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Using the System-Wide-Monitoring-Program (SWMP) to Quantify Short-term Variability and Detect Long-term Changes in Estuaries

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National SWMP Program

The National Estuarine Research Reserves System (NERRS) is a coordinated network of 27 reserves that represent 11 biogeographic regions across the USA and its territories (Figure 1). The Reserves are being preserved and protected for long-term research, water-quality and meteorological monitoring, education, training, and coastal stewardship.



Figure 1. Biogeographic regions of the NERRS. A biogeographic region is a geographic area with similar dominant plants, animals, and prevailing climate. Map from the NOAA / NERRS at <http://www.nerrs.noaa.gov/ReservesMap.aspx>.

The System-wide Monitoring Program (SWMP) was created and developed by the NERRS in 1995 as a nationally-coordinated long-term monitoring program. The primary mission of the NERRS-SWMP is to measure changes in estuarine water quality and biotic diversity, and to map land-use changes in Reserves and their watersheds. These data are then translated and disseminated in order to contribute to effective coastal zone management.

SWMP in Narragansett Bay

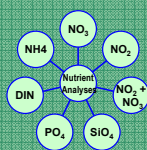
At the Narragansett Bay Research Reserve (NBRR or Reserve) in Rhode Island, the collection of abiotic water quality data through the NERRS-SWMP began in 1995 with the establishment of one long-term water quality monitoring station at Potter Cove. By 2002, the Reserve had established a total of four stations around Prudence Island: Potter Cove, Nag Creek, T-Wharf Surface, and T-Wharf Bottom (map at right).



At the NBRR, meteorological data have been recorded continuously since 2001 at a weather station near Potter Cove (image at left). By analyzing and summarizing this long-term information we can begin to examine how meteorology can help drive trends and patterns in water quality in Narragansett Bay.



The Reserve also began a dissolved nutrient monitoring program as part of SWMP in 2002. The two sub-components of this program include: 1) monthly grab sampling at each of the four water quality stations, and 2) monthly diel monitoring program at the T-Wharf Bottom station. All collected samples are analyzed for seven different nutrient species (image at right) as well as chlorophyll.



Methods and Data Examples

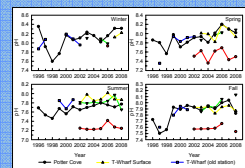
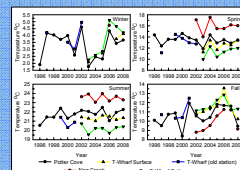
Estuarine Water Quality

Physical and chemical parameters are collected using Yellow Spring Instruments (YSI) 6600-EDS and 6600-V2 multi-parameter automated dataloggers also known as sondes (image at right). Water temperature (°C), salinity (ppt), dissolved oxygen (% saturation and mg L⁻¹), pH, turbidity (NTU), and chlorophyll (µg L⁻¹) data are collected simultaneously by sondes at each station.



All water quality data sondes are calibrated and deployed approximately every two weeks (image at left), collecting data every 15 minutes. For this project, we analyzed 14 yrs (1995-2008) of water quality data within each season. Seasonal means were calculated and the data were examined for significant trends across years within each season. Only datasets with 2/3 or more (>67%) of all potential data were included. Seasonal means were calculated based on the following: winter = Jan, Feb, Mar, spring = Apr, May, Jun, summer = Jul, Aug, Sep, fall = Oct, Nov, Dec.

Linear regression analysis showed that water temperature increased significantly only in winter across years at the T-Wharf Surface (R²=0.663, p=0.01) and T-Wharf Bottom (R²=0.663, p=0.04) stations. Water temperatures increased approximately 2.1°C overall (figures at right).

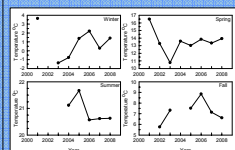


A significant increase in pH was found across yrs at Potter Cove and T-Wharf Bottom (figures at left). At Potter Cove, pH increased across years significantly in spring (R²=0.47, p=0.01), summer (R²=0.49, p=0.01) and fall (R²=0.44, p=0.01); It increased at T-Wharf Bottom in spring (R²=0.97, p=0.01) and fall (R²=0.90, p=0.01).

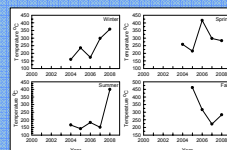
Meteorology

Since 2001, the NBNERR weather station has been collecting data for air temperature (°C), relative humidity (%), wind speed (m s⁻¹) and direction (degrees), barometric pressure (mb), rain (mm), and photosynthetically active radiation (PAR, mmol m⁻²). These data are collected every 5 seconds, averaged into 15-minute intervals, stored by a central datalogger, and then downloaded on an approximately monthly basis.

We analyzed 8 years (2001-2008) of meteorological data within each of the four seasons defined above. This long-term dataset was also examined for significant trends across years within each season using regression analysis. The same criteria described above for water quality were used to calculate seasonal means for meteorology.



The meteorological parameters analyzed exhibited seasonal patterns that are characteristic of temperate zones, but regression analysis showed no significant trends across years for any parameter.



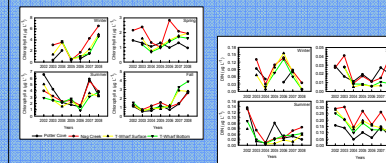
Despite the finding of no significant trends over time for any parameter, these data are still being used to characterize conditions within the NBNERR. In addition, as the dataset grows over time it will document any effects that global climate change has on local weather patterns and it will allow researchers to examine the effects of meteorology on Narragansett Bay water quality.

Nutrients and Chlorophyll

The NBNERR began monitoring dissolved nutrients as part of SWMP in 2002. It includes the grab sampling program to examine seasonal and spatial patterns, and a diel sampling program to examine the effects of tidal forcing.

Duplicate grab samples are collected monthly from Potter Cove, Nag Creek, T-Wharf Bottom and T-Wharf Surface; diel samples are collected every 2 hrs over a 24-hr period at the T-Wharf Bottom station only (image at right).

We analyzed 8 years (2001-2008) of nutrient and chlorophyll data using the same criteria described for water quality for calculating seasonal means; and examined the data for significant trends across years within each season using regression analysis.

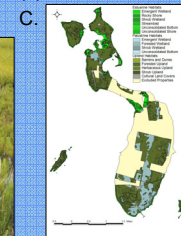
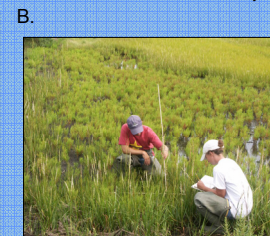
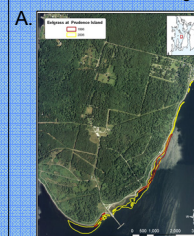


Linear regression analysis showed that chlorophyll and dissolved inorganic nitrogen (DIN) increased significantly in fall across years at the T-Wharf Surface only (R²=0.61 p=0.04, R²=0.66 p=0.03, respectively).



SWMP Phase 2 and 3

All 27 NERR sites also participate in the newer phases of SWMP. Phase 2 (Biological Monitoring) involves large-scale mapping of emergent marsh and SAV habitats (A) as well as on-the-ground monitoring of vegetation condition (B). Phase 3 (Habitat Mapping and Change) involves mapping all Reserve habitats according to the new NERR Habitat Classification System (C).



Summary

The NBNERR-SWMP makes it possible to study different ecosystem characteristics of Narragansett Bay. The abiotic data collected at the four water quality and meteorological station, as well as the data collected from the biological monitoring and habitat mapping SWMP components, are currently being used to enhance public awareness and understanding of Narragansett Bay and its watershed through education programs and outreach programs. These data also support innovative research projects and are an invaluable tool for scientists, managers, and decision makers to effectively address coastal resource management issues.

Acknowledgements

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