

Assessment of Narragansett Bay Waters Using Data from the Fixed-Site Water Quality Monitoring Network



By

Heather Stoffel

University of Rhode Island- Graduate School of Oceanography

Rhode Island Department of Environmental Management -Office of Water Resources

Narragansett, Rhode Island, USA

June 16, 2011



Narragansett Bay Fixed-Site Water Quality Monitoring Network

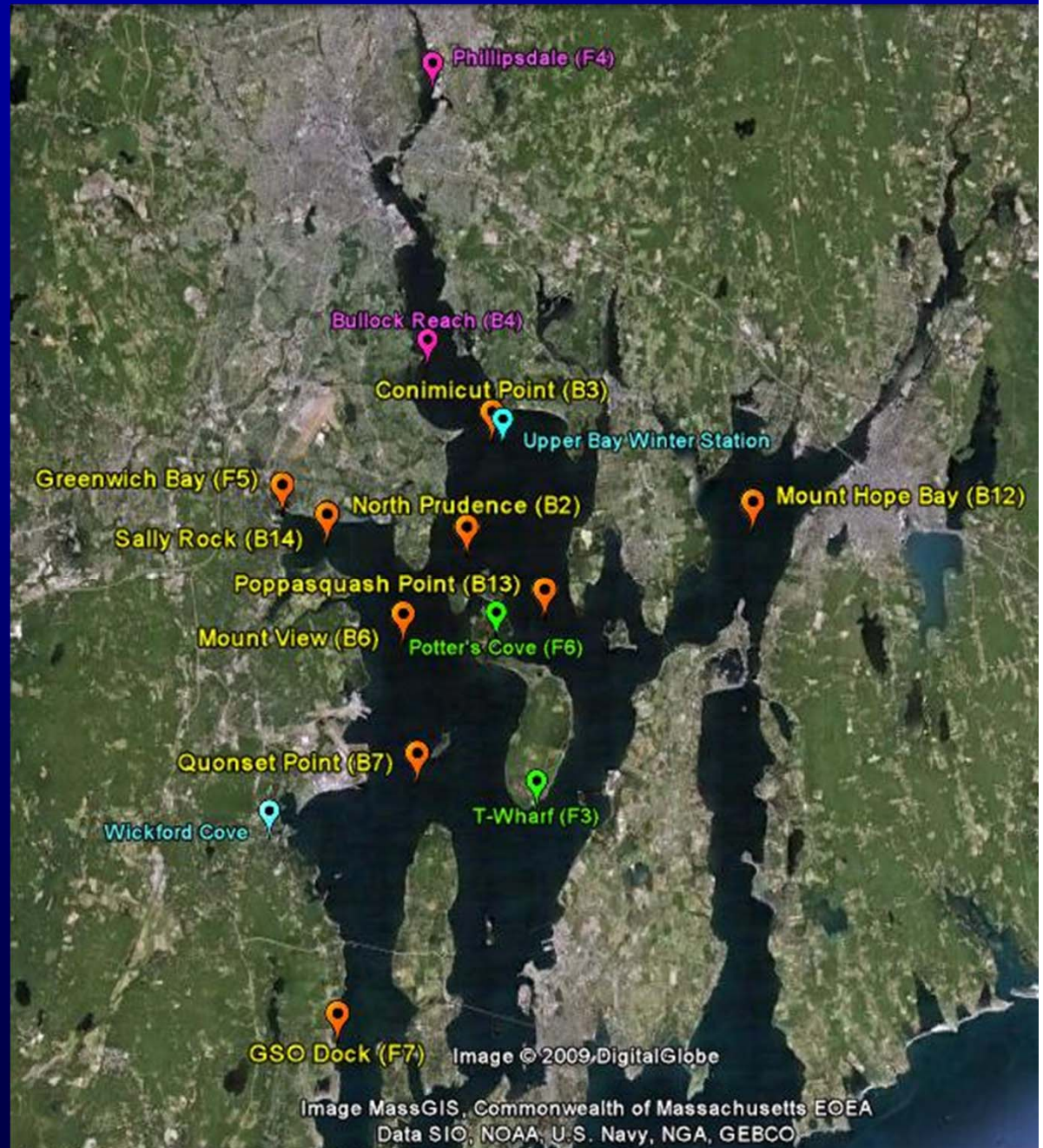
• **Agencies:** RIDEM-OWR, URI/GSO, NBC, NBNERR, NBNEP, & RWU

• **13 Site Locations:**

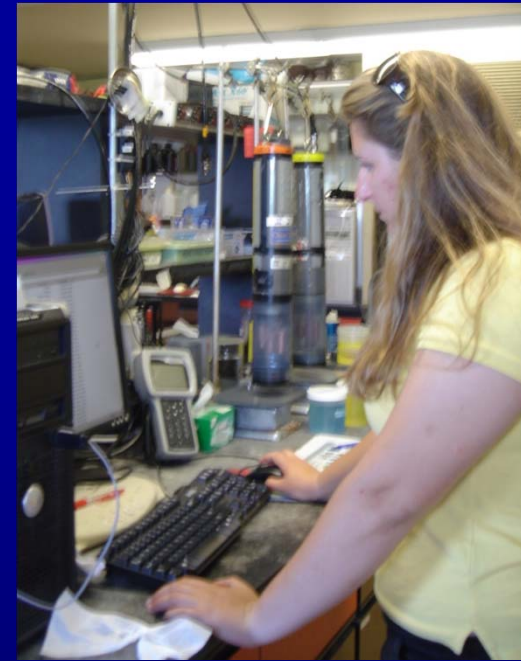
- West Passage (NP, MV, QP, GD)
- East Passage (PP, PC, TW)
- Providence River (BR, CP)
- Seekonk River (PD)
- Greenwich Bay (GB, SR)
- Mt. Hope Bay (MH)

• **Monitoring Season:** buoy stations (May-Oct) & land-based stations (year round)

• **Funding:** RIDEM-OWR, NOAA Bay Window Program, EPA, NBC, & NERRS



Data Collection



Temperature, Salinity, Dissolved Oxygen, pH
Chlorophyll, Turbidity



Data Usage & Availability

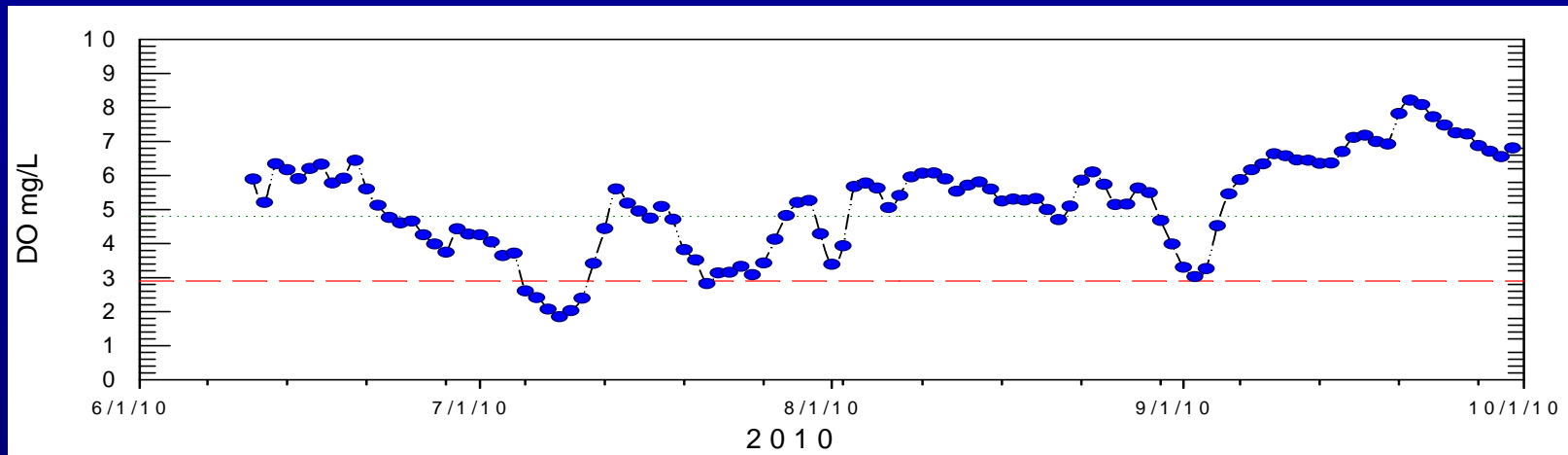
- Bay Alert Response Team (BART) reports conditions and conducts environmental responses. The data from the monitoring network is gathered in real-time via cellular connections to give scientist the most up to date data to assess the environmental conditions and response accordingly. This data is summarized for the public through weekly reports and posted to the BART webpage.
- BART (RIDEM-OWR)-weekly public posting of bay conditions: www.dem.ri.gov/bart
- URI/GSO-daily observations: www.narrabay.org
- NBNERR/NBC- station data available real-time: www.nbnerr.org, www.narrabay.com
- NBNEP-spatial survey graphics: www.geo.brown.edu/georesearch/insomniacs/
- ALL DATA SETS-yearly data and monthly graphics: www.dem.ri.gov/bart
- All data sets are used by the Narragansett Bay Coastal Hypoxia Research Program (CHRP). Updates and recent findings courtesy of Dan Codiga.

Characteristics of Hypoxia in Narragansett Bay based on Observations from the NBFSMN

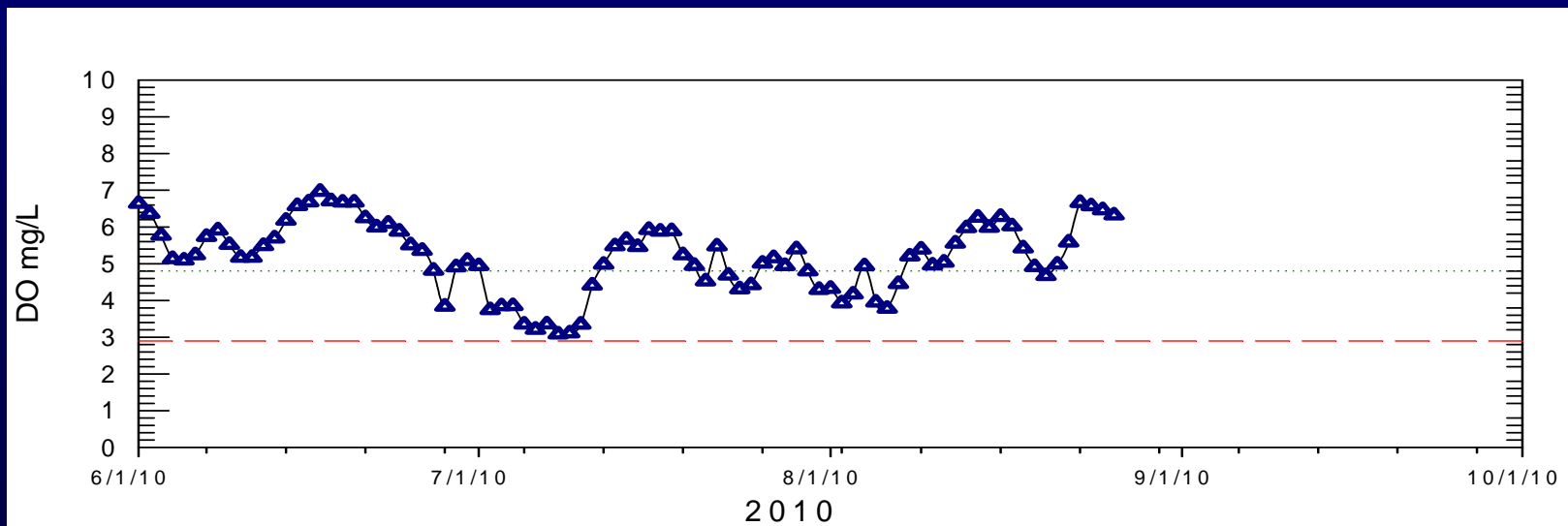
- Episodic events throughout the summer (June-September)
- Events have been documented at individual stations and Upper Bay wide
- Events usually begin earlier and persist longer in Providence River, Greenwich Bay, and other cove areas
- Low flow years generally produce mild seasonal hypoxia (i.e. 2010)

West Passage Hypoxia 2010

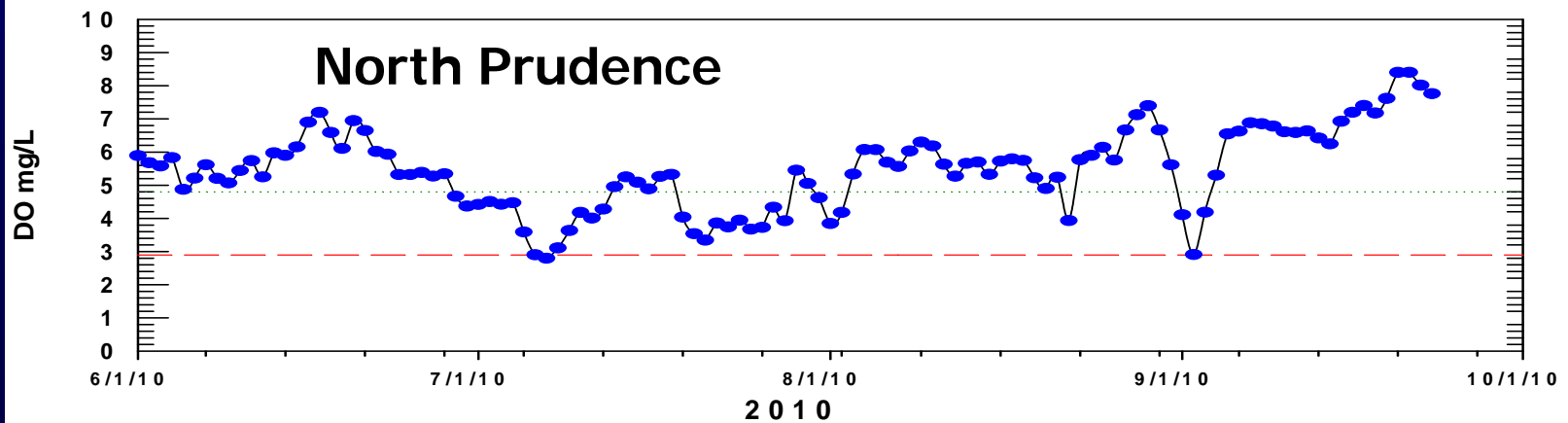
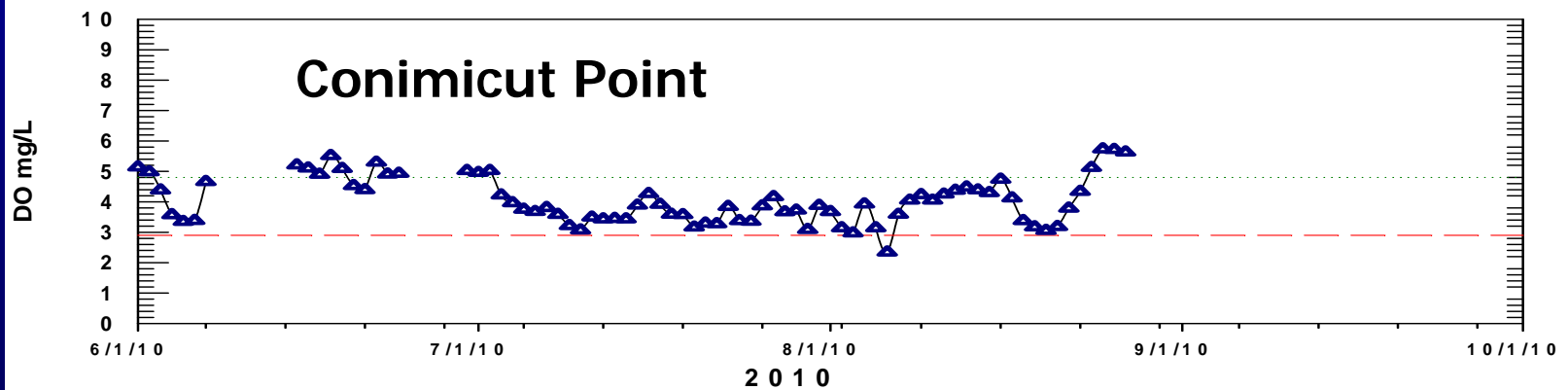
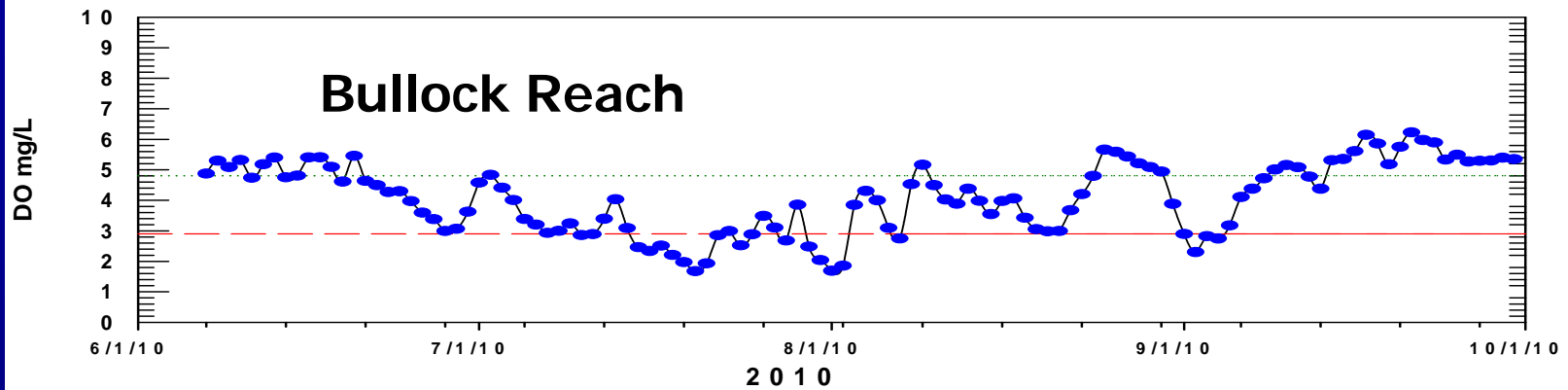
Mt. View



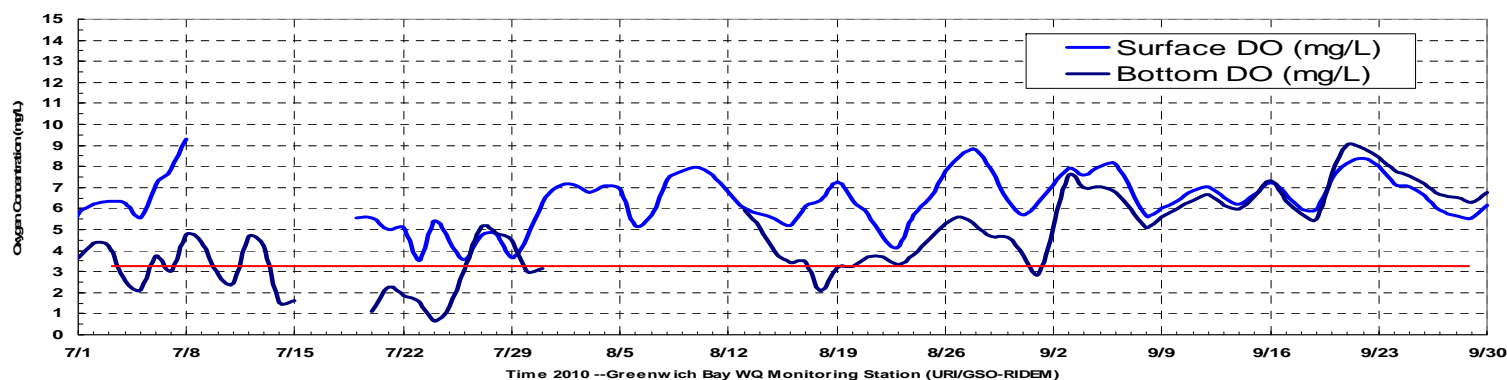
Quonset Pt.



Providence River and Upper Bay Hypoxia 2010

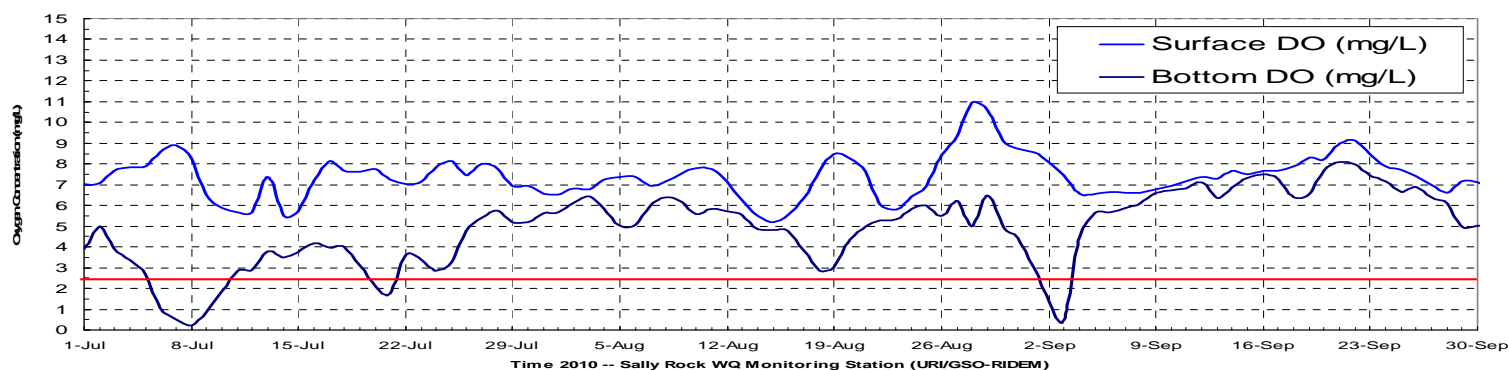


Greenwich Bay Hypoxia



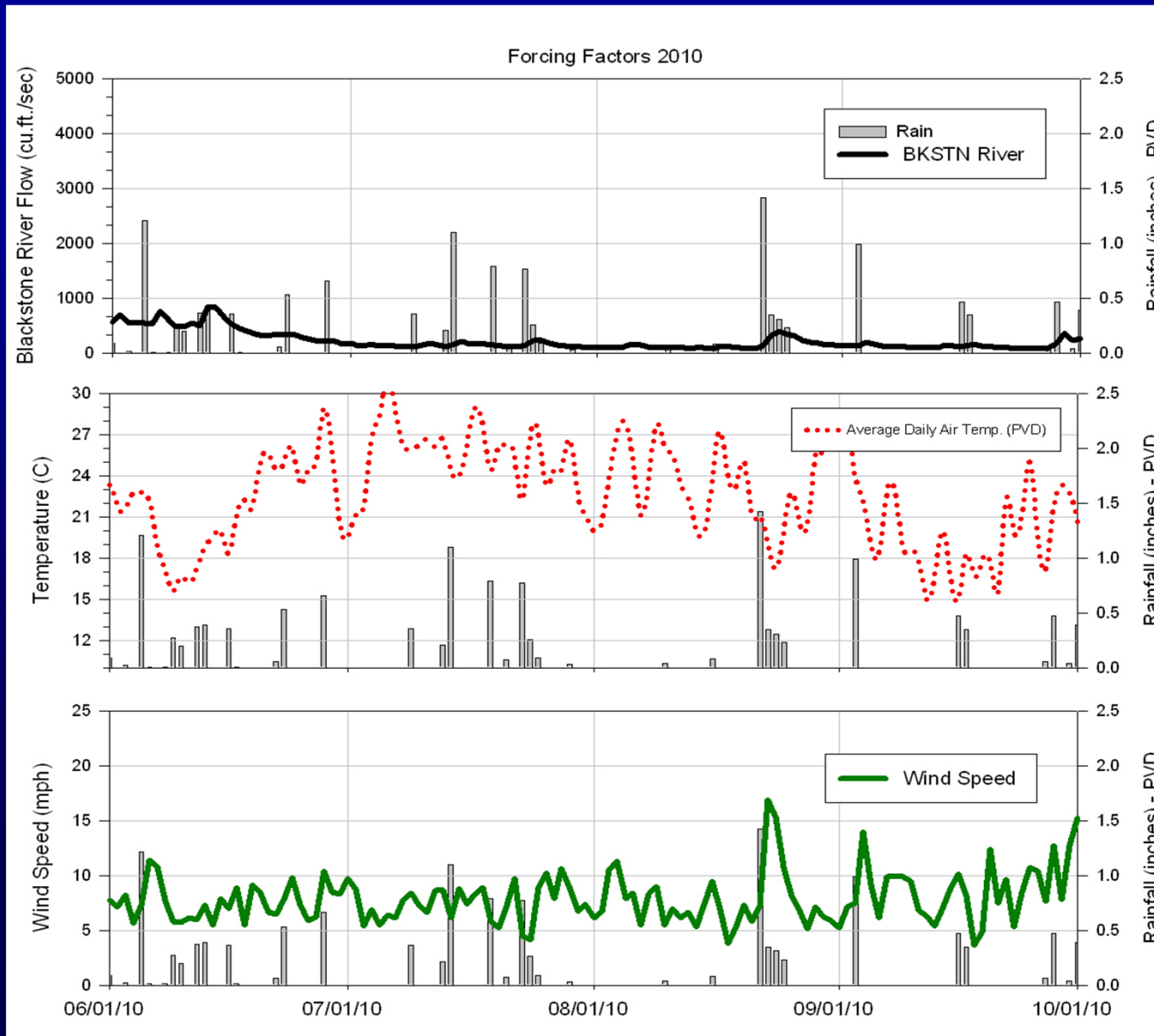
Greenwich
Bay
Marina

Sally Rock

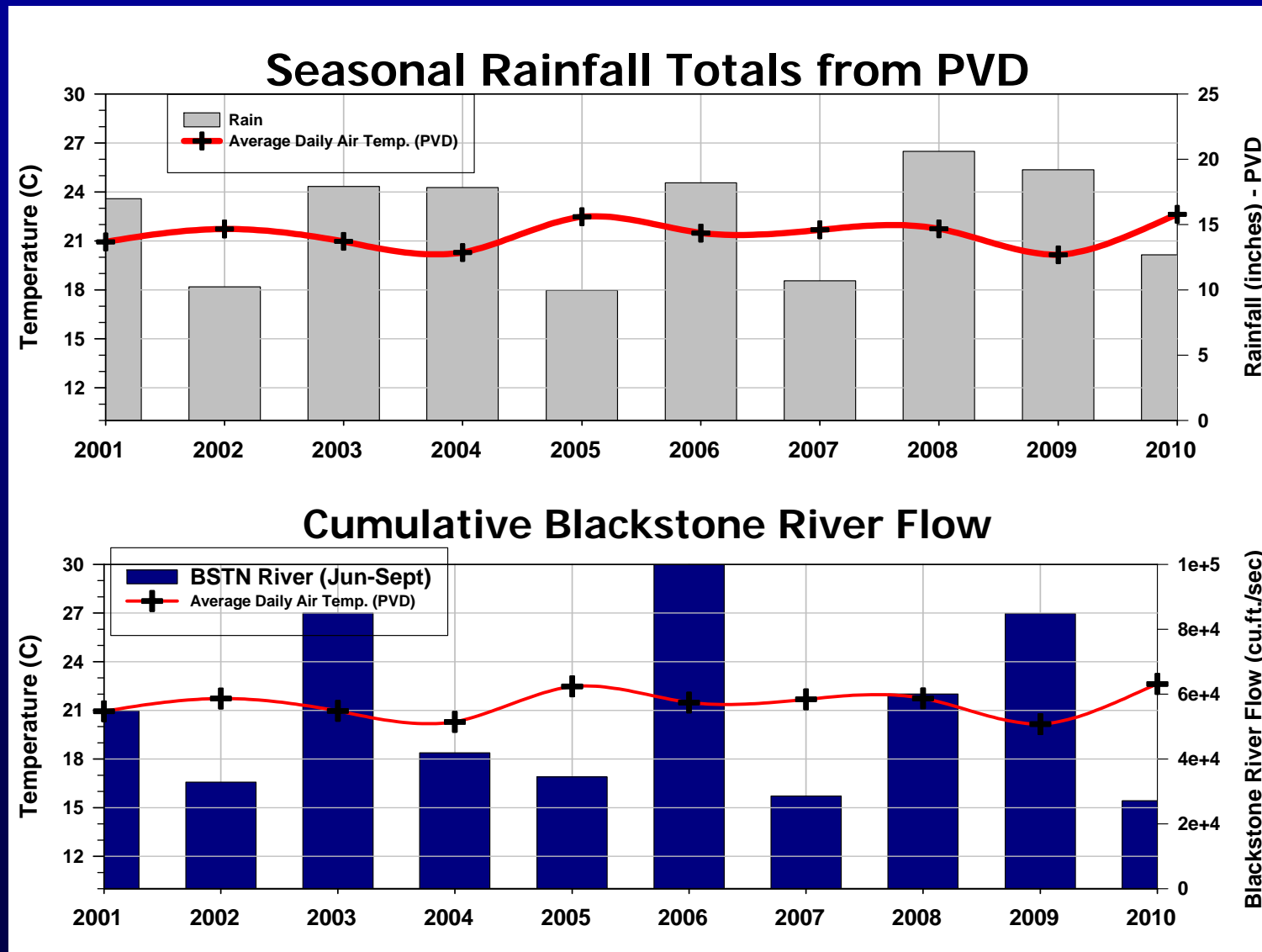


In the summer of 2010, the western side of Greenwich Bay, based on data from spatial and temporal stations, documented four hypoxic events from July to September. These events are represented in the dissolved oxygen data from two stations: Greenwich Bay Marina and Sally Rock. The most significant events were during July and early September.

Forcing Factors on Chlorophyll and Oxygen Levels: 2010

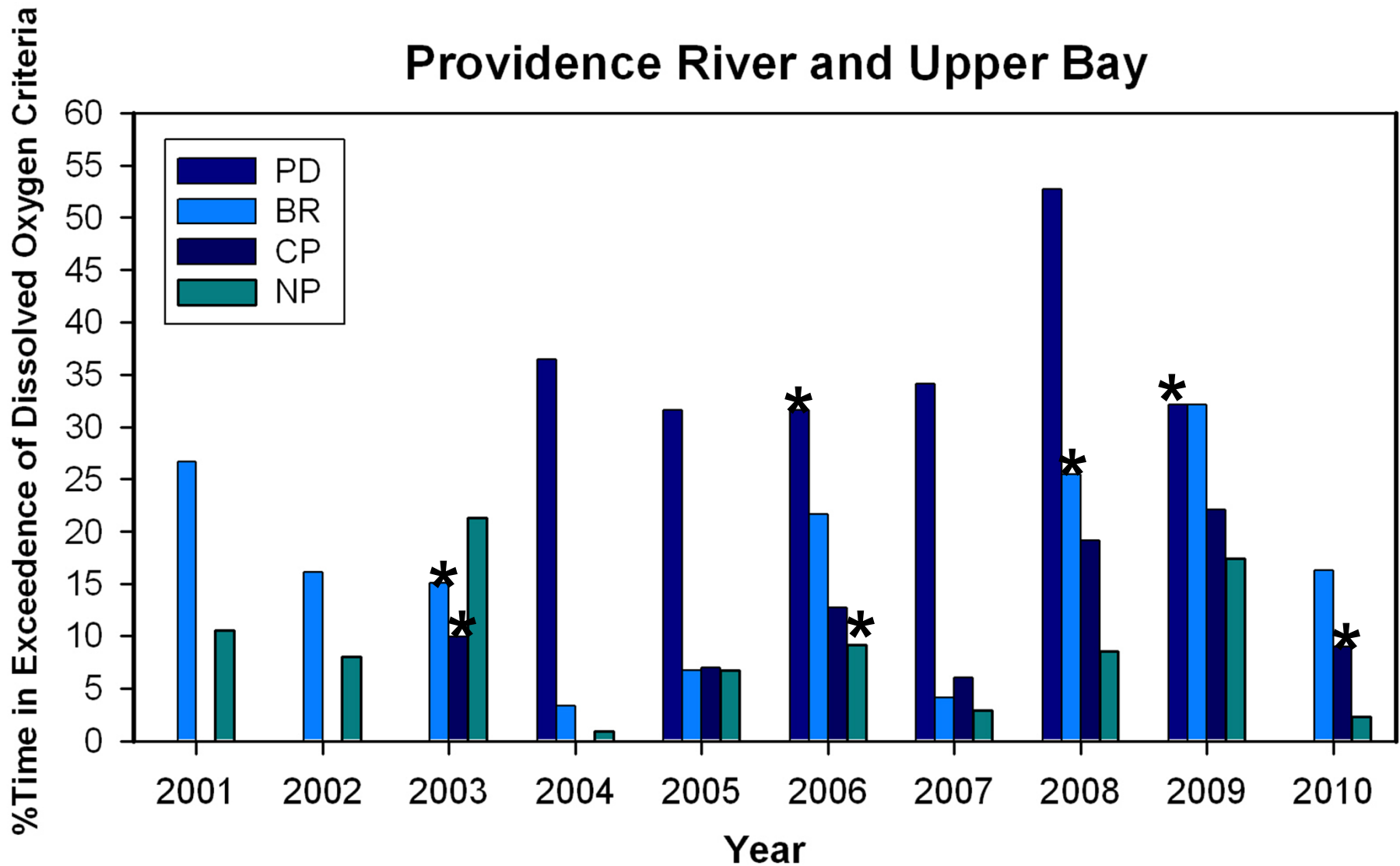


Seasonal (June-Sept) Average Temperatures with Total Rainfall and River Flows from the Blackstone River for 2001-2010



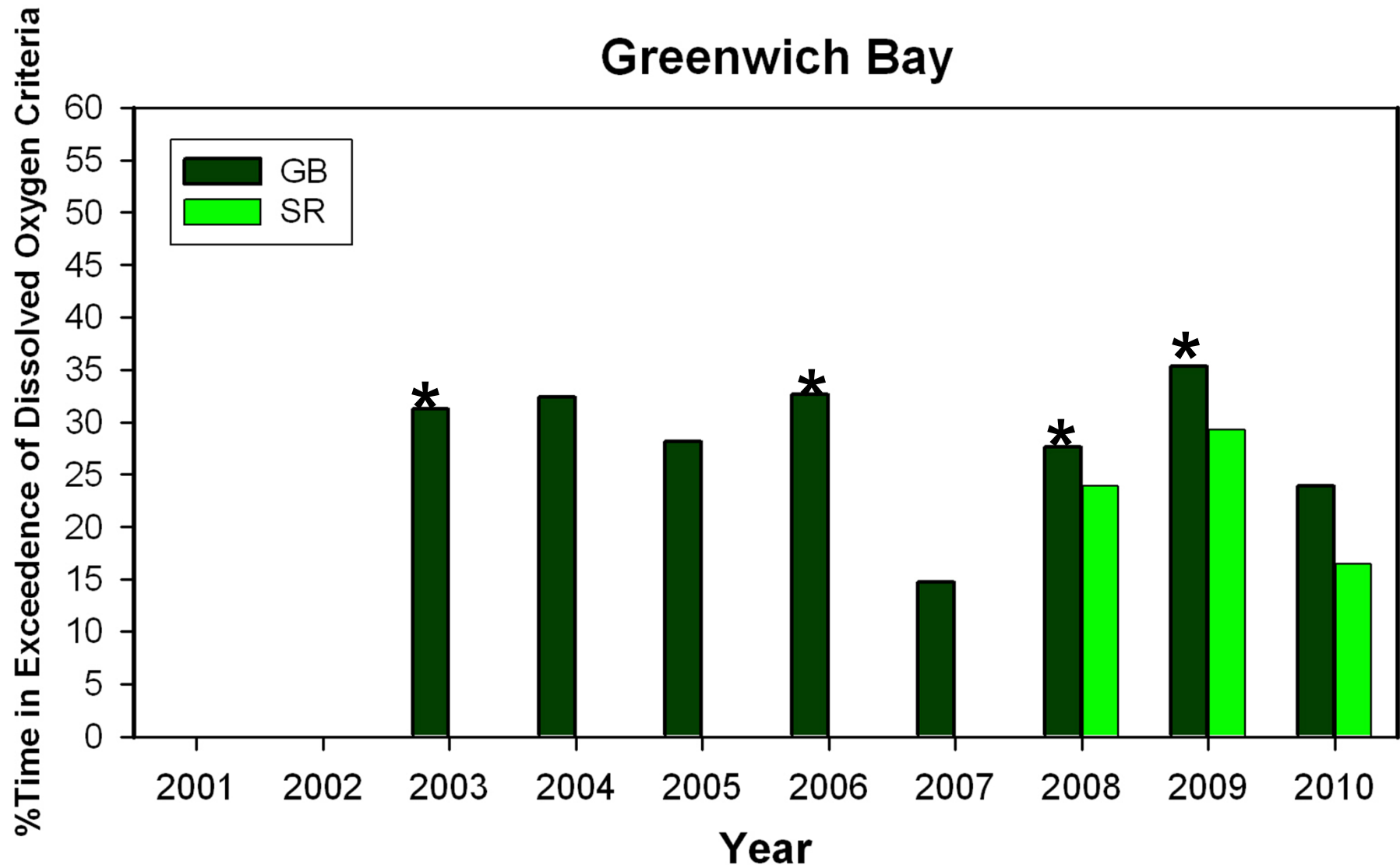
Providence River and Upper Bay RIDOCS results

* Indicate data gaps during recruitment season. Amounts maybe underestimated.



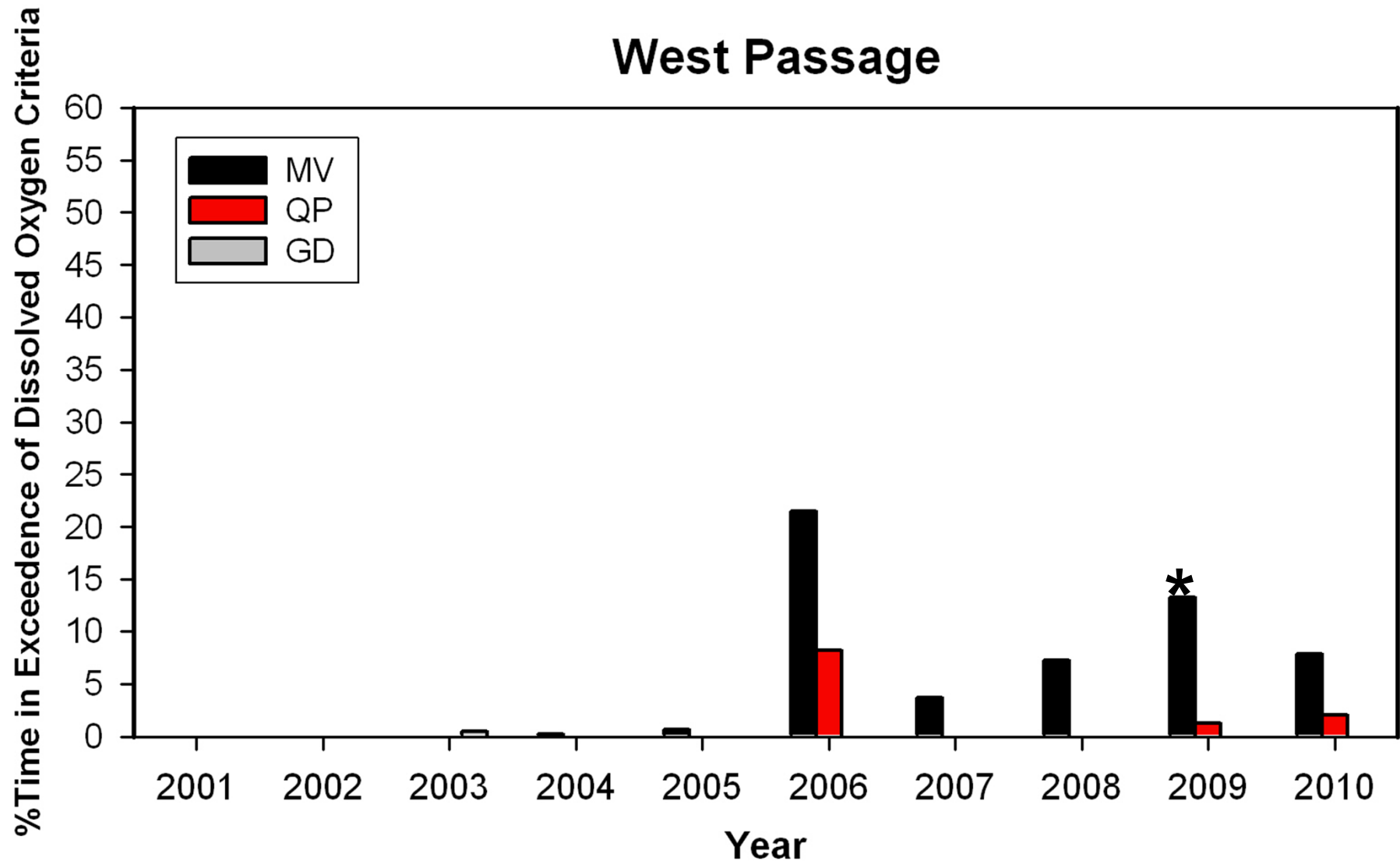
Greenwich Bay RIDOCS results

* Indicate data gaps during recruitment season. Amounts maybe underestimated.



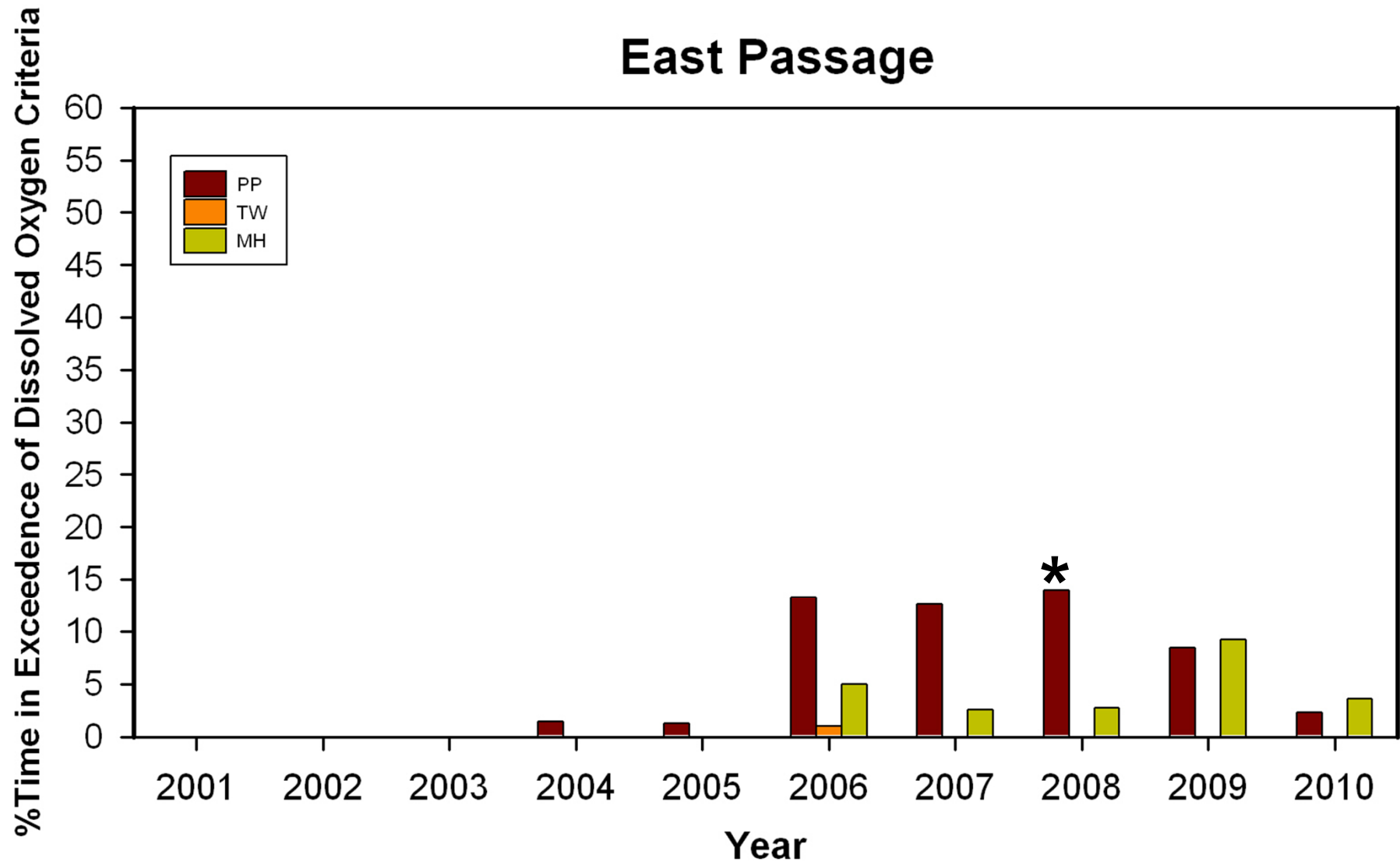
West Passage RIDOCS results

* Indicate data gaps during recruitment season. Amounts maybe underestimated.



East Passage RIDOCS results

* Indicate data gaps during recruitment season. Amounts maybe underestimated.

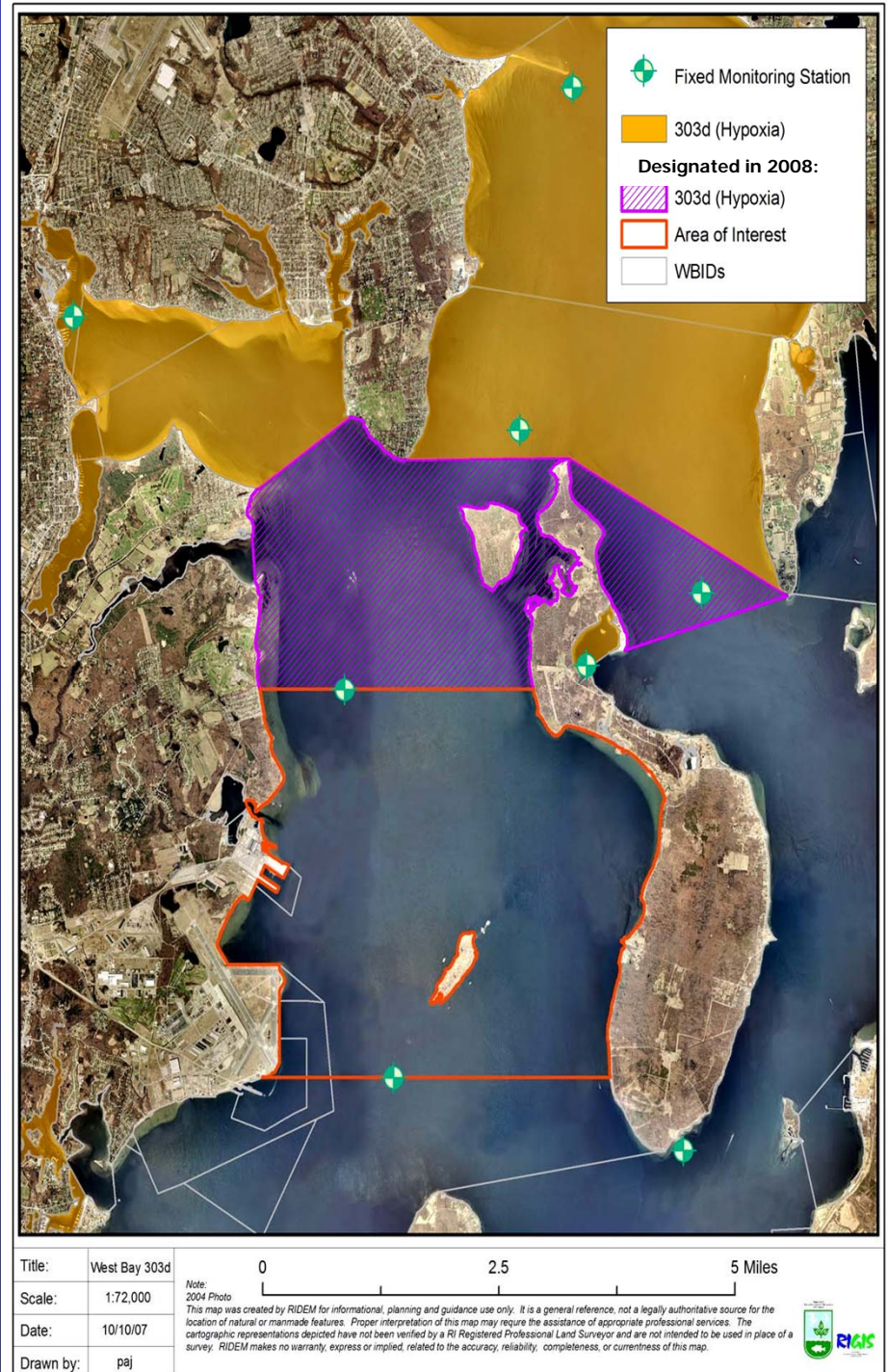


State Assessment Based on Recent Data

The state assessment results over the past few years were used to list an additional 7.62 square miles in Upper Narragansett Bay as impaired for dissolved oxygen.

This adjustment was made based on data from spatial and temporal datasets from NBFSMN, NBNEP, Brown, and others.

The goal of the network is to provide accurate data to users/managers tracking hypoxia and evaluating WWTF upgrades that are expected to reduce nutrient loadings to the Bay.



Summary of Narragansett Bay Assessment



- Seasonal Hypoxia (June-September)
 - High river flow years coincide with the most severe hypoxia
 - Episodic (days to weeks)
 - Inter-annual variability
 - More details through CHRP research
- Previously listed waters still experienced hypoxic events even during low-flow years
 - Providence River, Upper Bay, & Greenwich Bay
- RIDOCS observations using the NBFSMN data and other data
 - Mt. View and Poppasquash Pt areas are now listed as impaired for dissolved oxygen based on findings from the network.

**Update on Investigations of
Narragansett Bay Hypoxia
Funded by NOAA CHRP**
(Coastal Hypoxia Research Program)

Dan Codiga, URI/GSO
(representing the CHRP NB Team)

NBC Symposium
Providence, RI
June 16, 2011

- Summary of **CHRP NBI** (2005-present)
 - Team: *Oviatt/Codiga/Ullman/Kincaid/Nixon (GSO), Prell/Murray (Brown), Kremer/Vaudrey (UConn), Brush (VIMS), Deacutis/Kiernan (RI DEM)*
 - Key Observational Components
 - Fixed-site T/S/O/Chl network; *In situ* nutrients; Nutrient loads and denitrification; Spatial T/S/O/Chl surveys; Moored T/S/O profilers; Currents (moorings and surveys); Sediment fluxes
 - Key Modeling Components
 - Empirical analysis and synthesis
 - Hybrid Ecological/Hydrodynamic Models
 - ‘simplified’ ecology
 - material exchanges from Officer Box Model approach (EcoOBM)
OR high-res. ROMS hydrodyn. runs w/ realistic forcing (EcoGEM)
 - Workshops w/ Management/Regulatory Agencies

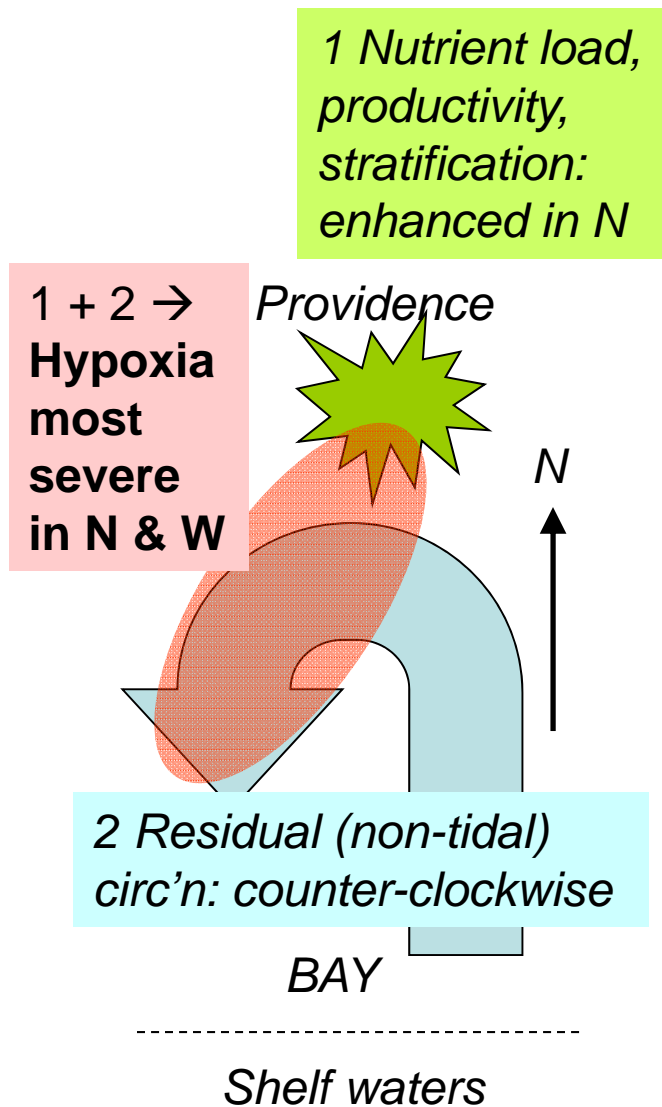
- **CHRP NB I:** **Some Key Findings & Products To Date**

1 *Some/all of talks today by Kincaid, Stoffel, Prell, Fields, Deacutis, Smith, Murray, Krumholz*

2 **Empirical analysis and synthesis (Codiga et al, 2009)**

- Hypoxia spatial extent: concentrated in northern/western areas
- Hypoxic event characteristics (rel. 2.9 mg/l) at an individual site
 - 2-5 events in typical year; each event 2-7 days long
 - Event-mean deficit-duration of 2-5 mg/l-day
- Weak spatial synchrony of hypoxic events among multiple sites
 - Due to local flushing/circulation/mixing influences: riverflow most important; then winds & sea level; spring-neap tidal phase less so
 - Need add'l circulation obs. to understand weather-band event var'ns
- Dramatic inter-annual hypoxia variability
 - Close link to inter-annual variation in river runoff & density stratification
- Benthic ecology: in N & W, direct mortality of sensitive species; bay-wide, indirect impacts (e.g. lower growth rates; pred.-prey shifts)

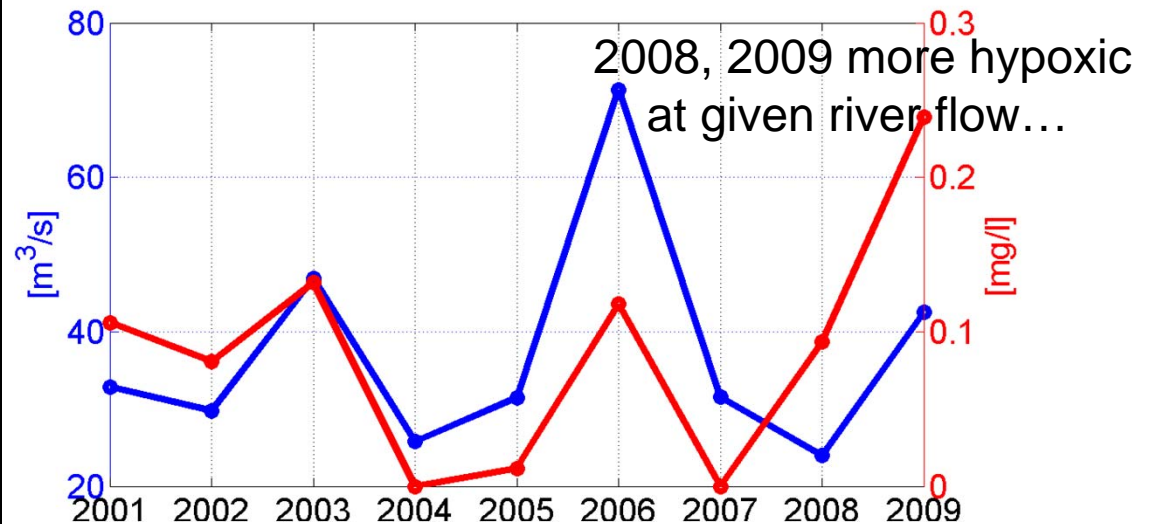
Spatial Distribution



Interannual variability

Hypoxia: Deficit-duration rel. 2.9 mg/l, sampling-normalized, average Bull. Rch. & N. Prudence

River flow: All rivers, May-June-July average



River flow → stratification and nutrient load

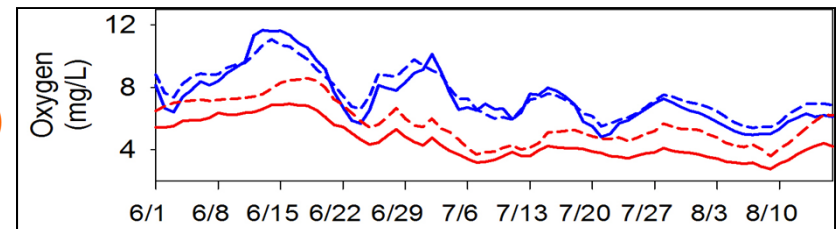
- Relative importance (of stratification and nutrient load) to inter-annual hypoxia variability not yet determined
- Empirical models: limited ability to distinguish influences b/c load covaries with river flow
- Mechanistic models (EcoOBM, EcoGEM) are needed and will be challenged by this question

- **CHRP NB I:** Some Key Findings & Products To Date

(cont.)

3 - Hybrid Ecol.-Hydrodynamic Models (Vaudrey, Brush)

- “Simple” ecological component
 - Minimal eutroph’n-related processes (primary prod, benthic fluxes)
 - 15 boxes bay-wide, surf./bott.; as justified by limits of avail. obs’ns
- Driven by material exchanges – two methods
 - Traditional Officer box model method “EcoOBM”
 - » Multiple years T/S obs., captures inter-annual variability
 - Gross Exchange Method “EcoGEM”
 - » Dyes in high-res. ROMS hydrodynamic model (Kremer et al, 2010)
 - » ROMS fidelity confirmed w/ obs., including moored T/S/O profilers
- All model rates and stocks compared against observations
- Enables scenario evaluation
 - Ex.: 2006, EcoGEM Box 3 (BR)
 - Blue shallow, Red deep
 - Dashed: nutrient load 50% lower



- **Overview of *CHRP NB II* (potential follow-up to *CHRP NB I*)**
 - Revised 2009 proposal invited; presently pending
 - 2011-15 (4 yrs), ~30-50% annual funds, rel. 5-yr *CHRP NB I*
 - Plus modest but important match funds from RI Bays, Rivers, Watersheds Coordination Team
- **If Funded: Key Planned Components**
 - **Nutrients: continued monitoring & budget analyses**
 - **Spatial T/S/O Surveys (partial support)**
 - **New Circulation Measurements**
 - Test hypothesis: coast-estuary exchange regulates hypoxic events
 - Bristol-Prudence ferry ADCP (ferry operator confirmation pending)
 - **Empirical Analysis & Synthesis**
 - Model for weather-band events; Multi-year trend analysis
 - **Hybrid Ecological/Hydrodynamic Models (EcoGEM/EcoOBM)**
 - Scenarios for changed nutrient load & changed climate
 - **End product: user-friendly tools to be run by, e.g., RI DEM**
 - **Workshops with management/regulatory agencies**