Peconic Estuary Program

2015 Ecosystem Status Report

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Executive Summary

Introduction

The Peconic Estuary, situated between the North and South Forks of eastern Long Island, New York, consists of more than 100 distinct bays, harbors, embayments, and tributaries. Concerns about the health of the Peconic Estuary were raised in 1985, after the first appearance of Brown Tide and a concerned citizenry called on and then joined with governments and other stakeholders to conserve and manage this important natural resource. That partnership is now known as the Peconic Estuary Program (PEP). The Peconic Estuary is exhibiting signs of stress including recurrent harmful algal blooms, declining eelgrass and wetland habitats, and even fish kills. These stresses are likely to worsen as the human population in the Peconic Estuary watershed increases and land uses intensify, unless steps are taken to reduce pollutant loading, specifically nitrogen loading, and protect habitats from physical alterations.

The Peconic Estuary Program 2015 Ecosysten Status Report (ES) is intended to outline the status and trends of thirteen environmental indicators to summarize the ecological health of the Peconic Estuary since the 2005 Environmental Indicators (EI) Report. The status of water quality in the estuary is based on harmful algal bloom presence, chlorophyll-a concentrations, water clarity, and nitrogen and dissolved oxygen concentrations. The status of living resources in the estuary is represented by eelgrass and wetland habitat, scallop, river herring, piping plover, and finfish populations. The status of pathogen pollution is represented by beach closures and shellfish bed closures.

Environmental Indicators

Harmful Algal Blooms

Presence and frequency of Harmful Algal Blooms (HABs), a proliferation or rapid increase in one or several species of microalgae, cyanobacteria or microalgae, is an indicator of the Peconic Estuary water quality. Although there have been no significant Brown Tide blooms in the Peconic Estuary since 1995, various other HABs have emerged and established annual recurrence in the Estuary. Nitrogen inputs from sanitary waste disposal, fertilizers, atmospheric deposition and stormwater runoff are believed to contribute significantly to the increased occurrences of HABs. Red tide blooms caused by *Alexandrium fundyense* have been identified in James Creek, Sag Harbor Cove and *Alexandrium* and red tide blooms caused by *Dinophysis acuminata* have been recorded in Meetinghouse Creek and western Flanders Bay. Rust tide blooms caused by *Cochlodinium polykrikoides* have been recorded in Flanders Bay and parts of Great Peconic Bay and have been implicated in fish and shellfish kills in the western Peconic Estuary. Toxic blue-green algae blooms caused by *Cyanobacteria sp.* have been limited to a few tributaries of a few embayments within the Estuary. While *Ulva lactuca* blooms are present in the Peconic Estuary, significant impacts have not yet been documented.

Chlorophyll-a

Chlorophyll-a, pigments in plants that absorb sunlight and facilitate photosynthesis, concentration in the water is an indicator of the amount of algae in the water and an indicator of water quality in the Peconic Estuary. Chlorophyll-a concentrations reveal a trend of higher chlorophyll-a and poorer water quality in the summer western estuary and better water quality in the non-summer months and eastern sections of the Estuary. Concentrations decrease from west to east resulting from increased tidal flushing in the eastern section as well as reduced nitrogen loading. Most of the average concentrations of Chlorophyll-a since 2005 are within guidelines for good water quality. Average summer chlorophyll-a concentrations are elevated but remain fair, except for the western estuary where mean concentrations are considered poor according to the US EPA's National Coastal Condition Assessment (NCCA).

Water Clarity

Water clarity is measured by the depth at which a Secchi disk is visible from the water's surface, higher water clarity is signified by greater Secchi disk depths. Water clarity correlates with the amount of sunlight that reaches submerged aquatic vegetation (SAV). Important SAV habitats for fish, shellfish and invertebrates, such as eelgrass beds, need sufficient sunlight in order to grow and survive. Water clarity in the Peconic Estuary is an indicator of the water quality that SAV and many aquatic organisms are dependent upon. Reduced water clarity can be caused by algal blooms, eroded sediments, or disturbed bottom sediments from runoff, wind or human activities. Water clarity data reveal the annual average water clarity has remained relatively stable since the 2005 EI Report. Water clarity increases from west to east in the Peconic Estuary. Lower water clarity coincides with higher plankton cell counts and usually occurs in summer months in shallower western sites and deep water eastern sites in winter months. Higher water clarity occurs in spring and fall.

Nitrogen

Nitrogen is an essential nutrient for healthy ecosystems; however, excess nitrogen from human activities can cause detrimental impacts such as hypoxia, harmful algal blooms, and loss of eelgrass and wetlands. The concentration of nitrogen is an indicator of water quality in the Peconic Estuary. Total nitrogen, dissolved organic nitrogen and dissolved inorganic nitrogen concentrations decrease from west to east in the estuary and typically concentrations are lowest in the winter and early spring, increase in magnitude in the summer and decline through the fall. Highest average total nitrogen concentrations are recorded in the western estuary tributaries and peripheral embayments and decrease in deeper, open water sites where flushing is greater; however, dissolved inorganic nitrogen concentrations increase in open waters east of Shelter Island. Correlations between total nitrogen and other environmental indicators reveal that locations with the highest percent of summer results exceeding the PEP total nitrogen guideline, concentration below 0.45 milligrams per liter (mg/L) be maintained to prevent hypoxia and 0.4 mg/L for optimal eelgrass habitat, were the same locations in the western estuary that exhibited hypoxia. Average total and dissolved nitrogen concentrations have decreased since the 2005 EI report. The greatest decrease is at Meetinghouse Creek, where nitrogen concentrations have historically been and remain the highest. Dissolved inorganic nitrogen concentrations have remained relatively stable since 2005. Overall, most average nitrogen concentrations have remained within guidelines, with the exception of Meetinghouse Creek.

Dissolved Oxygen

Dissolved oxygen is necessary for fish and other aquatic organisms to live, concentrations can be impacted by the amount of algae that is in the water column, the associated photosynthesis and decomposition rates, natural variations in temperature, and wave action and mixing. Dissolved oxygen concentrations indicate the amount of dissolved oxygen available for aquatic organisms in the Peconic Estuary and in relation the concentration of nitrogen in the water and the frequency and severity of algal blooms. The dissolved oxygen concentrations at the United States Geological Survey (USGS) continuous monitoring station in Riverhead measured frequent dissolved oxygen (DO) violations due to poor flushing and high concentrations of nutrients. In the eastern section of the estuary, however, Orient Harbor rarely experiences DO problems due to increased exchange with the ocean and lower pollution load to this area. Suffolk County Department of Health Services (SCDHS) monitoring data reveal that dissolved oxygen in the lower Peconic River and Meetinghouse Creek are measured below the chronic and acute DO standards. Periodic fish kills have been attributed to DO concentrations at sustained low or anoxic concentrations due to a bloom of non-toxic algae and an influx of bunker to the area.

Eelgrass

Eelgrass beds were reduced in the early 1930s due to wasting disease and in the 1980s and 1990s Brown Tide blooms. Other potential threats to eelgrass beds include increasing water temperatures, high turbidity, high levels of nutrients, boating activities and some shellfish harvesting practices. Eelgrass supports invertebrates, scallop populations, fish and waterfowl habitat, oxygenates bottom waters, stabilizes sediment and buffers storm energy. Analyzing the extent of eelgrass beds are an indicator of the health of the living resources in the estuary. A 2014 aerial survey identifies less than 90 eelgrass beds covering under 1000 acres, compared to 8,700 acres in 1930 and 1,550 acres and 119 eelgrass beds in 2000. Of the eight sites where PEP has maintained long-term monitoring within the Peconic Estuary, only four support eelgrass. Shoot density has been decreasing since the beginning of the long-term monitoring program in 1997. Submerged aquatic vegetation, specifically, the eelgrass *Zostera marina*, is an important species found in temperate areas along the East Coast, including in the Peconic Estuary.

Wetlands

Wetlands are among the most productive habitats on earth providing feeding, breeding, and nursery habitats for waterfowl, wading birds, shorebirds, fish and invertebrates and provide ecosystem services such as sediment retention, nutrient and organic matter recycling and storm and flood buffers. The extent and status of wetlands is an indicator of the health of the living resources in the Peconic Estuary. Between 1974 and 2005 the Peconic Estuary has lost approximately 10 percent of its tidal wetlands. East Hampton sustained the largest loss of marsh habitat, losing 145.8 acres for a 13.8 percent decrease from 1974 to 2005. The Town of Southold lost nearly 10 percent of marsh habitat from 1974 through 2005, while the Town of Riverhead exhibited a slight gain in native tidal wetland area. The highest percentage loss of marsh habitat occurred in the Town of Shelter Island where marsh habitat decreased in area by 17.5 percent. Throughout the Peconic Estuary, intertidal marsh increased while native high marsh and coastal fresh marsh decreased. *Phragmites australis* is increasing within the estuary. Eighty-six marsh complexes, out of 159 identified in the Peconic Estuary, are categorized as "at risk." The project team identified tidal marsh complexes using a classification system based on the Significant Coastal Fish and Wildlife Habitats (SCFWHs) identified by the New York State Coastal Atlas (Edinger et al., 2002).

Scallops

Bay scallops, *Argopecten irridans irridans*, are an iconic species on Long Island. Thier success depends on mostly on the water quality and presence of SAV; therefore, scallop populations are an indicator of the health of living resources in the estuary. In 1930s the eelgrass wasting disease decimated eelgrass beds, the preferred habitat of scallops, and caused a drastic decline in scallop populations. In 1985, Brown Tide blooms further decimated scallop populations. Restoration efforts were implemented soon after and even with favorable water quality, scallop populations remained at 1 to 2 percent of historical landings, until 2008 when there is evidence that the effects of the intensive restoration programs (initiated by East Hampton Town Shellfish Hatchery in 1997 and Long Island University (LIU) /Cornell Cooperative Extension (CCE) in 2006), first became apparent. Scallop landings between 2010 and 2013 were 13 times higher than those of pre-restoration levels. Statistical analysis has shown that the restoration success of scallop populations are not correlated to temporal changes in predator populations, SAV cover, water temperature, rainfall or chlorophyll-a; but is due to the increase in larval supply from the restoration efforts.

River Herring

River herring have an anadromous life cycle, spending most of their time in the ocean and returning to freshwater rivers, streams, and lakes to spawn, providing many vital ecosystem services throughout their life cycle including filtering the water column and serving as prey for commercially and recreationally important species. River herring populations have been declining for the past century due to over fishing, incidental catch, water pollution and loss of access to freshwater habitat. River herring populations are an indicator of the health of the Peconic Estuary and the availability of suitable habitats within the Estuary. The Peconic River and its tributary, the Little River, are the main source of freshwater to the Peconic Estuary and there are four main barriers to fish passage for River herring, Alewife (*Alosa pseudoharengus*) and Blueback herring (*Alosa aestivalis*), on the main stem of river and one barrier on its tributary, blocking access to a total of 360 acres and 88 acres of freshwater habitat. A fish passage structure was installed in 2010 at Grangebel Park in Riverhead, restoring river herring access to 26 acres of freshwater habitat and preliminary results reveal alewife populations have benefited from the fish passage restoration.

Finfish Index

The finfish species presence and species richness is an indicator of the health of the living resources in the Peconic Estuary. Peconic Estuary fishery trawl surveys reveal that cold adapted fish (fish that prefer 15˚ Celcius or 60˚ Farenheit) are more abundant in the northern region of the Peconic Estuary than the southern region. Warm-adapted fish (fish that prefer 11˚- 22˚ C or 50˚- 72˚ F) are more abundant in the southern region of estuary than the northern region. From 1987 to 2014 the overall trend in the average number of warm-adapted species captured in the spring and the fall increased while the average number of cold-adapted species captured decreased over the same time period, signifying that the increase in average water temperature is impacting species composition in the Peconic Estuary. The species richness data from 1987 to 2014 indicates a strong balance of species with a stable population of forage fish species providing the ecosystem with a stable food base.

Piping Plover

The population and productivity of the Piping Plover, a Federally Threatened and New York State Endangered species, in the Peconic Estuary is an indicator of the presence of suitable habitat and living resources within the Peconic Estuary. Since the mid-1980s the number of breeding pairs of Piping Plovers on Long Island has generally increased. Since 2005 the number of breeding pairs within the Peconic Estuary does not appear to be increasing and nesting success seems to be decreasing. In 2001, reproduction within the Peconic Estuary averaged 1.35 birds that successfully fledged per nest. In 2014, this rate was reduced to 0.52 birds that were successfully fledged per nest. Piping Plovers (*Charadrius melodus*) nest on beaches, making their nesting and reproduction susceptible to human intrusion, storm tides and predators. Nesting site protection has been established with the cooperation of private and public landowners.

Shellfish Bed Closures

Pathogens can enter the marine water through untreated or inadequately treated human sewage and through the waste of domestic and wild animals, stormwater runoff, waste discharge from boats and septic systems and harmful algal blooms that generate toxins can cause unsafe conditions for shellfish harvest and consumption and cause shellfish closures in the Peconic Estuary. Presence of coliform bacteria, an indicator of the potential presence of human pathogens, exceeding National Shellfish Sanitation Program guidelines in marine waters may lead to closed shellfish beds to protect public health.

Therefore, the frequency and shellfish bed closures are an indicator of the water quality of the Peconic Estuary. Bacteriological water quality is generally good throughout most of the larger bodies of water in the Peconic Estuary. Shellfish closures occur in Flanders Bay, as well as in sheltered creeks, harbors and bays which are affected more by land-based sources. During the period of 2004 to 2014, there was a net increase of 318 acres of certified or seasonally certified shellfish lands in the Peconic Estuary. These certified lands are 95.4 percent or 115,433.4 of the 121,000 acres of shellfish lands are available for shellfish harvesting. As of January 2014, there were 3,445.6 acres uncertified and 2,121 acres seasonally certified.

Beach Closures

The SCDHS tests bathing beaches for *Enterococcus* (EN) bacteria, an indicator of beach water quality. Beach closures also occur for reasons other than high bacteria levels, such as stinging jellyfish and algal blooms. Frequency and location of beach closures are an indicator of the water quality of the Peconic Estuary. There are 28 public bathing beaches monitored by the SCDHS which are generally safe for swimming. Influences such as stormwater runoff, waterfowl and wildlife waste, septic systems and cesspools, illegally discharged vessel waste, limited tidal flushing and malfunctions in sewage treatment plants can negatively impact the water quality at these locations. Twenty-one or 75 percent of bathing beaches are classified as low risk, seven or 25 percent are classified as medium risk and no public bathing beachses are considered high risk in the Peconic Estuary. Since 1980 there have been 42 bathing beach closures in the Peconic Estuary, that total includes the 28 precautionary bathing beach closures in 2011 for all Peconic Estuary bathing beaches due to Hurricane Irene. Only one closure resulted from measurements of elevated *Enterococcus* levels at South Lake Drive Beach, the 13 other closures were due to precautionary rainfall related advisories. Since the 2005 report there have been 8 closures, not including the Hurrican Irene closures in 2011, starting in 2006 every year until 2015, except in 2012, at Havens Beach in Sag Harbor due to a precautionary rainfall related advisory.

Conclusions

Overall, the Peconic Estuary has remained a healthy and diverse marine community with significant opportunities for water dependent recreation. Many indicators, however, are exhibiting worsening trends. Low dissolved oxygen conditions occur in the tidal Peconic River, western Flanders Bay and tidal creeks; nitrogen concentrations remain high in the western Peconic Estuary and various harmful algal blooms are common. Eelgrass beds are now virtually absent west of Shelter Island, and those that do exist are not expanding. The amount of marsh is decreasing and a majority of the identified marshes in the Peconic Estuary are considered “at risk.” Critical habitats for fish spawning and breeding birds continue to decrease in availability and quality.

It is possible to reverse some of the trends revealed from the environmental indicators through the combined efforts of government, businesses, organizations and citizens to preserve open space, reduce pollution from existing development, and ensure that any future development is done in a way that minimizes its impact on the environment. The Ecosystem Status Report is a method to gage the progress toward achieving actions identified in the PEP Comprehensive Conservation and Management Plan (CCMP). Revisions to the 2001 CCMP began in 2016 and a new plan with updated priorities and actions is expected in 2018. The 2018 CCMP will reflect the changing environment and priorities on the East End, address emerging issues that were not included in the 2001 CCMP and continuing issues that are discussed in this Ecosystem Status Report. The PEP’s Monitoring Plan and environmental indicators will be evaluated during this process and changes will be reflected in future ES reports.

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Acronyms

BGA	-	Toxic Blue Green Algae
BNL	-	Brookhaven National Laboratory
BT-CAMP	-	Suffolk County's Brown Tide Comprehensive Assessment and Management Plan
CCE	-	Cornell Cooperative Extension of Suffolk County
CCMP	-	Comprehensive Conservation and Management Plan
Chla	-	Chlorophyll-a
CLPS	-	Critical Lands Protection Strategy
CPS	-	Peconic Estuary Community Preservation Fund
CRR-NY	-	New York Codes, Rules and Regulations
CWA	-	United States Clean Water Act
DIN	-	Dissolved Inorganic Nitrogen
DN	-	Dissolved Nitrogen
DO	-	Dissolved Oxygen
DON	-	Dissolved Organic Nitrogen
DSP	-	Diarrhetic Shellfish Poisoning
EI	-	Environmental Indicators
EN	-	Enterococcus
ES	-	Ecosystem Status
EPA	-	United States Environmental Protection Agency
FM	-	Fresh Marsh
FWS	-	United States Fish and Wildlife Service
GIS	-	Geographic Information Systems
HAB	-	Harmful Algal Bloom
HM	-	High Marsh
IM	-	Intertidal Marsh
IMA	-	Inter-municipal Agreement
LISS	-	Long Island Sound Study
LIU	-	Long Island University
NCCA	-	National Coastal Condition Assessment
NDA	-	Vessel Waste No Discharge Area
NEIWPCC	-	New England Interstate Water Pollution Control Commission
NY	-	New York State
NYS	-	New York State
NYS DEC	-	New York State Department of Environmental Conservation
PEP	-	Peconic Estuary Program
PEP LTEMP	-	Peconic Estuary Program Long- Term Eelgrass Monitoring Program
PR	-	Precautionary Rainfall Related Advisory
PSP	-	Paralytic Shellfish Poisoning
SAV	-	Submerged Aquatic Vegetation
SCDHS	-	Suffolk County Department of Health Services
STP	-	Sewage Treatment Plant
TN	-	Total Nitrogen
TDN	-	Total Dissolved Nitrogen
TNC	-	The Nature Conservancy
TOGS	-	Technical & Operational Guidance Series
TSS	-	Total Suspended Solids
USGS	-	United States Geological Survey
UV	-	Ultraviolet

Introduction

The Peconic Estuary is located just 80 miles east of New York City (Figure 1). The Peconic Estuary's watershed is composed of nearly 128,000 acres of land and over 158,000 acres of surface water. The Nature Conservancy designated the Peconic system as one of the "Last Great Places" due to the high concentration and diversity of rare and endangered species and assemblages of natural communities.

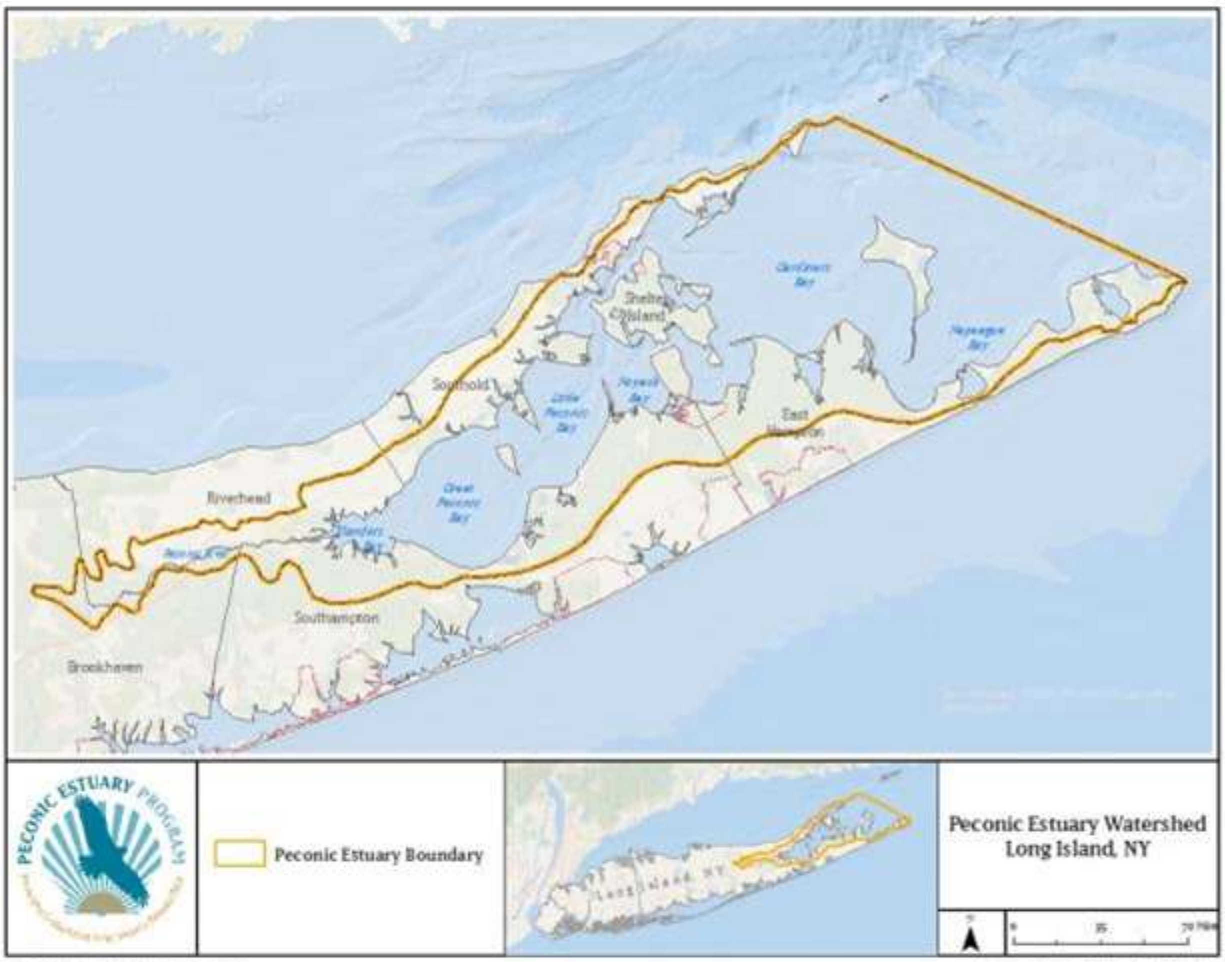


Figure 1: Peconic Estuary Program study area

The Peconic Estuary Program (PEP) Comprehensive Conservation and Management Plan (CCMP) promotes a holistic approach to improving and maintaining the estuary and its watershed. It includes objectives and measurable goals for each of the six priority management topics. There are 85 broad actions within the CCMP, and each action is broken down into one or more steps. In total, there are 340 steps, including 79 that the program has identified as priorities. The CCMP proposed an Environmental Monitoring Plan which included 32 core elements to assist in determining whether the CCMP measurable goals are being met and are focused towards chemical, physical and biological conditions of the estuary.

The Peconic Estuary Program (PEP) expects to issue a revised CCMP in 2018 that will reflect the changing environment and priorities within the watershed and include emerging issues. The revised CCMP will also include a revised set of indicators and an updated monitoring plan.

Since the 2005 Environmental Indicators (EI) Report was published, the PEP Technical Advisory Committee (TAC) revised the previous environmental indicator list to determine those most appropriate for this report. Considerations in developing the primary environmental indicators list included: 1) identifying information and measurements that are meaningful and understandable to the public across the range of management topics in the plan, and 2) the availability of data that could be used to assess current conditions and trends over time. The 2015 Ecosystem Stats (ES) Report utilizes 13 environmental indicators that depict the status of water quality, living resources and pathogens in the Peconic Estuary.

Environmental Indicators

I. Water Quality

Suffolk County Department of Health Services (SCDHS) has routinely monitored the water quality of the Peconic Estuary since 1977. This sampling consists of periodic sampling conducted from boats or from shore. In 2012, the Peconic Estuary Program and Suffolk County partnered with the United States Geological Survey (USGS) to install two continuous monitoring stations in the Peconic Estuary, one located in Orient Point Harbor and another located at the mouth of the Peconic River in Riverhead. Together, these two monitoring systems provide temporal and spatial sampling of the water quality conditions within the estuary.

In June 1985, an unusually large and persistent algal bloom, now known as Brown Tide, was first noted in the Peconic Estuary. Brown Tide blooms persisted in high concentrations for extended periods in all or part of the Peconic Estuary from 1985 through 1988, 1990 through 1992, and 1995. While a significant amount of research has been completed, the chemical, physical, and biological factors that cause, sustain, and end brown tide blooms are yet to be determined. Brown tide has had a serious impact on natural resources, the local economy, the general aesthetic value of the estuary and possibly regional tourism. Brown Tide has not bloomed in high concentrations in the Peconic Estuary since the mid 1990s; however, one of the suspected causes of Brown Tide, excess nitrogen loading, is currently the most serious problem affecting water quality on Eastern Long Island, causing other harmful and toxic algal blooms, low dissolved oxygen and degraded aquatic habitats. The relationship between excessive nitrogen and low dissolved oxygen levels in estuaries is also well documented. When excessive levels of nitrogen are introduced to the estuary, nuisance algae and "seaweed" blooms are likely to result. Oxygen is consumed by plant growth at night ("water column respiration"), contributing to low dissolved oxygen levels by the early morning hours. Excessive aquatic plant growth can also create problems as it settles to the bay bottom and is decomposed by bacteria, a process that consumes oxygen. Turbidity (water cloudiness) is driven by two main factors: plankton abundance (free-floating microscopic organisms including phytoplankton, zooplankton, and bacteria) and suspended sediments (organic and inorganic). Increases in either within the water column result in reduced water clarity, which has a direct impact on subsurface communities that require high light levels, such as eelgrass. The Peconic Estuary Program has identified five indicators of water quality. These are: (1) Harmful algal bloom presence; (2) Chlorophyll-a concentrations (a proxy for micro-algae abundance); (3) Water clarity; (4) Nitrogen concentrations; and (5) Dissolved oxygen concentrations (hypoxia/anoxia).

Peconic Estuary Water Quality Sampling

Vessel-based and ground-based sampling in the estuary is conducted year-round, on a monthly basis in order to provide spatial coverage of the estuary and its freshwater tributaries. These data are sufficient to document seasonal variability and trends in the waterbodies being measured, and SCDHS, Office of Ecology, Bureau of Marine Resources staff collect water quality data at 38 marine locations in main bays and peripheral embayments, and an additional 26 stream and point source sites in the Peconic Estuary to assess status of the Peconic Estuary (SCDHS, 2015b).

The USGS collects continuous monitoring data from two USGS monitoring gauges in the Peconic Estuary in Riverhead and Orient providing excellent temporal coverage at these two sites. Nitrogen, chlorophyll-a, dissolved oxygen, temperature, and Secchi disk depth data collected at these sampling locations were used in this ES Report (Figure 2). Links to monitoring data and information are provided below:

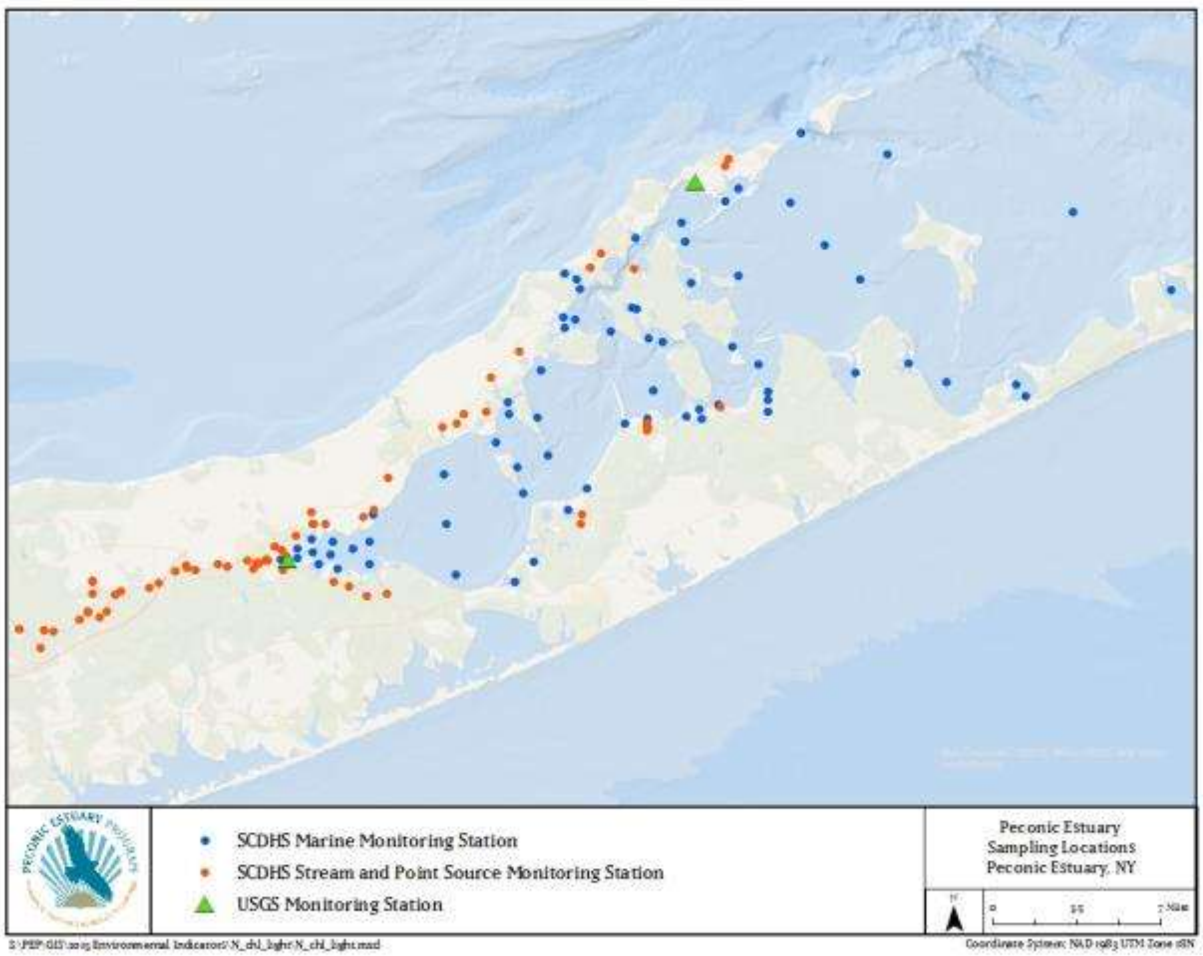


Figure 2: The SCDHS marine, stream and point source monitoring stations and USGS monitoring stations in the Peconic Estuary

USGS Continuous Monitoring at Riverhead, NY:
http://waterdata.usgs.gov/nwis/uv/?site_no=01304562

USGS Continuous Monitoring at Orient, NY:
http://waterdata.usgs.gov/ny/nwis/uv/?site_no=01304200

Suffolk County Department of Health Services Peconic Estuary Water Quality Data and Information:
https://gisportal.suffolkcountyny.gov/gis/home/item.html?id=58cb2a1108ff4ccea11716cec9175f65

Peconic Estuary Program Surface Water Quality Monitoring Quality Assurance Project Plan:
http://www.peconicestuary.org/reports/8f19bcfec766edb791d40c26812b5855c4f1927b.pdf

I-A. Harmful Algal Blooms

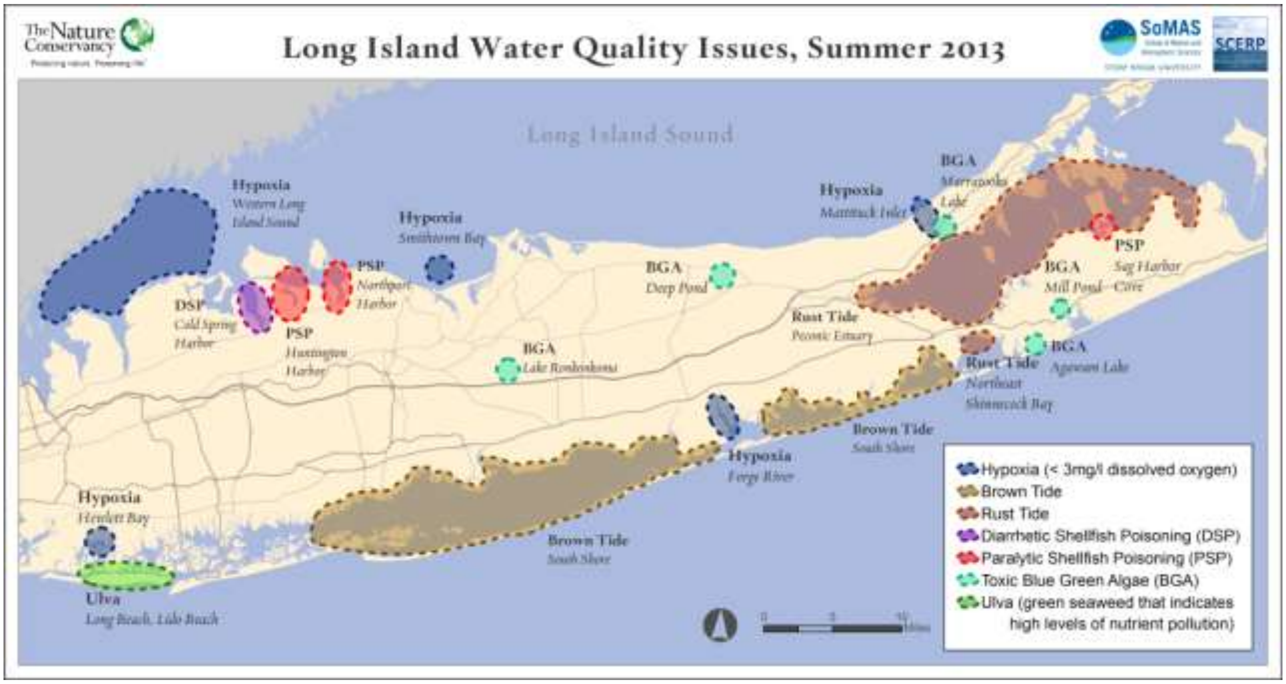
The 2005 EI Report identified Brown Tide cell counts as one of eighteen indicators of environmental quality for the Peconic Estuary. In the 2015 ES Report, this index has been broadened to include all Harmful algal blooms (HAB)s. An algal bloom consists of any proliferation or rapid increase in one or several species of microalgae (phytoplankton), cyanobacteria (blue-green algae) or macroalgae (seaweed) within marine or freshwaters. The negative impacts of algal blooms are broad; ranging from causing severe illness or death in humans, fish and wildlife, and domestic animals to changes in water quality parameters such as reduced dissolved oxygen and water clarity, to aesthetic impacts and reduced recreational values resulting from discolored water or foul odors. For the purposes of this report, a bloom is considered "harmful" if it creates any health impact to other living organisms or otherwise degrades or impairs a valued quality of the surface waters, benthos or other habitat within the estuary.

Globally, there has been a documented increase in the frequency, distribution and duration of HABs over the past decade or more and the Peconic Estuary has not escaped this alarming trend (Bushaw-Newton & Sellner, 1999). Algal blooms occur naturally when one or more limiting condition changes in a manner that favors rapid algae growth and reproduction. Various factors that can cause or contribute to a bloom include nutrient availability, temperature, duration and intensity of sunlight exposure, sediment exchanges with the water column, circulation patterns and stratifications within the water column, freshwater inputs, climate and weather. While some of the documented increases in HAB occurrences are due to more sophisticated monitoring techniques; there is a consensus among researchers that nutrient enrichment from anthropogenic sources plays a prominent role in the occurrences of HABs (Bushaw-Newton & Sellner, 1999). In many marine systems, including the Peconic Estuary, nitrogen pollution from sanitary waste disposal, fertilizers, atmospheric deposition and stormwater runoff are believed to contribute significantly to the increased occurrences of HABs.

The earliest, chronic HAB within the Peconic Estuary began with the now widely known 'Brown Tide' caused by *Aureococcus anophagefferens*. This microalga was first documented in many mid-Atlantic and northeastern coastal waters in 1985. Its proliferation has been closely associated with the near collapse of the bay scallop (*Argopecten irradians*) population in addition to severe declines in other shellfish species and eelgrass (*Zostera marina*), the most ecologically significant species of eelgrass in the Peconic system. The Brown Tide bloomed intermittently within much of the Peconic Estuary and its tributaries from 1985 through 1998 (Peconic Estuary Program, 2001).

Status and Trends

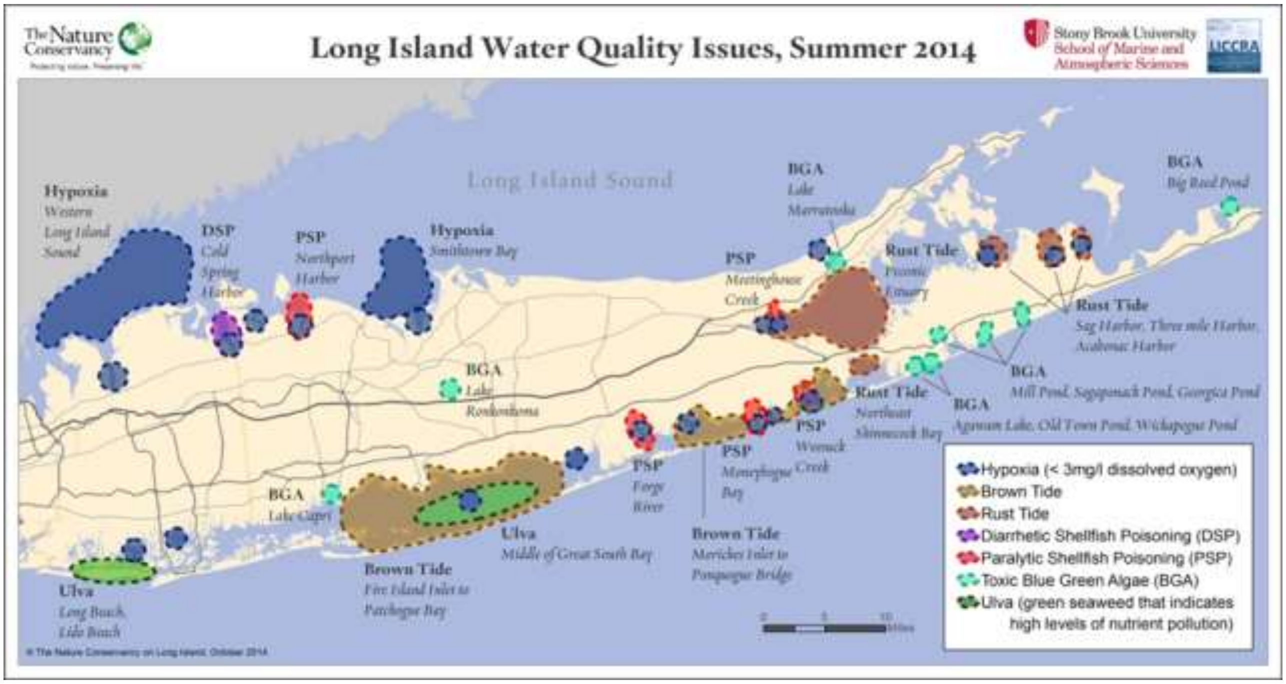
Although cell densities have not been high enough to result in visible blooms, *A. anophagefferens* cells are routinely recorded in water samples from West Neck and Flanders Bay in the western portion of the estuary. Brown Tide blooms continue to proliferate throughout the South Shore Estuary system, including within Shinnecock Bay which is physically connected to the surface waters of Great Peconic Bay by the Shinnecock Canal (Figure 3, Figure 4 and Figure 5).



(Lloyd, 2013)

Figure 3: Long Island Water Quality Issues, Summer 2013

The areas labeled Brown Tide on the map signify that the phytoplankton species *Aueococcus anophagefferens* is present. The areas labeled Rust Tide on the map signify that the phytoplankton species *Cochlodinium polykrikoides* is present. The areas labeled Toxic Blue Green Algae on the map signify that the microscopic organisms *Cyanobacteria sp.*are present. The areas labeled as DSP on the map signify that *Dinophysis acuminate*, a phytoplankton associated with red tide that causes the medical condition Diarrhetic Shellfish Poisoning (DSP), is present. The areas labeled as PSP signify that *Alexandrium fundyense*, a phytoplankton associated with red tide that causes the medical condition Paralytic Shellfish Poisoning (PSP), is present. No reported cases of the medical condition DSP or PSP have occurred on Long Island.



(Lloyd, 2014a)

Figure 4: Long Island Water Quality Issues, Summer 2014

The areas labeled Brown Tide on the map signify that the phytoplankton species *Aueococcus anophagefferens* is present. The areas labeled Rust Tide on the map signify that the phytoplankton species *Cochlodinium polykrikoides* is present. The areas labeled Toxic Blue Green Algae on the map signify that the microscopic organisms *Cyanobacteria sp.*are present. The areas labeled as DSP on the map signify that *Dinophysis acuminate*, a phytoplankton associated with red tide that causes the medical condition Diarrhetic Shellfish Poisoning (DSP), is present. The areas labeled as PSP signify that *Alexandrium fundyense*, a phytoplankton associated with red tide that causes the medical condition Paralytic Shellfish Poisoning (PSP), is present. No reported cases of the medical condition DSP or PSP have occurred on Long Island.

(Lloyd, 2015)

Figure 5: Long Island Water Quality Issues, Summer 2015

The areas labeled Brown Tide on the map signify that the phytoplankton species *Aureococcus anophagefferens* is present. The areas labeled Rust Tide on the map signify that the phytoplankton species *Cochlodinium polykrikoides* is present. The areas labeled Toxic Blue Green Algae on the map signify that the microscopic organisms *Cyanobacteria sp.*are present. The areas labeled as DSP on the map signify that *Dinophysis acuminate*, a phytoplankton associated with red tide that causes the medical condition Diarrhetic Shellfish Poisoning (DSP), is present. The areas labeled as PSP signify that *Alexandrium fundyense,* a phytoplankton associated with red tide that causes the medical condition Paralytic Shellfish Poisoning (PSP), is present. No reported cases of the medical condition DSP or PSP have occurred on Long Island.

Two species of phytoplankton have been responsible for red tide blooms within the Peconic Estuary. *Alexandrium fundyense* is a dinoflagellate that produces a powerful neurotoxin called saxitoxin. This toxin concentrates in shellfish and is responsible for a syndrome known as PSP. Symptoms of this illness are determined by the quantity of toxin that is ingested and can be fatal to humans in high enough concentrations. While blooms have been recurrent annually in various Long Island embayments; thus far, PSP-induced shellfish bed closures by the New York State Deparment of Environmental Conservation (NYS DEC) due to blooms of *Alexandrium* within the Peconic Estuary have been limited to Sag Harbor Cove first recorded in 2012 and James Creek in 2015. Even more intense and longer lasting blooms of *Alexandrium* have occurred in Meetinghouse Creek and western Flanders Bay, but this region is closed to shellfishing. *Dinophysis acuminata* is another phytoplankton associated with red tide blooms, recently identified in western Flanders Bay and Meetinghouse Creek where it formed the densest bloom ever recorded of this algae of two million cells per liter in 2012 (Reguera et al., 2012). This dinoflagellate produces the biotoxin okadaic acid which causes DSP when shellfish that have fed upon *Dinophysis* are consumed by people.

A bloom of the dinoflagellate *Cochlodinium polykrikoides* (syn. *C. heterolobatum*) was first confirmed in September, 2004 within Flanders Bay and parts of Great Peconic Bay (although data suggests the possibility of a bloom as early as 2002 in West Neck Bay) (Nuzzi & Waters, 2004; Nuzzi & Waters, 1989). *Cochlodinium* blooms are sometimes referred to as ‘Rust Tides’ which differentiate them somewhat from the red tides associated with *Alexandrium* & *Dinophysis* blooms. *Cochlodinium* has been implicated in fish and shellfish kills in the western Peconic Estuary specifically a large softshell clam kill in Flanders Bay in 2005 and a large fish kill of multiple species in Cases Creek in 2012.

Cyanobacteria are a phylum of bacteria, often referred to as 'blue-green algae' because they contain photosynthetic pigments that give them that color and behave similarly to algae populations in fresh and marine waters. Harmful algal blooms in marine and freshwaters have been associated with a variety of species of these cyanobacteria and these blooms are sometimes collectively referred to as resulting from 'cyanoHABs.' Many cyanobacteria blooms produce neurotoxins or hepatotoxins that can harm, or even kill zooplankton, fish, shellfish, marine mammals, humans and pets. Their blooms have caused hypoxia and anoxia, contributing to fish kills, foul odors and contact dermatitis in humans after recreational contact. Although an increase in cyanoHAB blooms have been documented in coastal freshwater habitats on eastern Long Island in recent years, their occurrences within the Peconic Estuary to date have been limited to a few tributaries of some embayments within the estuary such as Big Reed Pond in Montauk and Maratooka Lake in Southold.

While most harmful algal blooms are associated with microalgae, it should be noted that blooms of the common macroalgae, *Ulva lactuca,* have also been correlated with nutrient enrichment in surface waters. Monitoring of the locations and abundance of this species should be considred in the future.

The impacts of climate change are likely to directly influence the occurrences, types, and duration of harmful algal blooms. Changes in surface water temperatures, freshwater inputs resulting from precipitation, the stratification and circulation of nutrients, and the alteration of photosynthesis rates due to changes in the extent of cloud cover are all likely to affect the abundance and distribution of phytoplankton (National Ocean Service, 2015). Many cyanobacteria and dinoflagellates thrive in warmer surface waters and consequently, harmful blooms of these species may shift to an earlier time period as a result of increased temperatures or may intensify during summer (Dale et al., 2006).

Limitations on these data

While the Peconic Estuary Program benefits from a great deal of HAB research conducted in the estuary, there is currently no routine monitoring of HABs other than *Aureococcus anophagefferens* cell counts conducted during SCDHS marine sampling and monitoring at Meetinghouse Creek. Monitoring at Sag Harbor and other sites in the Peconic Estuary is conducted by the NYS DEC Shellfisheries Program. The harmful algal blooms depicted in the maps are limited by the locations in which people have spotted the blooms and by the frequency and sampling locations of the monitoring program. In addition, the areas labeled as having hypoxia are limited by where the dissolved oxygen sensors are located. The new monitoring plan developed during the upcoming CCMP revision should establish monitoring protocols and indicators designed to accurately reflect the full suite, location and frequency of HABs currently impacting the Peconic Estuary.

I-B. Chlorophyll-a

Chlorophylls are pigments in plants that absorb sunlight and facilitate photosynthesis. Chlorophyll-a (Chla) is a type of chlorophyll that is most common in all oxygen-evolving photosynthetic organisms including plants, algae, and cyanobacteria. The concentration of chlorophyll-a in a sample is a direct measurement of the portion of the pigment that is actively respiring and photosynthesizing at the time of sampling. It is a proxy for phytoplankton concentrations, which makes it a good indicator to analyze the amount of algae that are present in a water body. Surface waters that have a high chloropyll-a concentration have relatively large phytoplankton populations.

The amount of algae in a water body greatly impacts the water’s physical, chemical and biological components. Algae depend on nutrients to survive. However, when excess nutrients enter a waterbody, a eutrophic system develops and can foster large and sometimes harmful algal blooms. Algae produce oxygen through photosynthesis during daylight hours; but during the night will respire using oxygen. Oxygen is also depleted during the bacterial breakdown of organic matter that includes algae that have died and sunk to the bottom. Decay of algae releases nutrients into the water body which may cause additional algal growth. On top of reducing dissolved oxygen levels, which is the primary cause of hypoxia, presence of algae reduces water clarity and algae respiration effects water pH. High levels of nutrients can be indicators of pollution from man-made sources such as septic systems, waste water treatment plants and fertilizer runoff (Peconic Estuary Program, 2001).

Chlorophyll-a measurements can be used as an indirect indicator of algal presence and growth and nutrient levels. Monitoring chlorophyll-a helps to track the health of the Estuary and improves understanding about harmful algal blooms.

Water Quality Standard

According to the Peconic Estuary Program's 2001 CCMP, the proposed chlorophyll-a concentration water quality criteria from a preliminary SCDHS analysis of mean seasonal water quality parameters and light attenuation with respect to existing submerged aquatic vegetation (SAV) beds and Long Island Sound Study (LISS) parameters for the Peconic Estuary is 5.5 ± 0.5 µg/L. The proposed criteria are based on the fact that lower nutrient levels relate to greater water column light penetration which is an important factor for eelgrass survival (Peconic Estuary Program, 2001). The United States Environmental Protection Agency’s (EPA) National Coastal Condition Assessment (NCCA) uses the following ratings for chlorophyll-a concentrations (EPA, 2012) :

- Good: <5 µg/L
- Fair: 5-20 µg/L
- Poor: >20 µg/L

Status and Trends

Factors such as sunlight, temperature and nutrients affect algal amounts and chlorophyll-a concentration. SCDHS, Office of Ecology, Bureau of Marine Resources staff collect water quality data at all marine sampling locations in the Peconic Estuary to assess the chlorophyll-a concentrations (Figure 2). Mean concentrations of chlorophyll-a from 1976 through 2004 were 5.9 µg/L, a minima of 0.1 µg/L was observed in the eastern estuary and a maxima of 372 µg/L was observed at the Peconic River station in the summer of 1976. Chlorophyll-a concentrations were generally lowest in the winter and early spring and increase in the summer. Secondary concentration increases occur in eastern main-bay sites in December and/ or January which can at times be higher than summer maxima. Long term trends in chlorophyll-a are not visible but spikes in the mid to late 1990s and in the last decade coincide with the

Brown Tide (*Aureococcus anaphagefferens)* blooms of the mid 1990s and rust tide blooms first noted in 2004 (*Cochlodinium polykrikoides)*(Gobler et al., 2005). The SCDHS did not regularly conduct cell counts during this time period (SCDHS, 2015b).

Summer chlorophyll-a has been elevated for the past two decades in the western estuary and continues to be elevated in the most recent data. A trend present in historic data shows a decrease in chlorophyll-a in the main stem of the estuary eastward as tidal flushing increases. According to the 2012 Peconic Estuary Water Quality Status and Trends Report, from 1976-2008 there was a decrease in 37 percent of the stations in the Peconic Estuary and 63 percent were unchanged. In an estuary with historic water quality issues, this reflects a decrease in Brown Tide cell counts and an increase in water quality. Chlorophyll-a decreased in all quintants of the estuary, western central estuary and tributaries, northeastern estuary and tributaries, northeastern estuary and tributaries, southeastern estuary and eastern boundary (Cameron Engineering & Associates, 2012). According to SCDHS data from 2005 to 2014 the mean concentration of chlorophyll-a is 5.6 µg/L, a minima of 0.1 µg/L was observed in the eastern estuary and a maxima of 1,377.8 µg/L was observed at Meetinghouse Creek in the fall of 2009. Compared to previous decade, 2010-2014 values are generally greater and the rate of exceedance of the 5.5 µg/L threshold are generally greater in 2000-2009 than in the 1990s (Figure 6).

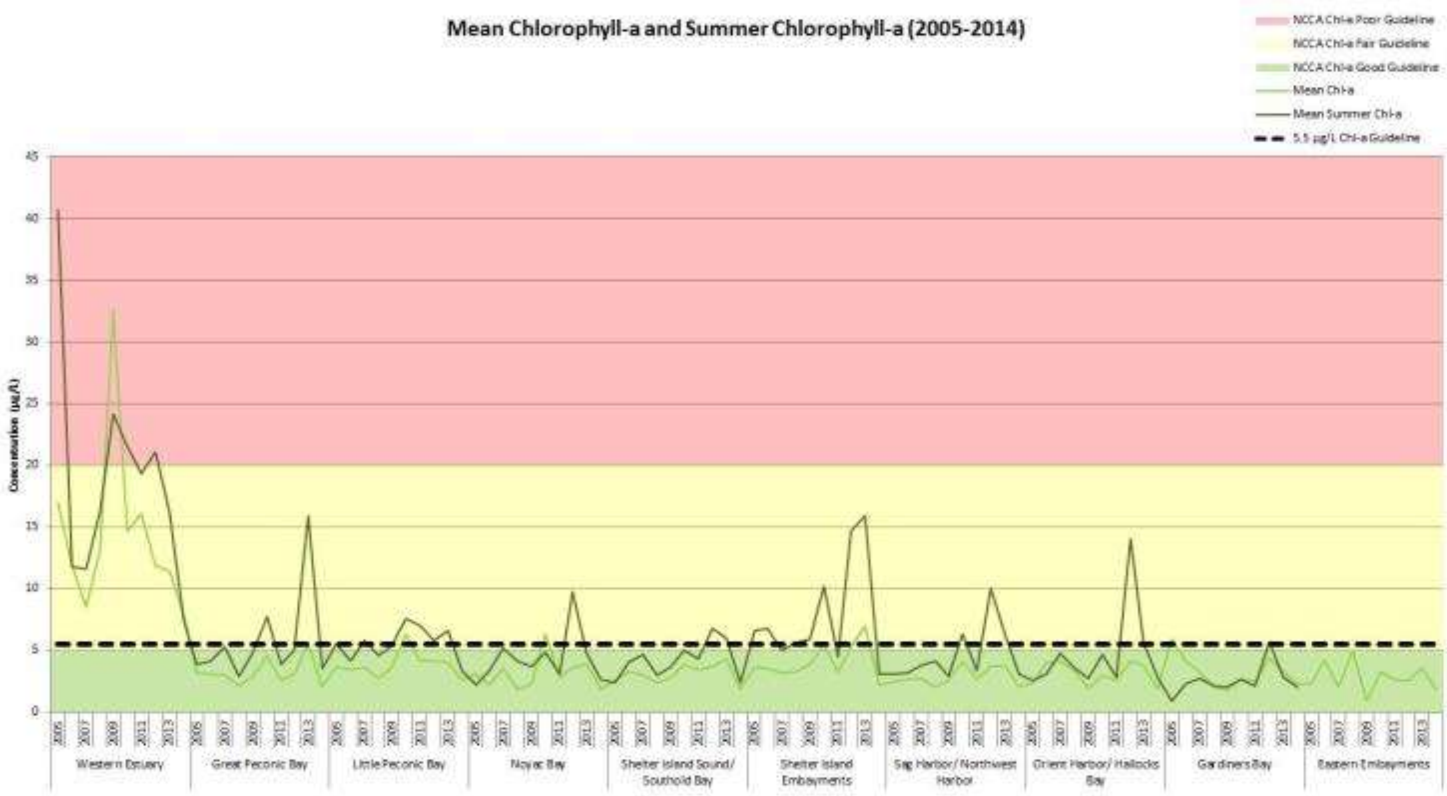


Figure 6: Mean chlorophyll-a and summer chlorophyll-a by Peconic Estuary section

Similar to the previous decade, the highest mean concentrations of chlorophyll-a are in the western estuary and declined eastward. The SCDHS data from 2005 to 2014 show a west to east decrease in chlorophyll-a concentrations across the Estuary (Figure 7). The western Estuary concentrations decreased 75 percent from 2009 to 2014.

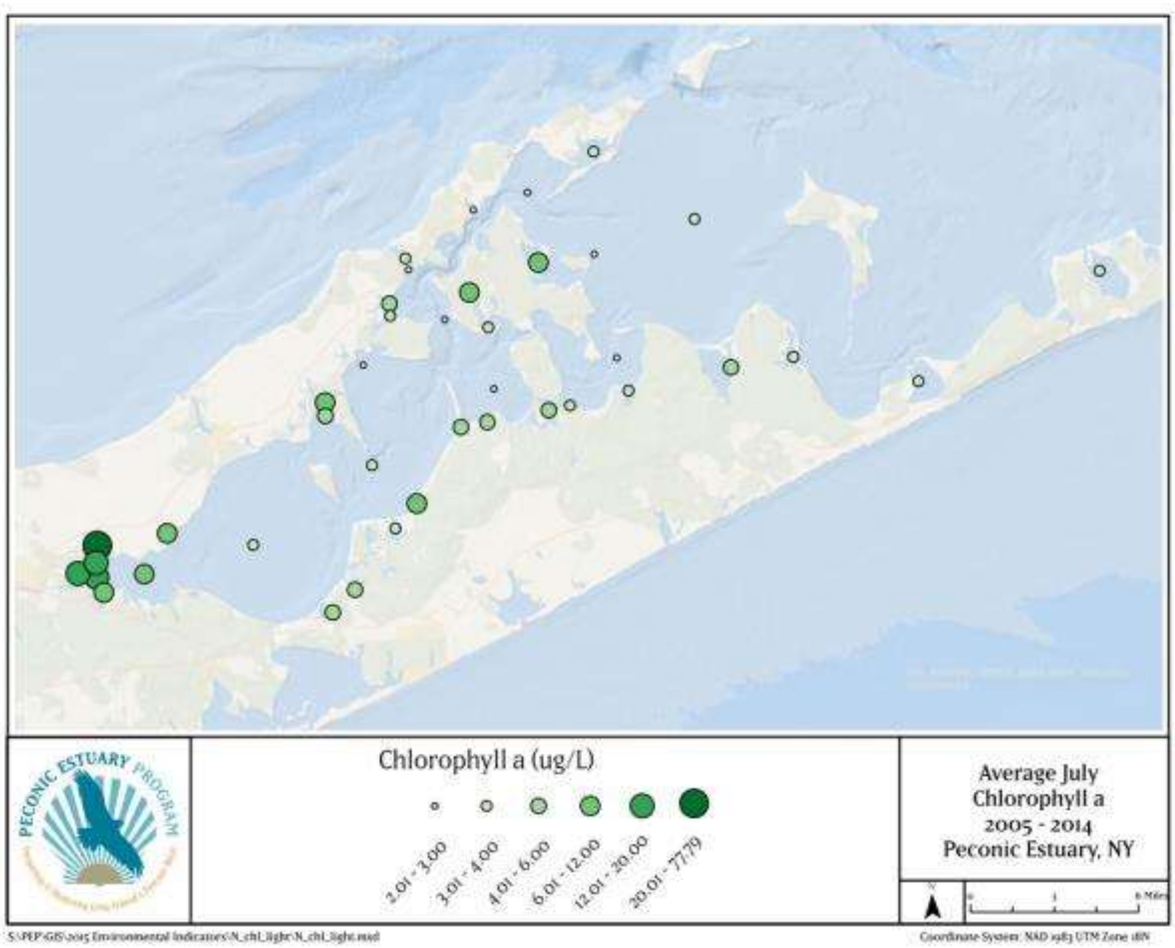


Figure 7: Average July chlorophyll-a in the Peconic Estuary marine sample stations between 2005 and 2014

According to data recorded between 2005 and 2014, the western estuary, and West Neck Bay in the Shelter Island embayments, Mill Creek in Noyac Bay and Accabonac Harbor in the eastern embayments are eutrophic (> 7 µg/L), the other 27 sites are mesotrophic (2-6 µg/L). Generally, the chlorophyll-a concentration trends follow the trends of mean total nitrogen and dissolved organic nitrogen and dissolved inorganic nitrogen (Figure 8, Figure 9).

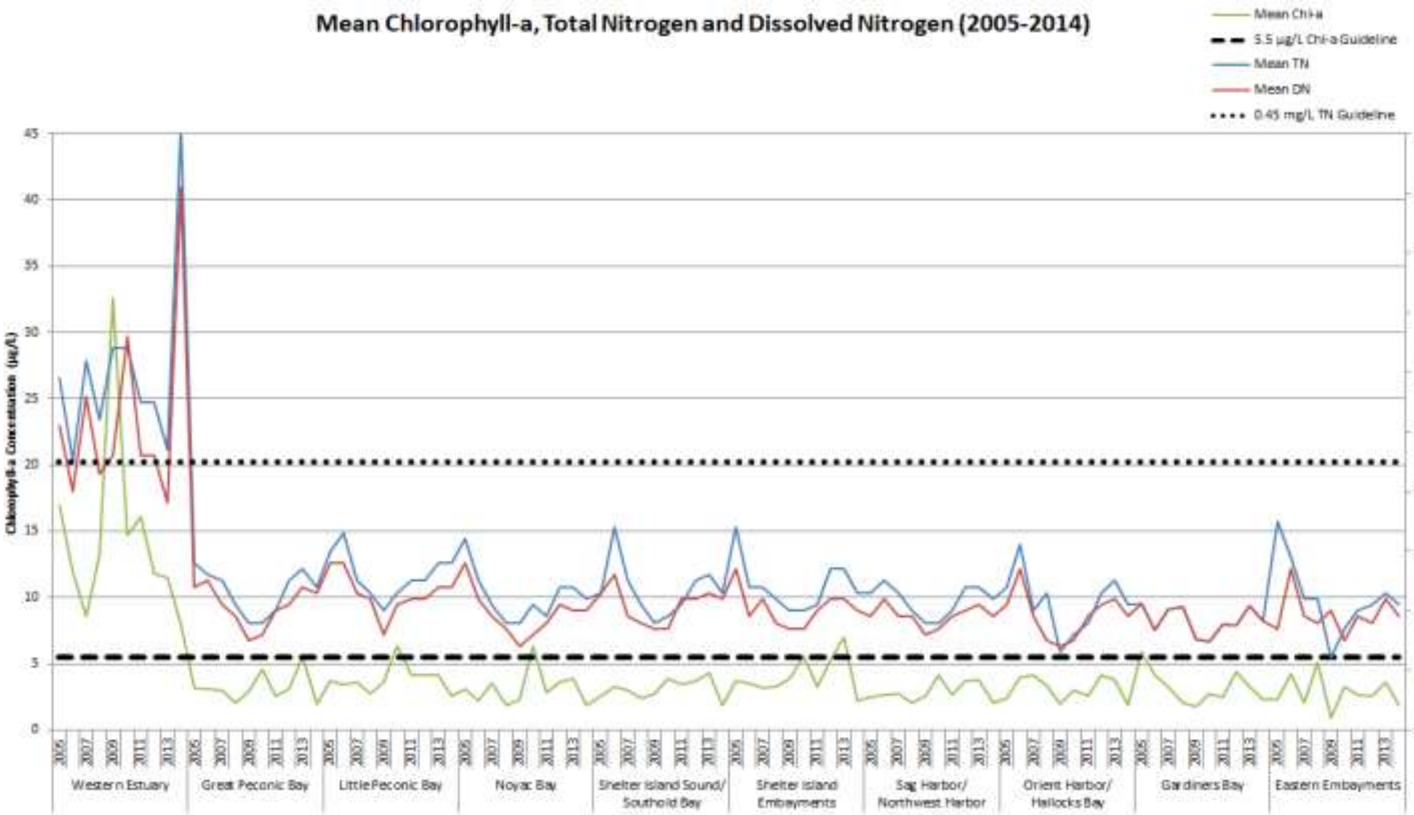


Figure 8: Mean chlorophyll-a, total nitrogen and dissolved nitrogen in the Peconic Estuary by section between 2005 and 2014

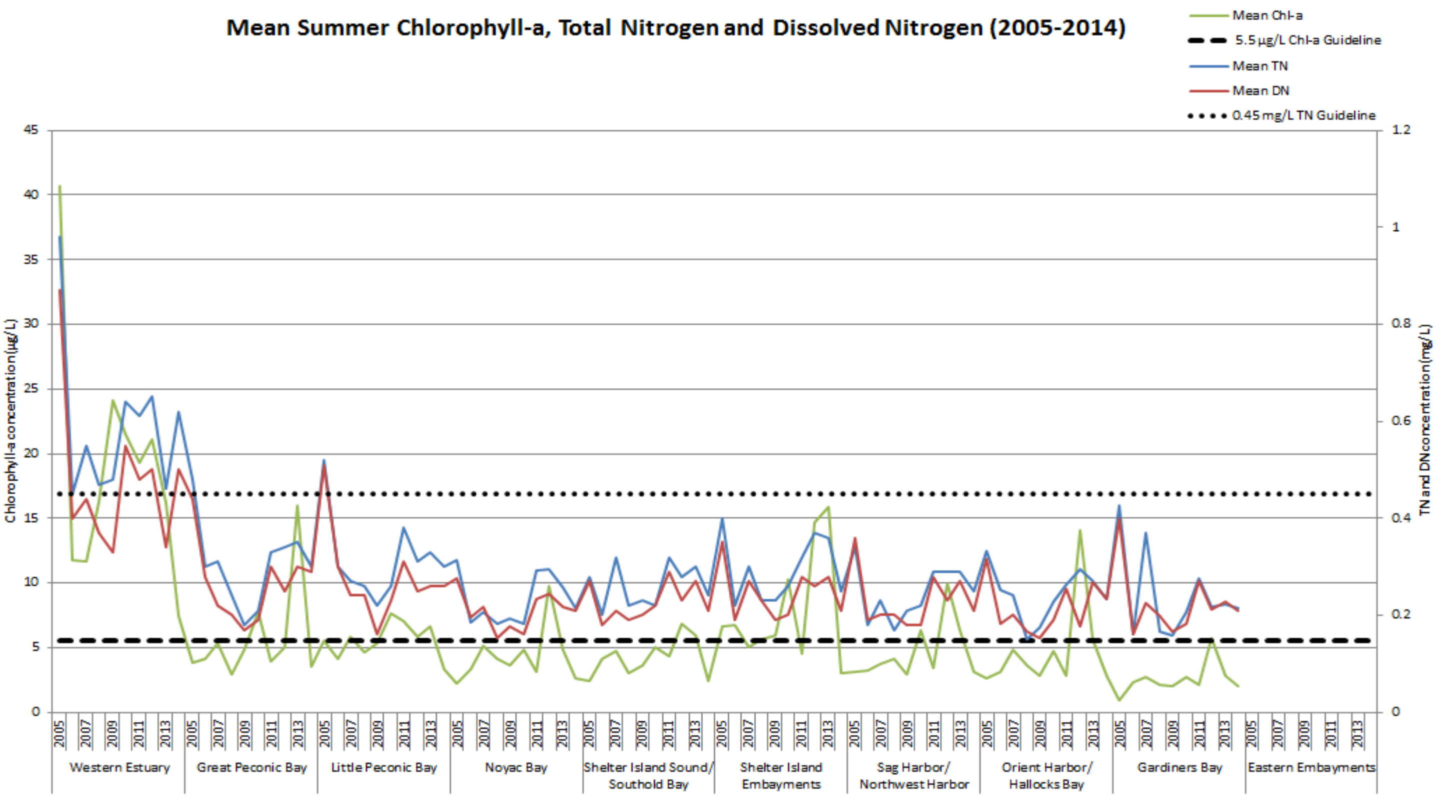


Figure 9: Mean summer chlorophyll-a, summer total nitrogen and summer dissolved nitrogen in the Peconic Estuary by section between 2005 and 2014

Chlorophyll-a is historically the highest in the summer months (July- September), increasing at least 25 percent at a majority of the sites from mean concentrations for the year and increasing 50 percent from winter concentrations at more than half of the estuary sections. Concentrations of chlorophyll-a increase 139 percent in summer months, compared to annual average concentrations. Following the same decreasing trend from west to east, the highest mean concentrations were recorded at the western stations; Meetinghouse Creek, East Creek in South Jamesport and the Peconic River mouth, Reeves Bay, Flanders Bay. Between Great Peconic Bay and Orient Harbor, concentrations exceed 7 µg/L during at least one sampling date between 2005- 2014 in the summer with the exception of Gardiners Bay and eastern embayment locations. Summer chlorophyll-a decreased 81 percent from 2005 to 2014 in the western estuary. Summer chlorophyll-a is steadily decreasing at all locations from 2013 through 2014. Chlorophyll-a is consistently above the guideline in the western estuary where total nitrogen and dissolved nitrogen are at the highest concentrations (SCDHS, 2015c).

Limitations on these data

The SCDHS chlorophyll-a data were collected at all 38 marine sample stations across the Estuary; data were recorded for only 35 stations consistently from 2005 through 2014 for the all seasons and 24 stations consistently from 2005 through 2014 in the summer (July-September). Chlorophyll-a and fractionated chlorophyll-a concentrations were recorded in 1976 and from 1988 to 2014. Chlorophyll-a concentrations were not consistently collected in eastern embayments in the summer data from 2005 through 2014 and were not included in the analysis. Estuary section means were computed based on locations that were consistently sampled from 2005 to 2014. Therefore, a thorough comparison could not be completed for all estuary locations.

I-C. Water Clarity

The 2005 EI report identified water clarity as one of 18 indicators of environmental quality for the Peconic Estuary. Water clarity is vital to the survival and growth of numerous benthic communities including eelgrass, microalgae and planktonic organisms. Aquatic plants use light from the sun to photosynthesize and the amount of light that passes through the water down to the benthos correlates with the health of aquatic plants. In addition to eelgrass, reduced water clarity negatively impacts subsurface phytoplankton and benthic microalgae; thus the health of estuarine habitats.

Water clarity is a measure of the amount of particles in the water, or the extent to which light can travel through the water. Water clarity affects the depth to which aquatic plants can grow, dissolved oxygen content, and water temperature, sufficient water improvements in conditions for eelgrass. In the Peconic Estuary submerged aquatic vegetation, specifically eelgrass (*Zostera marina*), provides critical habitat for bay scallop (*Argopecten irradians*), other shellfish, and nursery and spawning habitats for finfish and invertebrates. Submerged aquatic vegetation needs sufficient water clarity to survive and healthy eelgrass beds support habitat for shellfish, shellfish filter surrounding water (Balla et al., 2005). Factors that can impact the water clarity include presence of high concentrations of total suspended solids and harmful algal blooms. High concentrations of total solids and presence of harmful algal blooms decrease the passage of light through the water; reducing photosynthesis of aquatic plants. An excess supply of nutrients from sewage, fertilizers and stormwater runoff causes eutrophication and the proliferation of sometimes harmful algal blooms that reduce water clarity. Inputs from industrial discharges, sewage, fertilizers, stormwater runoff, and soil erosion, disturbed bottom sediments cause high concentrations of suspended solids. Additionally, high levels of total suspended solids will cause water to heat up more rapidly and hold more heat which will impact aquatic life adapted to lower temperatures and when sediments settle they can cover benthic or bottom dwelling organisms and habitats (Peconic Estuary Program, 2001).

Water clarity is expressed by Secchi disk depth, total suspended solids (TSS) and light attenuation. Water clarity is used as a measurement of trophic status, these parameters provide an understanding of environmental conditions that may be related to algal growth and are important for assessing conditions that support aquatic life. According to the 2005 EI Report, the Peconic Estuary Program is interested in improving water quality in all existing or potential eelgrass habitat areas identified as shallow estuary waters, three meters or less. It is essential to the health of the estuary to have light transfer to the benthos to support a healthy ecosystem.

Water Quality Standard

The ambient New York State water quality standards for turbidity for Class A, B, C, D, SA, SB, SC, I, SD (all waters within the Peconic Estuary fall within these classifications) waters are no increase that will cause a substantial visible contrast to natural conditions (Appendix A). The standards can be found at 6 NYCRR 703.2 (NY Department of State-Division of Administrative Rules, 2015).

To optimize eelgrass habitat and preserve water quality in eelgrass habitat areas, 0.4 mg/l nitrogen criterion is recommended for shallow (three meters or less) estuary waters in the Peconic Estuary. This recommendation is based on an anlysis of the relationship between mean summer nitrogen, cholorphyll-a, and light attenuation coefficient (Kd) data collected by SCDHS during 1994-1996 and a model verification period with respect to existing SAV beds and refinements to the LISS eelgrass habitat criteria; the Peconic Estuary criteria for optimizing eelgrass habitat is Kd: 0.75 ± 0.05 (m^{-1}) (Peconic Estuary Program, 2001).

Status and Trends

The SCDHS, Office of Ecology, Bureau of Marine Resources monitors water clarity at all marine stations in the Peconic Estuary (Figure 2). The surface water quality program focuses on indicator parameters that have been identified by the PEP CCMP. Water clarity data provide a general assessment of availability of light for submerged aquatic vegetation and support SAV restoration programs (SCDHS, 2015b). Historically, Secchi disk depths have remained constant with a mean of 7.1 feet from 1976 through 2004 with a minimum depth of 0.5 feet at the East Creek station in winter of 1999 and at the Peconic River sample station in the summer of 1976 and a maxima of 26 feet at Gardiners Bay South in the spring of 1996. The SCDHS data from 2005 to 2014 reveal that annual average Secchi disk depth has remained relatively stable with not much fluctuation over the time period since 2005. The SCDHS data from 2005 to 2014 shows a generally west to east increase in Secchi dish depth. The mean Secchi disk depth is 7.3 feet with a minima of 0.3 feet at Meetinghouse Creek in fall of 2009 and a maxima of 37 feet at the Gardiners Bay Central sample station in the spring of 2014. Data show an increasing Secchi disk depth from west to east (Figure 10). The data revealed that the mean Secchi depth was the lowest at Meetinghouse Creek and the highest at Gardiners Bay station. The lowest minima were recorded at western sites and the highest minima were recorded at eastern sites, east of Little Peconic Bay.

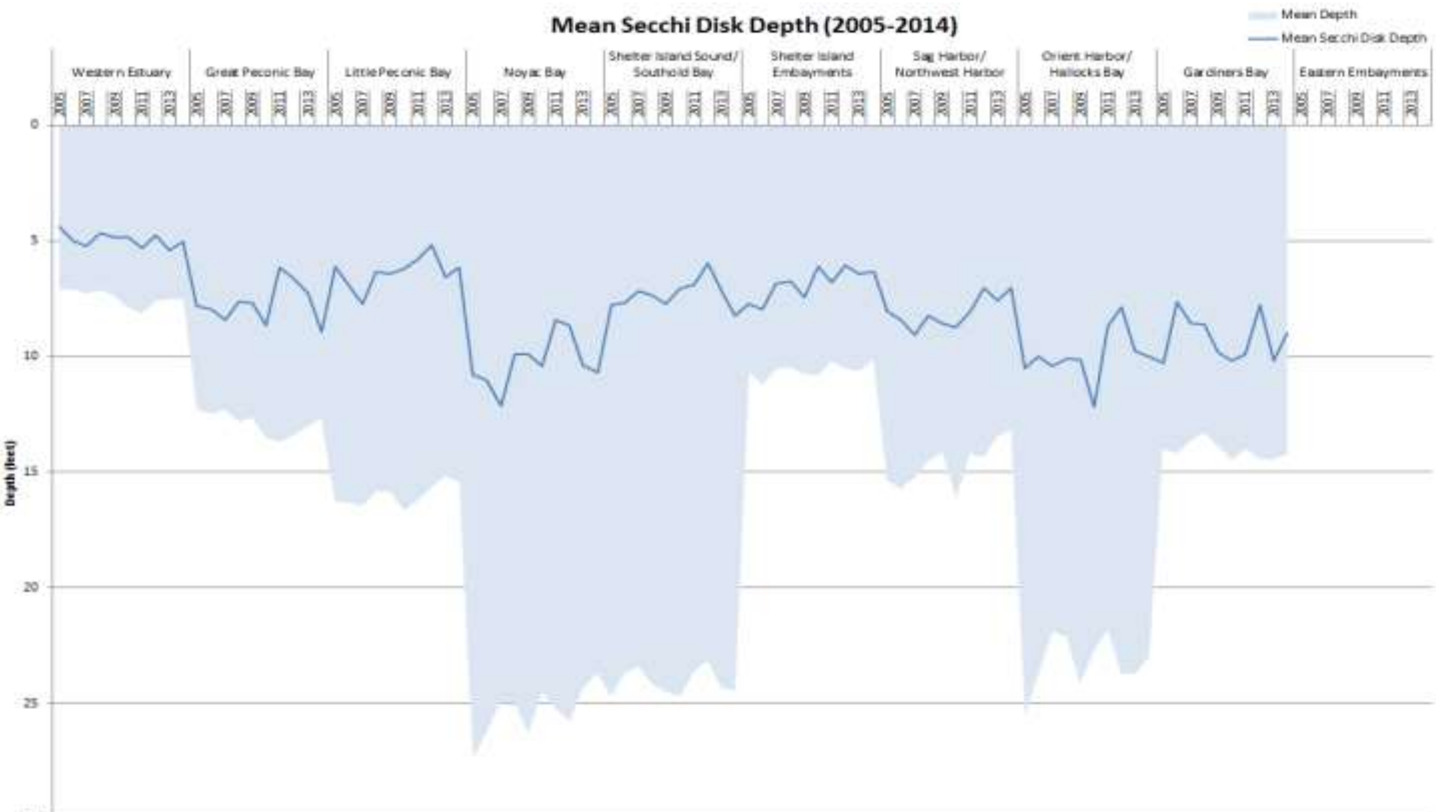


Figure 10: Mean Secchi disk depth in the Peconic Estuary by section between 2005 and 2014

Further, trends show that minima occurred during June through September in shallower western sites and at deep water eastern sites in winter months. Results show that minima coincide with higher plankton cell counts. Maxima occurred during spring and fall. The SCDHS mean Secchi disk depth from 2005 to 2014 reveals a variation in depth from spring to fall. In the summer there is a decrease in Secchi disk depth compared to the spring and fall season. West to east increase in Secchi disk depth is apparent (Figure 11, Figure 12, Figure 13).

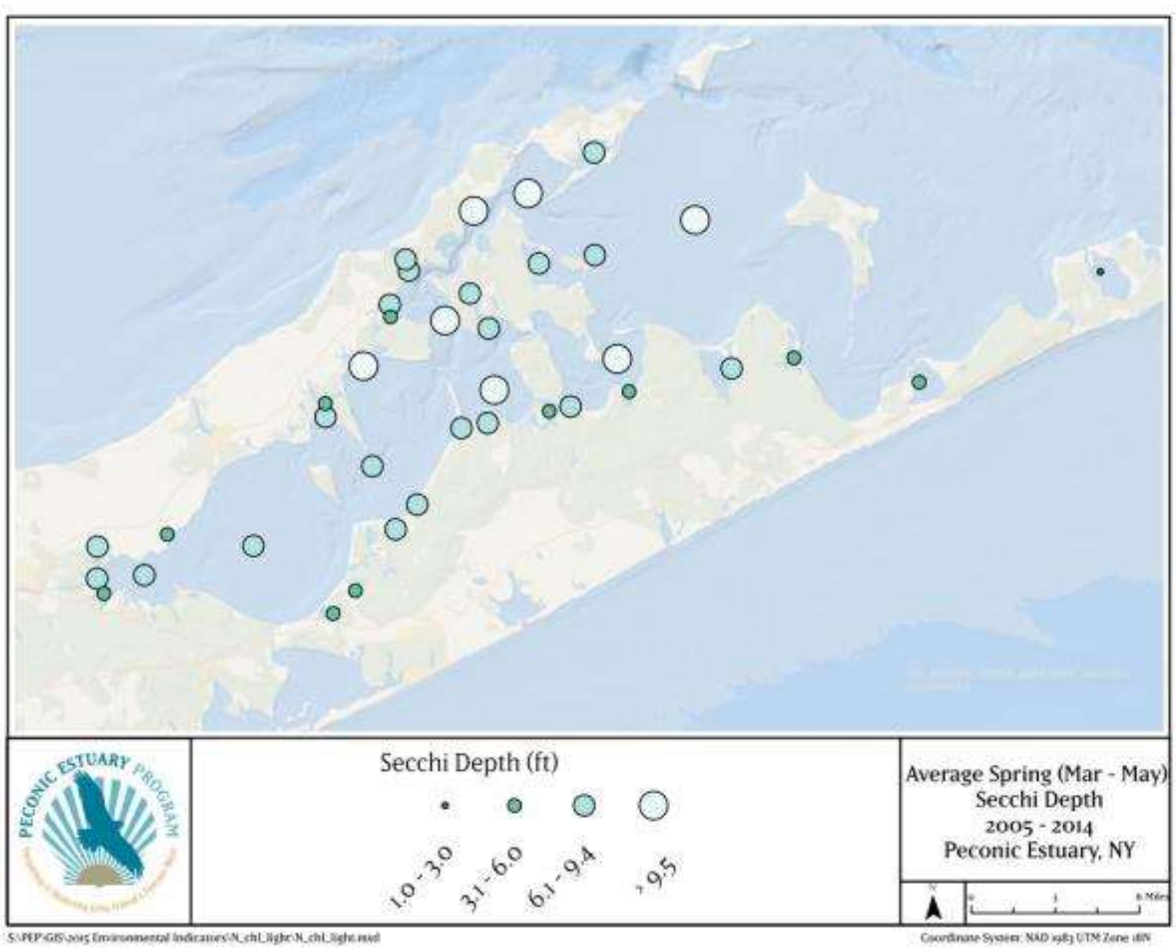


Figure 11: Average spring Secchi disk depth at Peconic Estuary SCDHS marine sampling stations between 2005 and 2014

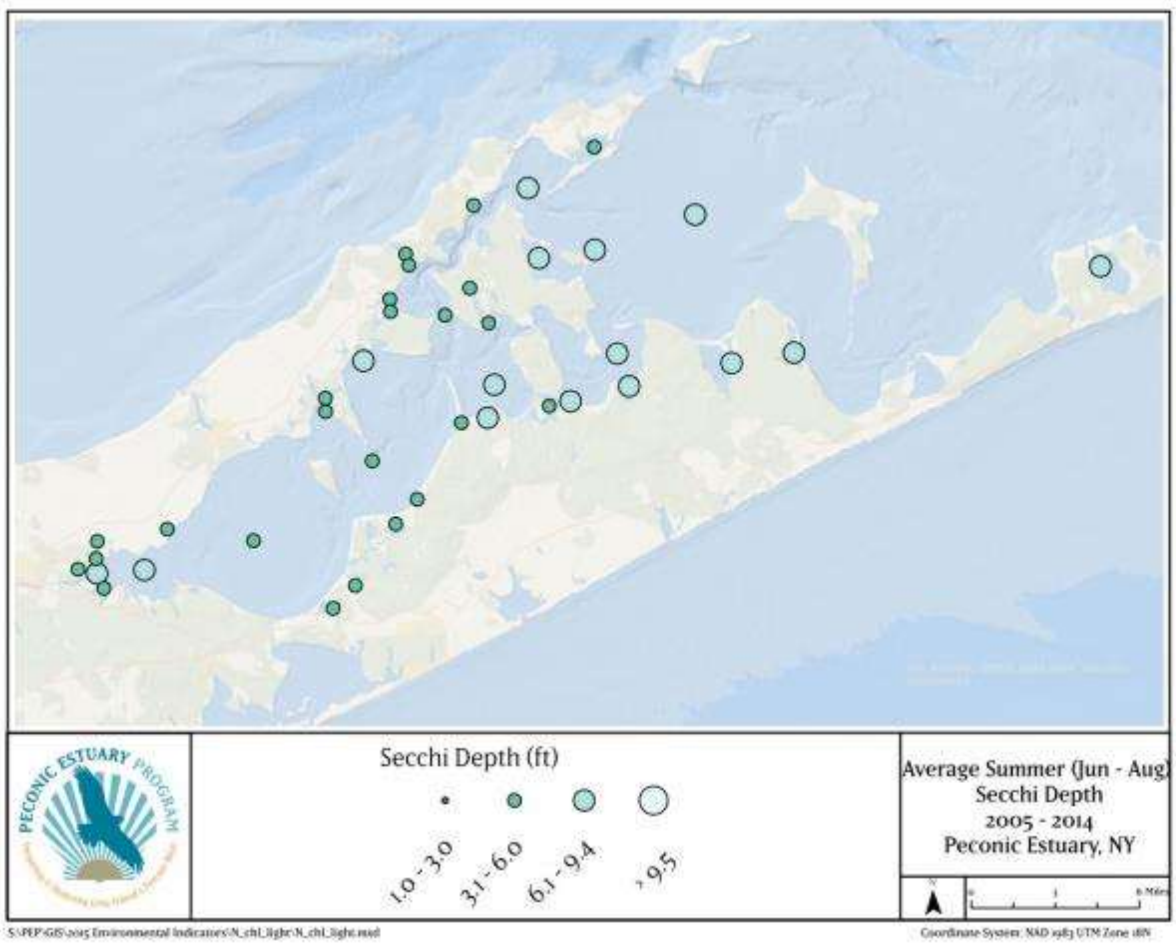


Figure 12: Average summer Secchi disk depth at Peconic Estuary SCDHS marine sampling stations between 2005 and 2014

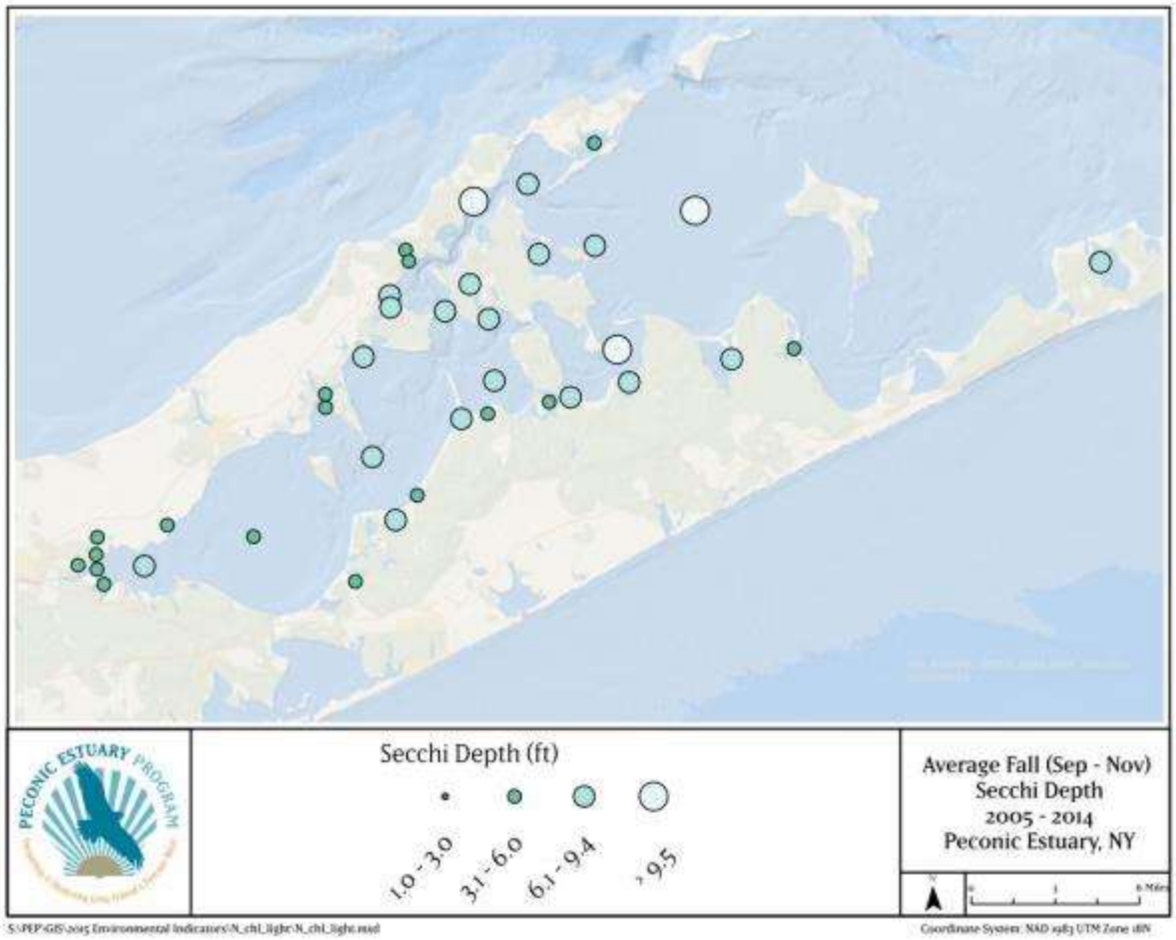


Figure 13: Average fall Secchi disk depth at Peconic Estuary SCDHS marine sampling stations between 2005 and 2014

Limitations on these data

Water clarity is monitored using Secchi disk depth, light attenuation coefficient measurements and, total suspended solids; however, for this report Secchi disk depth was the only parameter analyzed. Several factors may affect Secchi disk readings, including the eyesight of the reader, the time of day of the readings and the reflectance of the disk. The true Secchi depth could not be determined at all sample stations because Secchi disk depth readings are not possible where the Secchi disk was still visible at the bottom (SCDHS, 2015b). Secchi disk depth measurements have been measured at marine stations since 1976 with a period in 1982 to 1985 with no Secchi disk depth reporting. Twenty-three sampling locations were analyzed based on sampling locations that were consistently monitored from 2005 to 2014, no sampling locations in the eastern estuary were analyzed due to a lack in data for the study period. Although the Secchi disk method is commonly used for its simplicity, light attenuation coefficient measurements are a more accurate means of measuring water clarity, and can be performed regardless of depth. Light attenuation measurements were added to the SCDHS sampling protocol during the period of this report, so trends will be included in future updates to the Peconic Estuary ES Report. Total suspended solids, although a measured parameter by the SCDHS, results were not included in this report due to changes in the minimum reporting limit over the period since the 2005 EI Report. A turbidity meter, or nephelometer, may be a good substitute for laboratory analyses of total suspended solids when laboratory methods are not sufficiently sensitive.

I-D. Nitrogen

The 2005 EI report identified nitrogen as one of 18 indicators of environmental quality for the Peconic Estuary. Nitrogen is a commonly occurring element that is present in air, water, and soil. Nitrogen supports growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and invertebrates. When nitrogen enters the environment in excess, however, it can cause detrimental impacts such as hypoxia, harmful algal blooms, and loss of eelgrass and wetlands. Because its availability is what limits productivity, nitrogen is the primary nutrient of concern in the marine waters of the Peconic Estuary, especially during critical summer conditions when environmental stresses are greatest.

Nitrogen stimulates blooms of micro-algae, or phytoplankton. Some HABs negatively impact the ecosystem by producing toxins that harm humans, wildlife, or aquatic organisms. Others are not directly harmful, but their presence causes hypoxia (low oxygen conditions) due to high rates of night-time respiration in the water column, and increased sediment oxygen demand due to bacterial breakdown of dead algae. In addition to inducing hypoxia, algae blooms discolor water, and decrease water clarity, diminishing the amount of light reaching submerged aquatic vegetation. Excess nitrogen may also cause the growth of epiphytes on eelgrass blades, thus reducing the amount of sunlight available and hindering production. Loss of eelgrass reduces habitat available for shellfish and finfish and reduces the estuary's natural buffering capacity for storm energy.

Nitrogen enters the estuary from runoff, groundwater inflow, atmospheric deposition, or point source discharges (Peconic Estuary Program, 2001). Waste water is the largest land-based source, contributing about half of the land-based nitrogen load to the estuary (approximately 43 percent from on-site systems and 7 percent from sewage treatment plants (STPs)). Fertilizers (agricultural, residential and golf course) account for about ¼ , while atmospheric deposition accounts for the other ¼ (Lloyd, 2014b). The western estuary is particularly susceptible to the negative impacts of nitrogen loading due to the presence of multiple point and non-point sources and low levels of tidal flushing (Cameron Engineering & Associates, 2012).

Water Quality Standards

Dissolved inorganic nitrogen (DIN) includes nitrate, nitrite and ammonia (NO3-, NO2-, NH3). Dissolved organic nitrogen (DON) includes water-soluble protiens, amines, and amides. The DON is computed from the relationship DON = TDN - DIN, where total dissolved nitrogen (TDN) is total dissolved nitrogen after ultraviolet (UV) oxidation and DIN is the sum of the dissolved inorganic nitrogen species before UV oxidation. The TDN content of seawater is the concentration of nitrogen remaining in a seawater sample after all particulate nitrogen has been removed by filtration. The TDN is the DON plus the DIN (NH4+, NO3- and organic nitrogen). Total nitrogen (TN) is the sum of nitrate-nitrogen (NO3-N), nitrate-nitrogen (NO2-N), ammonia-nitrogen (NH3-N) and organically bonded nitrogen.

New York State does not have numeric water quality criteria for nitrogen, but has committed to developing them by 2020. According to 6 New York Codes, Rules and Regulations (CRR-NY) 703.2, narrative criteria suggest that nitrogen inputs should be below …"*amounts that result in the growths of algae, weeds and slimes that will impair the waters for their best usages."* (NY Department of State-Division of Administrative Rules, 2015). The US EPA's NCCA uses the following ratings for dissolved inorganic nitrogen concentrations (EPA, 2005):

- Good: < 0.1 mg/L
- Fair: 0.1–0.5 mg/L
- Poor: > 0.5 mg/L

Suffolk County's *Brown Tide Comprehensive Assessment and Management Plan* recommended a TN guideline of 0.5 mg/L for the Peconic River and Flanders Bay (Minei, 1989). The Peconic Estuary Program, in its 2001 CCMP, recommended a summer water column TN concentration above 0.45 mg/L be maintained to prevent hypoxia and 0.4 mg/L for optimal eelgrass habitat (Peconic Estuary Program, 2001).

Status and Trends

The SCDHS, Office of Ecology, Bureau of Marine Resources monitors all marine, stream and point source sites including sewage treatment plants for total nitrogen. Dissolved nitrogen is only monitored at marine and stream sites. USGS monitors two sites continuously at Riverhead and Orient for nitrate (Figure 2). Historic nitrogen input to the estuary was high, from duck farming which peaked in the late 1950s and early 1960s on Long Island, with 14 duck farms on Peconic Estuary tributaries. It has been hypothesized that, given average groundwater travel times of 20 to 30 years, the nitrogen inputs inland would have appeared in surface waters in the 1980s during the peak Brown Tide years. Data reveal that the total nitrogen concentrations increased in the mid to late 1990s and declined from 1994 to 2005. Since 2005, those declines generally continued until 2009 and then began to increase again.

Total nitrogen concentrations decrease from west to east in the estuary and typically concentrations are the lowest in the winter and early spring and increase in magnitude in the summer and decline through the fall (Cameron Engineering & Associates, 2012). The highest means were recorded at a number of tributary and peripheral embayment sites in the western estuary, including Meetinghouse Creek, East Creek in South Jamesport, Peconic River mouth and Reeves Bay. The DON and DIN concentrations show similar trends with a decline from west to east. Highest concentrations of DON and DIN are at Meetinghouse Creek and Peconic River Mouth and the lowest DON concentrations are in the eastern embayments. Peconic Estuary DIN concentrations were lowest in the southern embayments in the western and central estuary; however, DIN levels increase in open waters east of Shelter Island. Correlations between total nitrogen and other environmental indicators reveal that locations with the highest percent of summer results exceeding total nitrogen 0.45 mg/L guideline were the same locations in the western estuary that exhibited hypoxia. The stations east of the western estuary had fewer stations exceed the total nitrogen limit. The TN is mainly comprised of DON in the western and north fork tidal creeks while DIN is the main component of TN in the central estuary and south for creeks (SCDHS, 2015b).

Mean TN and dissolved nitrogen (DN) concentrations during July from 2005 to 2014 July portray the spatial distribution of high concentrations of nitrogen in the western estuary, decreasing eastward (Figure 14, Figure 15). Embayments generally have higher concentrations than deeper, open water stations where flushing is greater. Central and eastern stations show summer concentrations lower than annual averages.

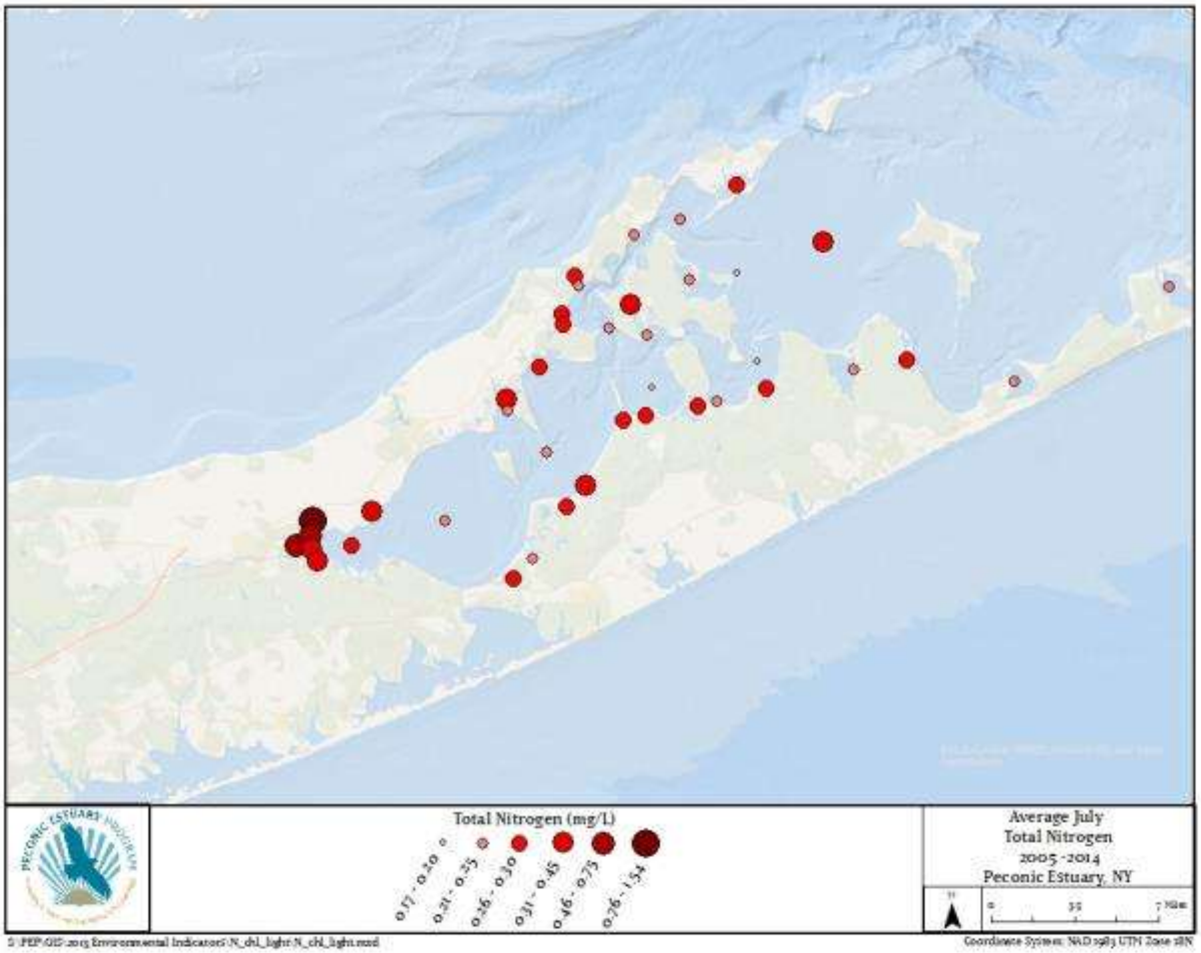


Figure 14: Average July total nitrogen at Peconic Estuary SCDHS marine sampling locations between 2005 and 2014

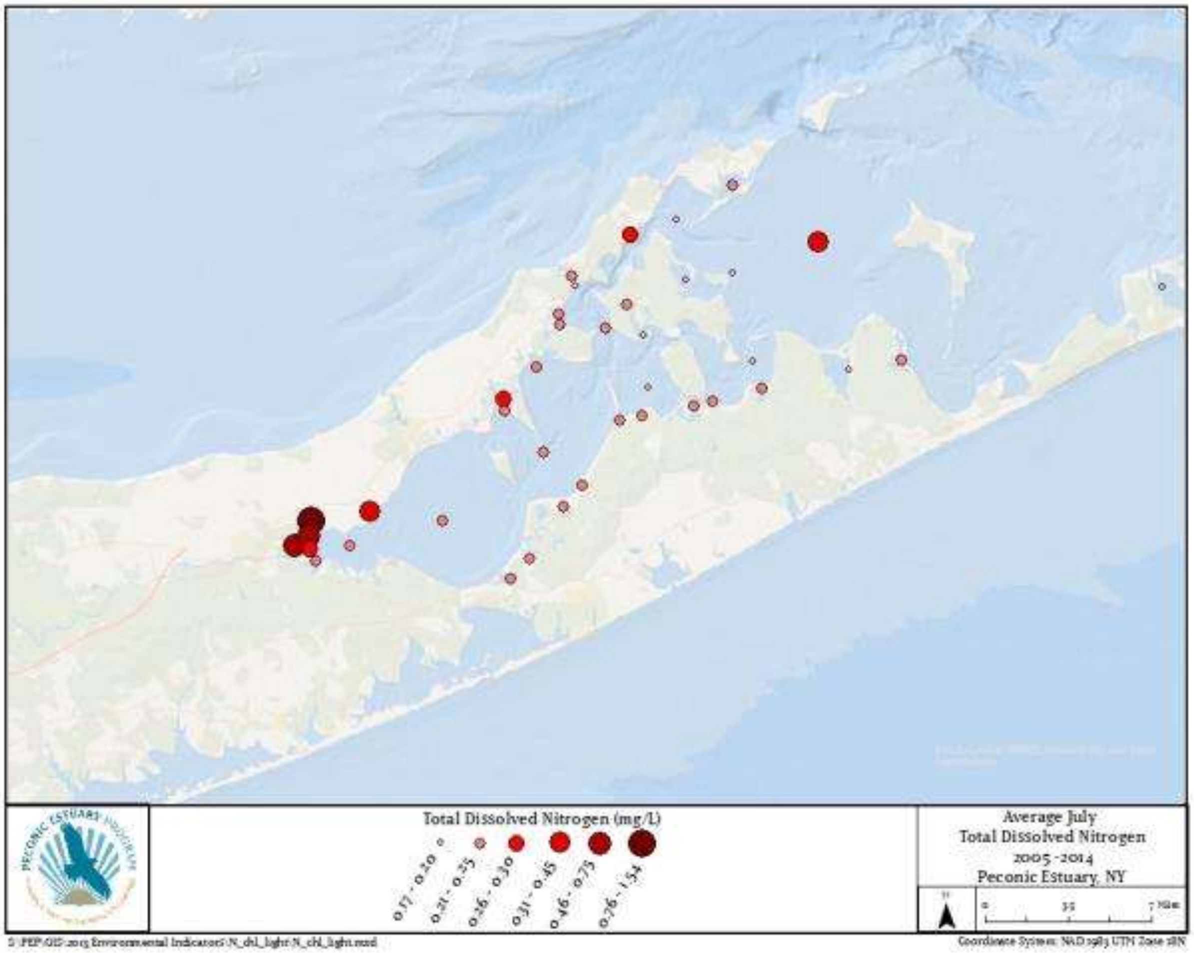


Figure 15 : Average July total dissolved nitrogen at Peconic Estuary SCDHS marine sampling locations between 2005 and 2014

Since 2005 the mean and minimum DN concentration remained at 0.27 mg/L and 0.05 mg/L respectively and the maximum increased to 8.56 mg/L at Meetinghouse Creek in the spring of 2014. Results show that average concentrations of marine nitrogen have generally remained similar to levels seen in the prior decade but are considerably lower than levels in the 1990s. SCDHS data from 1990s to 2012 illustrate TN, DON and DIN concentrations have generally declined over time and demonstrate a geographic gradient with higher concentrations in the western sections of the Estuary. Meetinghouse Creek has the highest levels of total nitrogen and dissolved inorganic nitrogen compared to the more eastern Peconic River Mouth and Flanders Bay stations. While dissolved organic nitrogen is the main component of dissolved nitrogen in Meetinghouse Creek; generally dissolved inorganic nitrogen is the main component in other areas of the Peconic Estuary. Looking at seven stations across the Estuary, from 1990 to 2004 the average TN concentration was 0.59 mg/L and a maximum of 5.07 mg/L was observed at Meetinghouse Creek in 1995. Since 2005 the average TN concentration has dropped to 0.44 mg/L and maximum of 3.43 mg/L was observed at Meetinghouse Creek in 2014. From 1990 to 2004 the average DON concentration was 0.28 mg/L and a maximum of 1.07 mg/L was observed at Meetinghouse Creek in 1995. Since 2005, the mean DON concentration has declined to 0.18 mg/L and a maximum of 0.36 mg/L was observed at Meetinghouse Creek in 2014. From 1990 to 2004 the average DIN concentration was 0.21 mg/L and a maximum of 3.79 mg/L was observed at Meetinghouse Creek in 1994. Since 2005, the average DIN concentration has remained relatively stable at 0.22 mg/L; however the maximum decreased to 2.87 mg/L at Meetinghouse Creek in 2014. The largest decrease in nitrogen is measured at Meetinghouse Creek;

since 1994 TN decreased 74 percent, the DON decreased 67 percent and DIN decreased 77 percent. Comparatively, at Peconic River Mouth TN and DON decreased 50 percent and DIN decreased 70 percent. From 1990 to 2012 TN and DON at Flanders Bay decreased 45 percent. Since 2005, TN concentrations have continued to decline through 2014 and DON concentrations have remained stable with an exception of the Peconic River mouth were TN concentrations remained elevated in the non-summer season through 2008 and Meetinghouse Creek were DIN is the main component and remained elevated through 2008 in the non-summer season (Figure 16).

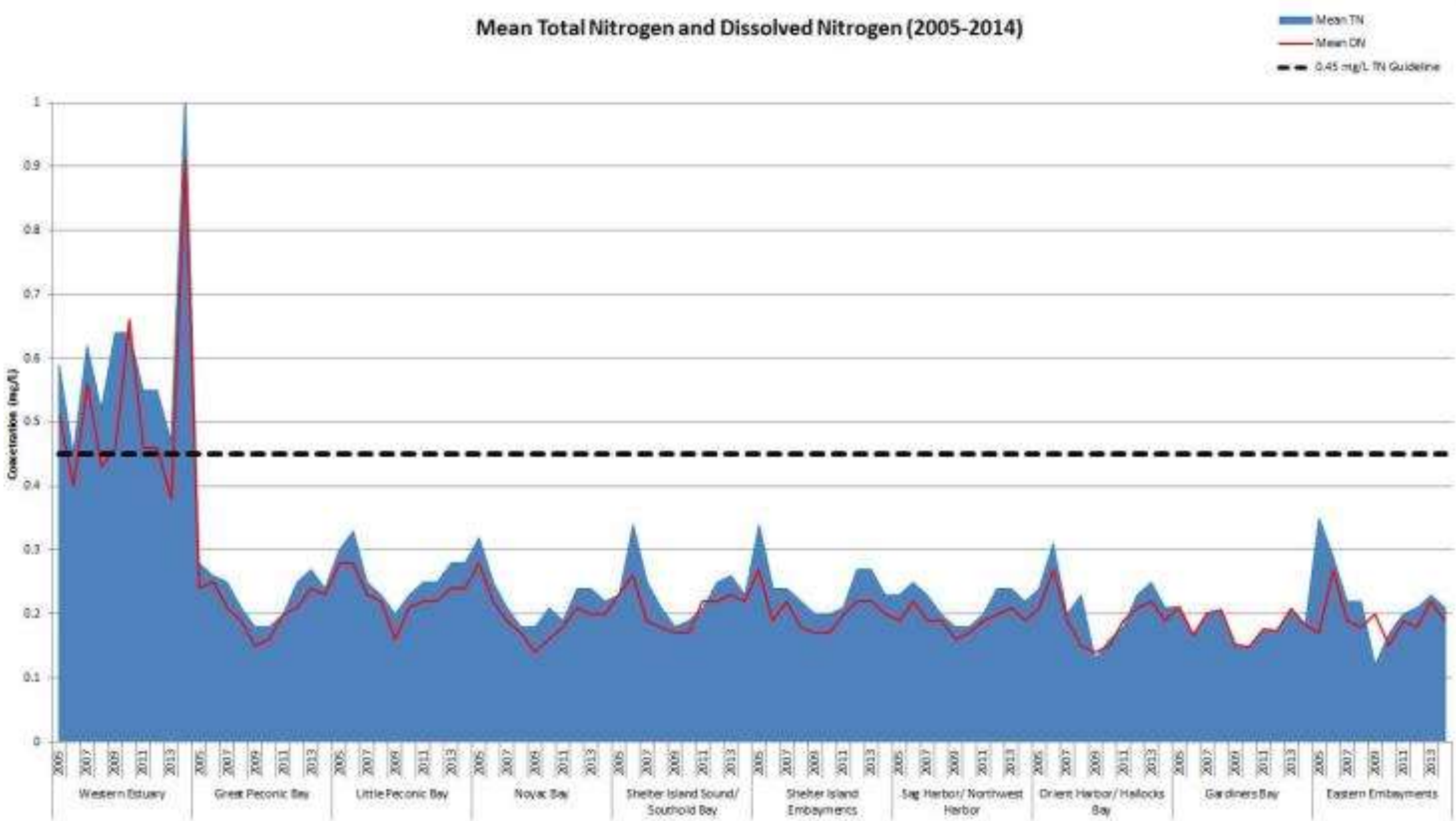


Figure 16: Mean total nitrogen and dissolved nitrogen in the Peconic Estuary by section between 2005 and 2014

Stream nitrogen has historically fluctuated; changes can be attributed to changing land uses over the decades. Stream nutrient levels may be affected by a number of factors such as area land use, precipitation, groundwater levels, point source proximity, biological activity, stormwater runoff and tidal exchange; variations in these conditions influence the nitrogen concentrations. Stream monitoring reveals that total nitrogen concentrations are comprised primarily of DIN in western estuary, western north fork and Peconic River (Brookhaven National Laboratory (BNL) location); however there is no seasonal pattern in nitrogen levels in streams. Furthermore, a declining trend is present at the western tributaries where TN is decreasing at the Peconic River stations and Meetinghouse Creek due to decreasing levels of DIN, which may be the result of a shift in land use because from agriculture to residential (Figure 18). Highest concentrations of total nitrogen were at Meetinghouse Creek and at the Crescent Duck Farm, Reeves Creek and East Creek in South Jamesport. Although nitrogen input to the Estuary from STPs is minimal compared to other sources estuary-wide, it is a significant source in the poorly-flushed western estuary and mouth of the Peconic River. Point source monitoring reveals the Riverhead STP and Atlantis

Aquarium discharged below their 10 mg/L permit standard with an exception of two days for the Riverhead STP. Point source data from Riverhead STP show total nitrogen decreased 29 percent from an average 25.6 mg/L before 2000 and after the installation of a tertiary treatment decreased to an average of 7.5 mg/L in 2001 to 2012. Additional decreases are expected beginning in 2016 when an upgrade to membrane bio-reactor treatment are complete and with the commencement of seasonal effluent reuse for irrigation at the Indian Island County Golf Course.

Summer nitrogen trends reveal the highest decline in total nitrogen was in Meetinghouse Creek. The number of samples exceeding the TN guideline decreased for all of the estuary except Meetinghouse Creek where the exceedance is still at 100 percent, Peconic River mouth and East End Creek in South Jamesport (Figure 17).

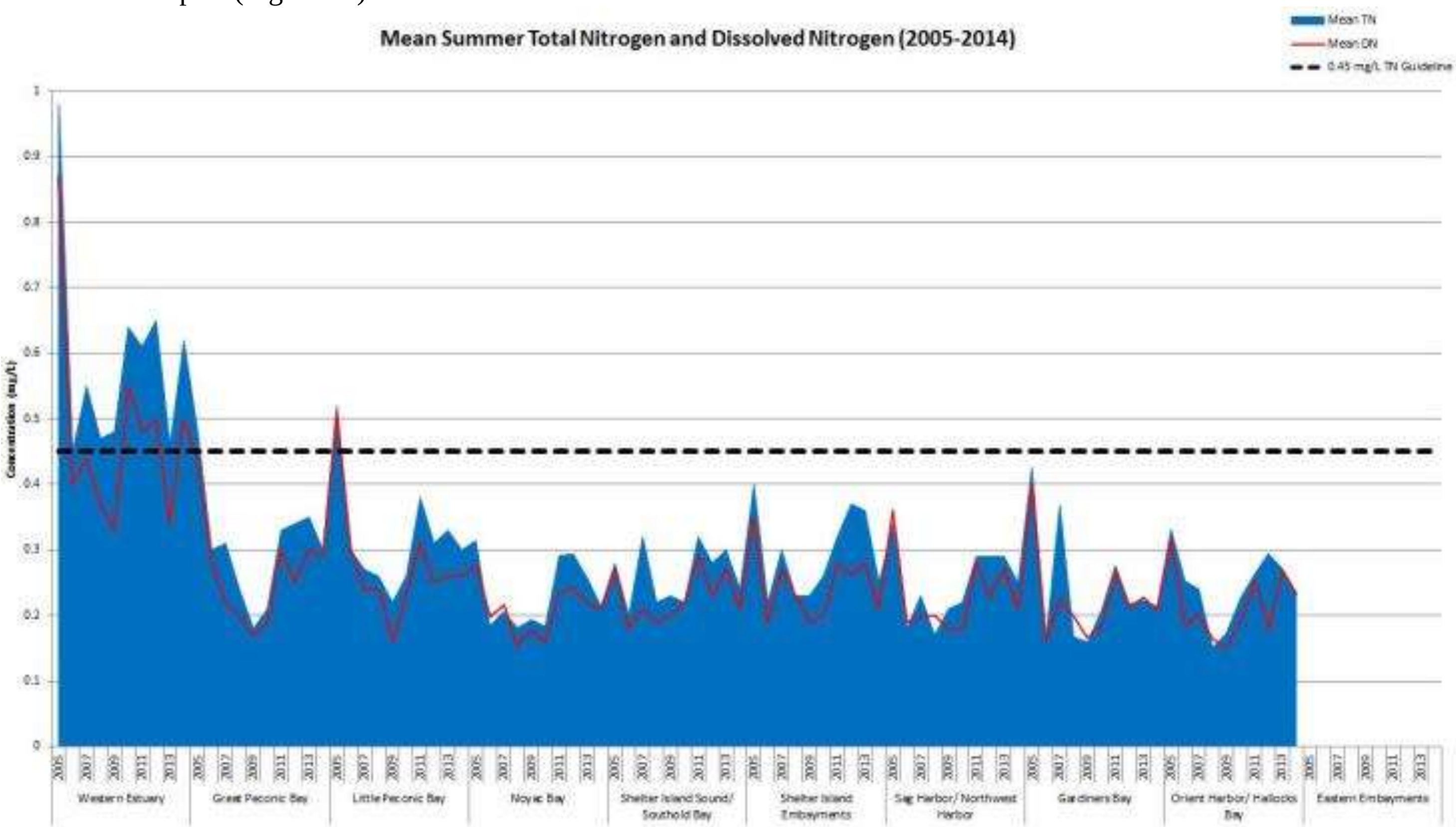


Figure 17: Mean summer total nitrogen and dissolved nitrogen in the Peconic Estuary by section between 2005 and 2014

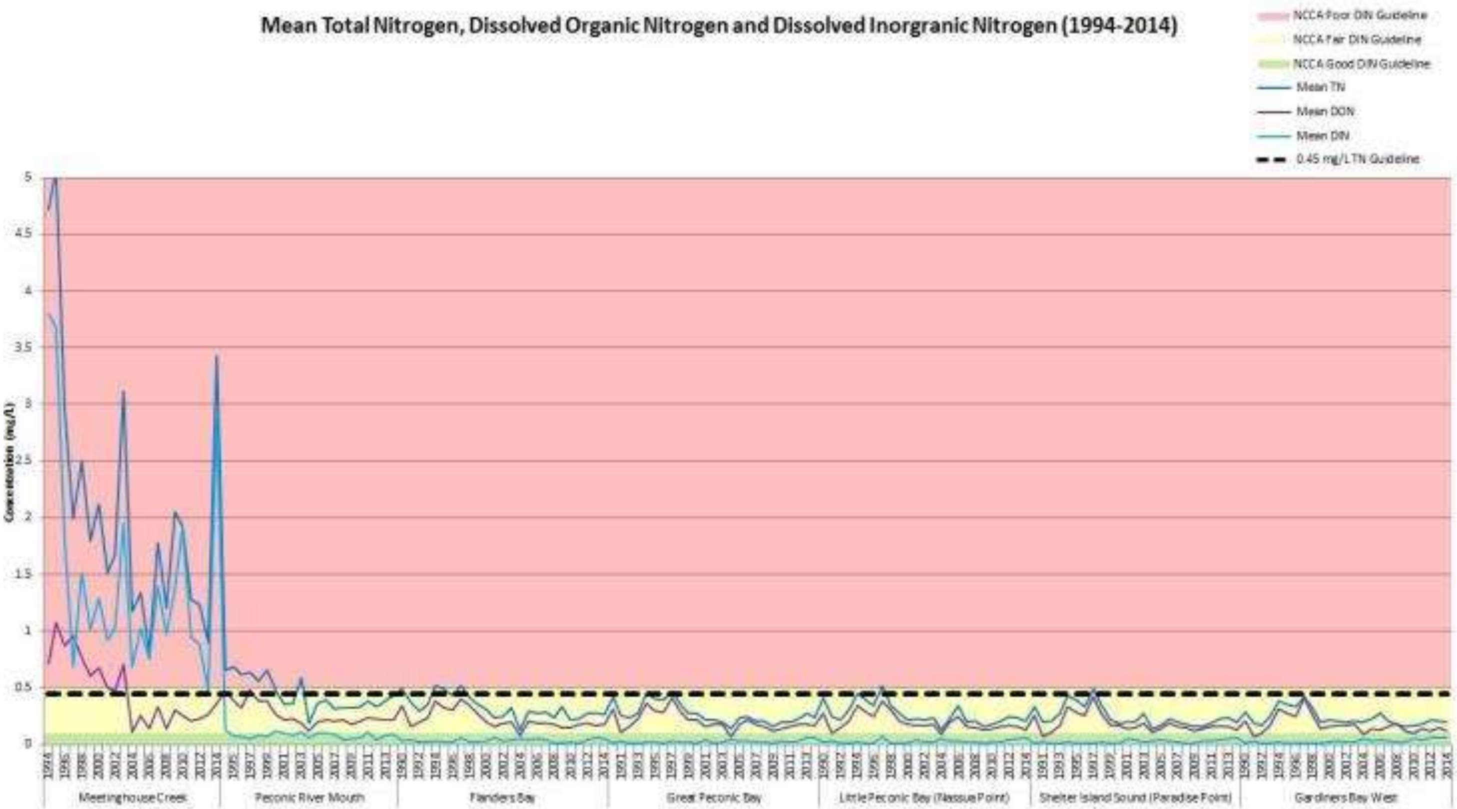


Figure 18: Mean total nitrogen, dissolved organic nitrogen and dissolved inorganic nitrogen in Peconic Estuary between 1994 and 2014

The USGS continuous monitoring stations at Riverhead and Orient record multiple parameters every six minutes. The resulting data and graphs illustrate the relationship between water quality parameters. Figure 19 represents nitrate, total chlorophyll-a and temperature data recorded at the Riverhead USGS station. It is apparent that increases in nitrogen occur after increases in chlorophyll-a and that increases in temperature correspond with increased concentrations of nitrate and chlorophyll-a. Figure 20 represents temperature and nitrate data recorded at the Orient USGS station. Nitrate concentrations are lower at the Orient station than at the Riverhead station and increases in nitrate correspond with increases in temperature. A spike in temperature in the summer of 2013 at both the Riverhead and Orient stations seems to correlate with increased nitrate concentrations at the Orient station and increased nitrate and chlorophyll-a concentrations at the Riverhead station. It is important to note that the USGS monitoring sampling depth does not change with the water depth during tidal flow. The photic zone does change but that is not reflected in the USGS data; therefore some of the fluctuations in chlorophyll-a may not be captured in the data.

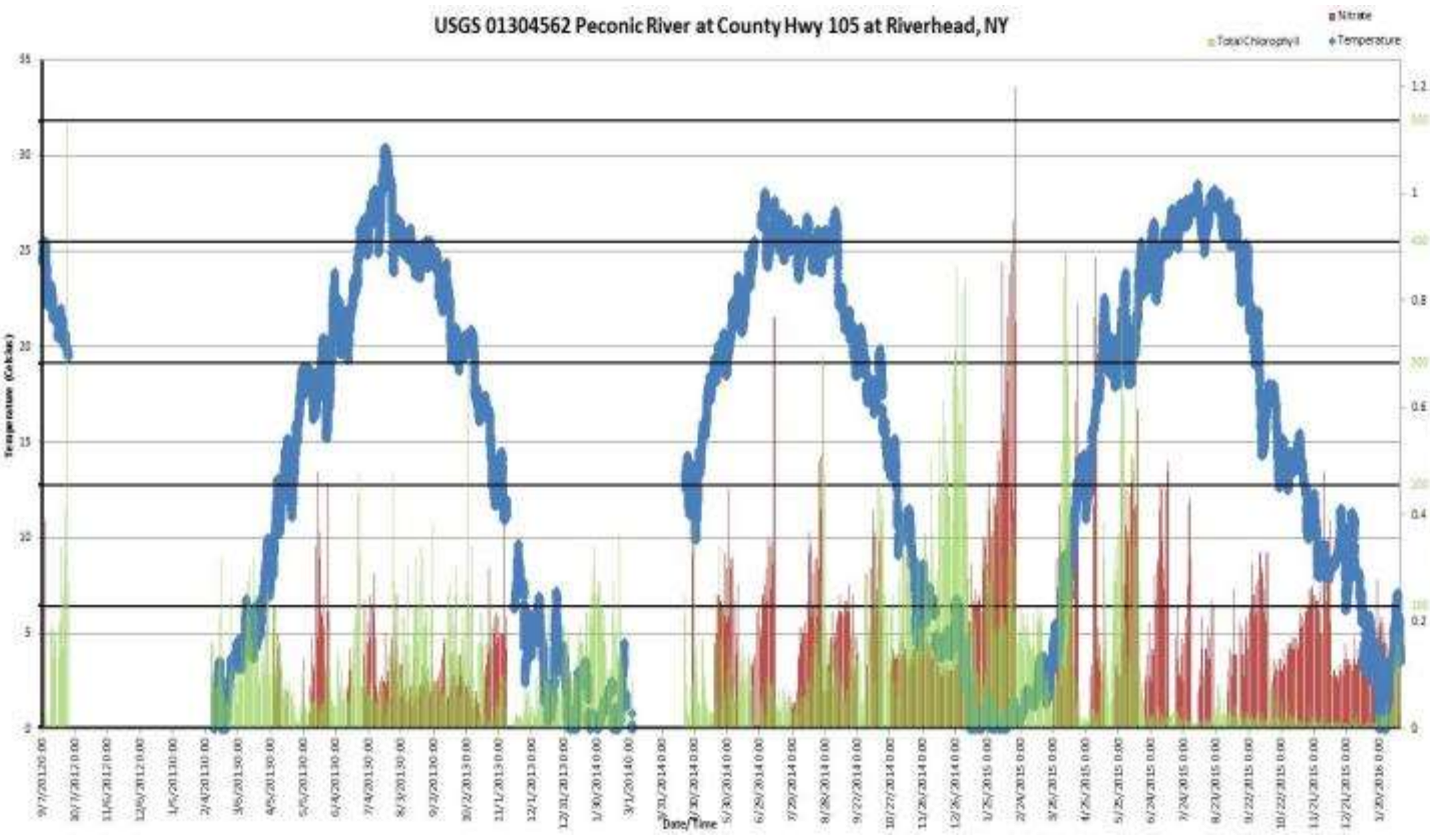


Figure 19: The USGS Riverhead continuous monitoring station, nitrate, total chlorophyll-a and temperature data September 2012 to January 2016

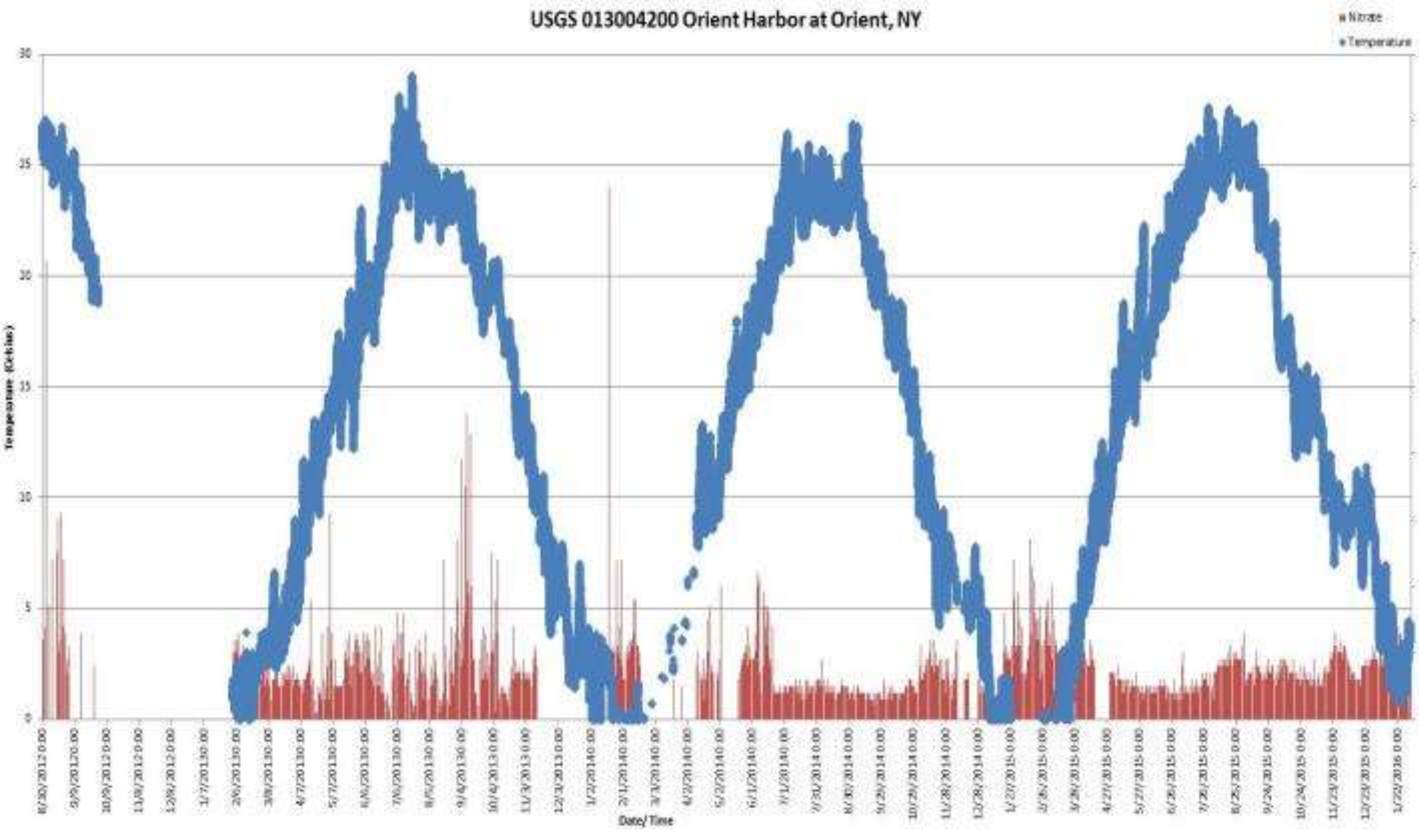


Figure 20: The USGS Orient continuous monitoring station, nitrate and temperature data August 2012 to January 2016

Limitations on these data

SCDHS nitrogen data were collected at 38 sample stations across the Estuary and 26 stream and point source; data were recorded for only 40 stations consistently from 2005 through 2014. Marine nitrogen data analyzed include seven sampling locations that generally received a majority of the sampling effort during the study period to determine trends in DIN and DON analysis. The TN and DN analysis were based on 35 sampling locations for all season analysis and 24 sampling locations in the summer season analysis that consistently were sampled between 2005 and 2014. It is unclear if changes in nitrogen concentrations in the years surrounding 2000 are due to an upgrade in the Riverhead STP or changes to the scientific method used to analyze samples for nitrogen. An investigation into whether those changes may have impacted nitrogen concentration results is recommended. Orient USGS continuous monitoring station does not record total chlorophyll-a, analysis of this parameter would be useful to understand relationships between nitrate and chlorophyll-a.

I-E. Dissolved Oxygen

The 2005 EI report identified dissolved oxygen (DO) as one of 18 indicators of environmental quality for the Peconic Estuary. The 2015 ES Report will continue to look at DO as one of the indicators. Like land-dwelling animals, fish and other aquatic organisms need oxygen to live. As water moves past their gills (or other breathing apparatus), microscopic bubbles of oxygen gas in the water, called dissolved oxygen, are transferred from the water to their blood. Like any other gas diffusion process, the transfer is efficient only above certain concentrations. In other words, oxygen can be present in the water, but at too low a concentration to sustain aquatic life. The condition of low DO is known as hypoxia.

Reasons for Natural Variation

Oxygen enters the water when oxygen from the atmosphere dissolves and mixes into the water's surface. This process is controlled by diffusion and aeration. Aeration is affected by processes such as wave action and strength, and wind direction. Additionally, oxygen is produced by plants and algae during photosynthesis and consumed during respiration and decomposition of organic matter. Because it requires light, photosynthesis occurs only during daylight hours. Respiration and decomposition, on the other hand, occur 24 hours a day. This difference alone can account for large daily variations in DO concentrations. During the night, when photosynthesis cannot counterbalance the loss of oxygen through respiration and decomposition, DO concentrations may steadily decline.

Another physical process that affects DO concentrations is the relationship between water temperature and gas saturation. Cold water can hold more of any gas, in this case oxygen, than warmer water. Warmer water becomes "saturated" more easily with oxygen. As water becomes warmer it can hold less and less DO. So, during the summer months, the total amount of oxygen present may be limited by temperature. Since warmer water holds less DO, the effects of respiration and decomposition depressing DO levels is even more significant since the maximum DO levels will be less (Michaud, 1991).

Dissolved oxygen concentrations may change dramatically with depth. Oxygen from the atmosphere dissolves into the top portion of a waterbody in the same area where sunlight drives the engines of photosynthesis. As such, oxygen levels in waters are typically greatest in the photic zone. Oxygen consumption is greatest near the bottom of a waterbody, where settled organic matter accumulates and decomposes. If the waterbody is shallow and easily mixed by wind, the DO concentration may be fairly consistent throughout the water column. When winds are calm, a pronounced decline with depth may be observed. Other reasons for natural variation include the shape of the water body, strength and direction of flow, water residence time and freshwater input.

Seasonal changes also affect dissolved oxygen concentrations. Warmer temperatures during summer speed up the rates of photosynthesis and decomposition. When all the plants die at the end of the growing season, their decomposition results in heavy oxygen consumption. Other seasonal events, such as changes in water levels, volume of inflows and outflows, and presence of ice cover, also cause natural variation in DO concentrations.

Impacts of Hypoxia

Oxygen depletion may occur in estuaries when many plants die and decompose, or when wastewater with large amounts of organic material enters the estuary. In some estuaries, large nutrient inputs, typically from sewage, stimulate algal blooms. When the algae die, they begin to decompose. The process of decomposition depletes the surrounding water of oxygen and, in severe cases, leads to conditions that kill aquatic animals. Shallow, well-mixed estuaries are less susceptible to this phenomenon because wave action and circulation patterns supply the waters with plentiful oxygen (Moore, 1989). Hypoxia causes indirect and long-term impacts to ecology such as changes in sediment biogeochemistry, shifts in species composition, juvenile mortality, and unstable populations. Economic impacts include negative effects on commercial fisheries, recreation and tourism industry.

Water Quality Standard

Since the 2005 EI report New York State water quality standards for dissolved oxygen have changed. The ambient New York water quality standards for DO for Class SA, SB and SC (all waters within the Peconic Estuary fall within these classifications) waters are 4.8 mg/L, with allowable excursions to not less than 3.0 mg/L for certain periods of time (NY Department of State-Division of Administrative Rules, 2015) (Appendix A). The standards can be found at 6 CRR-NY 703.3. Guidance for interpreting compliance with the chronic DO standard can be found in the NYS DECs Technical & Operational Guidance Series (TOGS) 1.1.6. The EPA dissolved oxygen criterion for juvenile and adult survival is 2.3 mg/L (EPA, 2000). The US EPA's National Coastal Condition Assessment (NCCA) uses the following ratings for dissolved oxygen concentrations (EPA, 2012):

- Good: > 5 mg/L
- Fair: 2-5 mg/L
- Poor: < 2 mg/L

Status and Trends

Suffolk County data is collected over a range of depths from 0.5 to 95 feet below the water surface, and are a result of discrete sampling events. Whereas the two USGS gauges monitor DO at six minute intervals and collect readings from 1.6 feet above the bottom. Analyzing discrete sampling values alone does not capture the short-term variability in the environment as shown by the data recorded during the summer of 2014. This can be seen in Figure 21 below where the squares represent individual sampling events and the line represents the USGS continuous monitoring station in Riverhead. This shows that many of the peaks and valleys in the DO concentrations were not captured and this could lead to a misunderstanding of the actual range of conditions in the environment, i.e. with the discrete sample results shown below it would be difficult to demonstrate an actual DO impairment.

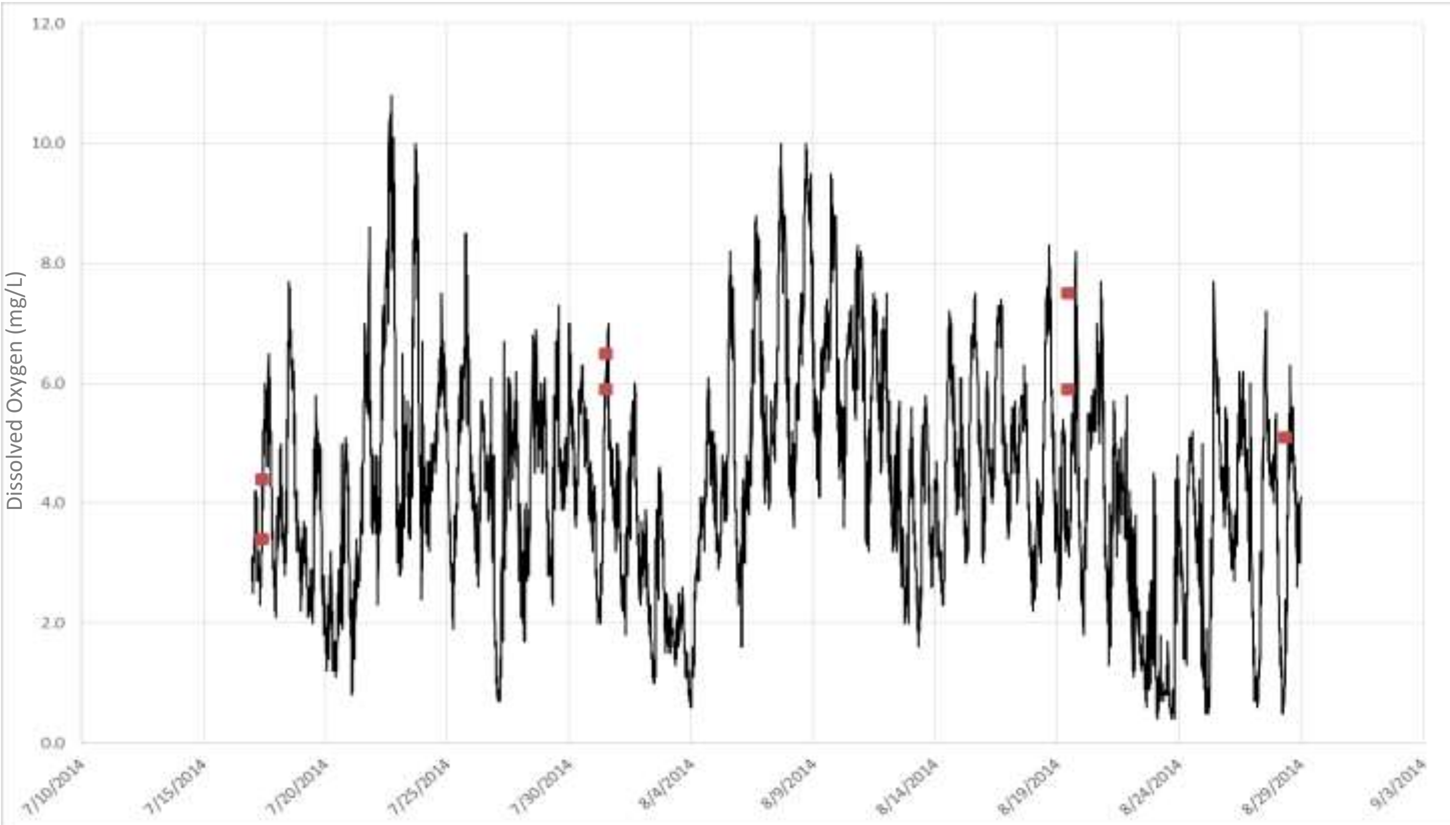


Figure 21: The SCDHS DO sampling events and USGS continuous monitoring data in the Lower Peconic River

Figure 22 depicts the min, max, and average dissolved oxygen concentrations in the Peconic River at Riverhead from 2012 to 2015. As per the graphic, it is typical for this location to experience violations of both the acute DO standard occasionally concentrations remain below the chronic DO standard for an extended period of time. The Riverhead station captures consistent DO impairments likely due to poor flushing, and impacts from continued pollution.

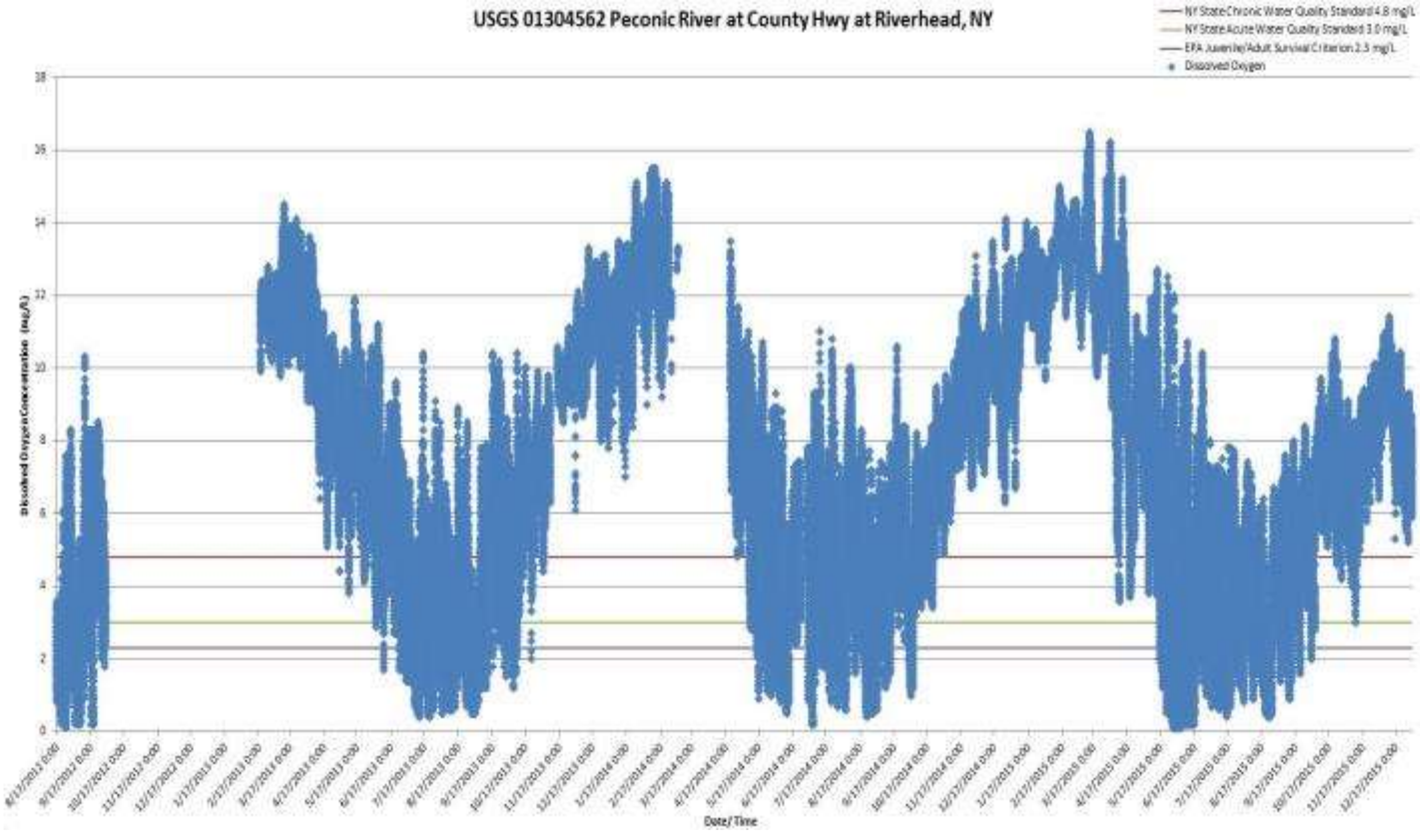


Figure 22: The USGS continuous monitoring of DO data at Riverhead, NY sampling station

The other USGS monitoring station is located in Orient Harbor in Orient New York. Results are shown below in Figure 23. Orient Harbor rarely experiences low DO most likely due to the increased exchange with the ocean and a lower pollution load to this area.

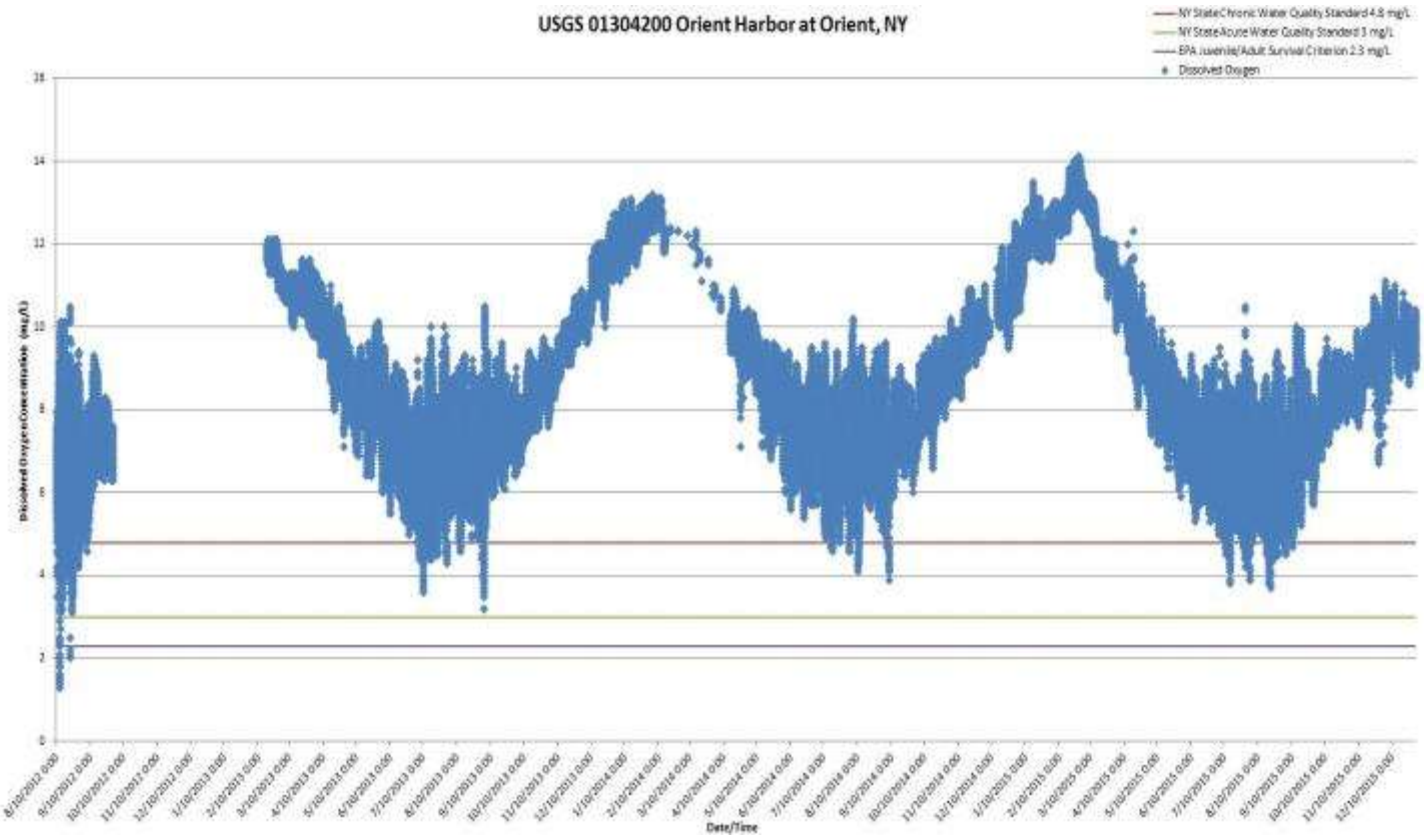


Figure 23: The USGS continuous monitoring of DO data at Orient, NY sampling station

Western Peconic Water Quality Trends

Suffolk County has been collecting water quality data in the Peconic Estuary since the late part of 1976. The entire record of this data has yet to be evaluated; however, Figure 24 presents data collected by Suffolk County from four sampling locations within the western portion of the Peconic Estuary, particularly in the areas that are impaired for dissolved oxygen. The majority of this dataset starts in 1987 and indicates that water quality with respect to dissolved oxygen at these sampling locations has remained the same. DO at the Flanders Bay location is generally measured above the chronic water quality standard. DO data for Reeves Bay is less robust than for the other locations. Reeves Bay data indicates DO is generally above the chronic water quality standard published at the time when the samples were collected. There is no apparent change in the DO value over time from these locations.

Samples collected at the mouth of the lower Peconic River and in Meetinghouse Creek both frequently are measured below both the chronic and acute DO standards, however, there is neither an apparent increase nor decrease in the frequency or magnitude of the exceedances of the DO standards in these locations since 1987. Water quality at these locations based on the Suffolk County data indicate that DO at these locations frequently does not meet the water quality standards.

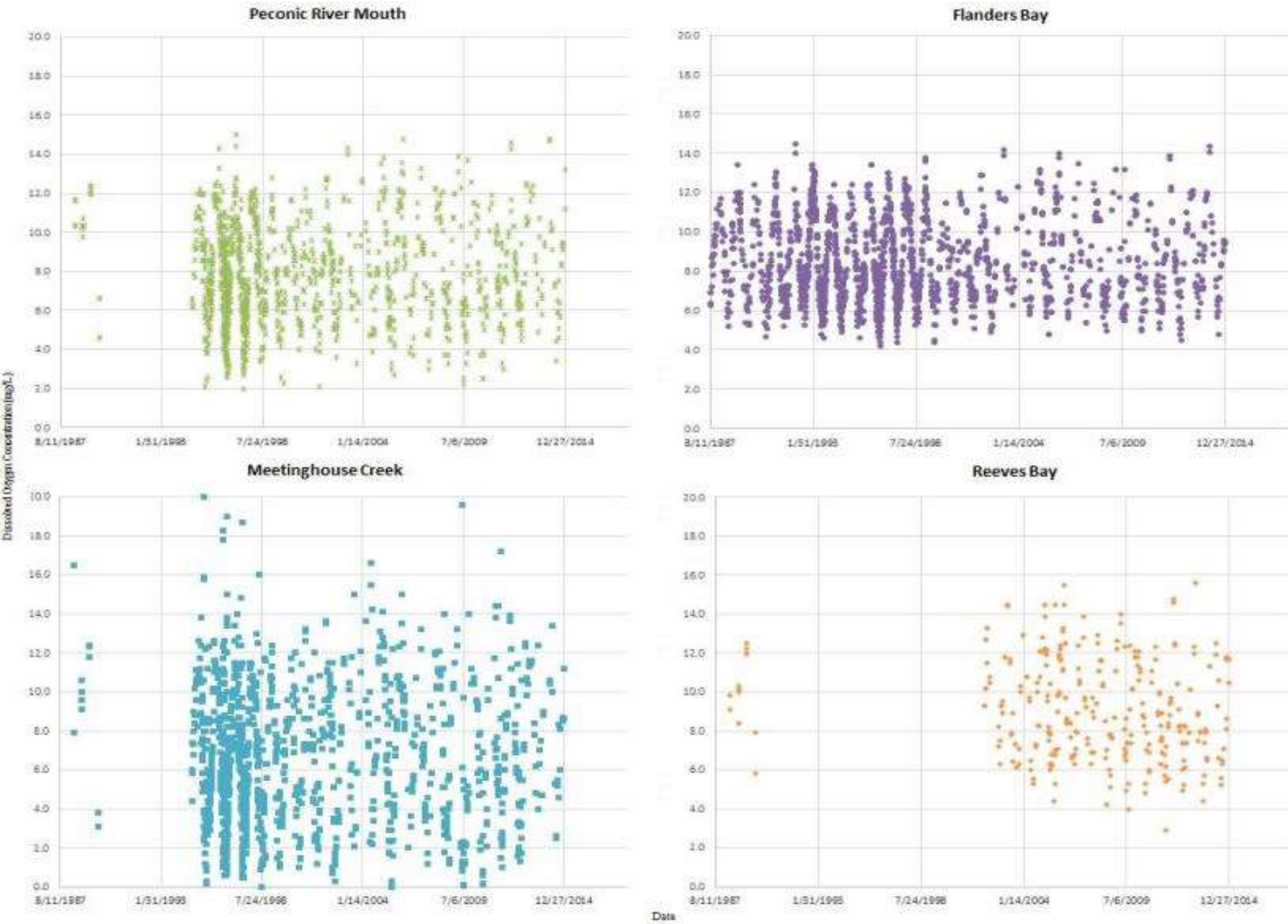


Figure 24: Western Peconic Estuary SCDHS DO water quality data from 1987 to 2014

Impacts of Low DO: 2015 Fish Kill

Thousands of "bunker" or Atlantic menhaden washed up on the shores around Flanders Bay in the Peconic Estuary in June 2015. Bunker are a filter-feeding fish that are an important food source for many predatory fish, such as striped bass and bluefish, in local waters. The monitoring station in Riverhead shows dissolved oxygen levels falling below biological thresholds for much of the day and reaching zero for sustained periods, Figure 25.

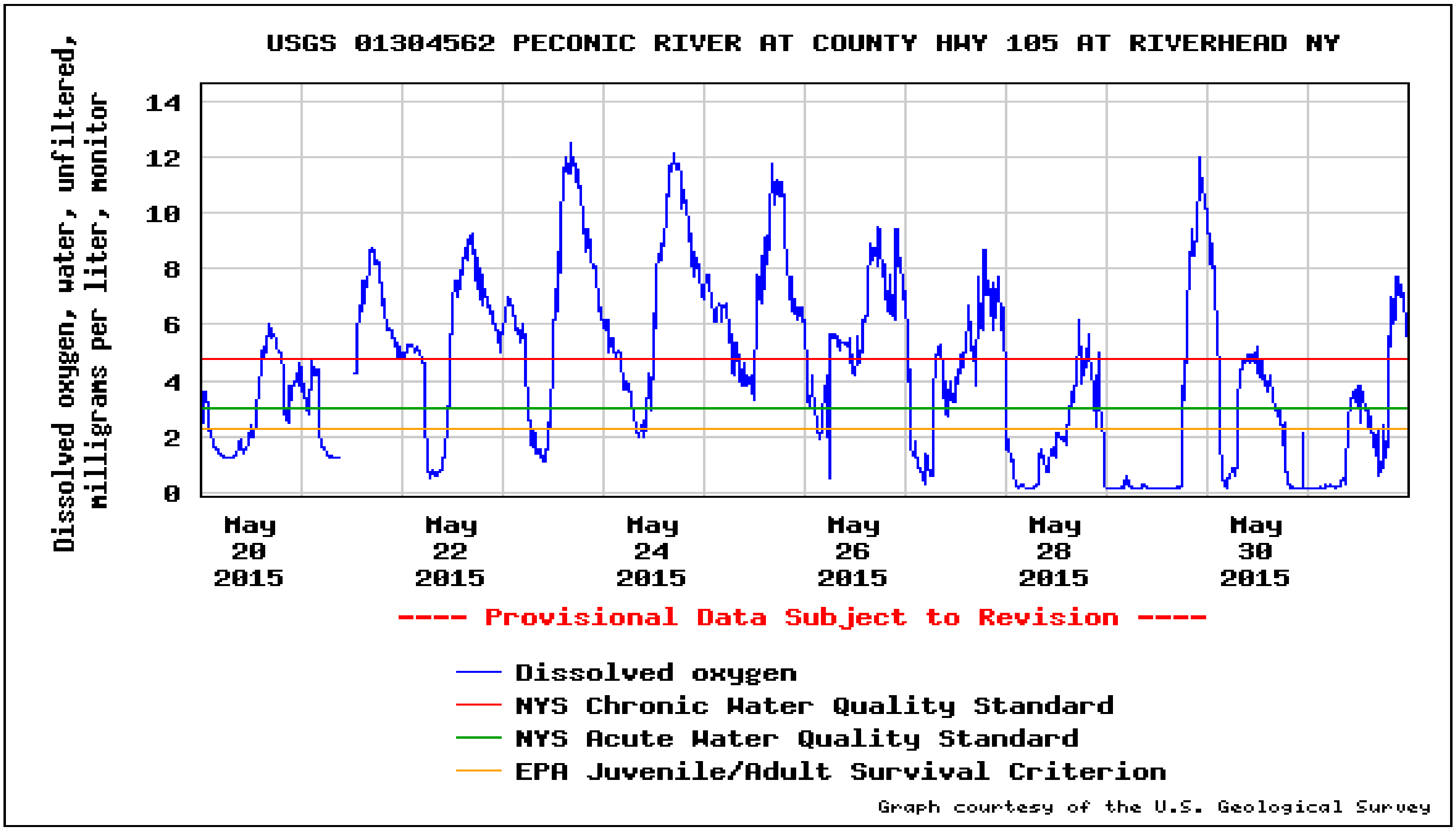


Figure 25: The USGS continuous monitoring of DO data at Riverhead, NY- Spring 2015

Dissolved oxygen was low in this situation due to a bloom of non-toxic algae (*Prorocentrum*) that reduced night-time oxygen, the already stressed system then was flooded with thousands of fish, in high densities. Predators like bluefish herd fish into shallow waters where they cannot escape. The influx of fish used up more oxygen exacerbating already low oxygen conditions. This caused mass fish deaths and fish carcasses washing up along the shoreline. Conditions were intensified by poor flushing in the western estuary and seasonally rising water temperatures (NYS DEC, 2016). There are no short term solutions to keep algae blooms from occurring. However, reducing the load of nitrogen to the Peconic Estuary from septic systems, fertilizer use, and STPs will, over time, help to reduce the frequency and severity of algal blooms and their adverse impacts. Although algae blooms can occur naturally in the spring, they are made worse by excess nitrogen loading. Nitrogen loading in the Peconic Estuary comes primarily from treated sewage, but fertilizer and atmospheric deposition are also significant sources. According to a recent Nature Conservancy study, in Flanders Bay, land-based sources are roughly made up of ¼ from sewage treatment plants, ¼ from septic systems and cesspools, ¼ from fertilizer, and ¼ atmospheric deposition (Nitrogen load modeling to forty-three subwatersheds of the Peconic Estuary, (Lloyd, 2014b).

II. Living Resources

Estuaries, areas where fresh and salt water mix, are unique habitats. Estuarine habitats range from sandy or rocky bottom in the marine zone at the estuary's mouth to eelgrass beds and salt marshes in the bays to riparian zones of tidal creeks. Because of the varied habitats and high productivity, estuaries support an incredible diversity and abundance of plant and animal life. However, human encroachment and exploitation, resulting in excess nutrient and chemical inputs, the introduction of invasive species, and physical alterations, have resulted in signs of stress in some estuarine habitats and species assemblages.

The Peconic watershed encompasses a variety of habitats, from dwarf pitch pine forests to salt marshes to soft bay-bottom communities, all of which are important to the ecology and productivity of the estuarine ecosystem. Some of these habitats are found nowhere else in New York State and are rarely found elsewhere in the United States. Unfortunately, certain habitats are in danger of becoming fragmented, degraded, overused, or completely lost. Many economically important species, such as the bay scallop, weakfish, and winter flounder, spend all or part of their life in the estuary.

The PEP is undertaking initiatives estuary-wide to protect and restore plant and animal populations and the habitats in which they live. With the PEP Habitat Restoration Plan and the PEP Eelgrass Management Plan, the program continues to restore and protect priority habitats with ecological significance and critical natural resource areas. In addition, the PEP supports numerous projects that address the protection of shellfish, finfish and endangered species and the habitats that support them, including eelgrass, wetlands and natural shorelines. Open space preservation is protecting habitats and natural resources before they are fragmented or lost entirely.

The PEP identified six environmental indicators for habitats and living resources. These are: (1) Eelgrass beds distribution; (2)Tidal wetlands distribution; (3) Bay scallop commercial landings; (4) River herring population and spawning access; (5) Finfish population abundance index; and (6) Piping plover nests and nesting productivity.

Land Protection

The status and trends of living resource indicators are closely related to the amount of land preserved in the Peconic Estuary. The 2005 EI report identified land protection as one of 18 indicators of environmental quality for the Peconic Estuary. Seemingly ever increasing development pressure is leading to the loss of open spaces and natural habitats, threatening ground and surface water quality and stressing remaining natural communities. The region's growing population and rate of development, as well as threats from sea level rise, have underscored the need for action to protect the remaining developable acreage in the Peconic Estuary Study Area. There are many benefits to land protection, including preserving unique species and natural communities, controlling nitrogen loads to optimize dissolved oxygen in the water for fish and shellfish, and protecting surface water quality and groundwater recharge areas from other adverse effects. In addition, the public has exhibited a strong attachment to the natural resources of, and amenities provided by, the Peconic Estuary region, even if they do not use them directly or frequently.

The most significant source of funding for land protection is the Community Preservation Fund (CPF), administered by the five East End towns. This funding is supplemented by County and State governments, and not-for-profit organizations (especially The Nature Conservancy and the Peconic

Land Trust). The Peconic Estuary Program has developed a Critical Lands Protection Strategy (CLPS) that outlines land still available for development (including developed lands that can be further subdivided) that also meet criteria used to determine land protection priorities. These criteria include: (1) proximity to shorelines or tidal creeks; (2) categorization as a freshwater or tidal wetland, as classified by the U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory; (3) location within a Critical Natural Resource Area; and (4) location within a nitrogen-stressed subwatershed. The Program shares this information, and is currently updating the strategy to accommodate changes such as sea level rise due to climate change, with the towns for use in establishing acquisition/protection priorities.

Status and Trends

As the amount of land available for protection diminishes, land value increases, and development pressure increases, land acquisition has continued to be a critical component of water quality protection within the Peconic watershed. Since 2006, approximately 2,443 acres of land were protected in the Peconic Estuary watershed (Figure 26). The cumulative land protected in the Peconic Estuary watershed represented in the figure depicts total acres protected, the data available does not distinguish between CPF funded land protection and land protection funded through other sources.

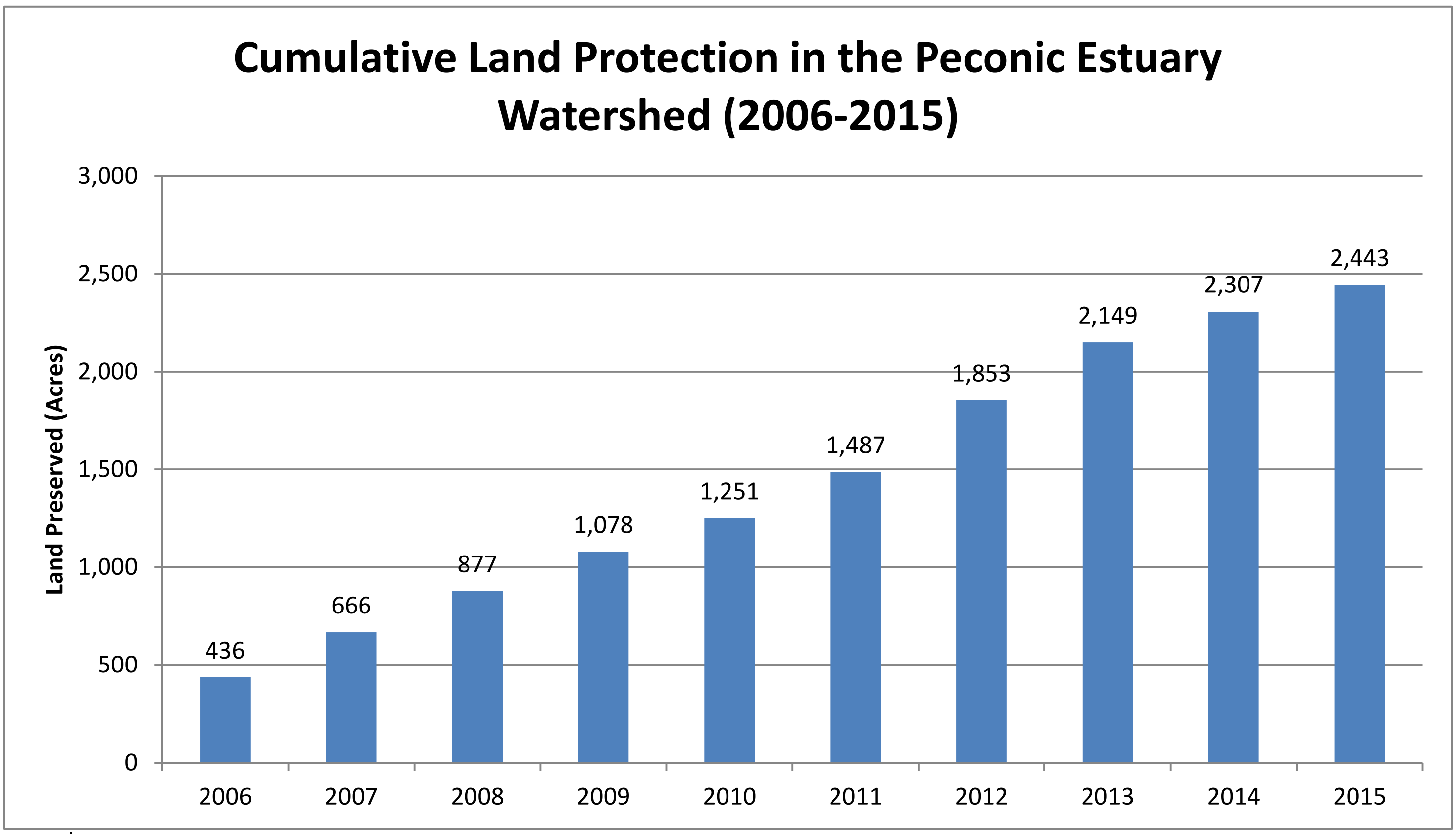


Figure 26: Total acres acquired within the Peconic Estuary Study Area cumulatively between 2006 and 2015

II-A. Eelgrass

The 2005 EI report identified eelgrass as one of 18 indicators of environmental quality for the Peconic Estuary. Eelgrass (*Zostera marina*) is a rooted, vascular plant, which is an important species of SAV found in temperate areas along the East Coast. It is limited to areas of high light penetration, and usually only grows at depths down to six to ten feet of water. Eelgrass and other SAVs support abundant populations of invertebrates that are food for waterfowl and fish. SAVs stabilize sediment, oxygenate bottom waters, and are critical habitat for many estuarine species, most notably juvenile bay scallops that attach to the eelgrass blades. Eelgrass beds provide nursery and feeding habitat for many fish species, including winter flounder, juvenile bluefish, striped bass and weakfish. Some waterfowl, primarily brant and mergansers, feed on eelgrass.

Due to wasting disease, nuisance algal blooms, and human disturbance of the near shore environment, eelgrass has suffered numerous acute and chronic die-offs over the last century. While wasting disease (caused by the slime mold, *Labyrinthula*) is not a significant problem in Peconic eelgrass beds today, this pathogen decimated eelgrass beds all over Long Island in the early 1930s. Eelgrass beds in the Peconic Estuary were further impacted by the periodic Brown Tide blooms in the 1980s and 1990s which reduced light penetration. Eelgrass can be impacted by turbidity, which influences light penetration, and increased nutrients, which promote the growth of epiphytes and algae. Eelgrass can also be damaged by anchor scarring, boating in shallow water and by some shellfish harvesting activities such as tonging or raking. Increased water temperature has been shown to impact eelgrass bed extent. Groundwater seepage into sediment surrounding eelgrass beds has been theorized to mitigate the impacts of warm water on eelgrass beds (S. Schott & C. Pickerell, personal communication, June 13, 2016).

Status and Trends

According to Cornell Cooperative Extension of Suffolk County (CCE) Peconic Estuary Program Long-Term Eelgrass Monitoring Program (PEP LTEMP), Peconic Estuary Program Long-Term Eelgrass Monitoring Reports, there were over 8,700 acres of eelgrass (a conservative estimate) in the Peconic Estuary during the 1930s. Of the submerged aquatic vegetation beds delineated by the FWS using 2000 aerial photographs, only 1,550 acres of eelgrass (comprised of 119 beds) remained in 2000. The 2014 aerial survey identified less than 90 eelgrass beds covering less than 1000 acres. All the eelgrass beds remaining in the Peconic Estuary are located east of West Neck Bay, Shelter Island, except for the meadow in Bullhead Bay, Southampton. Cornell Cooperative Extension continues to attempt to reestablish eelgrass in numerous locations in the Peconic Estuary. These projects have shown some success in areas east of Shelter Island and in Greenport Harbor, but projects at sites west of Shelter Island and in creeks have not been as successful (Nace & Grothe, 2015).

Through the PEP, CCE conducts long-term monitoring at eight sites within the Peconic Estuary (Table 1). Of the eight sites, currently only four support eelgrass. Since the 2005 EI Report, eelgrass declined and was completely lost in Northwest Harbor, Orient Harbor, Southold Bay, and Three Mile Harbor. Of the remaining extant eelgrass meadows in the monitoring program, the Cedar Point, Gardiners Bay and Orient Point meadows have shown some decline in overall size of the meadows over the last several years, due, in part, to the impacts of Hurricane Sandy and severe winter storms, while maintaining or showing slight increases in eelgrass shoot density (Figure 28, Figure 29, Figure 30). The Bullhead Bay meadow had been in decline since 2004, and in 2010, monitoring reported no eelgrass observed within the six permanent monitoring stations within the bay and the aerial extent of the meadow had been reduced to less than 6 acres (

Figure 27). The Bullhead Bay meadow showed signs of recovery in 2011 and in 2014, the meadow had expanded to almost 57 acres with eelgrass shoot densities approaching 200 shoots·m-2.

Table 1: The 8 Peconic Estuary Program Long-Term Eelgrass Monitoring Program reference eelgrass beds and township

Eelgrass beds	**Township**
Bullhead Bay	Southampton
Gardiners Bay	Shelter Island
Northwest Harbor	East Hampton
Orient Harbor	Southold
Southold Bay	Southold
Three Mile Harbor	East Hampton
Cedar Point	East Hampton
Orient Point	Southold

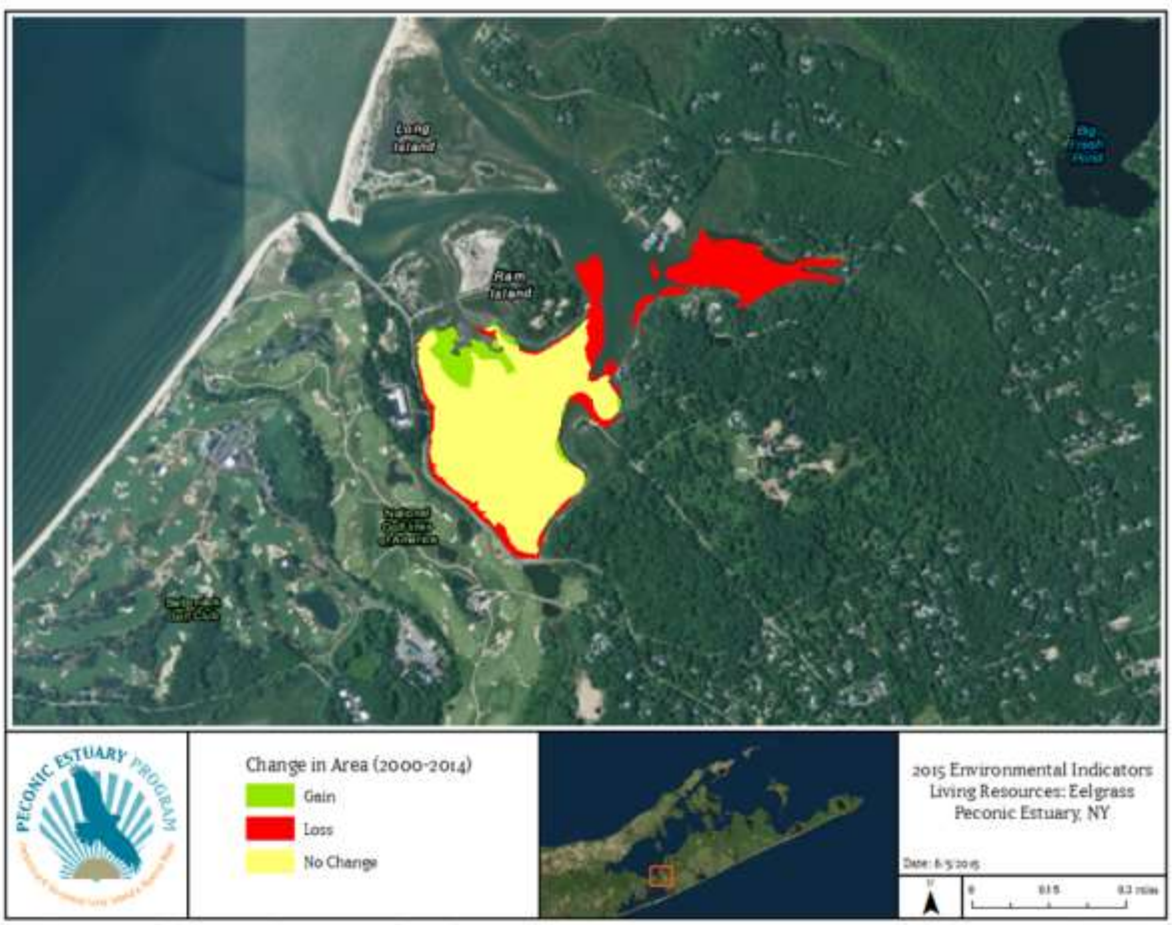


Figure 27: Bullhead Bay eelgrass bed area change between 2000 and 2014

Figure 28: Napeague Bay area eelgrass bed area change between 2000 and 2014

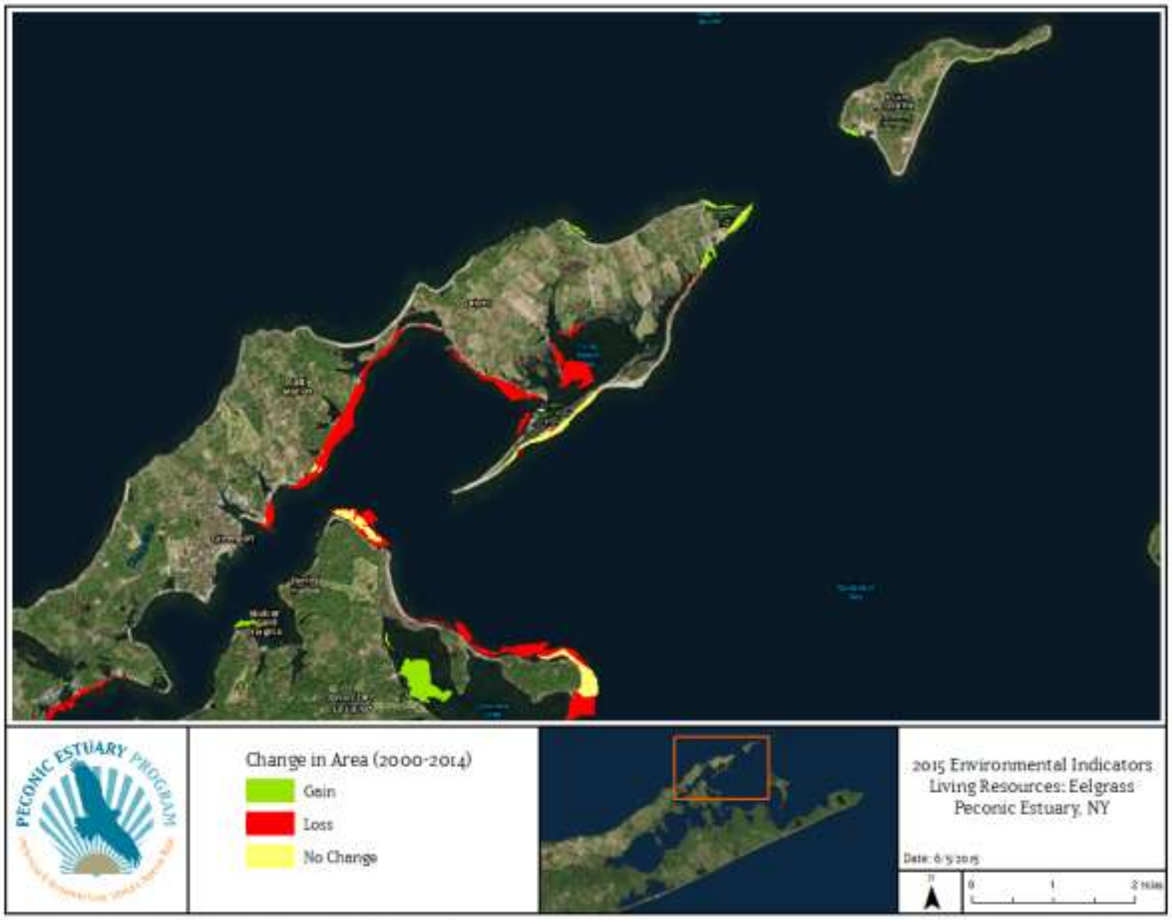


Figure 29: Orient Point eelgrass bed area change between 2000 and 2014

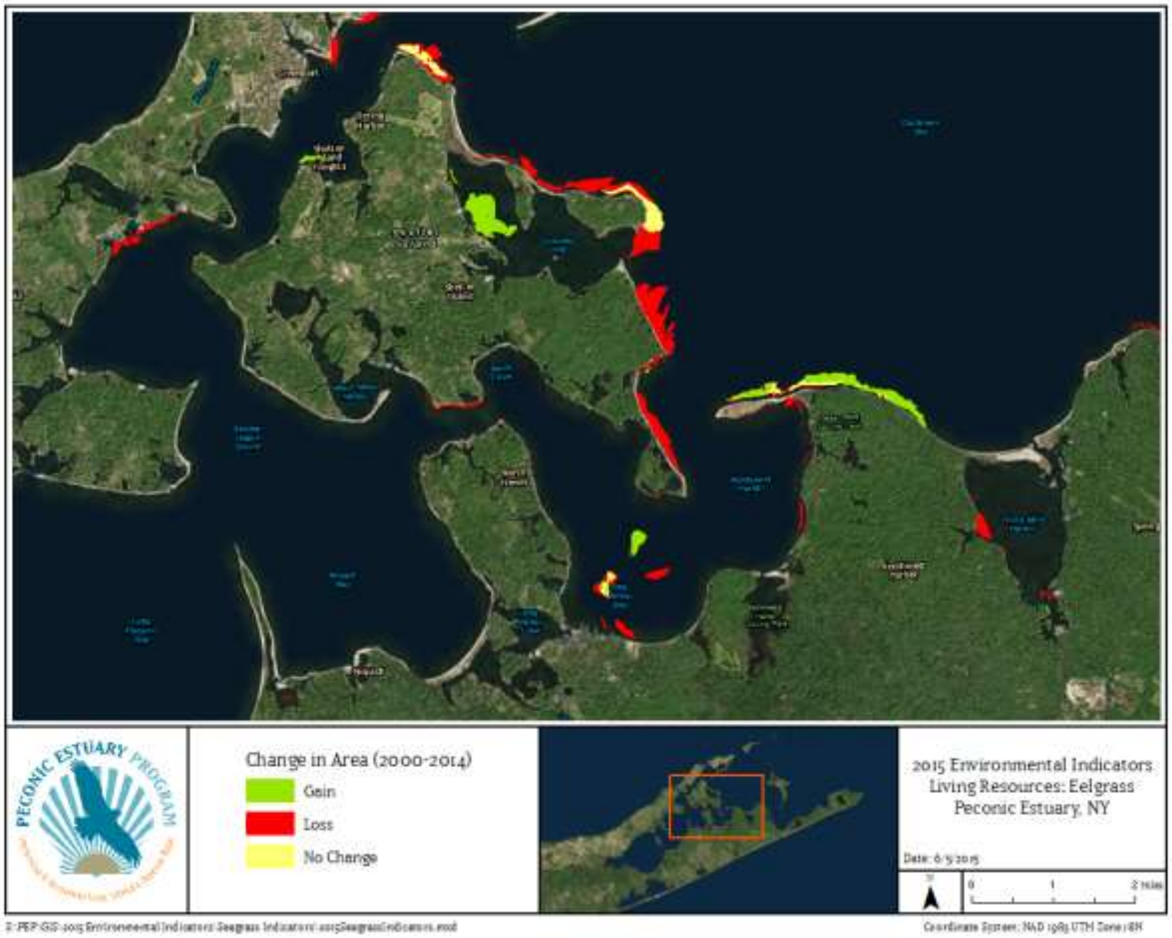
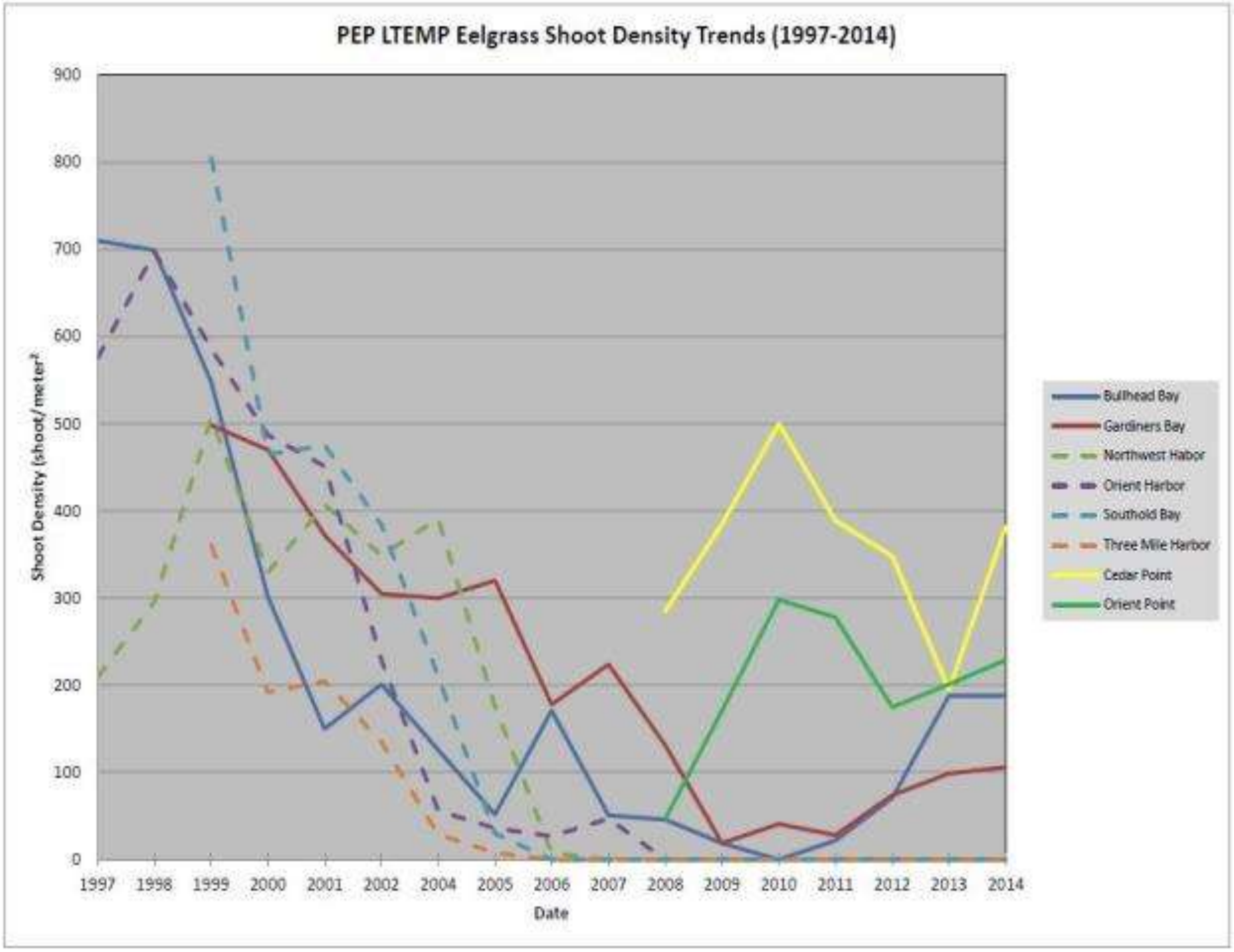


Figure 30: Gardiners Bay eelgrass bed area change between 2000 and 2014

Throughout the estuary, there has been an overall decline in eelgrass shoot density since the beginning of the long-term monitoring program, but recent trends have shown the meadows to be stable, and even increasing in density (Figure 31). This trend may be a response to better water quality or reduction in disturbance in these areas.



(Schott, 2014)

Figure 31: Peconic Estuary Long-Term Eelgrass Monitoring Program eelgrass shoot density between 1997 and 2014

CCE continues to attempt to reestablish eelgrass in numerous locations in the Peconic Estuary. These projects have shown some success in areas east of Shelter Island and in Greenport Harbor, but projects at sites west of Shelter Island and in creeks have not been as successful. Attempts at re-establishing eelgrass have proven to be labor intensive, difficult and costly, though some new and promising methods are being tested. Conserving existing eelgrass beds and re-establishing new ones will be most successful if there is good water quality and clarity, minimal physical disturbance, and few predators (Pickerell & Schott, 2015).

Limitations of data

The 2014 eelgrass survey was the first survey done since the 2000 FWS eelgrass inventory. More frequent mapping efforts and continued long-term eelgrass monitoring are important, especially due to the lack of frequent aerial surveys, going forward to identify trends in health threats to the declining eelgrass population and formulate appropriate responses to these threats in a timely manner. This monitoring program will be reviewed to determine whether it could be made more effective by replacing the four meadows that no longer support eelgrass with four new meadows that would provide relevant data on eelgrass health in the Peconic Estuary.

II-B. Wetlands

The 2005 EI report identified wetlands as one of 18 indicators of environmental quality for the Peconic Estuary. Tidal wetlands are some of the most diverse habitats in the coastal region and form the transition zone between the upland and open water. They are among the most productive habitats on earth, and some biologists believe they are rivaled only by coral reefs and tropical rainforests with regard to their primary productivity. Tidal wetlands are composed of low marsh, intertidal areas dominated by cordgrass (*Spartina alterniflora*), and high marsh, occasionally flooded areas are populated by a variety of plant species such as *Spartina patens*, *Distichlis spicata* and *Juncus gerardii*. Wetlands trap sediments, recycle nutrients and organic matter, attenuate floodwaters, and are important feeding, breeding, and nursery habitats for waterfowl, wading birds, shorebirds, fish and invertebrates. Two-thirds of commercially harvested fish, sportfish and shellfish depend upon tidal wetlands for at least part of their life cycle. Freshwater wetlands are also critical habitats in estuarine systems.

Wetlands provide multiple environmental benefits such as high quality coastal wildlife habitat for native plants as well as foraging and nesting grounds for resident and migratory bird species. Wetland areas also act as buffers that intercept nonpoint pollutants such as sediments, suspended and dissolved solids, nutrients associated with fertilizers, and other chemical compounds that affect the water quality of the Peconic Estuary and its tributaries. The root system of the vegetation helps to stabilize the shoreline, minimizing the risk of erosion. Prior to the adoption of tidal wetlands laws and regulations in 1972, wetlands were subject to intense development pressure and were ditched, dredged, filled and bulkheaded. While these laws and regulations prevent the filling of wetlands, there are many current threats, including rising sea levels, the loss of high marsh, poor water quality, erosion, and invasion by common reed (*Phragmites australis*), which can displace native species.

Status and Trends

The most current data and status is provided by the 2015 Long Island Tidal Wetlands Trends Analysis project. The purpose of this project was to quantify the magnitude of landscape-level changes in wetlands loss and changes in marsh condition within the Long Island Sound, Peconic, and South Shore Estuaries including all or parts of Westchester, Bronx, Queens, Nassau, and Suffolk Counties.

Changes, including degradation, fragmentation and severe acreage losses have been observed in several Long Island, NY tidal wetland complexes during discrete and limited trends analyses. The results of this effort support other studies that have demonstrated substantial loss of tidal wetlands area over the past 40 years. Typical indicators of native marsh loss (i.e., not including *Phragmites australis* marsh) that were observed in the study area include retreat of the seaward edge of the marsh, loss of marsh islands, widening of tidal creeks and ditches, panne/mudflat, pond formation, and encroachment of invasive *Phragmites australis*. In addition to native marsh loss, conversion of high marsh to low marsh is indicative of sea level rise. The trends analysis was conducted across the three major tidal wetland classes (i.e., Intertidal, High and Fresh Marsh) and *Phragmites australis* over two time periods: 1) Year 1974 and

2) Year 2005/2008.

Overall, Long Island's estuaries have lost 13.1 percent of native intertidal (IM), high marsh (HM), and coastal fresh marsh (FM) communities between 1974 and 2005/2008. The Peconic Estuary and South Shore Estuaries have slightly lower percentages of marsh loss (-10.4 percent and -11.6 percent, respectively) compared to the Long Island Sound Estuary (-22.6 percent). The Peconic Estuary spans the Towns of East Hampton, Riverhead, Shelter Island, Southampton and Southold. East Hampton sustained the largest loss of marsh habitat, losing 145.8 acres for a 13.8 percent decrease from 1974 to 2005. The Town of Southold lost nearly 10 percent of marsh habitat from 1974 through 2005, while the Town of Riverhead exhibited a slight gain in native tidal wetland area. The highest percentage loss of marsh habitat occurred in the Town of Shelter Island where marsh habitat decreased in area by 17.5 percent (Table 2).

Table 2: Tidal Wetland Area Change (1974-2005) in the Peconic Estuary by Class

Wetland Type	**1974 Wetland Area (acres)**	**2005 Wetland Area (acres)**	**Change (%)**
Intertidal Marsh	1,457.1	1,652.6	13.4
High Marsh	1,865.9	1,393.8	-25.3
Coastal Fresh Marsh	117.2	31.0	-73.5
Marsh Subtotal	3,440.2	3,077.4	-10.5
Phragmites australis	304.3	573.6	88.5
Vegetated Area Total	3,744.5	3,651.0	-2.5

(Cameron Engineering & Associates, 2015)

Each marsh complex was identified as "stable" (less than 10 percent decrease in marsh area between 1974 and 2005/2008), or "at-risk" (more than 10 percent loss in marsh area). Eighty-six "at-risk" marshes – out of a total of 159 (54%) – were identified within the Peconic Estuary. "At-risk" marshes are located throughout the estuary; however, clustering is apparent in the western portions of the estuary, particularly adjacent to more developed areas around Riverhead, Sag Harbor and along the north shore of Peconic Bay (Cameron Engineering & Associates, 2015) (Figure 32).

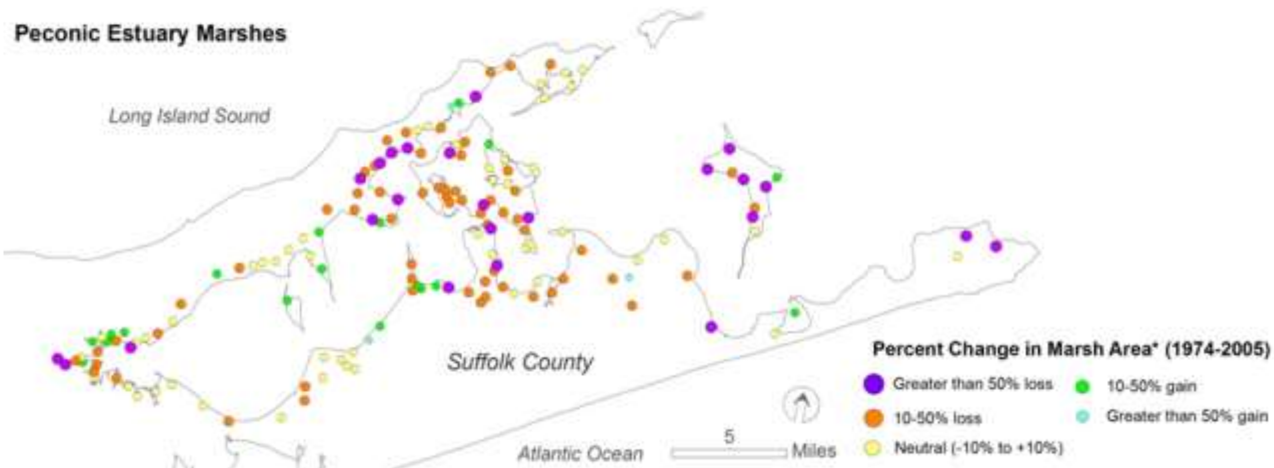


Figure 32: Peconic Estuary Wetland Complexes by Percent Change in vegetated March Area (1974-2005)

The major changes in the biological and physical structure of marshes observed in this study include:

• Conversion of High Marsh to Intertidal Marsh

• Formation of Pannes and Ponds within Marshes

• Conversion of Intertidal Marsh Islands to Mudflats

• Widening of Tidal Creeks and Man-made Ditches

• Erosion and Retreat of Seaward Edge, and

• *Phragmites australis* Encroachment

Salt marshes provide many critical benefits to human communities including fish and shellfish production, protection of shorelines from coastal storms, erosion control and sediment stabilization, water filtration through nutrient and sediment removal, carbon sequestration, and recreation and tourism (Barbier et al., 2011). The loss of nearly 3,000 acres of native wetlands implies a substantial loss of ecosystem services in Long Island's estuaries. The approximately 30 percent loss of high marsh habitats, in particular, throughout Long Island between 1974 and the mid 2000's and resulting loss of ecosystem services and habitat for wildlife and rare plants demands restoration efforts in complexes with greatest losses of high marsh area and increased management in the largest remaining high marshes.

Limitations of data

The most recent wetland data is from 2005/2008. New imagery is needed to provide a current assessment of tidal wetlands. The potential applicability and effectiveness to mapping marshes is not fully known for the wide range of tidal wetland mapping techniques presently available.

II-C. Scallops

The 2005 EI report identified scallops as one of 18 indicators of environmental quality for the Peconic Estuary. Bay scallops, *Argopecten irradians irradians*, are an iconic species on Long Island and are the object of a prized recreational and commercial fishery. They also have an unusual life history – unlike clams, they spend their entire life above the bay bottom; unlike oysters and mussels, scallops can swim to avoid predators or to relocate to a different habitat. Bay scallops are functional hermaphrodites and thus alternatively release eggs and sperm during a single spawning event. In the Peconic Bays, spawning typically is initiated between late May to mid-July, but may occur as late as September-October. For scallops that were themselves spawned in late Spring, reproduction takes place at an age of about one-year (Tettelbach et al., 1999).

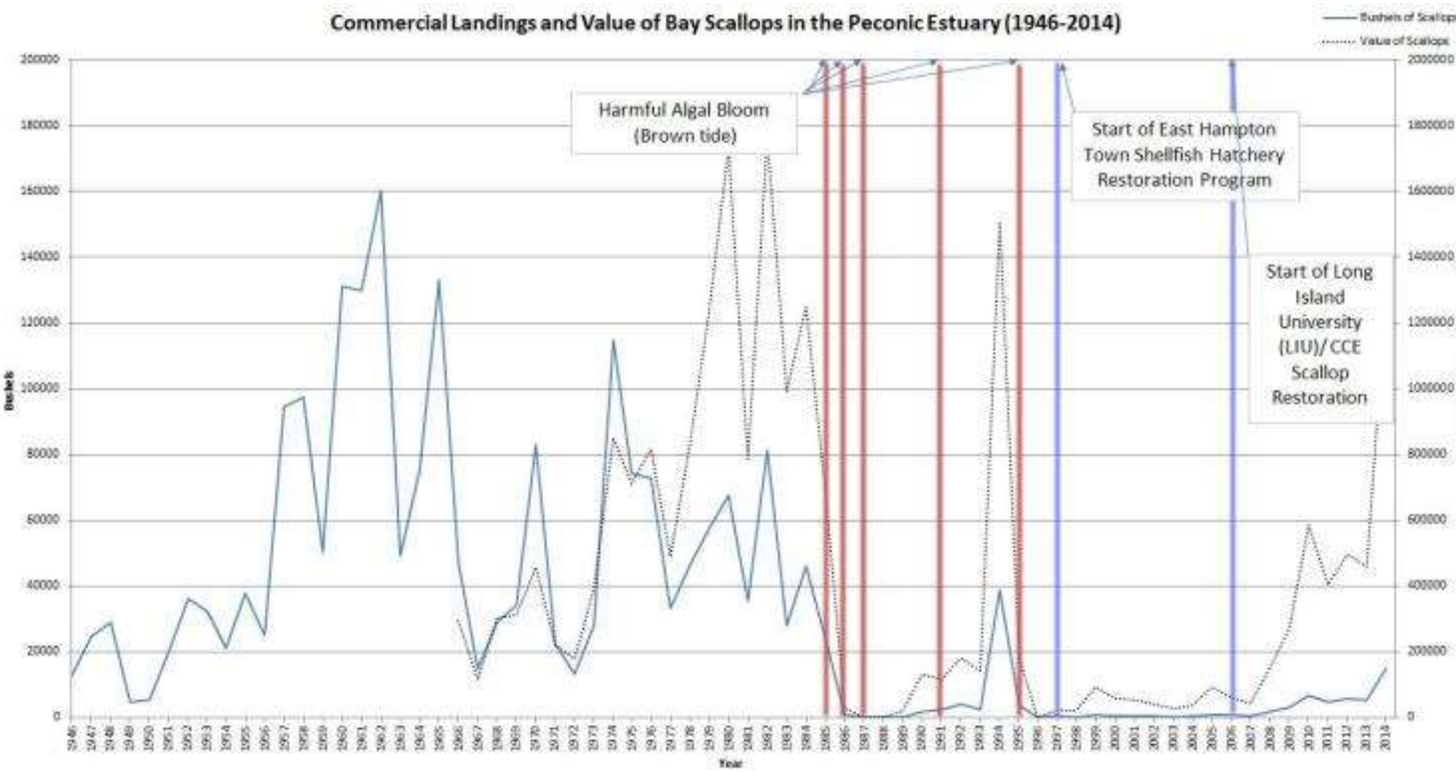
After successful fertilization takes place, scallop larvae typically remain in the plankton for about two weeks; then, they attach to a wide range of above-bottom substrates. Historically, eelgrass has been viewed as the preferred species of SAV to which bay scallop larvae attach, but in the Peconic Bays they will settle on at least 10 different SAV species as well as shells, stones and man-made materials (Bricelj et al., 1987). While scallops remain attached above the bottom, a spatial refuge is provided from many of their common predators (crabs, whelks, oyster drills, sea stars). Growth of juvenile scallops is very rapid (10-12 millimeters (mm)/month), so they may only remain in the SAV canopy for days to weeks. On the bottom, bay scallops may seek refuge by attaching to the inside/underside of shells or hide under vegetation or they may use their swimming abilities to evade potential predators (Garcia-Esquivel & Bricelj, 1993). By the time bay scallops reach a size of 35-40 mm they have outgrown most of the common predators found in New York embayments; by the end of the first growing season, early December, most bay scallops have reached a size of >50 mm. The winter is a harsh period for bay scallops as they may succumb to burial by shifting sediments; this appears to be relatively common in unvegetated habitats, mud or sand, and/or in areas with high tidal currents. During the winter, bay scallops begin to transfer energy reserves from their adductor muscle to the gonad; shell growth resumes once waters have warmed enough in the Spring, usually around late March or early April (Tettelbach et al., 1990).

Bay scallops usually spawn during the first year of their life cycle, but most live through the fall and winter before they die of natural causes at an age of 18-22 months. This is very advantageous for the fishery in that adult scallops can typically be fished without any overall quotas because the great majority of these scallops will die anyway if they are not caught. This peculiar life history, however, makes bay scallop populations and annual fishery landings prone to dramatic fluctuations (Belding, 1910). The commercial bay scallop fishery in New York currently opens on the first Monday of November and lasts until March 31; adults must have a raised annual growth ring and have a shell height of 2 ¼ inches (=57 mm) (NYS DEC, 2014; Tettelbach et al., 1990).

Status and Trends

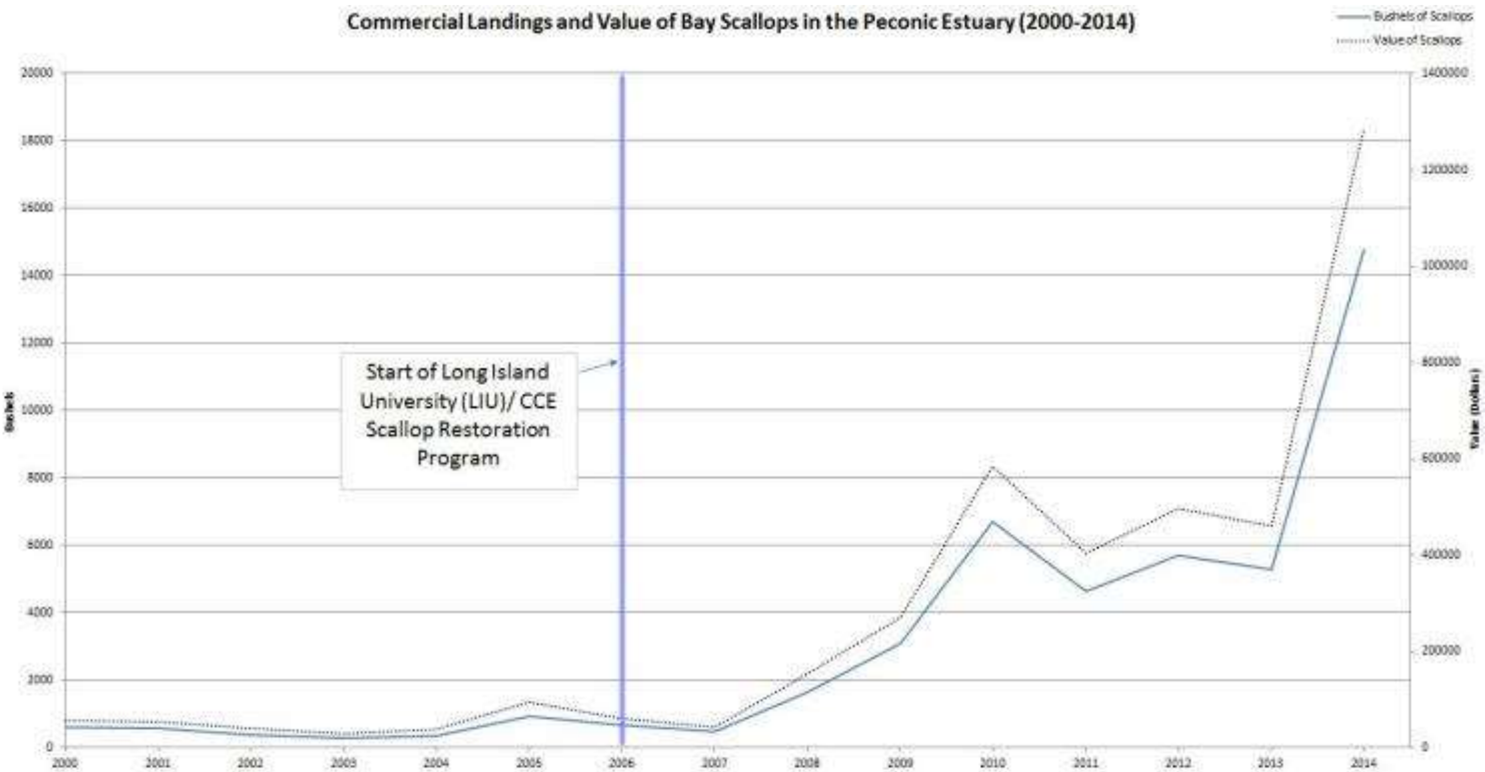
Historically, commercial landings of bay scallops in New York were common in Long Island Sound and embayments all over Long Island. However, in the 1930's, eelgrass wasting disease decimated beds of the scallop's preferred habitat; scallop populations and harvests then declined dramatically in many areas (Fonseca & Uhrin, 2009). Between 1946-2013, total annual commercial bay scallop harvests in New York ranged from 53 to ~988,000 lbs of meat (meat indicates the adductor muscle, the only part of the scallop that is usually eaten in the United States) (Figure 33). During this period, commercial harvests have come predominantly from the Peconic Bays, with occasional peak landings from Shinnecock, Moriches or Great South Bay (NYS DEC, 2014; Tettelbach et al., 1999)

In 1985, the first of a series of Brown Tide (*Aureococcus anophagefferens*) algal blooms occurred in Long Island waters, decimating bay scallop populations. Fishery landings declined from an annual average of 300,000 lbs of meats to approximately 300 lbs in 1987-1988 (Cosper et al., 1987). Restoration efforts in the Peconic Bays were initiated in 1986 and scallop populations rebounded for a few years in the late 1980's-early 1990's (Tettelbach & Wenczel, 1993). Restoration efforts by the East Hampton Town Shellfish Hatchery started in 1997 and restoration efforts by Long Island University and Cornell Cooperative Extension started in 2006. However, a severe brown tide in 1995 again decimated stocks; the total New York commercial harvest in 1996 was a mere 53 lbs. Despite the absence of brown tide blooms in the Peconic Bays since 1995, and seemingly favorable water quality, bay scallop populations have remained at very low levels and annual commercial fishery landings averaged just 1-2 percent of historical, pre-Brown Tide levels until 2008 when the first benefits of restoration became evident (Tettelbach et al., 2013) (Figure 34).



(NYS DEC, 2014)

Figure 33: Commercial landings of bay scallops in New York, 1946-2014



(NYS DEC, 2014)

Figure 34: Commercial landings of Peconic Bay scallops, 2000 to 2014

Statistical analyses have revealed that the resurgence of Peconic bay scallop populations since 2007 has not been correlated to temporal changes in predator populations, SAV cover, water temperature, rainfall, chlorophyll-a levels or other monitored environmental factors; very strong statistical relationships have been determined for adult scallop density and larval production as well as between larval settlement, juvenile abundance and fishery landings. This is evidence that the dramatic increases in bay scallop larval supply resulting from the intensive restoration efforts described above have contributed to the resurgence in bay scallop populations and fisheries since 2007. Eelgrass coverage in the Peconic Bays remains at very low levels; whether this limits the ceiling for bay scallop abundance and fishery landings is unknown. Anecdotal reports and preliminary data suggest that periodic blooms of rust tide (*Cochlodinium polykrikoides)* have impacted scallop populations in 2012 and 2013, but not in 2014, and may potentially lead to more volatility in scallop harvests.

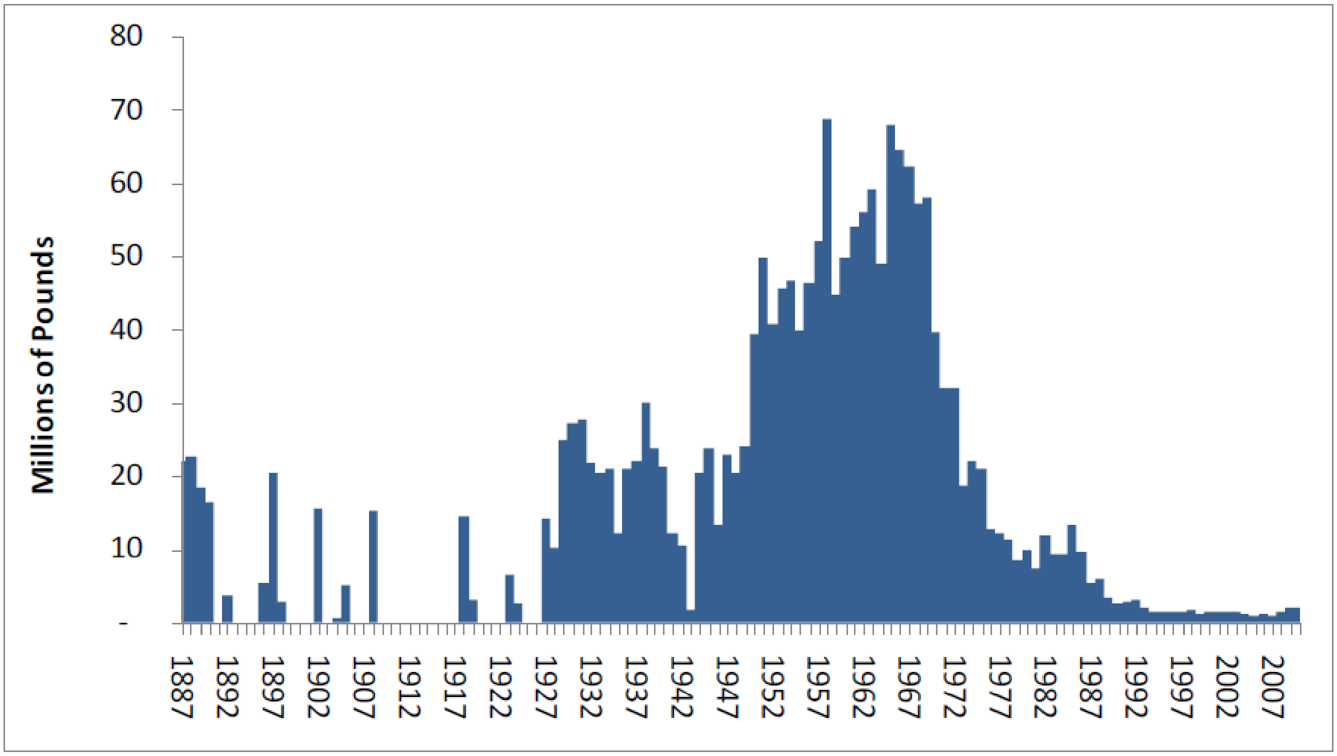
II-D. River Herring

River herring is the collective term for two separate species; Alewife (*Alosa pseudoharengus*) and Blueback herring (*Alosa aestivalis*). Adults average 25.4 - 28 centimeters (cm) in length and congregate in large schools. The coastal range of Alewife extends from Newfoundland to South Carolina, and the coastal range of Blueback herring extends from Nova Scotia to Florida. River herring have an anadromous life cycle, meaning that they spend most of their time in the ocean, but return to freshwater rivers, streams, and lakes to spawn. River herring are capable of spawning multiple times throughout their lifetime. Mature river herring enter streams and rivers in early spring to spawn, and then emigrate back to the marine environment shortly thereafter. The juveniles grow throughout the summer in the freshwater environment, and then move into the estuary in the fall. Little information is available on the life history of river herring after the juvenile stage before they mature, but their out-migrations are thought to be related to water temperature, food availability and precipitation.

At all stages of their life cycle, river herring provide many vital ecosystem services: they filter and consume plankton from the water column; they export nutrients from the freshwater environment to the ocean, which reduces freshwater algae blooms and improves water quality in those freshwater systems; they provide an excellent source of forage to marine predators both offshore and nearshore, as well as freshwater, terrestrial, and avian predators found throughout their range; and river herring act as a prey buffer, which may allow for reduced predation on, and support the recovery of species such as the Atlantic salmon (*Salmo salar*). River herring population is an indicator of living resource health in the Peconic Estuary.

Status and Trends

Throughout the coast, river herring have experienced a precipitous decline in abundance over the past century (Figure 35). Many factors have led to this decline including overfishing, incidental catch, water pollution, and loss of access to freshwater habitat. Due to their migratory nature, river herring traverse federal and multi-state jurisdictions.



(Atlantic States Marine Fisheries Commission, 2012)

Figure 35: Commercial landings of river herring (combined alewife and blueblack herring), (1887-2010)

There have been efforts to manage the incidental catch of river herring in federal waters in the Atlantic mackerel (*Scomber scombrus*), Atlantic Herring (*Clupea harengus*), Squid (*Loligo pealei* and *Illex illecebrosus*), and Butterfish (*Peprilus triacanthus*) fisheries, by introducing stricter regulations on those fisheries. In state waters, coastal fisheries managers have prohibited the commercial and recreational harvest of river herring (unless a state or jurisdiction has an approved sustainable management plan). There have also been many efforts throughout Long Island to restore access to critical freshwater spawning habitat by installing fish passage structures to mitigate barriers to migration. Dam removal and culvert replacement have also proven to be successful methods of restoring upstream access to diadromous fish in other states. The Peconic River and its tributary the Little River are the main source of freshwater to the Peconic Estuary. Currently, there are four major barriers to fish passage on the main stem of the river (Upper Mills Dam, Forge Road Dam, Edwards Avenue Dam, and Connecticut Avenue Dam) and one barrier on its tributary (Woodhull Dam) (Figure 36).

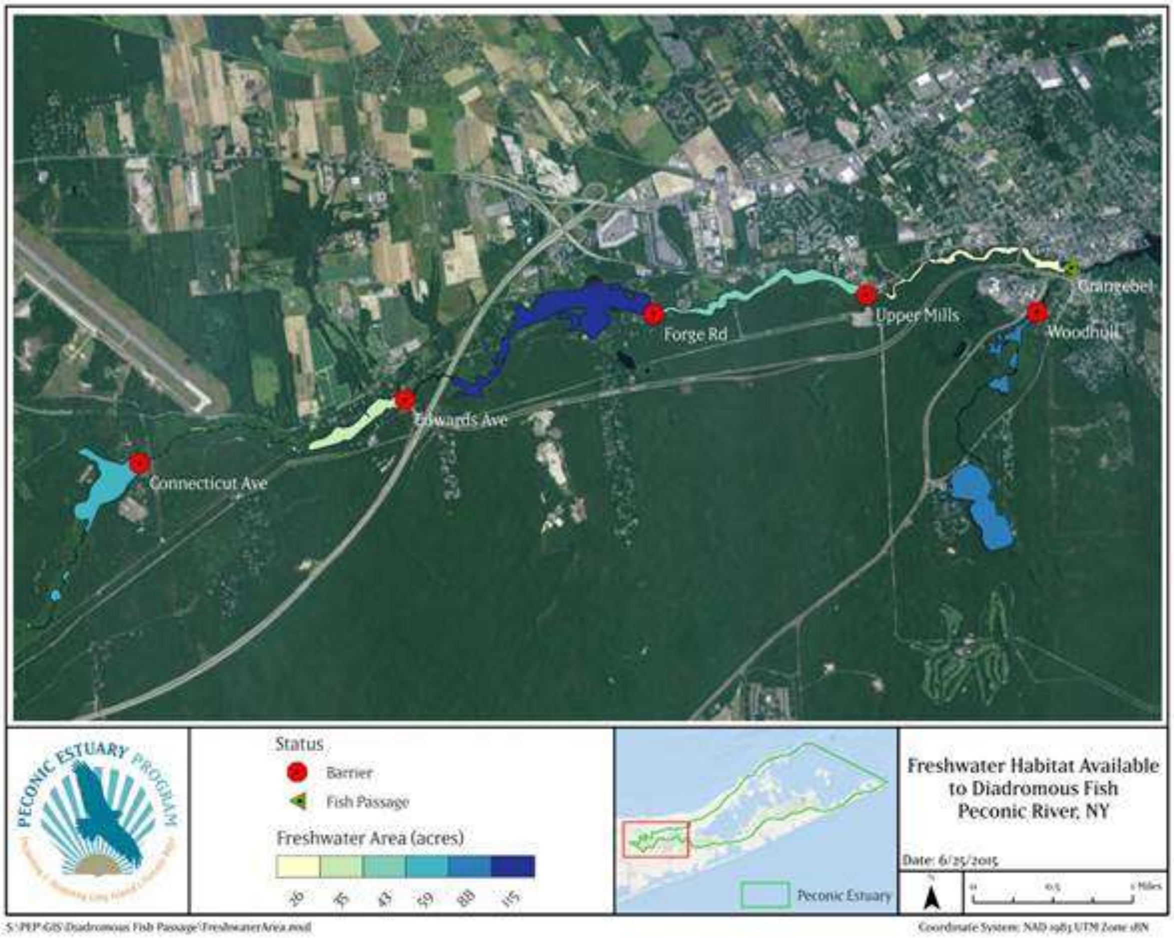


Figure 36: Main barriers to fish passage in main stem of Peconic River

A permanent fish passage structure (rock ramp) was installed in early 2010 at Grangebel Park in Riverhead to mitigate the first barrier to upstream migration in the Peconic River. This project has allowed river herring access to freshwater and has permanently restored 26 acres of habitat. The restoration at Grangebel Park has enabled some informal monitoring of fish passage at this location. A variety of methods have been employed to determine the size of the fish runs over the years including, visual estimates and video camera counting systems (Salmon Soft).

Cumulatively, the remaining four barriers on the main stem of the Peconic River are blocking diadromous fish access to approximately seven miles of river and 252 acres of freshwater habitat. Fish passage restoration projects for the Upper Mills andForge Road are currently in the planning stage.Construction of the Edwards Avenue Dam fish passage is nearing completion. The Woodhull Dam in Little River is blocking access to 88 acres of pristine upstream habitat. A fish passage restoration project for this barrier is also in the planning and design stage.

Peconic River Monitoring

Vounteers have been monitoring the abundance and size of alewife in the Peconic River at the base of Woodhull Dam where the alewife aggregate (Figure 37). While the population aggregating at Woodhull Dam does not include all fish successfully passing the Grangebel fish passage, it is representative of that group. This location provides an excellent platform to visually assess and sample alewife that gather in the large "pool" area below the dam. It is important to note that the spawning run estimates shown in Figure 37 are not actual tallies and qualitative in nature, but they have been consistently measured by the same recorder using dip nets (2010-2013) and cast nets (2014 and 2015) extrapolated to the size and depth of the pool. Therefore, they do provide a first-order approximation of the annual run spawning sizes from March-May and the overall trends (Young, 2013).

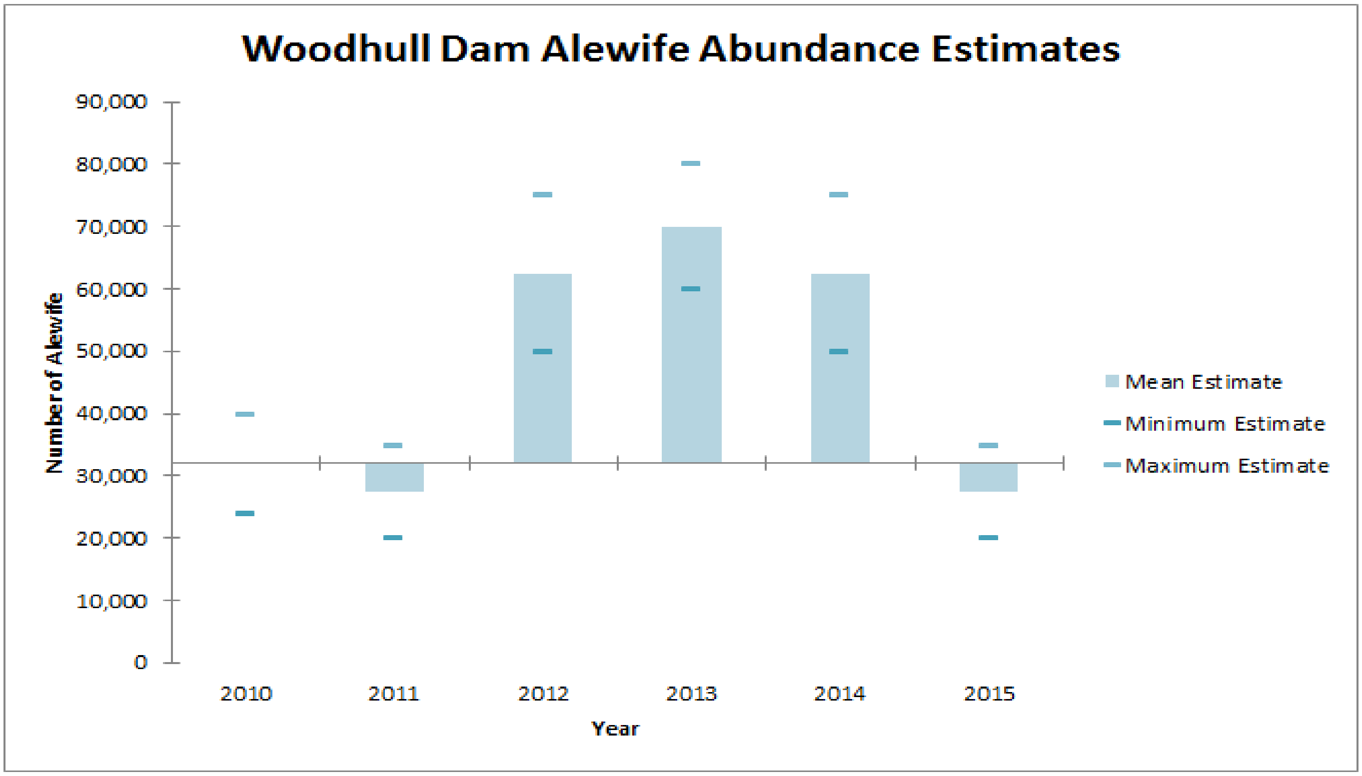


Figure 37: Estimates of annual spawning alewife counts at the base of Woodhull

A sub-sample of fish was also collected using dip and cast nets to determine their size (total length) and sex each year between March and May. Female fish were observed to be significantly larger than the males ($p < 0.01$) and both male and female fish were observed to be increasing in length over time (Figure 38). This data suggests that we may be seeing a dominant year class that is returning annually and increasing in length over time, but this requires further analysis (e.g. cohort analysis, otoliths or scale age analysis) (Young, 2015).

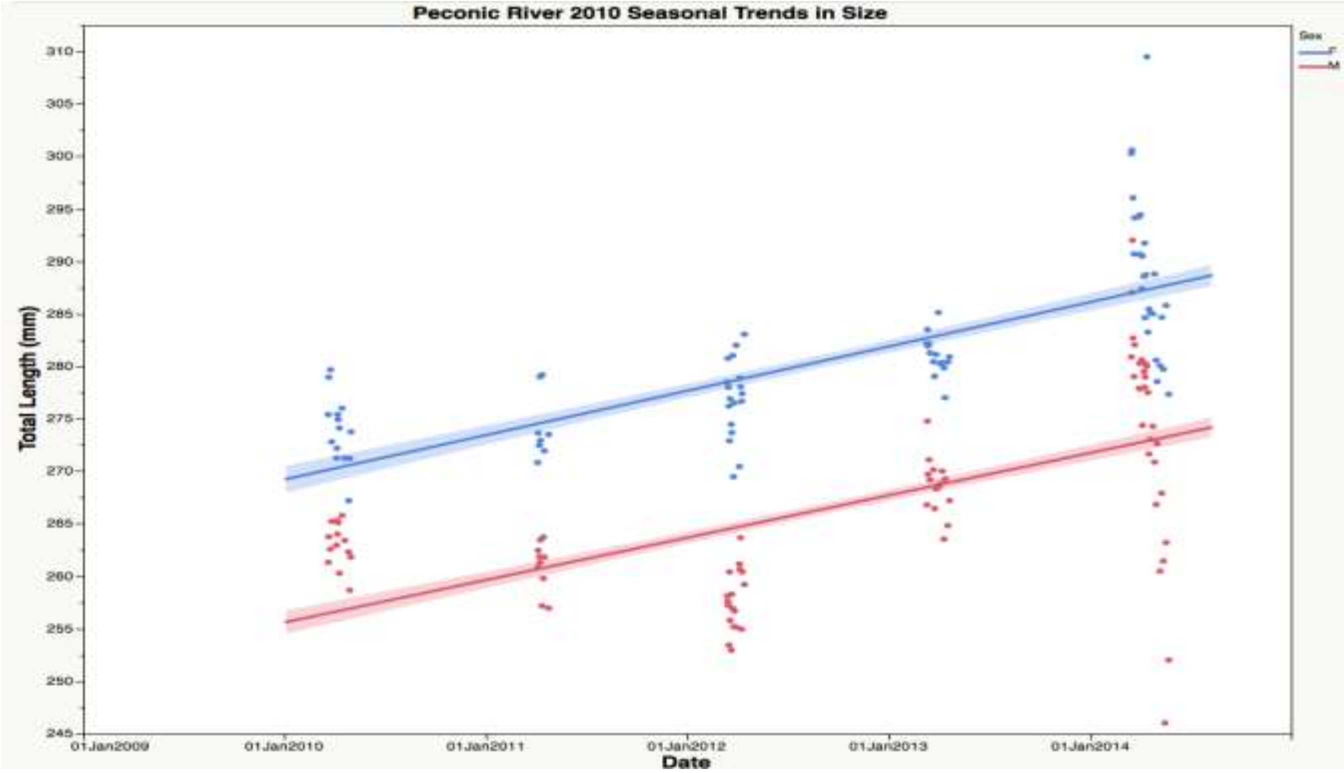


Figure 38: Plot of length vs year for female (blue) and male (red) alewife that were sampled at the base of Woodhull Dam, p<0.01, Least Square Regressions

Overall, the visual (first-order) estimates derived from monitoring the Peconic River spawning runs seems to indicate that the alewife have benefited from the fish passage restoration. The abundance increased for several years after the restoration and size has also increased. The drop-off in 2015 may partially have been the result of an unusually cold year and lower than average precipitation in May, or other factors such as offshore bycatch mortality. Clearly the understanding of the benefits of restoration and successes would be greatly improved with a more robust quantitative monitoring program in the future. Additional alewife spawning sites and barriers exist in the Peconic Estuary, depicted below (Figure 39, Figure 40, Figure 41). A total of 19 potential freshwater river herring spawning locations exist outside of the Peconic River system in the towns of Southampton, East Hampton, and Southold. Cumulatively, there are 540 acres of potential spawning habitat within the estuary outside the Peconic River system. There are three areas totaling 42 acres of freshwater in the Town of Southold, eight areas totaling 348 acres of freshwater in the Town of East Hampton, and eight areas totaling 150 acres of freshwater in the Town of Southampton.

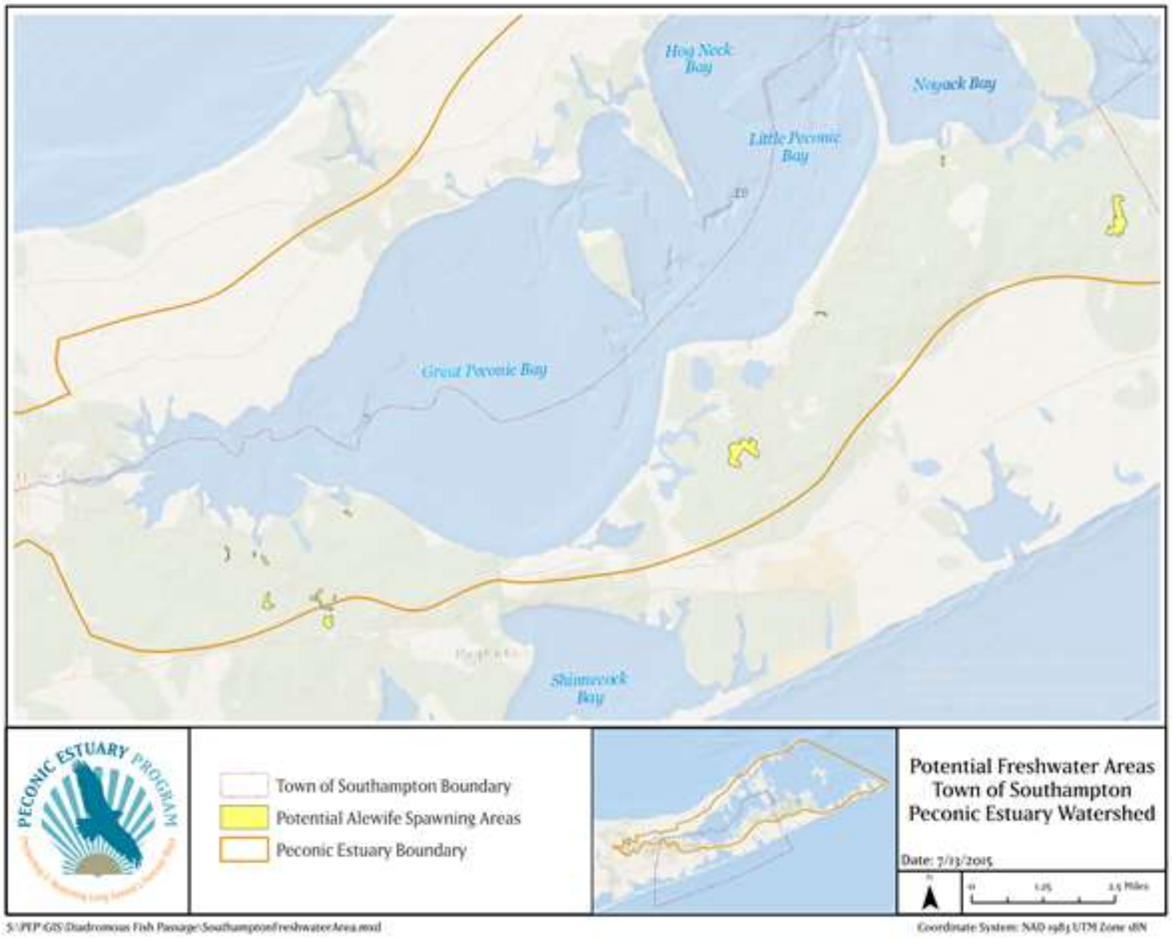


Figure 39: Potential freshwater spawning areas in the Town of Southampton

Figure 40: Potential freshwater spawning area in the Town of East Hampton

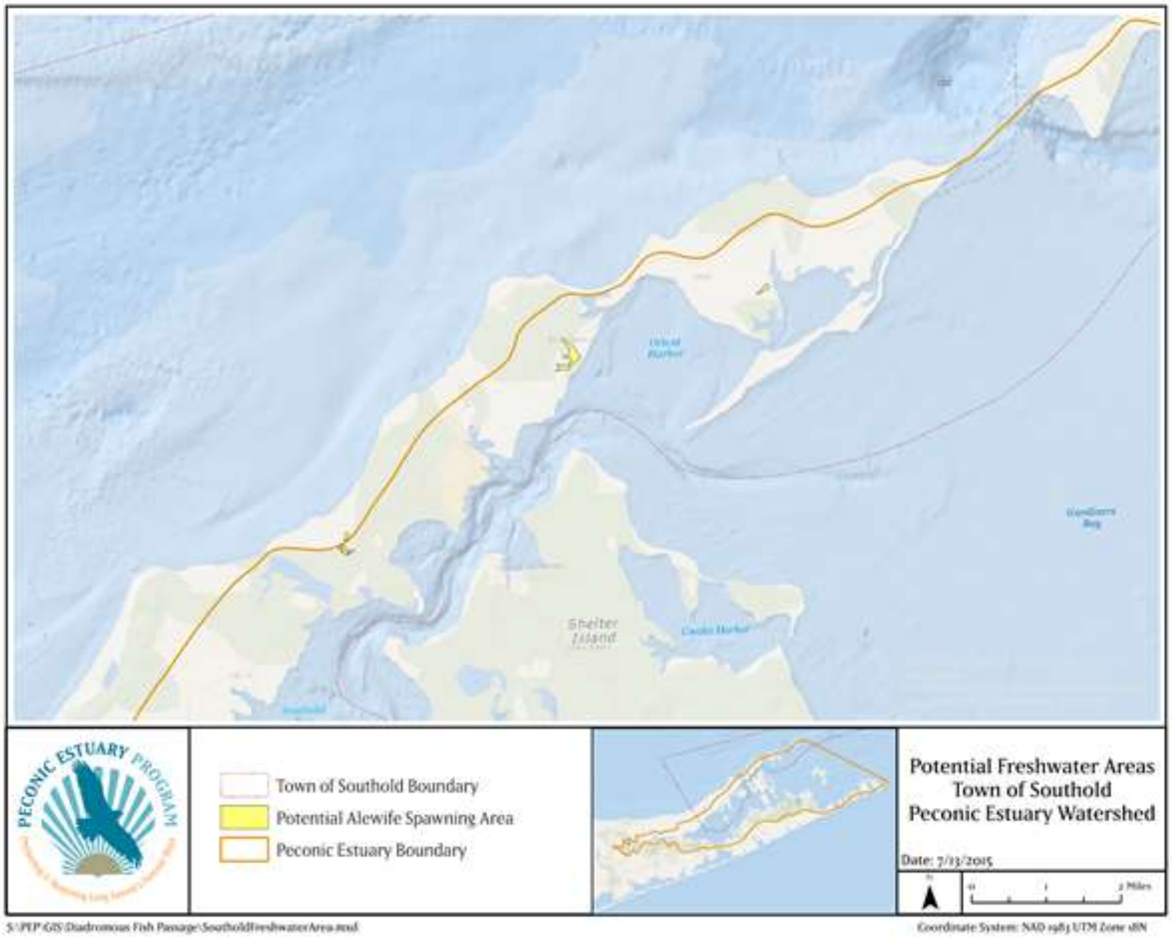


Figure 41: Potential freshwater spawning areas in the Town of Southold

Barriers to migration at these sites include dams, undersized culverts, stream constriction due to overgrowth of invasive *Phragmites spp.*, water level dependent stream access, and anthropogenic alteration of land which blocks the connection between marine and freshwaters. Alewife Creek, which leads to Big Fresh pond in the Town of Southampton, is currently the only stream in the estuary with partially unobstructed upstream access. Big Fresh Pond hosts a large annual spawning run of river herring. However, there are two culverts between this creek and pond which can impede upstream migration during low water levels. The river herring can only pass the first culvert during higher tides and water levels to reach the second culvert. In 2012, the Southampton Board of Trustees installed concrete parking blocks into the stream to raise water levels allowing river herring to pass the second culvert. This stream improvement project gives alewife unobstructed access to 87 acres of freshwater habitat in Big Fresh Pond. There is a large amount of freshwater area available in the Peconic Estuary for river herring for spawning. The Peconic Estuary Program, NYS DEC, and other partners are working to increase habitat connectivity in the Peconic System to allow fish to access this potential habitat.

II-E. Finfish Index

Since 1987, The NYS DEC Bureau of Marine Resources has been conducting a finfish trawl survey to monitor juvenile fish populations in the Peconic Estuary. The survey runs from May through October each year during daylight hours and weekdays only. Sampling station locations for this survey were selected on a block grid design (number of sampling blocks = 77, 1’ latitude by 1’ longitude) (Figure 42). All sampling stations are located west of Shelter Island. Each week 16 stations are randomly chosen and sampled by otter trawl. At each station the trawl is towed for 10 minutes at approximately 2.5 knots then retrieved with hydraulic trawl winches using an A-frame on the vessel. It should be noted that from 1987 to 1990 the trawl was hauled using hydraulic pot haulers. Fish collected in each tow are sorted, identified, counted and measured to the nearest mm (fork or total length) (NYS DEC, 1998).

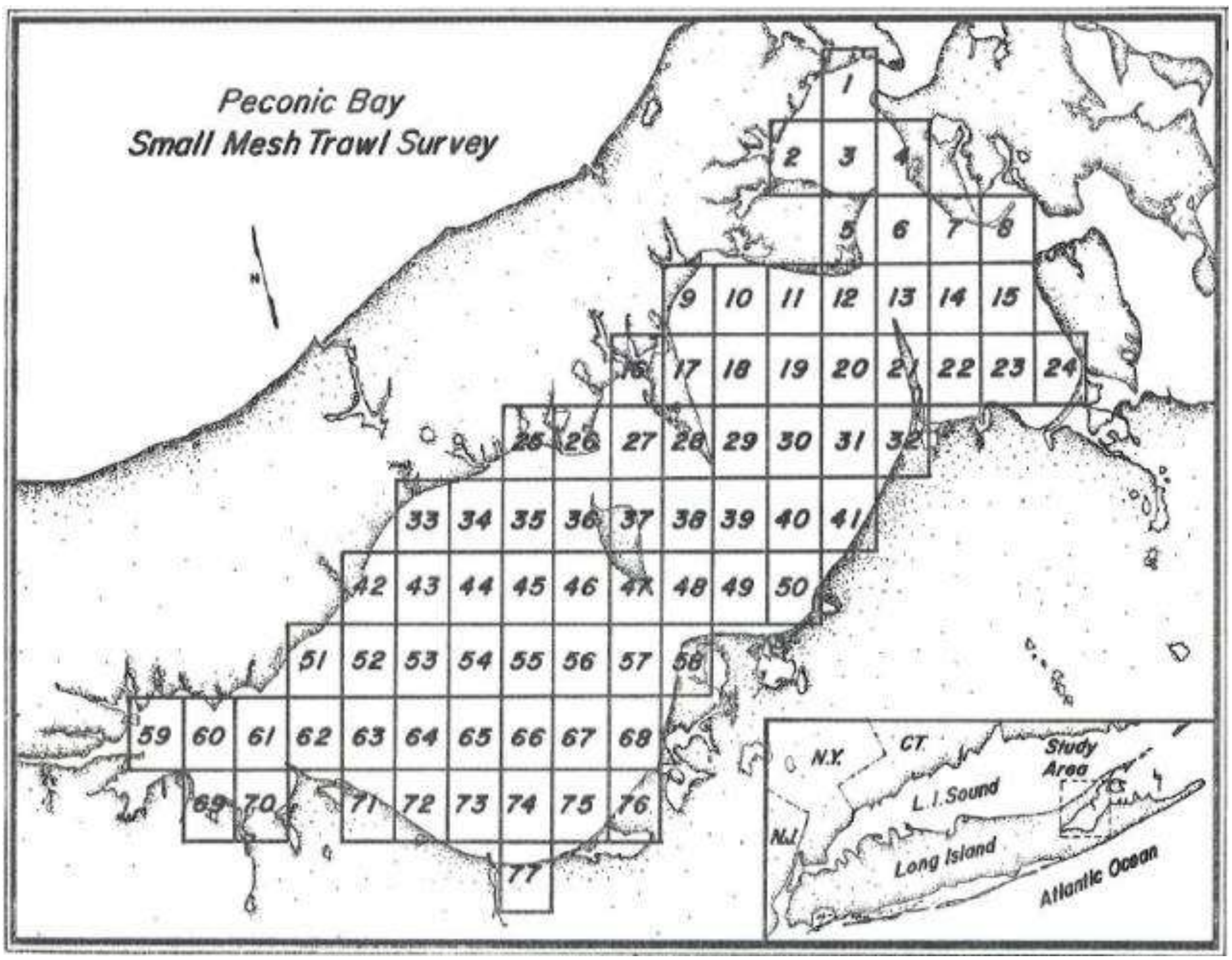


*Figure 42: Peconic Bay Small Mesh Trawl Survey block gri*d

Status and Trends

Warm Water/ Cold Water Fish Index

The data from the Peconic trawl survey was used to create this index, which is an indicator of finfish species sensitivity to water temperature change. Species captured in the NYS DEC Peconic Trawl Survey were divided into cold and warm adapted groups based on their temperature tolerances (specified by Howell and Auster 2012 (table A.1.1.)). Members of the cold-adapted group (numbering 19 species) prefer water temperatures below 15^{o} Celcius (C^{o}) (60^{o}Farenheit (F^{o})), and are generally more abundant north of the Peconic Estuary than south of the estuary. Members of the warm-adapted group (numbering 52 species) prefer warmer temperatures (11^{o}C- 22^{o}C or 50^{o}F-72^{o}F), and are generally more abundant south of the estuary than north of the estuary (Figure 43). This index shows the species richness of each adaptation group captured in spring and fall survey samples each year from 1987 through 2014 (note, no data was recorded in 2005, or in the spring of 2006 and 2008) (Howell & Auster, 2012).

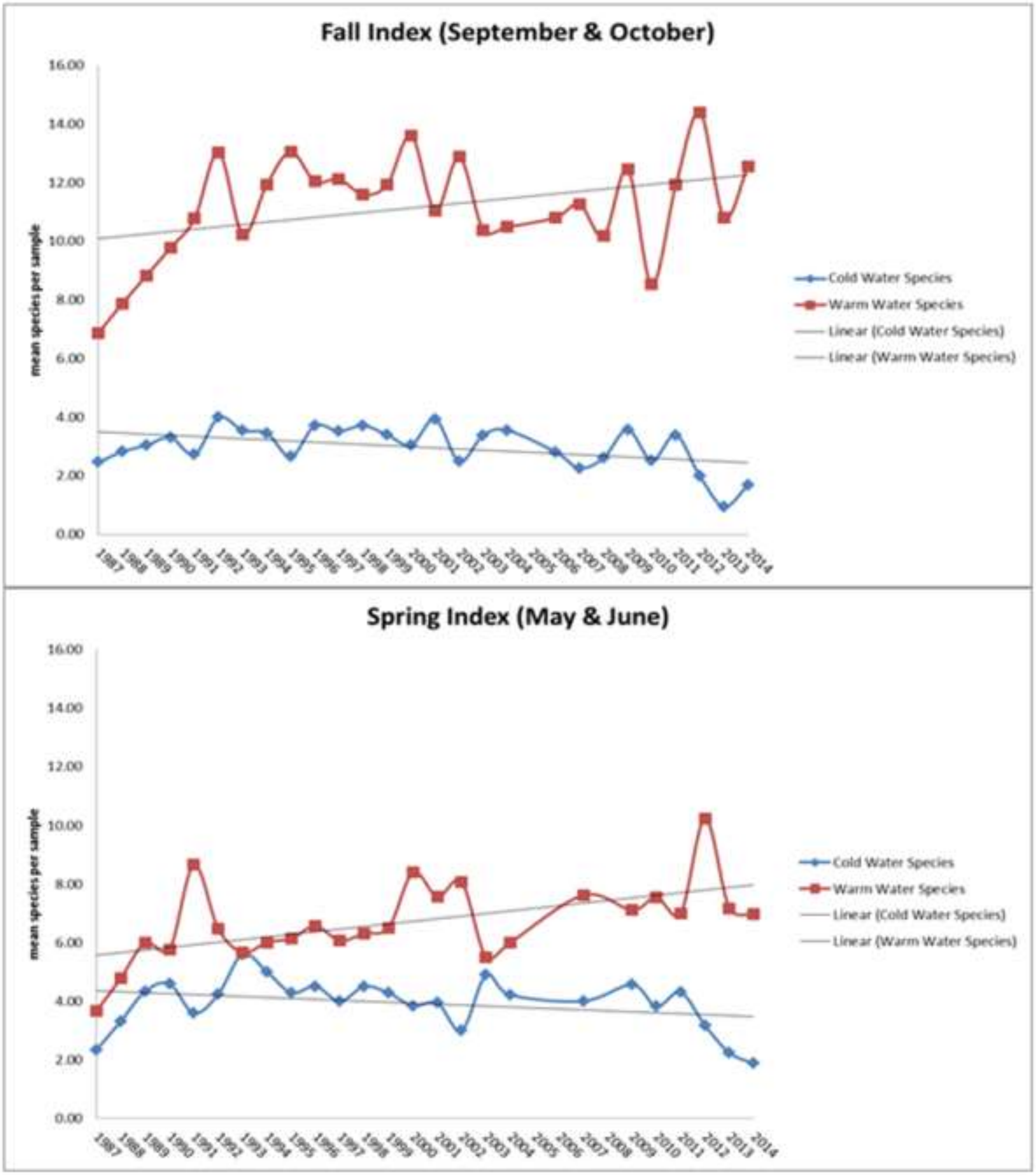


Figure 43: Spring and Fall cold water and warm water species finfish index

The overall trend in these indices show that the average number of warm-adapted species captured in the survey both in spring and in fall has increased while the average number of cold-adapted species captured has decreased over this 28-year time period. It is clear that rising average water temperature, a product of climate change, has the potential to alter the species composition throughout the Peconic Estuary. The estuary consists of a diverse community of native marine species which rely on specific food resources and habitats to survive and thrive. It is unclear exactly how a range shift of immigrating warm water tolerant fish species to the estuary and emigrating cold water fish species from the estuary will alter ecosystem dynamics for native community members.

Finfish Species Richness

Species richness is the number of different species represented in an ecological community (i.e., the Peconic Estuary). Species richness is a count of different species; it does not take into account the abundances of the species. The indicator below (Figure 44) shows the average number of finfish species caught in each tow. It also shows the average number of forage fish species caught in each tow. Forage fish are those species of small schooling fish which generally have short lifespans. They play a fundamental role in marine ecosystems by converting energy from lower trophic levels into food for larger marine predators. Examples of these prey species include bay anchovy, Atlantic silversides, and killifish.

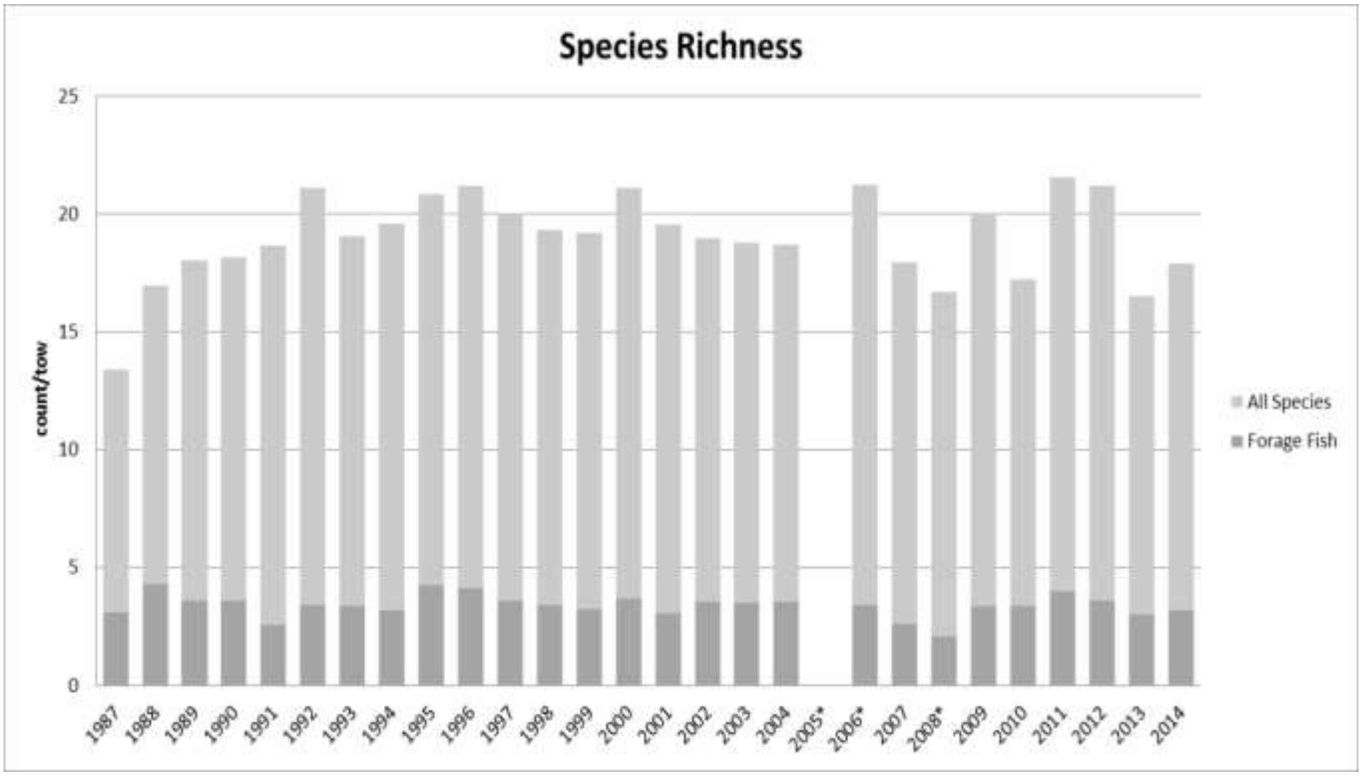


Figure 44: Finfish species richness in the Peconic Estuary

Species richness measures the diversity of species supported within the estuary's various habitats. The high and relatively stable number of counts per tow indicates that the Peconic Estuary has a strong balance of species able to exploit the resources available to them throughout the estuary. However, it should be noted that in recent years there has been a slight decreasing trend along with greater variability of counts per tow from year to year for total finfish counts. The steady trend in forage fish species counts indicates that the ecosystem has a stable food base to support the diversity of species throughout the estuary which rely on those forage species to survive.

II-F. Piping Plovers

The 2005 EI report identified Piping Plover as one of 18 indicators of environmental quality for the Peconic Estuary. Piping Plovers (*Charadrius melodus*) are listed as a Federally Threatened and New York State Endangered species. They are small shorebirds that nest on beaches, and as a result, their nesting and reproduction are susceptible to human intrusion, storm tides and predators. The majority of the population of New York Piping Plovers are found on the Atlantic Ocean beaches where there is a large amount of suitable habitat (NYS DEC, 2015a).

The piping plover is the first of the shorebirds to arrive on the breeding grounds, starting from early to mid-March. Nests, which are shallow scrapes, are made during courtship and are sometimes lined with pebbles and/or shells. They are usually placed well above the high tide mark on open, generally grassless sand beaches or dredged spoil areas. During May and June, one egg is laid every other day until the average clutch of four eggs is complete. If the first nesting attempt is unsuccessful, a second or third clutch may be laid, often containing only three eggs. The piping plover often nests with a colony of least terns. Incubation by both sexes begins with the laying of the fourth egg and takes 25-31 days. The young are precocial and leave the nest shortly after hatching and fledge in about 28-35 days. By early September, all but a few stragglers have departed for their wintering areas.

Diet consists principally of marine worms, insect larvae, beetles, crustaceans, mollusks and other small marine animals and their eggs. Food is obtained by foraging on beaches, dunes and in tidal wrack. Data on the breeding behavior of piping plovers shows that some adults return to the same nesting area annually and may retain the same mate as well. One recaptured individual on Long Island was 14 years of age (Peterson, 1988).

Protection and monitoring efforts for this species began in the mid-1980s. Survey groups from the NYS DEC, The Nature Conservancy, the Audubon Society and a network of concerned volunteers annually census the breeding colonies on Long Island. With the cooperation of private and public landowners, fencing and signs prohibiting entry have been erected to protect existing colonies from disturbance. Tern/plover stewards actively patrol and monitor nesting sites to increase nesting success and alert the public to the vulnerability of these species to human disturbance (Figure 45) (NYS DEC, 2015a).

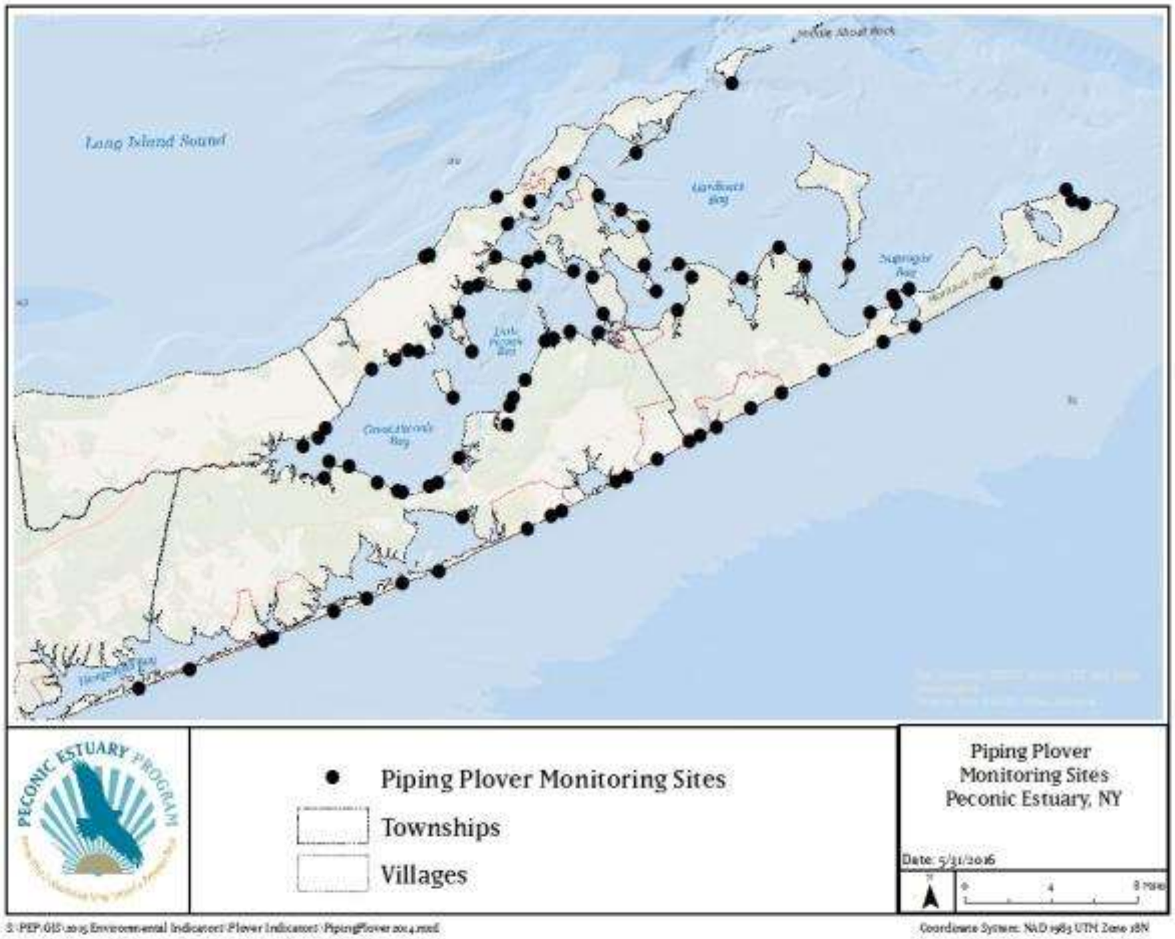


Figure 45: Piping Plover monitoring sites

Status and Trends

Breeding pairs on Long Island have generally increased since the mid-1980s when the total population was slightly over 100 pairs. The number of pairs increased to 249 by 1995, of which 63 were located in the Peconic region. By 2002, the number of Long Island breeding pairs rose to 383, of which 212 were found in the Peconic Estuary. During the period of 2001-2014, piping plover populations (pairs) in the Peconic Estuary have fluctuated between a low of 140 in 2014 and a high of 224 in 2009 (Figure 46). (Hamilton, 2015).

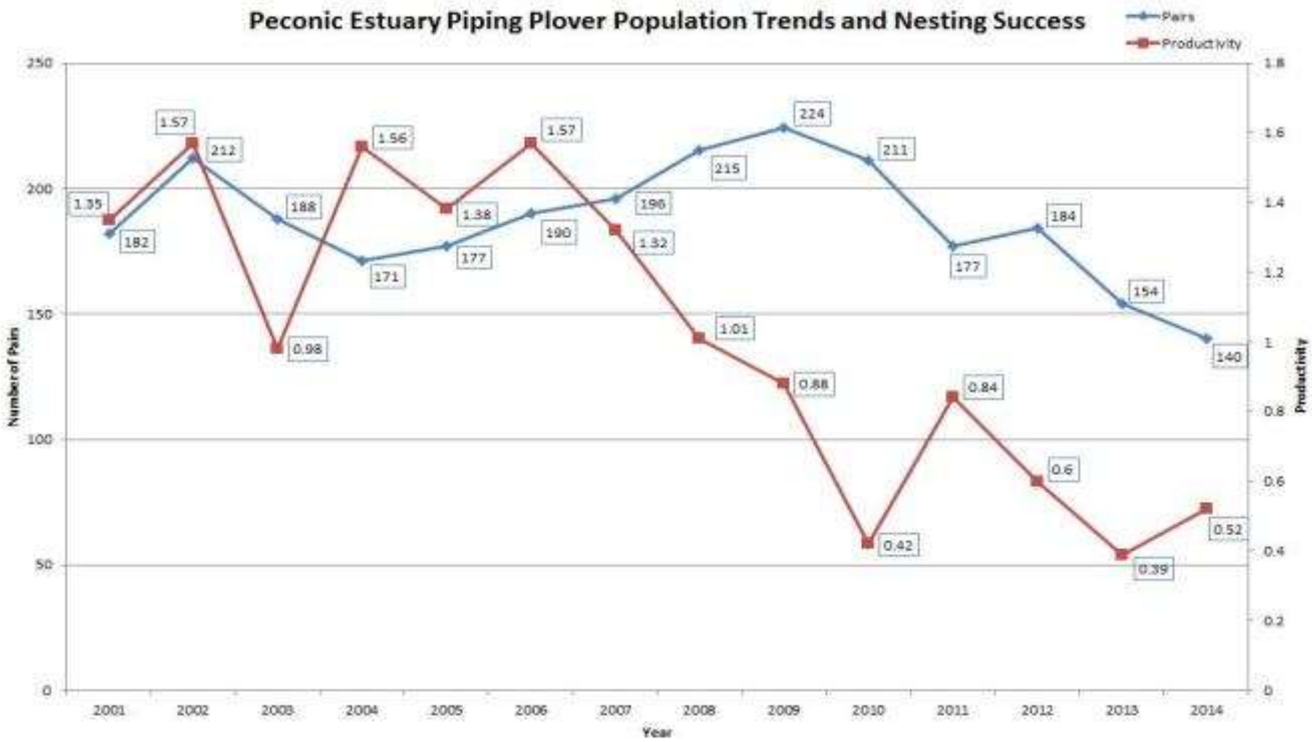


Figure 46: Piping Plover nesting productivity in the Peconic Estuary

The number of breeding pairs within the Peconic Estuary does not appear to be increasing and nesting success seems to be decreasing. In 2001, reproduction in the Peconic Estuary averaged 1.35 young birds successfully fledged per nest. By 2014, the number of young successfully fledged per nest decreased to 0.52. There are missing pair number and nesting productivity data for some towns in certain years.

III. Pathogens

Pathogens are viruses, bacteria, fungi, and protozoans that cause diseases in humans, other animals or plants. Pathogens that may be found in marine waters include those causing gastroenteritis, salmonellosis, and hepatitis A. It is difficult to directly measure the concentration of specific pathogens in seawater due to the variable nature of their occurrence. Instead, the potential for the presence of human pathogens in the water is measured using bacterial indicator species. Fecal indicator bacteria, total and fecal coliform bacteria, originate in the intestines of warm-blooded animals. Their presence in the water indicates that the waste of a warm-blooded animal, which may include pathogens, has entered the water. High pathogen levels may lead to closed bathing beaches and shellfish beds to protect public health. These closures can have economic ramifications by deterring tourism and limiting areas for fishing. In the Peconic Estuary, monitoring of bathing beaches is conducted by the SCDHS and monitoring and classification of shellfish growing areas is conducted by the NYS DEC, Division of Fish, Wildlife, and Marine Resources Shellfish Sanitation Unit to routinely monitor the presence of pathogens. The Peconic Estuary Program has identified two environmental indicators for pathogens. These are: (1) Shellfish bed closures; and (2) Bathing beach closures.

III-A. Shellfish Bed Closures

The 2005 EI report identified shellfish bed closures as one of 18 indicators of environmental quality for the Peconic Estuary. Pathogens can enter marine waters through untreated or inadequately treated human sewage and through the waste of domestic and wild animals. Stormwater runoff, waste discharges from boats, and improperly maintained septic systems are all pathogen sources.

Stormwater runoff is a contributor of pathogens to the Peconic Estuary. The great majority of the Peconic Watershed uses on-site disposal systems for waste treatment; these septic systems can introduce pathogens to localized areas. Illegally discharged sanitary wastewater from boats, particularly in the enclosed waters around marinas and mooring areas, may also contribute to problems locally. Pathogen contamination, or even the mere threat of pathogen contamination, results in shellfishing restrictions for significant areas of bay bottom.

The PEP has proposed a concerted effort to reduce the pathogen load to the Peconic Estuary, recognizing that upgrading failing septic systems, and controlling runoff from existing development is an extremely expensive and often complicated proposition that needs to be addressed over time. Suffolk County is currently changing the sanitary code to allow for innovative alternative septic systems, and has installed pilot systems throughout the Peconic Estuary. Many road runoff mitigation projects have been completed or are underway across the Peconic watershed, undertaken at the State, County, town, and village levels. The entire Peconic Estuary is a Vessel Waste No Discharge Area (NDA) to eliminate the discharge of boat wastes. Municipal pump-out boats and shore-based facilities aid compliance with the NDA.

Other important management components are the New York State Department of Environmental Conservation Shellfish Sanitation Program and the Suffolk County Department of Health Services bathing beach monitoring program. Because measuring the concentration of specific pathogens in seawater is so difficult, scientists and regulators use fecal and total coliform bacteria, as well as enterococcus bacteria, as indicators of pathogen contamination. Managers use the monitoring data to establish shellfish harvesting and bathing beach closures necessary to protect public health.

NYS DEC conducts sanitary surveys in approximately 121,000 acres of shellfish growing areas in the Peconic Estuary for conformity with the guidelines of the National Shellfish Sanitation Program. The surveys consist of two parts: a pollution source inventory/evaluation and water quality monitoring. Coliform bacteria are measured as an indicator of the potential presence of human pathogens. NYS DEC classifies growing areas as certified (open) or uncertified (closed) based on the results of the surveys (Figure 47). Closures are based on bacteriological water quality or are administrative, based on the presence of pollution sources such as sewage treatment plants or large concentrations of boats. NYS DEC also regulates certain growing areas through seasonal or conditional certification based on fluctuations in coliform levels related to changes in season or precipitation (NYS DEC Shellfish Bed Closures).

Figure 47: Eastern Long Island Shellfish Bed Closures

The major threats to shellfish harvesting areas include: failing septic systems; effluent produced during treatment failure from wastewater treatment plants; illegally discharged wastes from boats; and probably the largest contributor, contaminated stormwater runoff from developed areas (runoff from paved roads and parking lots) and runoff contaminated by waterfowl and other wildlife . Inadequately planned or implemented new development could increase the potential for additional shellfish closures due to increased stormwater runoff and loss of natural buffers.

The bacteriological water quality criteria for shellfish growing areas are more conservative than that used for bathing because shellfish are filter feeders that have the ability to concentrate human pathogens. If an area meets the shellfishing standards, it is also safe for all other uses. Shellfish growing area classification acts as an "early warning system" indicating that bacteria or other pollutants may be affecting the area. Safe shellfish are a benefit to the local economy due to both commercial and recreational harvests, as well as for cultural reasons.

Status and Trends

Bacteriological water quality is generally good throughout most of the larger bodies of water in the Peconic Estuary. Shellfish closures occur to a larger extent in Flanders Bay and in some of the more sheltered creeks, harbors and bays, which are often productive areas, but are affected more by land-based sources. There are also some administrative closures around Plum Island and in Shelter Island Sound and Shelter Island Cove. In 2015, there were Conditional Harvesting Programs in some of the uncertified portions of Sag Harbor, Flanders Bay, Orient Harbor and Hashamomuck Pond.

During the period of 2004 to 2014 there was a net increase of 318 acres of certified or seasonally certified shellfish lands in the Peconic Estuary. Of the 121,000 acres of shellfish lands, 115,433.4 acres (or 95.4 percent) are available for shellfish harvesting. As of January 1, 2014, there were 3,445.6 acres uncertified and 2,121 acres seasonally certified (Figure 48). The trend has been relatively level since 1995, following a period of fairly rapid increase in closed areas between 1980 and 1995, from about 1200 acres to about 5,200 acres. The relatively large amount of acreage closed between 1980 and 1995 may, in part, be due to increased sampling effort required by modifications to the National Shellfish Sanitation Program sampling protocol, so it is difficult to separate out reclassifications due to an actual decline in water quality from those resulting from increased sampling (NYS DEC, 2015b).

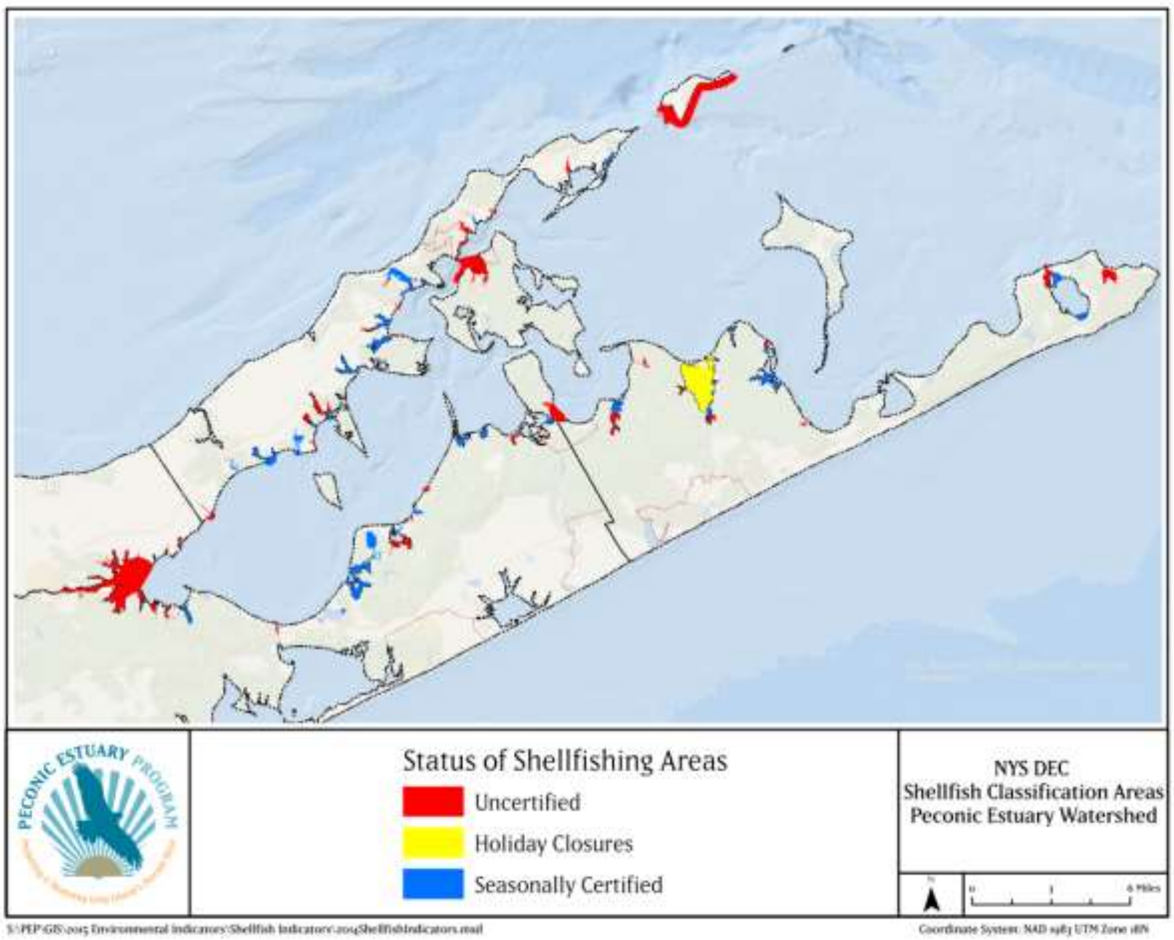


Figure 48: Status of Shellfishing Areas in the Peconic Estuary

Shellfish growing areas are usually sampled six to ten times per year. More frequent sampling may be done under specific precipitation conditions when local governments request Conditional Harvesting Programs for an area. Evaluations are based on a minimum of 30 samples. Administrative closures amount to approximately 1,000 acres of the 5,222 acres currently closed and may not reflect actual bacteriological water quality. In addition, acreage is now calculated using geographic information systems (GIS), as opposed to the old dot count methodology, which resulted in some variations not related to any changes in classification.

It is also important to properly maintain septic systems, observe vessel waste no- discharge laws, and prevent domestic animal, livestock and wildlife wastes from getting into runoff. Preventing or controlling runoff from new developments and improving and maintaining stormwater systems in existing developments can maintain and improve water quality.

III-B. Beach Closures

The 2005 EI report identified beach closures as one of 18 indicators of environmental quality for the Peconic Estuary. The Peconic Estuary boasts over 450 miles of shoreline and 28 public bathing beaches sampled for water quality by SCDHS. Most bathing beaches are located in areas that are least likely to be contaminated by pathogens. For example, bathing beaches are not sited in the immediate vicinity of sewage treatment plant outfalls due to the unlikely event that wastewater disinfection systems fail or malfunction. However, some beaches are subject to influences that can adversely affect water quality, possibly exposing bathers to microbial pathogens. While they are generally pollution free and provide a safe and healthy recreational environment, influences may include storm water runoff, waterfowl and other wildlife waste, poorly functioning septic systems, illegally discharged vessel wastes, limited tidal flushing, and malfunctions at sewage treatment plants. Based on such influences, Suffolk County ranks beaches in tiers according to the potential risk (low, medium, or high) associated with their use. The SCDHS tests bathing beaches at least twice weekly at high risk beaches and at least monthly at low risk beaches for *Enterococcus* (EN) bacteria, an indicator of beach water quality. Beach closures also occur for reasons other than high bacteria levels, such as stinging jellyfish and harmful algal blooms. Preemptive closures may occur after excessive rainfall, runoff from which is likely to carry pollutants into the surface water.

Status and Trends

The majority (21 or 75 percent) of bathing beaches in the Peconic Estuary are classified as low risk, seven (25 percent) are classified as medium risk, and none are classified as high risk. Figure 49 shows a map of all public bathing beaches in the Peconic Estuary sampled for water quality by SCDHS and also indicates the risk level of each beach.

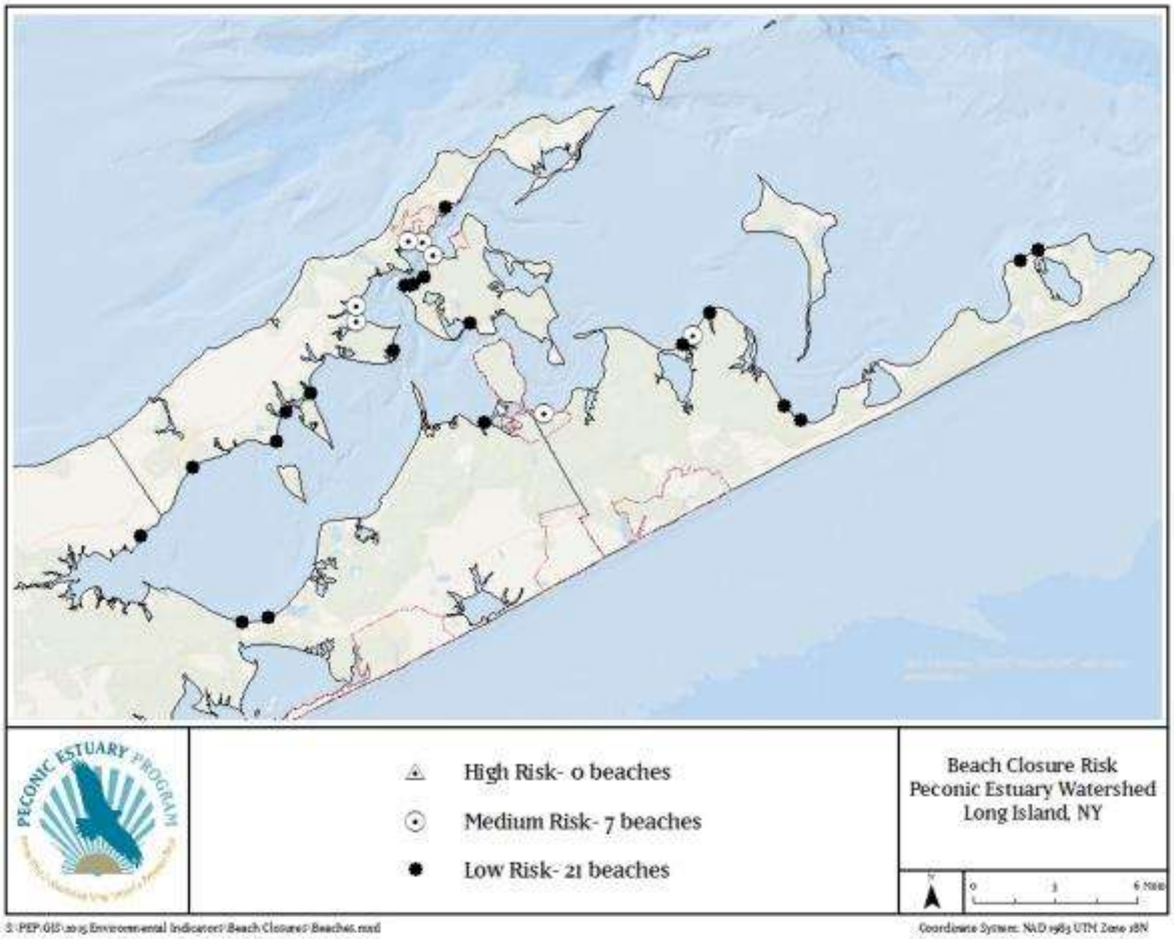


Figure 49: Location and risk level of Peconic Estuary public bathing beaches surveyed by SCDHS

Since 1980 there have been 42 bathing beach closures in the Peconic Estuary, that total includes the 28 precautionary bathing beach closures in 2011 for all Peconic Estuary bathing beaches due to Hurricane Irene. Only one closure resulted from measurements of elevated Enterococcus levels at South Lake Drive Beach, the 13 other closures weredue to precautionary rainfall related advisories. Since the 2005 report there have been 8 closures, not including the Hurrican Irene closures in 2011, starting in 2006 every year until 2015, except in 2012, at Havens Beach in Sag Harbor due to a precautionary rainfall related advisory. Havens Beach in Sag Harbor was added to the precautionary rainfall related advisory (PR) list in 2006 due to the presence of a drainage ditch discovered adjacent to the swimming area. The beach has been closed during heavy rain events out of precaution. Details of the closures are in Table 3. All four Shelter Island closures in 2001 and 2002 were precautionary closures due to a problem with the operation of the Shelter Island Heights STP. The East Hampton town beach on the south end of Lake Montauk was closed twice in 2004; once due to elevated Enterococci levels and once as a precaution following heavy rains. Several possible sources of the Enterococcus contamination at Lake Montauk have been suggested, including waterfowl and other wildlife, as well as shallow sanitary systems in the Ditch Plains community south of the lake. Since 2004, the Town of East Hampton no longer operates South Lake Drive Beach as a public bathing beach but it continues to be periodically monitored by the SCDHS (SCDHS, 2015a).

Table 3: Peconic Estuary bathing beach closures since 1980

Year	Area	Bathing Beach	Days Closed	Reason
2001	Shelter Island	Camp Quinipet	3	PR
2001	Shelter Island	Crescent Beach	3	PR
2001	Shelter Island	Shelter Island Heights Beach Club	7	PR
2002	Shelter Island	Shelter Island Heights Beach Club	10	PR
2004	Lake Montauk	South Lake Drive Beach	6	EN
2004	Lake Montauk	South Lake Drive Beach	14	PR
2006	Sag Harbor	Havens Beach	5	PR
2007	Sag Harbor	Havens Beach	5	PR
2008	Sag Harbor	Havens Beach	4	PR
2009	Sag Harbor	Havens Beach	2	PR
2010	Sag Harbor	Havens Beach	1	PR
2011	Sag Harbor	Havens Beach	7	PR
2011	Block Island Sound	East Lake Drive Beach (Gin BeacH)	3	PR
2011	Gardiners Bay	Camp Blue Bay	3	PR
2011	Napeague Bay	Devon Yacht Club, Inc.	3	PR
2011	Block Island Sound	Culloden Shores	3	PR
2011	Gardiners Bay	Maidstone Beach	3	PR
2011	Napeague Bay	Alberts Landing Road	3	PR
2011	Great Peconic Bay	South Jamesport Beach	3	PR
2011	Shelter Island Sound	Norman Slipp Park	3	PR
2011	Shelter Island Sound	Fifth Street Park Bench	3	PR
2011	Southold Bay	Goose Creek	3	PR
2011	Southold Bay	Founders Landing	3	PR
2011	Little Peconic Bay	Nassua Point Causeway	3	PR
2011	Cutchogue Harbor	Pequash Beach	3	PR
2011	Great Peconic Bay	New Suffolk Beach	3	PR
2011	Great Peconic Bay	Veterans Memorial Park	3	PR
2011	Little Peconic Bay	Cornell Cooperative	3	PR

		Extension Marine Center		
2011	Pipes Cove	Silver Sands Motel	3	PR
2011	Gardiners Bay	Clear Water Beach	3	PR
2011	Great Peconic Bay	Meschutt Beach	3	PR
2011	Great Peconic Bay	Southampton Peconic Beach and Tennis	3	PR
2011	Noyac Bay	Foster Memorial	3	PR
2011	Shelter Island Sound	Camp Quinipet	3	PR
2011	Shelter Island Sound	Perlman Music Camp	3	PR
2011	Shelter Island Sound	Pridwin Hotel	3	PR
2011	Shelter Island Sound	Cresent Beach-Shelter Island	3	PR
2011	Shelter Island Sound	Wades Beach	3	PR
2011	Shleter Island Sound	Shelter Island Heights Beach Club	3	PR
2012	Sag Harbor	Havens Beach	5.5	PR
2013	Sag Harbor	Havens Beach	5	PR
2015	Sag Harbor	Havens Beach	6	PR

(SCDHS, 2015a)

The days closed at each bathing beach per year is not consistently representative of continuous days closed. Precautionary closures in 2011 at all 28 bathing beaches in the Peconic Estuary were called because of heavy rainfall expected during Hurricane Irene.

Limitations on these data

The areal extent of the bathing beach data is extremely limited, covering only the area immediately adjacent to the beach. Additional data are available from routine monitoring of the estuary and their point sources. As most of the pathogen indicators found in the Peconic Estuary are from non-human sources, as opposed to other areas that may be in the vicinity of large municipal wastewater treatment plants served by a combined sewer system (e.g., the New York City metropolitan area), the actual potential for human disease may be significantly less than suggested by the bacterial values.

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Appendix A

New York State Water Classifications

Saline Surface Waters Class
SA- The best use for Class SA waters is shellfishing for market purposes, primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.

SB- The best use of Class SB waters is primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.

SC- The best use for Class SC waters is fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

I- The best use for Class I waters is secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.

SD- The best use for class SD waters is fishing. These waters shall be suitable for fish, shellfish and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for primary and secondary contact recreation and fish propagation.

Fresh Surface Waters Class
A-(a) The best usages of Class A waters are: a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish, shellfish and wildlife propagation and survival.
(b) This classification may be given to those waters that, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to reduce naturally present impurities, meet or will meet New York State Department of Health drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.

B-The best use of Class B waters are for primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.

C- The best use for Class C waters is fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

D- The best use for class D waters is fishing. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery, or stream bed conditions, the waters will not support fish propagation. These waters shall be suitable for fish, shellfish and wildlife survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for other purposes.