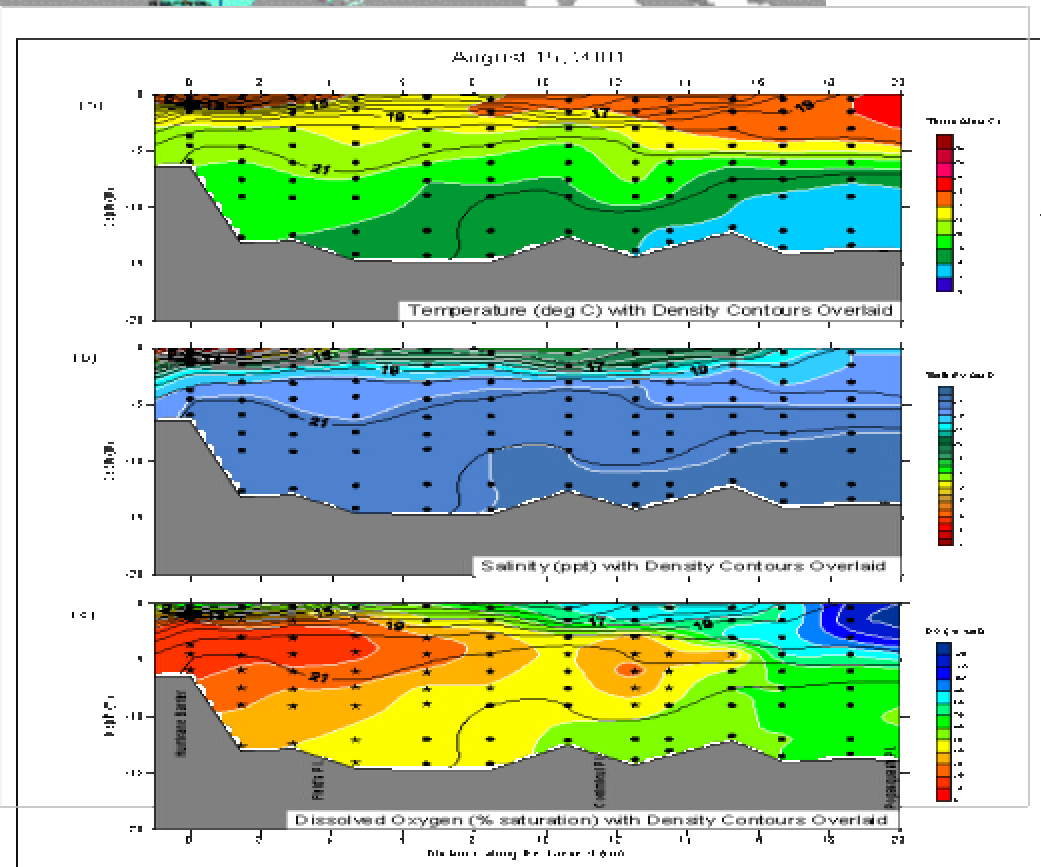
Labels at each point represent bottom depth (m)



2001 vs 2002

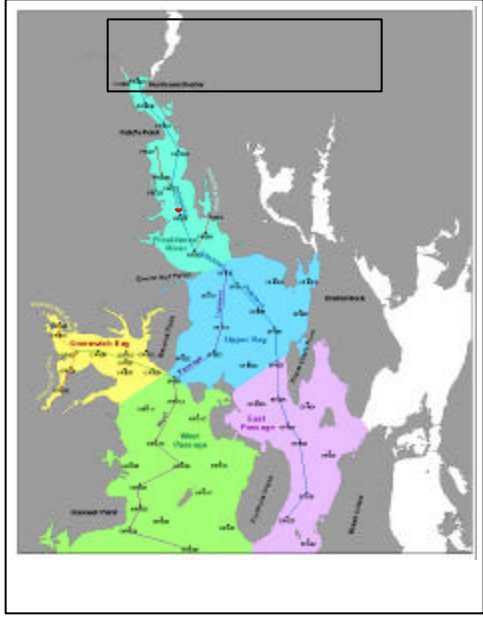
Ship Channel - Hurricane Barrier to Popasquash (East Passage)

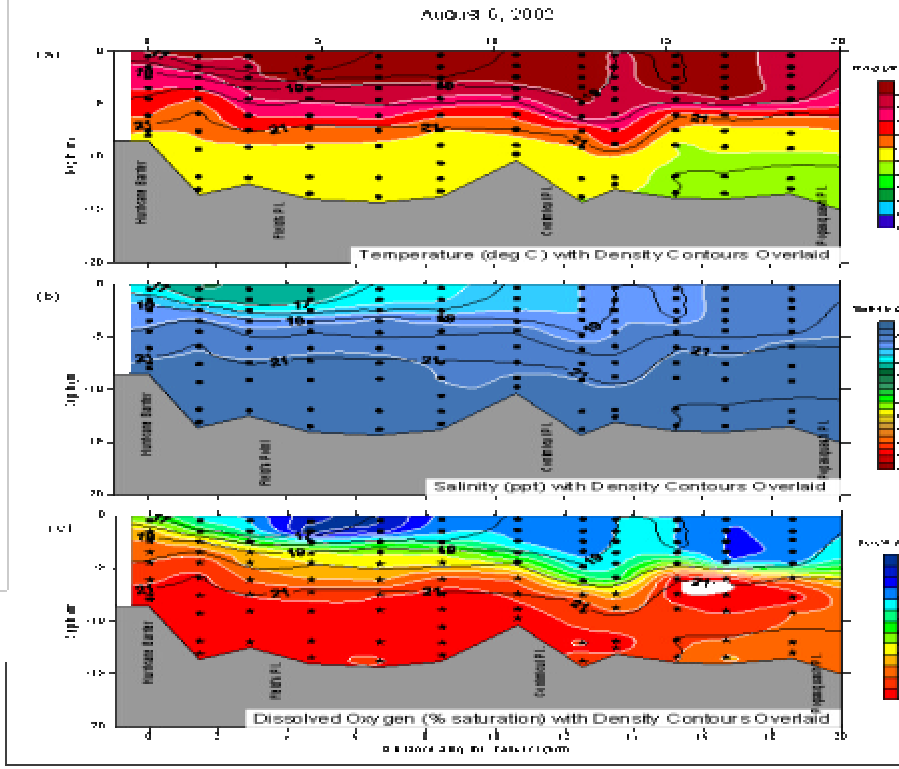


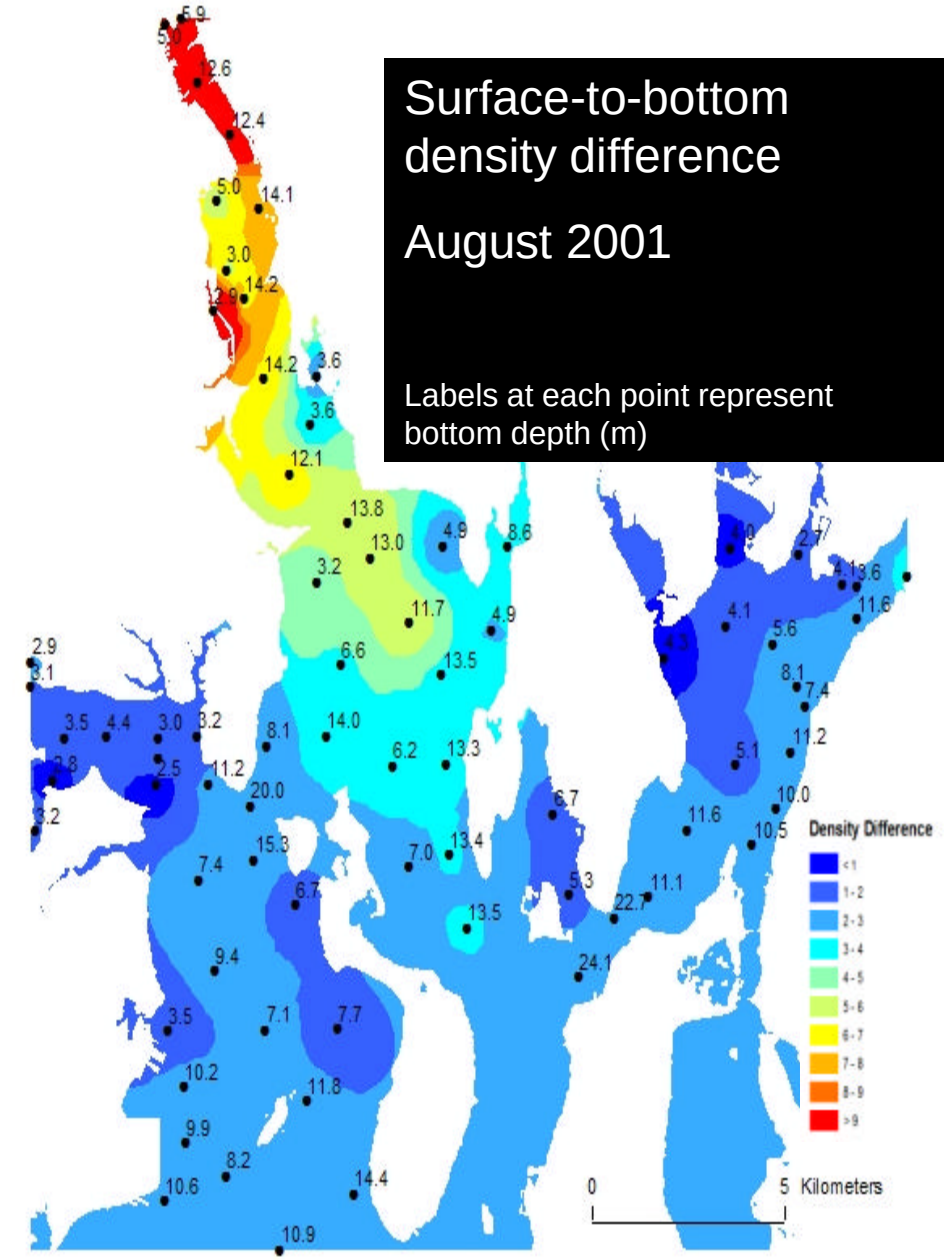


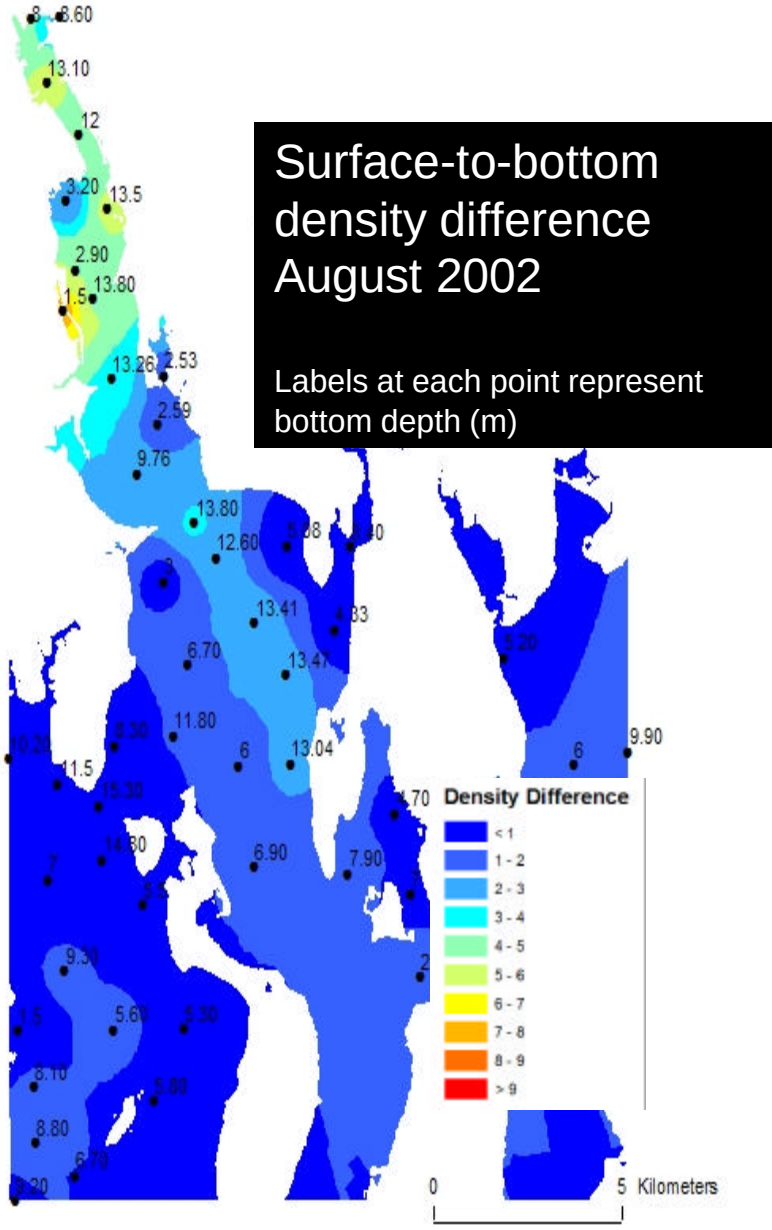
DRY + HOT

Aug 6, 2002



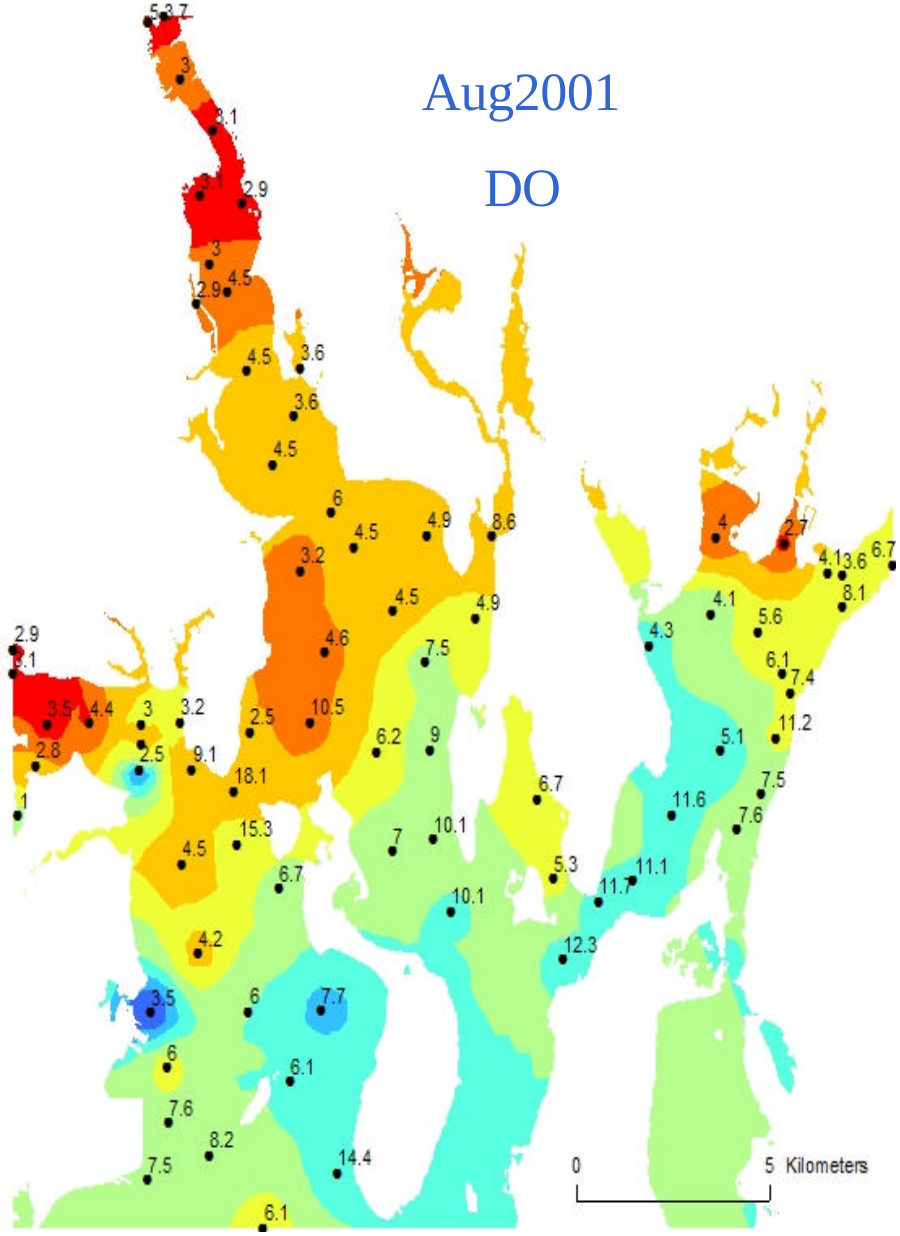



Surface-to-bottom density difference
August 2001
Labels at each point represent bottom depth (m)
Density Difference
< 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
> 9
0
5 Kilometers


Surface-to-bottom density difference August 2002
Labels at each point represent bottom depth (m)
Density Difference
< 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
> 9
0
5 Kilometers

Aug2001

DO



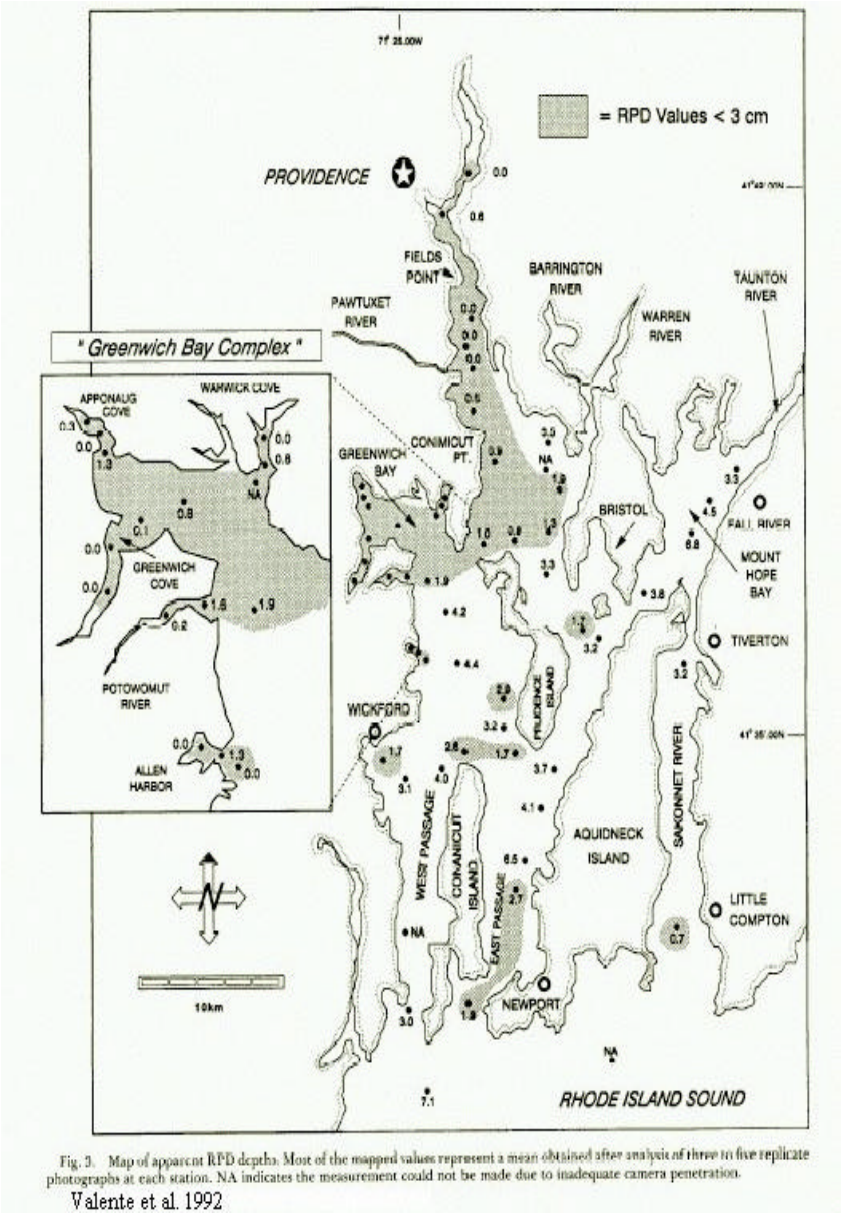


Fig. 3. Map of apparent RPD depths. Most of the mapped values represent a mean obtained after analysis of three to five replicate photographs at each station. NA indicates the measurement could not be made due to inadequate camera penetration.

Valente et al. 1992

Based on Sediment camera data – sampled Aug15-19,1988

Should We Care ???

2003 Severe Hypoxia – A Wet Summer

Fish Kill Report: http://www.state.ri.us/dem/pubs/fishkill.pdf

projo.com The Providence Journal

Greenwich Bay hit by huge fish kill

With up to a million fish dead already, officials worry that a season of hot weather and heavy rain may create another kill as early as today.

08:31 AM EDT on Friday, August 22, 2003

BY BARBARA POLICHETTI
Journal Staff Writer

WARWICK -- Tens of thousands of fish -- possibly as many as a million -- died in Greenwich Bay yesterday, starved for oxygen in water that is being choked by pollutant-fed algae, according to state environmental officials.

Arthur Ganz, supervising biologist for the Marine Fisheries division of the state Department of Environmental Management (DEM), said this is the worst fish kill he has seen in more than 50 years of living near and working on the bay.

"We have a major anoxia [lack of oxygen] event in Greenwich Bay," he said, explaining that dozens of samples taken yesterday show that there is virtually no oxygen in the bay water. "This is the worst I've ever seen," he said. "The water is this murky, grayish white.

"I call it the color of death."

Officials from DEM and Save the Bay were first alerted to the problem early yesterday morning when they received phone calls from horrified residents in Warwick's Apponaug Cove area, who had woken up to see their shoreline shimmering with dead fish, mostly juvenile menhaden.

John Torgan, spokesman for Save the Bay, said that there were dead fish on

August 20, 2003 – “The Big One”

Dead are bacteria- food +

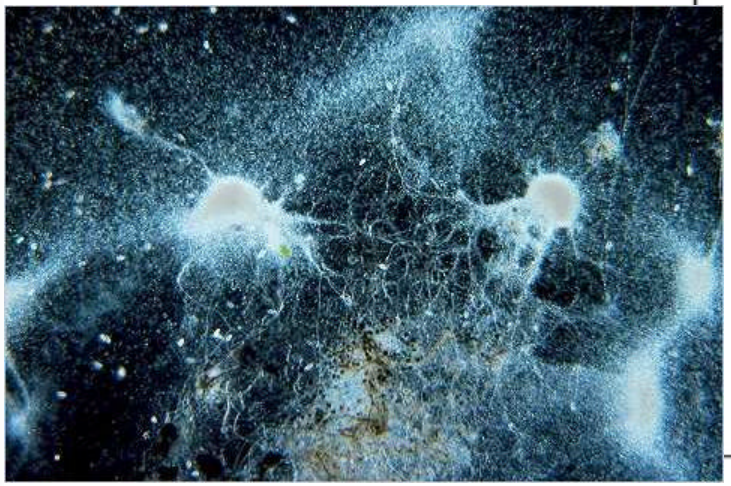
Hydrogen Sulfide

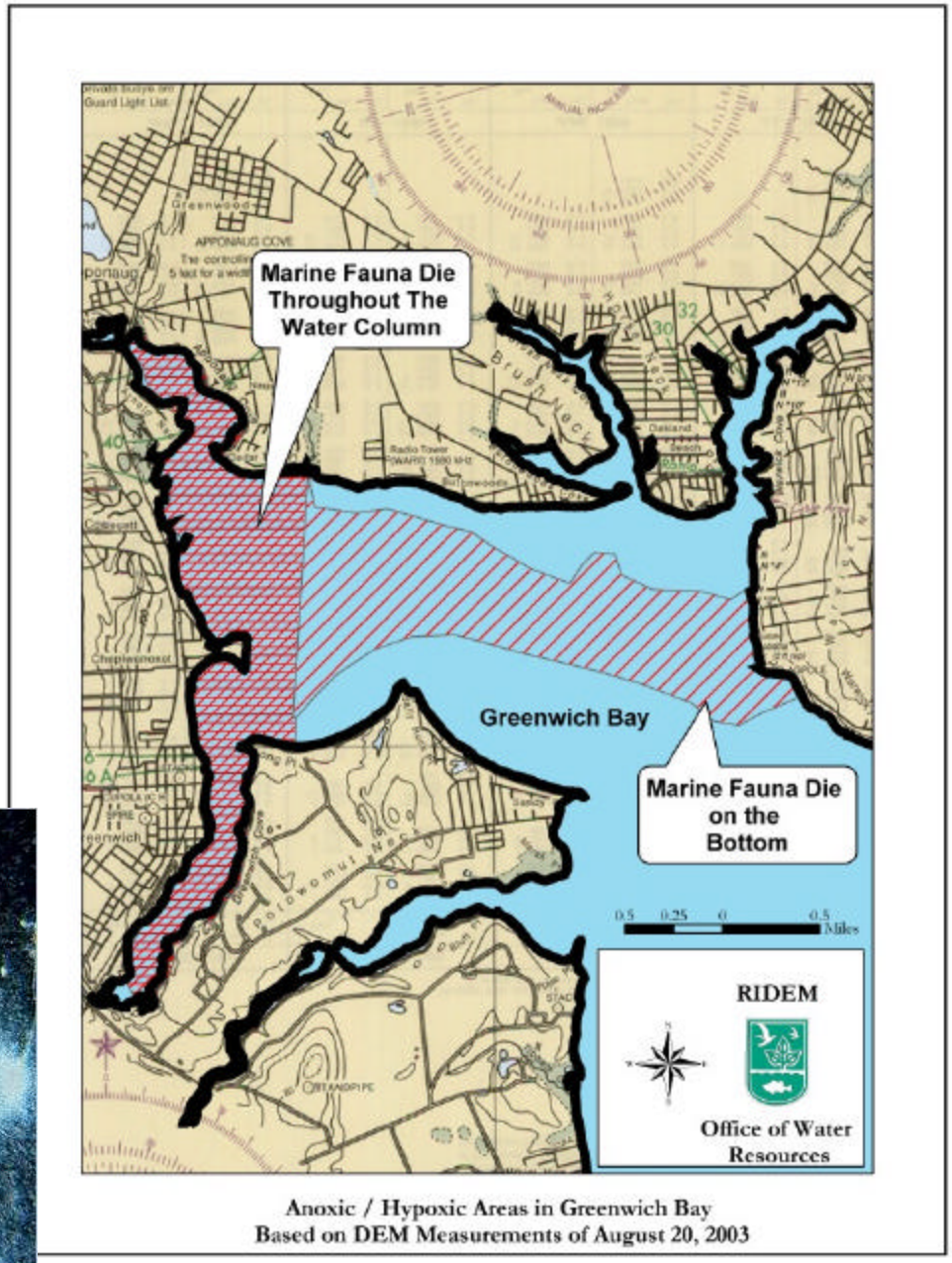
(rotten eggs) grows

sulfur bacteria mats on the

bottom in the anoxic areas

Beggiatoa mats on bottom – anoxic zone

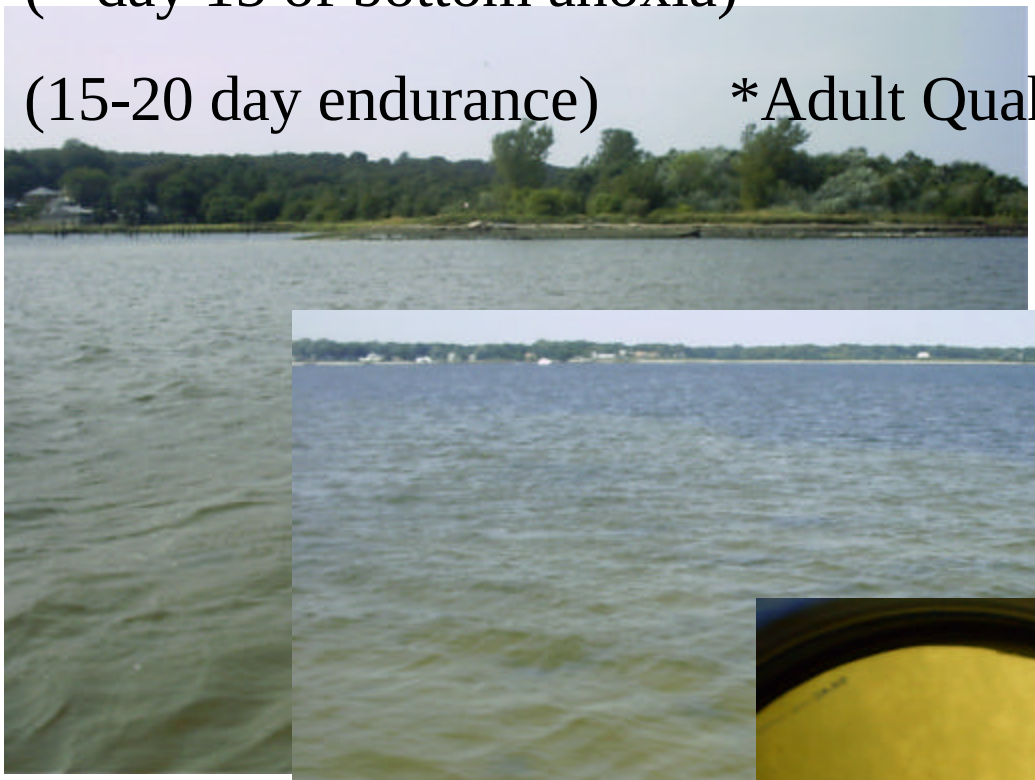


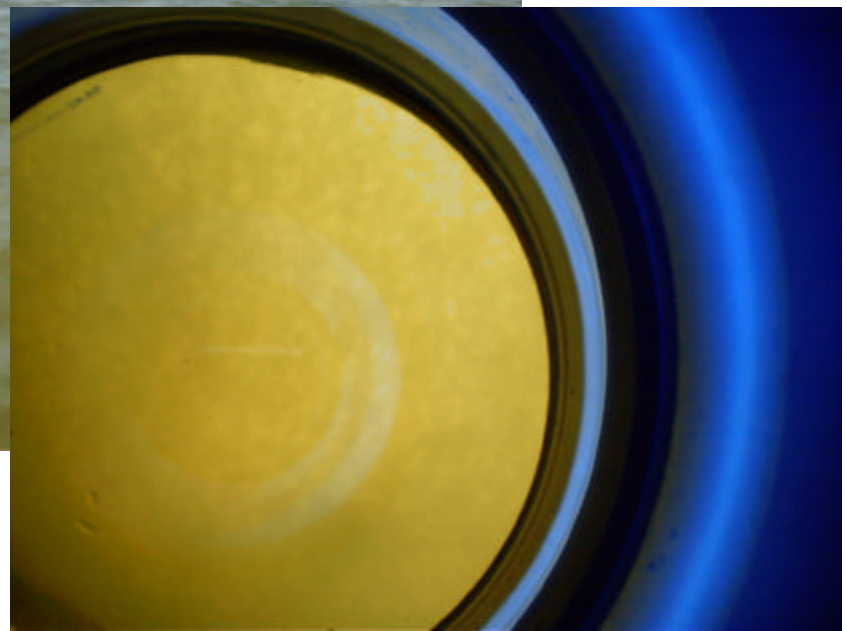


Anoxic / Hypoxic Areas in Greenwich Bay
Based on DEM Measurements of August 20, 2003

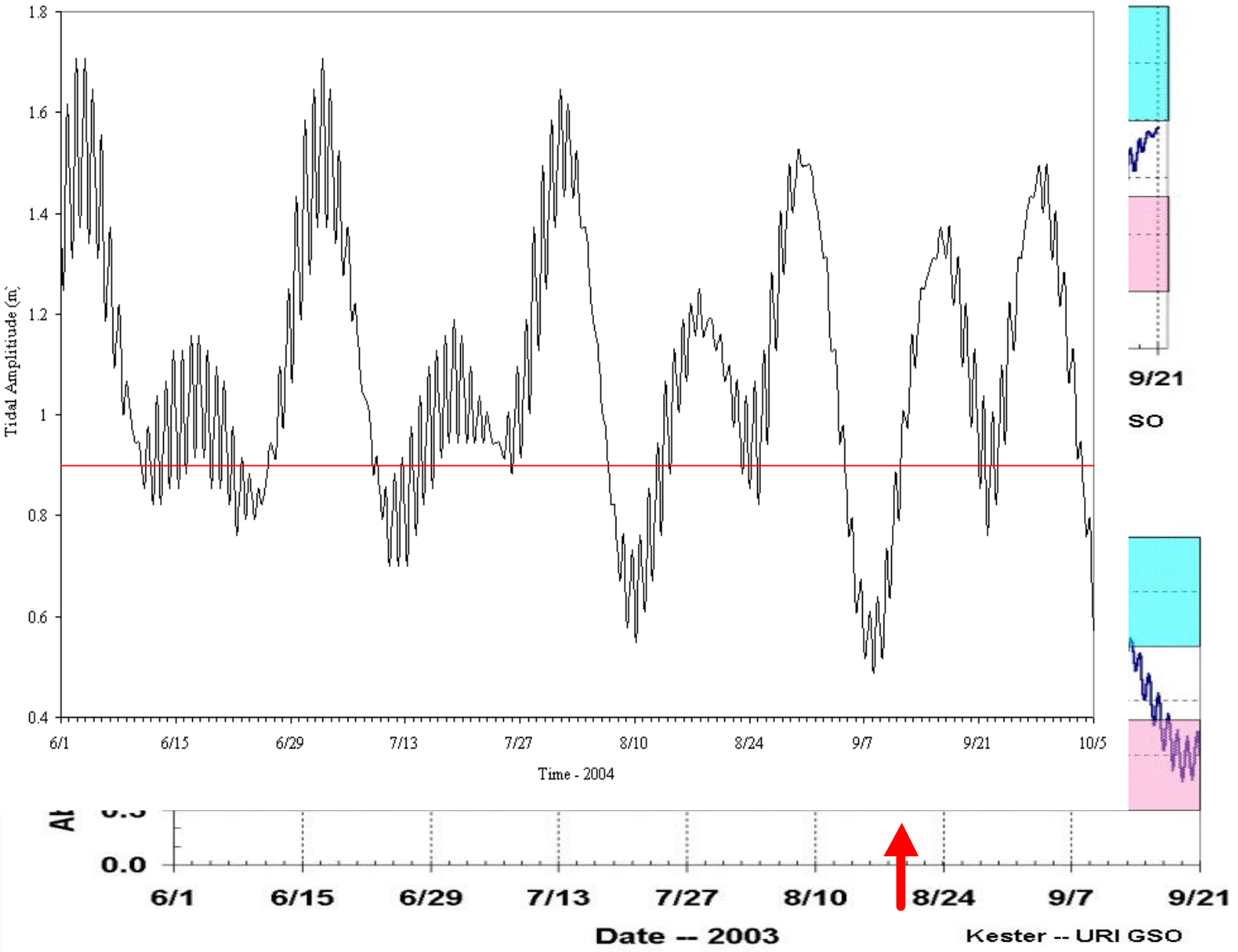
Softshell Kill (*Mya arenaria*) 8-28-03
So. of Chepiwanoxet + Cedar Tree Pt-Greenwich Bay
(~ day 15 of bottom anoxia)

(15-20 day endurance) *Adult Quahogs >30days!





This Summer ?


1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
Tidal Amplitude (m)
6/1
6/15
6/29
7/13
7/27
8/10
8/24
9/7
9/21
10/5
Time - 2004
9/21
SO
0.0
6/1
6/15
6/29
7/13
7/27
8/10
8/24
9/7
9/21
Date -- 2003
Kester -- URI GSO

CONCLUSIONS

- **Monitoring schedules ignoring tidal regimes for Narragansett Bay**
  - would likely miss hypoxic events + extent of hypoxia

- **Targeted sampling along pollution gradient : showed Hypoxia (<3.0 mg/L (~ 40% saturation) – occurs along the N-S gradient – Worst D.O. @No. end -- Prov. River, much of the Upper Bay, Greenwich Bay, Upper West Passage & Upper East Passage, &North MHB**

- **D.O. minimum – often just below shallow-to- mid-water pycnocline (especially in Providence R/ Upper Bay)**

- **Hypoxia: - more widespread than suspected + occurs DRY & WET yrs. + occurs even w/ *weak* stratification in Neap!!!**
  - **likely advects down-Bay**
  - **– direction affected by estuarine circulation**
  - **varies signif. between months / years**
  - **usually initiates on weak neap summer tides**