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Source: Journal of Coastal Research, 2008(10055) : 1-8

Published By: Coastal Education and Research Foundation

URL: https://doi.org/10.2112/SI55-012.1

Journal of Coastal Research	SI	55	1–8	West Palm Beach, Florida	Summer 2008

Research and Monitoring Components of the National Estuarine Research Reserve System

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ABSTRACT

MILLS, K.; KENNISH, M.J., and MOORE, K.A., 2008. Research and monitoring components of the national estuarine research reserve system. *Journal of Coastal Research,* SI(55), 1–8. West Palm Beach (Florida), ISSN 0749-0208.

The National Estuarine Research Reserve System (NERRS) consists of an integrated network of 27 reserve sites in 19 biogeographical subregions. These estuarine reserves are protected sites where comprehensive databases are compiled to characterize the natural and anthropogenic processes governing ecosystem stability and change. Data collected by research and monitoring programs of the NERRS provide the foundation for sound coastal management decision-making. Three principal areas of research and monitoring are targeted by the NERRS: (1) abiotic factors, including meteorological, water quality, and physical conditions; (2) biotic features, including both flora and fauna; and (3) land use and habitat change characterizations. Baseline conditions and trends in physical, chemical, and biological parameters are vital for evaluating changes that occur in response to various environmental stressors and long-term climate change throughout the network of estuarine ecosystems. The NERRS is a particularly effective program because its research and monitoring activities occur in all geographical regions of the United States and almost every recognized climatic zone. Because of the geographic expanse of the NERRS and its intensive and extensive research and monitoring initiatives, an ideal platform exists to characterize both the short-term variability and long-term changes in estuarine systems nationwide and to make these results available to support informed decision-making and increased public awareness of coastal systems.

ADDITIONAL INDEX WORDS: *NERRS, System-Wide Monitoring Program, research, monitoring.*

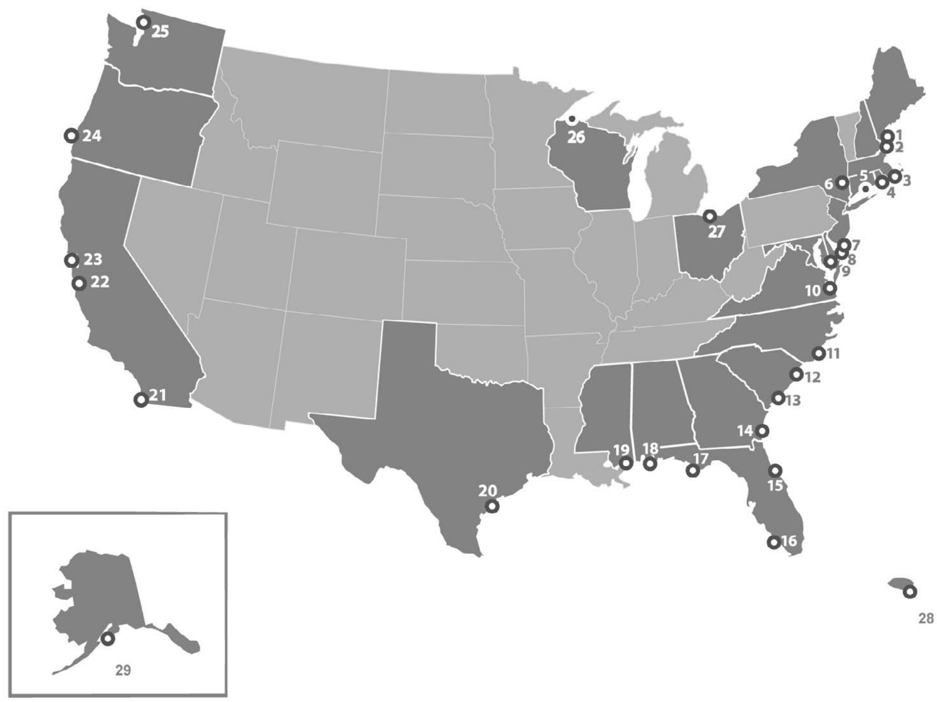
INTRODUCTION

The National Estuarine Research Reserve System (NERRS) is a network of protected and coordinated sites established to promote informed management of the nation's estuaries and coastal habitats. This coordinated system of estuarine sites was created by the *Coastal Zone Management Act of 1972,* as amended, Public Law 92-583, *U.S Code* 16, §§1451–1456, to augment the Federal Coastal Zone Management Program. The NERRS program establishes and manages, through federal–state cooperation, a national system of estuarine research reserves that represent the various regions and estuarine types in the United States and that provide opportunities for long-term research, education, and interpretation.

The NERRS is managed as a partnership between the National Oceanic and Atmospheric Administration (NOAA) and coastal states and territories. The Estuarine Reserves Division of NOAA is the management center of the NERRS program. This arrangement supports the coordinated implementation of nationally consistent monitoring programs at local sites in multiple estuaries. The standardization of sampling protocols is an unique element of the NERRS monitoring initiatives and is a primary functional strength of its System-Wide Monitoring Program (SWMP), which enables accurate data comparisons among the reserve sites comprising NERRS (Kennish, 2004; Small, 2008). In addition to carrying out standardized national monitoring programs, individual reserves also pursue research and monitoring projects that address questions specific to management needs at their sites or within their regions (NERRS, 2006a). In this manner, the NERRS capitalizes on a unique opportunity to develop databases that are comparable across multiple estuaries while also providing locally relevant scientific information useful for coastal zone management.

The reserve system currently consists of 27 reserves in 21 states and 1 territory (Puerto Rico) (Figure 1). Covering more than half-a-million hectares of estuarine habitat, adjacent wetlands, and contiguous uplands, these NERRS sites span 19 biogeographical subregions along the coasts of the Atlantic Ocean, Gulf of Mexico, Caribbean Sea, Pacific Ocean, and Great Lakes. The reserves are essentially demonstration sites where monitoring and research data are used to assess coastal issues of local, regional, and national interest for the purpose of sustaining estuarine systems (NERRS, 2007). The sites represent an array of different types of estuaries from relatively pristine to significantly altered by anthropogenic activity. They ensure a stable environment for research through long-term protection of resources. A central goal of the NERRS is to facilitate the development of sound science to support informed coastal decision-making and increased

DOI: 10.2112/SI55-012.1.



1. Wells, Maine
2. Great Bay, New Hampshire
3. Waquoit Bay, Massachusetts
4. Narragansett Bay, Rhode Island
5. Connecticut *
6. Hudson River, New York
7. Jacques Cousteau, New Jersey
8. Delaware
9. Chesapeake Bay, Maryland
10. Chesapeake Bay, Virginia
11. North Carolina
12. North Inlet-Winyah Bay, South Carolina
13. ACE Basin, South Carolina
14. Sapelo Island, Georgia
15. Guana Tolomato Matanzas, Florida
16. Rookery Bay, Florida
17. Apalachicola, Florida
18. Weeks Bay, Alabama
19. Grand Bay, Mississippi
20. Mission-Aransas, Texas
21. Tijuana River, California
22. Elkhorn Slough, California
23. San Francisco Bay, California
24. South Slough, Oregon
25. Padilla Bay, Washington
26. Wisconsin *
27. Old Woman Creek, Ohio
28. Jobos Bay, Puerto Rico
29. Kachemak Bay, Alaska

* *Proposed Reserve*

Figure 1. Location of designated and proposed sites within the National Estuarine Research Reserve System.

public awareness for the protection of natural resources (NERRS, 2006a), with a focus on four priority coastal management issues: (1) land use and population growth, (2) habitat loss and alteration, (3) water quality degradation, and (4) changes in biological communities (NERRS, 2006b).

The NERRS established the SWMP in 1994 to track physical, chemical, and biological conditions and ecological processes of estuarine ecosystems using systemwide monitoring procedures and quality assurance protocols (Sanger *et al.,* 2002; Wenner *et al.,* 2001). Since its initiation, the long-term monitoring and iterative habitat assessments conducted within the NERRS have gathered data for multiple purposes. Monitoring data serve as a basis for research to enhance fundamental understandings of the temporal and spatial dynamics of estuarine processes. In addition, the data provide management-relevant information to evaluate changes in the ecosystem in response to natural perturbations and anthropogenic disturbance. Moreover, continued operation of the long-term monitoring effort will yield valuable data that will inform assessments and models of the cumulative effects of environmental stressors and climate change in estuarine ecosystems (NERRS, 2007).

The compilations in this special issue of the *Journal of Coastal Research* are the outcome of recent research and monitoring projects conducted within the NERRS program. The volume consists of 17 articles that highlight these projects and the array of estuarine research and monitoring efforts that are ongoing in the NERRS. The articles showcase both basic and applied uses of the physical, chemical, and biological data that are being collected and managed by the NERRS.

SYSTEM-WIDE MONITORING PROGRAM

As noted above, a major focus of the SWMP is to improve the understanding of estuarine variability associated with both natural processes and anthropogenic activities through measurements of short-term variability and long-term changes in water quality, biotic community structure, aquatic habitat characteristics, and watershed land use and land cover (NERRS, 2007). In this regard, SWMP initiatives have included efforts to obtain extensive and useful databases on a variety of environmental and biological features of estuaries in the NERRS. According to NERRS (2002), examples of problems that could be addressed by the collection of these comprehensive databases include the following:

- Changes in water quality associated with land use change, nutrient loading, or altered freshwater flow
- Comparison of natural, altered, and restored habitats
- Correlation of water quality over broad spatial scales with occurrence, density, and distribution of biological resources

Research and monitoring at the NERRS sites have yielded data on the processes that govern stability and change in estuarine ecosystems. The SWMP anchors research and monitoring efforts at NERRS sites and ensures the standardization of sampling protocols, which allows reliable comparisons of data among reserve sites. The SWMP consists of three major elements: (1) abiotic monitoring, (2) biotic monitoring, and (3) land use and habitat change characterizations (NERRS, 2007). Each of these elements contributes long-term data that are valuable for tracking changes in ecosystem features and for assessing relationships between those features to better understand the drivers of the observed changes.

Abiotic Monitoring

Abiotic monitoring focuses on data acquisition of three major SWMP components: (1) water quality, (2) physical conditions, and (3) weather. Baseline data acquisition for these three components provides important contextual information on the physicochemical dynamics of an estuary. They also help track, over time and across space, changes that may be induced by human activities. For example, nutrient enrichment has increased dramatically in estuaries around the country and has become recognized as a significant stressor in many estuarine ecosystems (Kennish and Townsend, 2007). The abiotic monitoring conducted through the SWMP provides important data on nutrient concentrations, on how nutrient concentrations are influenced by physical processes (*e.g.,* tidal cycles, precipitation), and on how nutrient concentrations may affect other ecosystem conditions (*e.g.,* chlorophyll *a* and dissolved oxygen). As this example shows, tracking abiotic features in the NERRS facilitates greater understanding of estuarine processes and the factors that influence those processes; it also provides baseline information to guide improved management of estuarine ecosystems.

SWMP fills an important void for an integrated national program that evaluates the status of marine environmental resources and the trends in estuarine water quality over extended time periods and across large spatial regions. Therefore, it differs from most existing nationwide monitoring programs, which monitor local estuarine conditions over shorter periods each year. Water quality parameters—temperature, conductivity, pH, dissolved oxygen, turbidity, and water depth—have been monitored within all NERR sites since 1995. Data are gathered using 6-series data sondes from Yellow Springs Instrument Company (YSI), Yellow Springs, Ohio (YSI 6600 or YSI 6600 EDS models) deployed at four principal, long-term stations in each reserve. Each parameter is measured at 15- to 30-minute intervals; data from at least one data sonde per reserve are telemetered hourly *via* satellite to a central receiving station for near–real-time use (NERRS, 2007). All data and metadata are archived and Web-available *via* the Centralized Data Management Office (CDMO) currently located at the North Inlet–Winyah Bay NERR in South Carolina (http://cdmo.baruch.sc.edu). The measured parameters track changes in key physicochemical conditions and are indicative of habitat quality for numerous species. They also document environmental criteria that relate to human health and influence human use of estuarine areas.

Nutrients have been monitored at the data sonde sites since January 2002. Replicate grab-samples are collected monthly; in addition, monthly diel samples are taken at 2.5 hours or shorter intervals over a lunar day (24 h and 48 min) at one site using an ISCO (Teledyne Isco, Inc., Lincoln, Nebraska). All NERRS reserves gather data on ammonium, nitrate, nitrite, orthophosphate, and chlorophyll *a*. Additional nutrient parameters are measured by some of the reserves (*e.g.,* silica, particulate nitrogen and phosphorus, dissolved total nitrogen and phosphorus, particulate and dissolved carbon, and total suspended solids) (NERRS, 2007). As coastal development and associated eutrophication problems have increased, nutrient monitoring is important for investigating patterns and drivers of change in nutrient concentrations and for devising effective mitigation and remediation strategies (Kennish, 2003; Kennish and Townsend, 2007).

Meteorological data are also collected through the NERRS

SWMP. Monitoring stations are sited at locations typical of natural conditions of each reserve and are installed according to National Weather Service guidelines. The parameters (*i.e.,* air temperature, wind speed and direction, barometric pressure, relative humidity, precipitation, and photosynthetically available radiation) are measured every 5 seconds, with an average or total value output every 15 minutes. Data are telemetered hourly *via* satellite to a central receiving station for near–real-time use (NERRS, 2007). The meteorological monitoring provides valuable contextual data for interpreting water quality implications of short-term weather events and for investigating estuarine responses to longer-term climatic variability. In addition, understanding links between atmospheric deposition and nutrient loading to estuaries (GAO, KENNISH, and MCGUIRK FLYNN, 2007; PAERL, 1997; PAERL, DENNIS, and WHITHALL, 2002) requires accurate meteorological records.

Biotic Monitoring

Biotic monitoring or "biomonitoring" as part of the SWMP characterizes biological diversity in NERRS estuarine ecosystems by assessing community composition and species abundance and distributions. These data document baseline biotic conditions, provide near-term indications of change in estuarine biota, and track long-term changes in biotic communities. Biomonitoring data also address specific research questions or management issues, such as those associated with relationships between water quality and species distributions or the influence of habitat degradation or restoration on biotic communities.

Implementation of the biomonitoring component of the SWMP commenced in 2004 using the protocols of MOORE and BULTHUIS (2003), with initial efforts focused on monitoring submerged aquatic vegetation (SAV) and emergent vegetation. Since that time, baseline data have been collected at most reserve sites to document the presence, growth, and spatial distribution of emergent and submerged vegetation. Vegetation monitoring is conducted using two approaches. One approach (referred to as Tier I) documents the overall areal extent and spatial distribution of SAV and emergent vegetation within the reserve boundary at annual or multiannual time scales. Mapping is conducted using remotely sensed data, field surveys, or a combination of these techniques using protocols adopted for NOAA's Coastal Change Analysis Program and the Chesapeake Bay Program (DOBSON *et al.,* 1995; NERRS, 2001). The second approach (referred to as Tier II) focuses on the community and vegetative characteristics at permanent sampling stations located along transects within selected stands of SAV and emergent vegetation. It uses methods that are common in other monitoring programs (NECKLES and DIONNE, 2001; NECKLES *et al.,* 2002; ROMAN, 2001; SHORT *et al.,* 2002) and in a variety of studies (*e.g.,* MOORE and JARVIS [this issue]; KENNISH, HAAG, and SAKOWICZ [this issue]). This more-detailed characterization of the local vegetation community captures patterns of vegetation growth and compositional change over short or long time scales.

As the biomonitoring program is expanded, it will track a suite of ecosystem components to elucidate basic ecological processes in estuaries and to better understand the implications of abiotic and biological changes at the ecosystem level. Other components to be incorporated into the biomonitoring program include plankton, nekton, benthos, invasive species, and marsh birds (KENNISH, 2004; NERRS, 2007). These biotic groups have ecological roles ranging from primary producers to top-level consumers in the food web. They can serve as indicators of disturbance (*e.g.,* nutrient enrichment, habitat alteration, climate change) and represent biotic responses that are of interest and concern to managers and the public. As part of the SWMP, consistent protocols will be developed and tested for monitoring these additional biotic groups across the NERRS. Some NERRS sites already conduct site-specific monitoring and research on these groups of organisms to address issues of local interest and concern.

Land Use and Habitat Change Characterizations

Human settlement and population growth in the coastal zone have significantly altered the landscape of estuarine watersheds *via* habitat destruction and fragmentation. Secondary effects of landscape change have degraded water quality due to increased surface water runoff, accelerated loading of nutrients and sediments, and freshwater diversions (KENNISH, 2002). The land use and habitat characterization component of SWMP tracks the magnitude and extent of habitat change and facilitates an understanding of how these changes are linked to watershed land-use practices.

To track land use and habitat change, a set of two standard monitoring procedures is applied at relevant scales that encompass each reserve and its surrounding watershed. Through a partnership with NOAA's Coastal Services Center, land cover in each reserve's watershed is characterized at moderate resolution (30-m) using data and protocols associated with the Coastal Change Analysis Program (C-CAP) (NERRS, 2001). These products are developed using remotely sensed imagery, from which coastal intertidal areas, wetlands, and adjacent uplands are inventoried. Current inventories are maintained and change analyses are conducted by updating the land cover maps at 5-year intervals.

Fine-scale, high-resolution habitat mapping and change analyses are conducted within each reserve's boundaries using a standardized classification scheme that incorporates habitat types as well as land use types (KUTCHER, GARFIELD, and RAPOSA, 2005). This classification structure organizes habitats by their salinity zone, flooding regime, substrate type, and vegetation cover to provide very detailed inventories of resources within each reserve. In most reserves, data for this characterization are derived from aerial photographs or other high-resolution, remotely sensed images. Extensive ground-truthing ensures high levels of classification accuracy to support sensitive change analyses and trend assessments over time.

This component of the SWMP enables a comparison of local, regional, and national differences in watershed land use patterns, an understanding of how these differences influence estuarine habitat quality, and an assessment of the vulnerability of specific habitat types given land use change patterns. At local levels, these products provide important information needed for effective coastal land use planning and decision-making. They also provide critical data needed to assess specific issues, such as the risk posed to coastal habitats by sea level rise.

PLAN OF THIS VOLUME

Special Issue 55 of the *Journal of Coastal Research* highlights some of the research that has been conducted by the NERRS in recent years. It serves as a companion to an earlier special issue (Kennish, 2004) but places greater emphasis on the biological monitoring efforts ongoing within the NERRS, as well as on studies that investigate linkages between physical and biological components of ecosystems. It includes articles based on NERRS monitoring data alone, as well as investigations that pair NERRS data with data collected by other entities. The latter type of studies demonstrates the value of concurrently using data from multiple monitoring programs to more fully understand patterns and processes in estuarine ecosystems.

Physical dynamics play a large role in structuring chemical and biological features of estuaries. Sheng *et al.* ("Circulation and flushing in the lagoonal system of Guana–Tolomato–Matanzas National Estuarine Research Reserve [GTMNERR], Florida") model the three-dimensional barotropic and baroclinic circulation and flushing in estuarine waters of the reserve. The model focuses on flushing rates in different areas of the estuary. Model results reveal that tidal exchange was the dominant flushing mechanism for the estuary, but river inflow and salinity played important roles in circulation in areas far from the tidal inlets. The three-dimensional model provides fundamental insights into physical dynamics of the estuarine system, and the approach can provide guidance on sampling strategies for further studies within the GTMNERR.

In addition to the structuring forces associated with routine physical dynamics, major storms can intermittently, yet substantially, influence physical, chemical, and biological processes in estuaries. Dix, Phlips, and Gleeson ("Water quality changes in the Guana Tolomato Matanzas National Estuarine Research Reserve, Florida, associated with four tropical storms") investigate the effects of extreme winds and rainfall caused by tropical storms on salinity, nutrient concentrations, and water clarity in the GTMNERR. High-frequency water quality, meteorological, and nutrient data gathered in the reserve could be used to distinguish the initial effects of winds from later effects of rainfall. Temporal patterns of salinity and nitrogen concentrations show changes as the storms make landfall and after they have passed through an area. Findings of this study provide detailed insights into the complex processes by which natural disturbances can influence estuarine water quality conditions, and why they must be considered in designing, implementing, and justifying management responses.

In another study of the effects of storm events on estuaries, Edmiston *et al.* ("Tropical storm and hurricane impacts on a Gulf Coast estuary: Apalachicola Bay, Florida") document the short-term and long-term impacts of major storms on water quality, physical features, and biological components of the Apalachicola Bay ecosystem. They show that some storms induce only short-term changes to water level, water quality, and some biota (*i.e.,* sea turtle nest loss). Other storms, such as Hurricane Dennis in 2005, cause long-term impacts that restructure certain features of the ecosystem. Some examples of these lasting impacts include alterations of the physical structure of shorelines; loss of, or changes in, the distribution of submerged aquatic vegetation; and damage to oyster reefs and populations. This study highlights the variability in storm-induced impacts to estuarine ecosystems and explains factors that influence the persistence and severity of impacts.

Two articles in this volume address general challenges associated with making comparisons of ecological conditions across diverse estuaries in which environmental features and processes may differ substantially. In the first of these articles, Shields and Weidman ("A quantitative approach to characterizing hypoxic events") concentrate on hypoxia as an important stressor for which standardized methods of comparison do not exist across estuaries. They create an index to compare the frequency and severity of hypoxia in a standard manner based on the temporal duration of and oxygen concentration during hypoxic events. Such an index captures the transient nature of hypoxic events and allows for a comparison of the frequency and severity of hypoxia across space and time, either within or among estuaries.

In another attempt to facilitate ecological comparisons across diverse estuarine ecosystems, Apple, Smith, and Boyd ("Temperature, salinity, nutrients and the covariation of bacterial production and chlorophyll-*a* in estuarine ecosystems") develop a multivariate framework to classify estuaries based on their sources of environmental variability. Their analysis shows that salinity and temperature are the main factors driving variability among the NERRS sites. They also consider relationships between environmental conditions and biological processes, noting that salinity and temperature significantly affect bacterial production and chlorophyll-*a* concentrations across estuarine ecosystems. This finding links broadscale physicochemical differences with primary biological patterns in estuaries.

Developing a better understanding of nutrient dynamics in the Mullica River–Great Bay Estuary in New Jersey is a primary goal of a study by McGuirk Flynn ("Organic matter and nutrient cycling in a coastal plain estuary: carbon, nitrogen, and phosphorus distributions, budgets and fluxes"). This study examines the cycling of dissolved organic matter and dissolved inorganic nutrients, including the distribution of these components and the factors that influence their patterns in time and space. In addition, a nutrient budget is developed for the system that accounts for both dissolved organic and inorganic components. Seasonal sources and sinks of nutrients within the estuary are identified, and it is demonstrated that the estuarine system plays an important role in the cycling and processing of nutrients, ultimately controlling the delivery of organic and inorganic forms to the coastal zone.

The influence of climate change and variability on estuarine fauna is explored by Allen *et al.* ("Mesozooplankton responses to climate change and variability in a southeastern

U.S. estuary [1981–2003]"). This article presents long-term trends in abundance and composition of large mesozooplankton in the North Inlet Estuary, South Carolina, and links these patterns to climate change and variability of physical characteristics of the ecosystem, including water temperature and salinity. The coupling of biological and physical data in such a manner is critical for understanding how community composition, larval recruitment, trophic interactions, and secondary production may be affected by climate change.

Links between physical variability and biological communities are also examined by WHYTE *et al.* ("The invasion and spread of *Phragmites australis* during a period of low water in a Lake Erie coastal wetland"). This study documents a shift in the vegetation community at the Old Woman Creek NERR, from a predominantly open water system to a shallow, emergent system dominated by the common reed, *Phragmites australis,* during a period of time when water levels in Lake Erie declined. It tracks the invasion process from its early stages through large-scale vegetation community changes and provides insights into how hydrologic patterns may facilitate biological changes, in this case, an increase in an invasive species that may have substantial secondary ecological implications (*e.g.,* see also WELLS *et al.* [this issue]).

RUMRILL and SOWERS ("Concurrent assessment of eelgrass beds (*Zostera marina*) and salt marsh communities along the estuarine gradient of the South Slough, Oregon") investigate emergent and submerged vegetation communities in a shallow tidal inlet near the mouth of Coos Bay. They assess multiple metrics that may serve as reliable indicators of the ecological status and condition of estuaries in the Pacific Northwest. They focus on two dominant estuarine habitat types—seagrass beds and salt marshes—to understand features that can be reliably used to describe ecological conditions of these vegetation communities. Their study offers a framework for conducting integrated estuarine assessments that account for multiple key habitats and processes in evaluating ecological health.

Three articles in this volume specifically focus on seagrass, including its spatial and temporal dynamics in two East Coast estuaries, as well as monitoring techniques for tracking its distribution and condition. MOORE and JARVIS ("Environmental factors affecting recent summertime eelgrass diebacks in the lower Chesapeake Bay: implications for long-term persistence") sampled eelgrass along fixed transects at the downriver and upriver regions of the York River estuary from 2004 to 2006. Their sampling period spanned the unusually hot summer of 2005, and during that period, an episode of nearly complete dieback of the eelgrass was observed. Patterns of loss and recovery indicate that eelgrass diebacks can occur suddenly and that recovery can be slow. These findings suggest that eelgrass in the York River is highly susceptible to the combined effects of high temperatures, low oxygen, and reduced light conditions and that it may be growing near the limits of its physiological tolerance.

Using a similar research approach, KENNISH, HAAG, and SAKOWICZ ("Seagrass demographic and spatial habitat characterization in Little Egg Harbor, New Jersey, using fixed transects") conducted an extensive study of seagrass in the Jacques Cousteau NERR. Their work documents temporal and spatial demographic patterns of *Zostera marina* over the course of a growing season, detailing changes in biomass, bottom areal coverage, blade length, and other factors. They also simultaneously monitored the areal coverage and composition of macroalgal species and assessed the potential shading impact of algae on the seagrass beds. Blooms of *Ulva lactuca* blanketed parts of the seagrass beds and appeared to degrade substantial areas of this highly eutrophic estuary.

HAAG, KENNISH, and SAKOWICZ ("Seagrass habitat characterization in the estuarine waters of the Jacques Cousteau National Estuarine Research Reserve using underwater videographic imaging techniques") conducted an innovative field study to assess the efficacy of high-resolution underwater videographic imagery of seagrass beds relative to more conventional data-acquisition methods. Results from this technique show a high correlation with diver observations of presence/absence and percentage of cover by seagrass throughout the growing season. Underwater videographic imaging may offer several advantages over *in situ* monitoring of seagrass habitats; it requires much less field time and provides files that can be analyzed by multiple investigators or stored for analyses in subsequent studies. This study offers an example of the types of technological and methodological testing that is conducted in the NERRS from which improved monitoring protocols can be developed.

Although many management efforts seek to restore degraded salt marshes, careful documentation of the ecological changes that occur as a result of restoration activities is vital for knowing whether the restoration effort produced the intended outcomes and for planning more-effective restoration designs in future situations. RAPOZA ("Early ecological responses to hydrologic restoration of a tidal pond and salt marsh complex in Narragansett Bay, Rhode Island") monitored vegetation, birds, and nekton to track the biological changes that resulted from restoring tidal exchange to a salt pond and marsh complex. Increasing the tidal range from 4 cm to 120 cm through this restoration effort resulted in a decline in the invasive grass, *Phragmites australis,* whereas native marsh vegetation remained unchanged. Following restoration, more bird species and a greater abundance of birds were observed using the marsh, but nekton density decreased substantially due to a change from subtidal to intertidal conditions, as well as increased predation by birds. Monitoring a suite of factors helped to document the varied physical and biological responses as the marsh shifted toward a more naturally functioning system, thereby confirming the effectiveness of the restoration project.

Two studies in this issue focus on nekton in coastal habitats of South Carolina. The first of these articles examines the population trends of white shrimp, *Litopenaeus setiferus,* and the relationships to physical, environmental conditions. DELANCEY, WENNER, and JENKINS ("Long-term trawl monitoring of white shrimp, *Litopenaeus setiferus* [Linnaeus], stocks within the ACE Basin National Estuarine Research Reserve, South Carolina") document trends in the abundance and size of white shrimp between 1979 and 2005 and note differences over years and seasons. Significant relationships are identified between shrimp abundance and both winter water temperature and summer dissolved oxygen concentrations. The study also shows an inverse relationship between the size and abundance of shrimp, which may reflect density-dependent controls on the population.

UPCHURCH and WENNER ("Fish and decapod crustacean assemblages from the Ashepoo–Combahee–Edisto Basin, South Carolina (1993–1999)") compiled data from monthly trawl surveys conducted along the salinity gradient of rivers in the Ashepoo–Combahee–Edisto (ACE) Basin NERR between 1993 and 1999. During these surveys, 79 species of fish and 26 species of decapod crustaceans were caught, with coastal marine species representing over 80% of this diversity. Salinity gradients strongly influence the spatial distribution of species, and seasonal variations in abundance and diversity appear to be related to migration and recruitment of species to the estuary. This study describes how nekton use of the ACE rivers is structured by life history attributes, seasonal movement patterns, and salinity regimes.

SCHMID *et al.* ("The effect of Australian pine [*Casuarina equisetifolia*] removal on loggerhead sea turtle [*Caretta caretta*] incubation temperatures on Keewaydin Island, Florida") investigate the potential interactions between an invasive species, the Australian pine, and a threatened species, the loggerhead sea turtle. Australian pine proliferates in coastal areas, but the trees fall over easily during strong winds, thereby making sea turtle nesting habitat inaccessible. However, these trees also shade nesting areas, and nest temperatures influence the sex ratio of hatchings. This study concludes that Australian pine and native vegetation offer similar levels of shading and result in comparable substrate temperatures, thus indicating that removal of the invasive pines would not impair loggerhead sea turtle populations.

WELLS *et al.* ("Temporal changes in the breeding bird community at four Hudson River tidal marshes") replicated a 1986–87 study of avian breeding habitats to investigate changes that had occurred between then and 2004–05. Their study documents the bird species breeding in four marshes, determines changes in the community, and relates the spatial distribution of bird species to habitat variables. In two marshes, they found that bird species diversity had decreased significantly, while the density of Red-winged Blackbirds (*Agelaius phoeniceus*) increased. In one marsh, this shift to an avian community dominated by Red-winged Blackbirds coincided with a shift in the vegetation community from one dominated by *Typha angustifolia* to one of *Phragmites australis.* These results demonstrate that the changes to habitat structure that result from the invasion of *Phragmites* can have significant implications for faunal communities in salt marsh habitats.

The aforementioned articles provide examples of the types of research and monitoring projects that are being conducted at NERRS sites throughout the country. As these cases indicate, studies seek to understand topics as diverse as estuarine physical dynamics, biogeochemistry, and species–habitat associations. They also seek to provide information that is needed for better management and increased public awareness of these ecosystems by developing ways to assess environmental conditions across estuaries, tracking water quality and habitat changes, monitoring species use of the estuary, documenting the spread and impacts of invasive species, and evaluating the effectiveness of restoration projects. The fundamental and applied information that is generated through NERRS research and monitoring enhances the broader knowledge and understanding of short-term variability, long-term change, and factors driving these processes in estuaries.

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