Peconic Estuary Partnership's Water Quality Monitoring Strategy

2021

Peconic Estuary Partnership

PROTECTING AND RESTORING LONG ISLAND'S PECONIC BAYS

NE IW PCC

Peconic Estuary Partnership's
Water Quality Monitoring Strategy

Background

The 2020 revision to the Comprehensive Conservation and Management Plan (CCMP) for the Peconic Estuary Partnership (PEP) sets goals to restore and maintain the chemical, physical, and biological integrity of the Peconic Estuary and surrounding study area (Figure 1). The Technical Advisory Committee (TAC), Citizens' Advisory Committee (CAC), Local Government Committee (LGC), Management Committee (MC) and Policy Committee (PC) for PEP worked with partners and the public to develop Goals, Objectives and Actions to guide the Partnership over the next decade.

The 2020 PEP CCMP focuses on four Goals: Strong Partnerships and Engagement; Resilient Communities Prepared for Climate Change; Clean Water; and Healthy Ecosystem with Abundant, Diverse Wildlife. As outlined in the FY 2021- 2024 Clean Water Act §320 National Estuary Program Funding Guidance, a revised CCMP should include revisions to a Monitoring Plan to track and detect changes and/or improvements within the study area and effectiveness of CCMP Actions.

The Water Quality Monitoring Strategy (this document) is a component of the Peconic Estuary Monitoring Plan and addresses water quality-related elements contained within three of the four CCMP Goals: Resilient Communities Prepared for Climate Change; Clean Water; and Healthy Ecosystem with Abundant, Diverse Wildlife. A separate document, The Habitat and Wildlife Monitoring Strategy, will address habitat and wildlife-related elements contained within the four Goals of the 2020 PEP CCMP. Within 3 years of the final Revised 2020 CCMP the Habitat and Wildlife Monitoring Strategy will be developed as an addendum to the Water Quality Monitoring Strategy. The Water Quality Monitoring Strategy and the Habitat and Wildlife Monitoring Strategy together represent the complete Peconic Estuary Monitoring Plan.

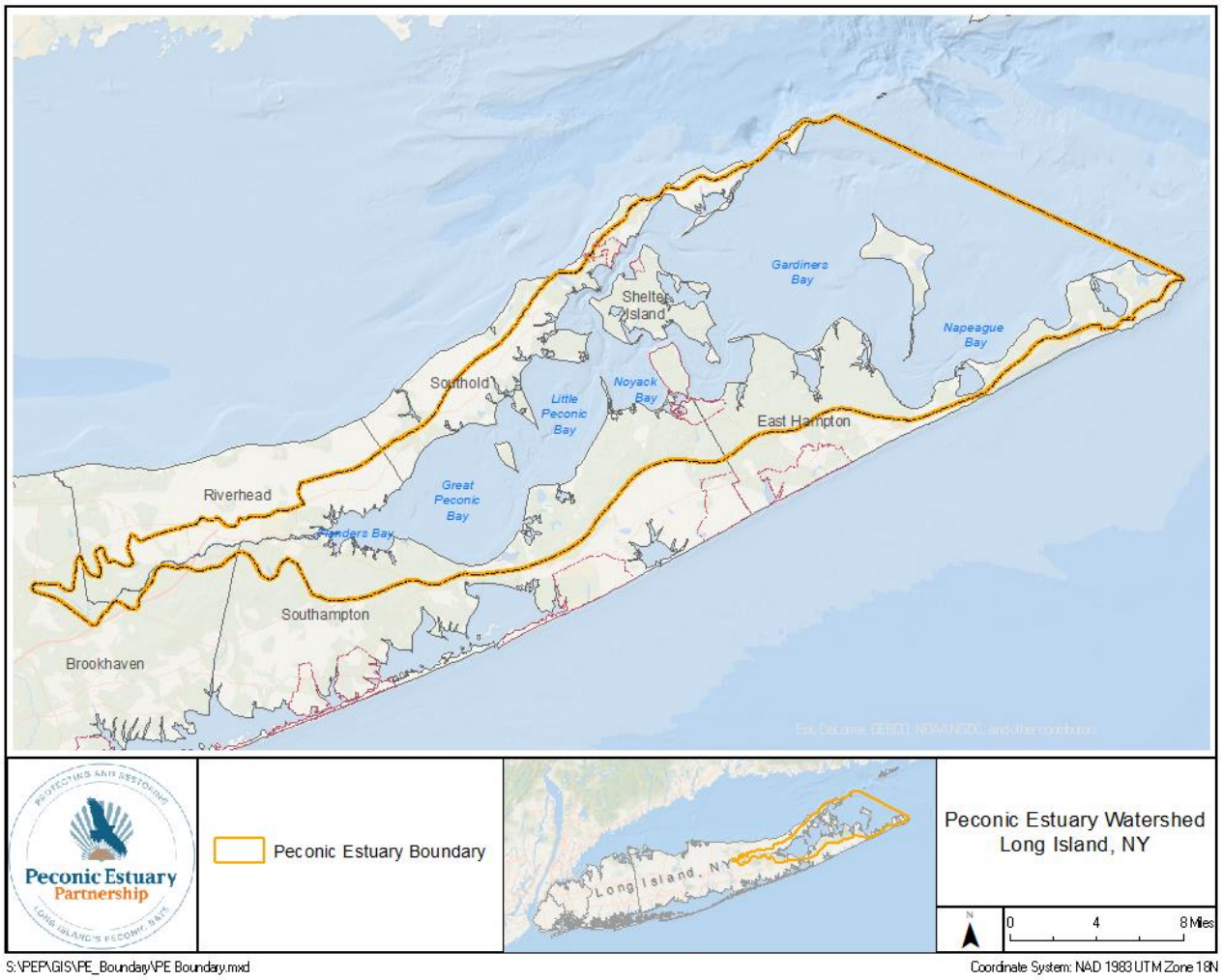

Figure 1. Peconic Estuary watershed and study area.

This Water Quality Monitoring Strategy focuses on water quality-related Objectives and Actions identified in the Goals (as stated in the 2020 PEP CCMP), and includes the following:

GOAL: RESILIENT COMMUNITIES PREPARED FOR CLIMATE CHANGE

OBJECTIVE C: Help local communities to take meaningful, well-informed action to prepare for and adapt to climate change impacts in the Peconic Estuary

ACTION 13: Collaborate on coastal and ocean acidification monitoring and research

* Several Actions within the Climate Change Goal also note the importance of monitoring.

GOAL: CLEAN WATERS

OBJECTIVE D: Protect areas with clean water from degradation

ACTION 16: Identify areas of clean water quality and deliver information that local governments and others can use to protect those areas

OBJECTIVE E: Increase understanding of nutrient pollution in groundwater and surface waters, and decrease negative impacts from legacy, current, and future nutrient inputs

ACTION 17: Plan science-based approaches for monitoring and reducing nutrient pollution

ACTION 19: Collate results of harmful algal blooms (HABs) monitoring and deliver findings to support management decision making

OBJECTIVE F: Reduce current and future inputs of toxics, pathogens, and marine debris into groundwater and surface waters, and minimize their impacts

ACTION 20: Conduct analysis to understand the sources of toxic contaminants and implement measures to reduce their impacts

ACTION 21: Expand non-point source subwatershed management plans to all pathogen-impaired waterbodies and continue to use existing plans

GOAL: HEALTHY ECOSYSTEM WITH ABUNDANT, DIVERSE WILDLIFE

OBJECTIVE H: Restore and protect key habitats and species diversity in the Peconic Estuary and its watershed

ACTION 29: Maintain, restore, and enhance viable diadromous fish spawning and maturation habitat in the Peconic Estuary watershed

ACTION 30: Monitor and protect existing eelgrass beds; where appropriate, restore and expand eelgrass beds

Within the CCMP, the history, successes, issues, and plans for continuing the improvement of the Peconic Estuary ecosystem are described including background documentation relevant to this Water Quality Monitoring Strategy.

The finalized Water Quality Monitoring Strategy will be provided as a technical supplement to the CCMP, and, as such, will focus on the technical aspects of monitoring data collection, reporting and uses. Please refer to the 2020 CCMP for full descriptions of the development of management strategies to meet adopted goals and targets, and actions needed to accomplish those strategies.

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Overview

It is critical to assess whether the goals of the PEP CCMP are being met and if the CCMP actions are having their desired effects. For each CCMP water quality-related goal, objectives were developed to help evaluate progress towards meeting those goals and linked to one or more specific actions in the CCMP. Each element of this Water Quality Monitoring Strategy is linked to one or more of these Goals.

Measuring the effectiveness of CCMP actions in bringing about environmental change is accomplished with the monitoring of a suite of indicators. These indicators are used to report on progress toward meeting PEP's CCMP goals and objectives, and to assess the status and trends in the water quality and health and abundance of the Peconic Bays' habitats and living resources.

The purposes of the Water Quality Monitoring Strategy are to:

1. Provide the data necessary to routinely track water quality trends and assess the environmental health of the PEP study area.

2. Describe how the synthesis of data from ongoing water quality monitoring programs can assist in evaluation of the effectiveness of CCMP actions.

In general, there are two types of monitoring, output and outcome, also called programmatic and environmental. Output monitoring measures programmatic progress and address implementation of the CCMP. Outcome monitoring focuses on the results of CCMP actions such as changes in ambient conditions, ecological functions, and biological populations. The PEP Water Quality Monitoring Strategy focuses on outcome monitoring.

As noted, the PEP Water Quality Monitoring Strategy (this document) focuses on water quality-related Objectives and Actions identified in the 2020 PEP CCMP. This Strategy was developed from assessments and recommendations made by the Peconic Estuary Partnership's TAC in 2019, as summarized in the following documents prepared by CoastWise Partners:

> 2019a. (link) Summary of Existing Water Quality Monitoring Programs in the Peconic Estuary and Watershed
>
> 2019b. (link) Summary of May 29, 2019 TAC and Monitoring Partners Workshops on Existing Water Quality Monitoring Programs
>
> 2019c. (link) Summary of Methods Used to Report Results from Existing Water Quality-Related Monitoring Programs in the Peconic Estuary
>
> 2019d. (link) Developing an Updated Reporting Strategy for Water Quality Monitoring Information: Background for Dec. 4, 2019, TAC meeting
>
> 2019e. (link) TAC Workshop Summary, Recommended Water Quality Targets and Templates for Reporting Monitoring Results

All documents of these are available at https://www.peconicestuary.org/.

This Strategy provides a framework that builds on existing water quality monitoring programs within the PEP study area administered by organizations involved in the development and implementation of the CCMP**.** CCMP Actions addressed within the water quality monitoring plans, water type, monitoring entities, a summary of types of data they collect, sampling frequency, number of stations, and period of record are summarized in Table 1. Additional details on specific parameters collected by entity and sampling location maps can be found in Report 2019a link.

The PEP monitoring partners will assess management decision making-based data needs and conduct a re-evaluation of the PEP Water Quality Monitoring Strategy every five years to ensure data gaps are addressed. During this process, the field sampling and handling and laboratory analysis methods used, and data collected and analyzed will be checked for current relevance, applicability to emerging needs, and potential changes for protocols as necessitated by improvements in technology and quantitative advancements. If necessary, PEP will revise the PEP Water Quality Monitoring Strategy to reflect any updates.

Coordination, collaboration, and long-term support for monitoring are key elements to successful implementation of PEP's CCMP (National Academy of Sciences 1990; 2017). PEP will need to continue to work with multiple agencies, institutions, organizations and partners to obtain, share, and evaluate monitoring data, and to communicate the resultant findings to the public, decision makers, and stakeholders.

Table 1. Summary of key water quality monitoring programs and CCMP Actions addressed in the Peconic Estuary study area. See Report 2019a (link) for more detailed descriptions and additional water quality monitoring program descriptions including NYSDEC, Division of Marine Resources, Fishery-Independent Trawl Survey; NYSDEC, Division of Water, RIBS Program; PEP Long-term Eelgrass Monitoring Program (PEP LTEMP); Surf Rider Foundation/ Blue Water Task Force; National Atmospheric Deposition Program (NADP).

CCMP Actions addressed	Water Type	Monitoring Entity	Parameter types	Sampling Frequency	No. of Stations	Period of Record
16 17	Surface waters; estuarine/ marine	Suffolk County Department of Health Services, Office of Ecology	Ambient water quality; pathogens; harmful algal blooms; physical/chemical measurements	Approximately Monthly	Numbers of stations vary from year to year: Min=10 Mean=31 Max=49	1976-present
16 17	Surface waters; freshwater and streams	Suffolk County Department of Health Services, Office of Ecology	Ambient water quality; physical/chemical measurements; streamflow	Approximately quarterly	Numbers of stations vary from year to year: Min=8 Mean=22 Max=39	1976-present

CCMP Actions addressed	Water Type	Monitoring Entity	Parameter types	Sampling Frequency	No. of Stations	Period of Record
16 21	Surface waters: fresh/estuarine/ marine bathing Beaches	Suffolk County Department of Health Services bathing beach monitoring program	*E. coli* (freshwater beaches) *Enterococcus* (estuarine/marine beaches)	Risk-based; twice per week at higher-risk beaches, less frequently at lower-risk beaches	30+ in Peconic system. Sampling performed mid-May through mid-September	2000 - present
21 (potential)	Surface waters; estuarine/ Marine/ shellfish beds	New York State Department of Environmental Conservation, Division of Marine Resources, Shellfish Growing Area Classification Unit	Fecal coliforms; salinity; water temperature	Variable, depending on station requirements (typically 2-15+ per year)	Variable, based on potential pollution sources	Varies
30	Surface water estuarine/ marine eelgrass habitat	Cornell University, Cooperative Extension of Suffolk County	Eelgrass shoot density; water temperature; light availability (PAR) macroalgae cover (%)	Annually or every 3 years	Variable	1997 - present
19	Surface water fresh/estuarine/ marine	Stony Brook University, School of Marine and Atmospheric Sciences	Minimum dissolved oxygen (mg/l); Secchi depth (m); site depth (m); fecal coliform (per 100ml); chlorophyll-*a* (ug/l); harmful algal blooms (cells/ml)	Weekly from the Monday after Memorial Day to the Monday before Labor Day	6 in Peconic system	2014 - present
17 29 13 (partial)	Surface water fresh/estuarine/ marine	U.S. Geological Survey continuous monitoring stations	Water stage (ft.); water temperature; specific conductivity; salinity; dissolved oxygen; turbidity; nitrate; pH	Water quality monitoring at 6 to 30-minute intervals, depending on parameter	2 stations: Peconic River and Orient Harbor	2012 - present
20	Groundwater	Suffolk County Department of Health Services, Water Resources	Various Pesticides; Bacteria; Metals; Dacthal & Metabolites; Herbicide Metabolites; 1,4-Dioxane; Standard Inorganics; Semi-volatiles; Volatile Organic Compounds	variable	variable	variable

Several environmental monitoring programs are carried out by multiple entities in the Peconic Estuary study area. The PEP Water Quality Monitoring Strategy does not intend to be an integrated monitoring plan that pulls all of those activities together. PEP is neither in a position nor has the resources to develop such a comprehensive unified plan for all of the Peconic Estuary and its watershed. Rather, the PEP Water Quality Monitoring Strategy, through the guidance of the PEP Water Quality Monitoring Collaborative (described on page 11), will direct the efforts of PEP and its partners to measure the status and effectiveness of actions, establish performance criteria, and make use of environmental indicators to assess status and trends in the Peconic Estuary study area. This is essential to evaluate the successful implementation of the 2020 PEP CCMP.

The distributed water quality monitoring system, with the shared responsibilities of multiple partners for project implementation, can be effective in forwarding science-based management for the PEP study area. Although PEP does not sample and generate data to a great extent, as a public program within the state of New York, PEP provides access to reports it creates and the datasets developed to support report findings, supports technical assessments and acts as a coordinator for collaborative decision making by the monitoring partners.

Numeric Water Quality Targets

The establishment and tracking of measurable water quality targets to support critical living resources in the Peconic Estuary is crucial for assessing whether the goals of the PEP CCMP are being met and if the CCMP actions are having their desired effects. During its December 4, 2019 water quality monitoring workshop, the PEP TAC recommended the following numeric water quality targets (Report 2019e link), which were approved by the PEP Policy and Management Committees on February 5, 2020:

- Adopt provisional targets for water clarity (Secchi disk depth), chlorophyll-*a*, and dissolved oxygen (DO) as proposed in the Suffolk County (2020) Subwatersheds Wastewater Plan (SWP):
  - Median Secchi disk depths should be 2 meters (m) or greater during the April 1 through October 31 growing season;
  - Median chlorophyll-*a* concentrations should be no greater than 5.5 ug/l during the April 1 through October 31 growing season; and
  - Dissolved oxygen concentrations should comply with New York State's acute (never less than 3 mg/l) and chronic (> 4.8 mg/l as daily average in 90% of samples) dissolved oxygen criteria.

- As an initial target for pathogens, adopt the existing threshold for fecal indicator bacteria (*Enterococcus*) that is used by Suffolk County to determine swimming beach closures: *Enterococcus* counts at estuarine/marine swimming beaches should not exceed 104 colony forming units per 100 milliliter water sample (104 cfu/100ml). New *Enterococcus* standards are currently in review. Once these standards are in place, revise the target to reflect the new standards going forward.

- Adopt three estuary segments—west, central and east illustrated in Figure 2—as the reporting/management units, based on chlorophyll-*a* concentrations and Secchi depths

observed at Suffolk County Department of Health Services monitoring stations in each segment.

- Use 'stoplight graphics'—green = target met; red = target not met—for public-facing documents, collating data by estuary segment. Update annually as soon as monitoring data are available from the previous year. Where possible, also include a yellow (intermediate) category in each stoplight graphic to reflect small-magnitude and/or short-duration failures to meet targets. Approaches for doing so with the Secchi depth, chlorophyll-*a* and *Enterococcus* targets are outlined in the *Sharing, Reporting, and Use of Data* section below.

- Track and report water temperature, salinity, pH and harmful algal blooms on an annual basis as the adoption of numerical targets are not currently anticipated for these parameters.

- Finalize and adopt PEP water quality targets for pathogens, water clarity (Secchi depth), and chlorophyll-*a* and dissolved oxygen concentrations in time for the 2021 PEP Conference.

Figure 2. Water quality management and reporting zones for the Peconic Estuary adopted in 2020.

The PEP Water Quality Monitoring Collaborative has formally adopted the PEP water quality numeric targets listed above for pathogens, water clarity (secchi depth), and chlorophyll-a and dissolved oxygen concentrations at the October 19, 2020 PEP Water Quality Monitoring Collaborative and November 18, 2020 TAC meeting.

The PEP Water Quality Monitoring Collaborative approved a modification to the three estuary segments to align with the NYSDEC Priority Waterbodies List boundaries at the January 29th, 2021 meeting- west, central and east illustrated in Figure 3.

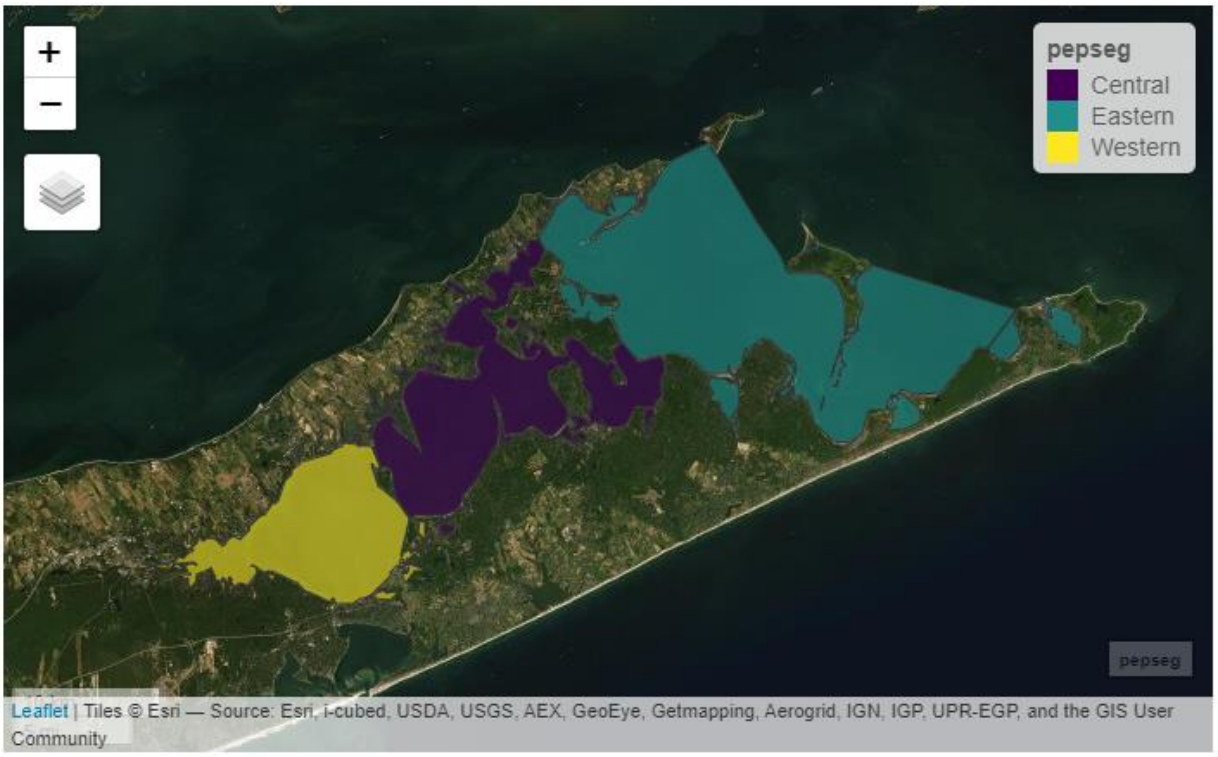

Figure 3. Water quality management and reporting zones for the Peconic Estuary adopted in 2021.

Monitoring Questions and Data Gaps

In addition to describing current monitoring efforts within the PEP study area, this PEP Water Quality Monitoring Strategy includes recommendations for expanding existing programs or establishing new ones to address gaps and needs, as identified by the TAC (Report 2019b link). Data gaps were generally focused on whether existing water quality monitoring programs could answer the following monitoring questions:

1. What is the trend of partial pressure of carbon dioxide (pCO2), pH, dissolved inorganic carbon and total alkalinity in the Peconic Estuary?

2. How do phytoplankton biomass levels (as indicated by chlorophyll-a concentrations) compare with recommended provisional targets?

3. How does water clarity compare with adopted provisional targets?

4. How do dissolved oxygen concentrations compare with New York State's water quality standards?

5. How do concentrations of fecal indicator bacteria compare with Suffolk County thresholds?

6. Are nutrient concentrations in the estuarine waters increasing, decreasing or remaining stable?

7. Are nutrient loads delivered to the Peconic Estuary increasing, decreasing or remaining stable?

8. Are nutrient loads/concentrations consistent with what is expected from implementation of the SC Subwatersheds Wastewater Plan?

9. Are the frequency and spatial distribution of harmful algal blooms (HABs) increasing, decreasing, or remaining stable?

10. Are toxins delivered to the Peconic Estuary increasing, decreasing or remaining the same?

On May 29, 2019, the PEP TAC and Monitoring Partners provided input on data needs and gaps for each of the water quality-related actions from the spring 2019 draft CCMP (Report 2019b). The following is a summary of the TAC's input organized around water quality-related Goals and Objectives as identified in the January 2020 CCMP. Please refer to Report 2019b (link) for additional detail.

On May 4, 2020, the PEP TAC and Monitoring Partners recommended Management Committee approval of the Peconic Estuary Partnership's Water Quality Monitoring Strategy (this document).

Peconic Estuary Water Quality Monitoring Collaborative

To ensure effective and cost-efficient implementation of the PEP Water Quality Monitoring Strategy, the PEP Program Office has initiated the formation of the Peconic Estuary Water Quality Monitoring Collaborative in the fall 2020 as a subcommittee of the PEP TAC, consisting of the Peconic Estuary monitoring program partners and key advisors. The PEP Water Quality Monitoring Collaborative is responsible for providing guidance, support, and recommendations to the TAC on the water quality monitoring and reporting conducted in the Peconic Estuary and its watershed and guiding the implementation of the next steps and actions in the PEP Water Quality Monitoring Strategy.

The Peconic Estuary monitoring partners have developed a collaborative monitoring framework, outlining individual partner's roles and responsibilities; and shared responsibilities for decision making on data collection, analysis, interpretation and reporting of the results of the monitoring programs. This framework is outlined in the Organizational Structure, Governance Procedures and Guiding Principles for the Peconic Estuary Partnership document and concretely establishes the Peconic Estuary Water Quality Monitoring Collaborative, further referred to as the Monitoring Collaborative.

The Monitoring Collaborative members include representatives from Cornell Cooperative Extension of Suffolk County (CCE); New York State Department of Environmental Conservation (NYSDEC), Bureau of Shellfisheries; NYSDEC, Division of Marine Resources; NYSDEC, Division of Water; NYSDEC, Rotating Integrated Basin Studies (RIBS) Program; Seatuck Environmental Association; State University of New York at Stony Brook; Suffolk County Department of Health Services, Office of Ecology; Suffolk County Department of Health Services, Office of Water Resources; The Nature Conservancy (TNC); The Peconic Estuary Protection Committee (PEPC); United States Geological Survey (USGS). It is recognized that significant technical assistance will be required to support the efforts to be undertaken by the Monitoring Collaborative. The PEP-Suffolk County Annual Workplan will include an action to Implement the PEP Water Quality Monitoring Strategy. The Monitoring Collaborative will be supported by a Suffolk County water quality analyst as outlined in the FY20 PEP Budget and Workplan.

The Monitoring Collaborative has committed to roles and responsibilities, as outlined in the Organizational Structure, Governance Procedures and Guiding Principles for the Peconic Estuary Partnership document:

- Provide guidance, support, and recommendations to the TAC on water quality monitoring and reporting conducted in the Peconic Estuary and its watershed.
- Implement the next steps and actions in the PEP Water Quality Monitoring Strategy.
- Review, and advise adjustments to the water quality monitoring programs in the watershed and identify funding sources to implement priority actions to inform TAC decisions.
- Share and make accessible water quality data and analysis results on an annual basis within 60 days of the end of the calendar year, at minimum, with the Monitoring Collaborative for annual Peconic Estuary Water Quality Monitoring Reports.
- Advise the utilization and development of R-based analysis and reporting tools and package for the distribution of Peconic Estuary water quality data and results.
- Review and advise development of the annual Peconic Estuary Water Quality Monitoring Reports.
- Conduct reviews of technical documents, reports and studies related to water quality and monitoring as requested by the TAC.

Thus far, the Monitoring Collaborative has completed all of the tasks outlined in the Strategy for 2020 which includes the formal adoption of the PEP water quality targets for pathogens, water clarity (secchi depth), and chlorophyll-a and dissolved oxygen concentrations at the October 2020 Monitoring Collaborative and November TAC meeting. The Monitoring Collaborative will meet up to three times per year to maintain momentum to complete the annual next steps.
The Monitoring Collaborative has agreed to utilize the Peconic R-based open science package (https://tbep-tech.github.io/peptools/) developed by the Tampa Bay Estuary Program to analyze and annually report on water quality in the Peconic Estuary. The R package can be used to analyze the SCDHS Surface Water Quality data and USGS data utilizing the PEP water quality targets and three spatial segments. Stop light graphics can be produced in the R package to indicate if the target is being met or not, and direct management action for each parameter and segment.

Another tool that could be potentially used is The Long Island Quality of Water Integrated Data System (LIQWIDS). LIQWIDS is a multifaceted system, designed by the USGS, in coordination with the NYSDEC and the Long Island Regional Planning Council (LIRPC), which provides a custom, map-based user interface for sharing ambient water quality data in a format that allows local stakeholders to visualize their data along with all other available data.

The PEP and Monitoring Collaborative have committed to producing a Peconic Estuary Water Quality Report annually. The Monitoring Collaborative has committed to sharing data annually for the production of the report and committed to reviewing the annual Peconic Estuary Water Quality Report prior to public distribution.

GOAL: RESILIENT COMMUNITIES PREPARED FOR CLIMATE CHANGE

OBJECTIVE C: Help local communities to take meaningful, well-informed action to prepare for and adapt to climate change impacts in the Peconic Estuary

Current Status: The PEP study area currently does not have adequate monitoring in place to track ocean acidification metrics and cannot answer Monitoring Question 1 (coastal acidification trends). Current EPA guidelines recommend monitoring of pCO2, pH, dissolved inorganic carbon and total alkalinity to track water column acidification processes and changes in the carbonate system. Several water quality monitoring programs are already sampling water temperature, an important indicator of climate change (Table 1).

Next Steps:
By January 2021, the Monitoring Collaborative will initiate work with the New York State Ocean Acidification Task Force to define how to enhance existing monitoring network to include parameters specific to ocean acidification.

By May 2021, the PEP TAC, working with the Monitoring Collaborative, will evaluate the feasibility of including climate change adaptation in water quality models and/or ecosystem models to identify potential areas of impact. USGS has data from long-term water quality grab samples and recent continuous data collection at two sites. Other parameters which are needed to support model development and management decision-making will need to be considered, which may include mid-estuary current velocities.

GOAL: CLEAN WATERS

OBJECTIVE D: Protect areas with clean water from degradation

Current Status: Data collected by the current monitoring programs are capable of addressing Monitoring Questions 2 (chlorophyll-*a* concentration), 3 (water clarity), 4 (dissolved oxygen), 5 (fecal indicators) and 6 (nutrient concentration) for the three estuarine management zones of the Peconic Estuary, but not for all sub-watersheds or embayments within the Peconic Estuary.

Next Steps:
The PEP TAC identified several next steps needed to identify and assess areas with clean water, including the following:

For 2020 annual reporting, use the provisional targets for open water segments.

A number of statistical and methodological issues remain to be addressed prior to finalization of ambient water quality targets (see Report 2019d link). By Sept 2021, priority statistical issues will be evaluated by the Monitoring Collaborative (supported by the PEP Suffolk County data analyst).

By 2021, the TAC and the Collaborative will evaluate whether the provisional targets (e.g., for Secchi depth and chlorophyll-*a* concentration) are appropriate for all three estuary management zones. If zone-specific targets are necessary, the Monitoring Collaborative will work through the PEP TAC to develop and recommend adoption of these revised targets to the Management Committee by May 2022.

In 2021, the Monitoring Collaborative will work with the PEP TAC to explore the development of a tiered reporting system, summarizing water quality conditions on a broad scale (e.g., for the three proposed estuary segments) and also identifying problem areas in individual sub-watersheds or embayments.

New *Enterococcus* standards are currently in review. Once these standards are in place, the PEP TAC will revise the target to reflect the new standards going forward.

By May 2021, the Monitoring Collaborative will identify feasible and cost-effective methods for monitoring diel variations in dissolved oxygen at multiple locations within the estuary. Deployable continuous monitoring instruments have become more affordable in recent years and may be an option. It may also be possible to use statistical methods (such as regression analyses) to estimate daily minimum dissolved oxygen concentrations based on values observed at the SCDHS stations, which are measured during daylight hours, typically between mid-morning and mid-afternoon. The Collaborative will also evaluate the feasibility of including continuous near-bottom dissolved oxygen measurements.

Pathogen-related parameters were not included among the water quality indicators used by Suffolk County (2020) for the Subwatersheds Wastewater Plan development; some of these waters are classified as impaired by NYDSEC due to closures of shellfish harvesting areas. The Monitoring Collaborative will work with all parties on issues related to shellfish bed closures and pathogen-related TMDLs at the state and federal levels.

By May 2022, the Monitoring Collaborative will examine potential elements of an 'early warning system' (e.g., using hydrographic parameters such as salinity, dissolved oxygen, water temperature, pH), which could be used to alert decision-makers and the public to anticipated water quality issues such as fish kills and HABs. The Monitoring Collaborative will define metrics and potential budget requirements for development of an early warning system, for inclusion in a future PEP Annual Workplan.

By 2022, the Monitoring Collaborative will define additional indicators that may need to be tracked and reported to assess progress toward CCMP Objectives, such as the spatial distribution of nuisance macroalgae blooms, suitability of water quality for spawning and development of diadromous fish, and tissue levels of mercury and other potential toxins in river otters and other wildlife.

GOAL: CLEAN WATERS

OBJECTIVE E. Increase understanding of nutrient pollution in groundwater and surface waters, and decrease negative impacts from legacy, current and future nutrient inputs.

OBJECTIVE F: Reduce current and future inputs of toxics, pathogens, and marine debris into groundwater and surface waters, and minimize their impacts

Current Status: Data from the current water quality monitoring programs are capable of addressing Monitoring Question 6 (nutrient concentration) for the surface waters in the three estuarine management zones. Ambient freshwater water quality monitoring programs in some streams and rivers discharging to the Peconic Estuary are capable of partially addressing Monitoring Questions 6 (nutrient concentrations), but not for all. Groundwater monitoring programs are also capable of partially addressing Question 6, but not in all key locations.

Understanding impacts from legacy, current and future nutrient inputs will require estimating nutrient loadings over time, which requires both ambient monitoring data and an estimate of rate and volume of water flow from both surface water and groundwater sources. Existing monitoring programs are capable of partially addressing Monitoring Question 7 (nutrient loading).

Existing water quality monitoring programs conducted and reported by Stony Brook University and The Nature Conservancy are capable of addressing Monitoring Question 8 (tracking and reporting algal blooms) in the Peconic Estuary.

Additional work is needed for freshwater bodies within the watershed. The NYSDEC currently tracks freshwater cyanobacteria HABS in waterbodies throughout the state (http://www.dec.ny.gov/chemical/83310.html) and maintains a Suspicious Algae Report Form page at https://survey123.arcgis.com/share/66337b887ccd465ab7645c0a9c1bc5c0.

Current monitoring programs are generally not capable of addressing Monitoring Question 9 (toxins delivered to the Peconic Estuary). Current groundwater monitoring programs conducted by Suffolk County and the USGS include the monitoring and analysis of various toxins which include herbicides and pesticides and the degradants of those products in some locations. Suffolk County and the USGS groundwater monitoring programs work collaboratively to monitor and analyze various compounds in groundwater; however, an improved understanding of all of the compounds and locations of monitoring by the Monitoring Collaborative could be helpful in determining additional compounds that should be monitored and expansion of the monitoring network. The NYSDEC, Suffolk County and Cornell Cooperative Extension currently monitor and analyze concentrations in groundwater wells to detect agriculture-based pesticide (the term pesticide includes herbicides, miticides, insecticides, etc.) constituents, in support of implementing BMPs and pesticide monitoring strategies included in the NYSDEC's Long Island Pesticide Pollution Prevention Strategy (http://ccesuffolk.org/resources/long-island-pesticide-pollution-prevention-strategy).

Next Steps:
The PEP TAC and monitoring partners identified several hundred ideas and concepts to address water quality monitoring necessary to be capable of supporting water quality-related CCMP Goals in May 2019 (see Report 2019b link for a complete list). The list below highlights several key elements specifically addressing identified water quality monitoring needed, grouped by topic.

Surface water:

By 2022 the Monitoring Collaborative will determine what additional monitoring is needed to more fully characterize water quality status and trends within embayments of the Peconic Estuary.

Monitoring at the USGS gage on the Peconic River currently includes continuous flow measurements but only quarterly sampling of water quality parameters. By 2021, the Monitoring Collaborative will assess the feasibility and budget needed to increase the frequency of water quality monitoring at this site, which will decrease uncertainty in loading estimates to the Peconic Estuary. The Peconic River is also groundwater-driven, so nutrient loads observed there will have a groundwater component.

By 2022 Annual Workplan, the Monitoring Collaborative will work with NYSDEC's Division of Water and Division of Marine Resources to develop additional monitoring elements which will support 303(d) listings or other regulatory requirements as well as track progress toward PEP CCMP Goals and Objectives. The Priority Waterbodies List (PWL) delineations, available from the state, will be evaluated as a potential basis for segmentation and assigning station locations. Integrating groundwater sub-basins with surface water segments will be assessed as a potential method used to help decide where monitoring stations should be located.

Harmful Algal Blooms:

For HABs, PEP should continue to use the annual maps prepared by Stony Brook University and The Nature Conservancy to track and report blooms in the estuary. Additional work will be needed to develop methods for reporting and tracking cyanobacterial HABs in freshwater bodies within the watershed. Monitoring questions and research needed to characterize HABs in freshwater bodies will be defined by the Monitoring Collaborative by 2022.

By 2022, the Collaborative will evaluate the feasibility of calculating the amount of total chlorophyll *a* measured which is due to harmful algal bloom species.

Groundwater:

The PEP TAC will evaluate how the Solute Transport Model can be used to run scenarios and use the tool to support decision making and make recommendations to the PEP Management Conference by 2021.

By 2022, the Monitoring Collaborative will assess needed elements to monitor the quality and quantity of groundwater more comprehensively and consistently in order to fully estimate nutrient loads to the estuary by establishing a baseline groundwater monitoring network for ecosystem objectives, and resources needed to and sustain it through time. Groundwater plumes can show up in surface water and may contain nutrients and other contaminants (household products, pesticides, etc.). Some emerging contaminants do not yet have standard analytical methods, and their impacts are not yet known. Additional understanding of degradants/breakdown products is also needed. The County has access

to hundreds of groundwater monitoring wells, but resources have not been available to sample them on a regular basis. The Monitoring Collaborative will define priority groundwater monitoring wells by 2022.

By 2022, the Monitoring Collaborative will evaluate how to measure nutrient/toxin concentrations/loads in the hyporheic discharge zone to improve understanding of loads in this 'hand-off' zone between the watershed and the estuarine system. This is critical information supporting model calibration and validation and to evaluating in situ loadings from submarine groundwater discharges (SGD) in the estuary. Effort should include detailed analysis of the dynamic nature of the offshore SGD zones to determine suitable long-term monitoring stations. The understanding of the spatial and temporal conditions will produce reliable data for model projection on fate and transport on contaminants in the estuary.

Groundwater wells are currently sampled twice a year at about 50 wells in the Peconic River watershed. By 2022, the Monitoring Collaborative will verify which of the wells are on the flow paths of contaminants to the estuary. The data from these groundwater wells can be coupled with the Solute Transport Model, using these data to support model validation. Through application of the validated Solute Transport Model, design a more comprehensive monitoring program which, coupled with analysis of a suite of nutrients and site-specific groundwater studies, will provide part of the data needed to answer Monitoring Questions 6, 7 and 8.

Flows:

The Monitoring Collaborative will determine whether annual freshwater inflows ('hydrologic loads') to the estuary should be an element of tracking and reporting, and perhaps used to 'normalize' estimates of annual nutrient loads with respect to annual freshwater inflows, by 2022.

Pathogens and Toxins

In 2021, the Monitoring Collaborative will evaluate information sources, such as the shoreline surveys conducted by NYSDEC's shellfish monitoring program and microbial source tracking, as means to identify potential pathogen sources.

GOAL: HEALTHY ECOSYSTEM WITH ABUNDANT, DIVERSE WILDLIFE

OBJECTIVE H: Restore and protect key habitats and species diversity in the Peconic Estuary and its watershed (eelgrass habitat and diadromous fish spawning areas).

Current Status: Data from existing water quality monitoring programs are capable of addressing Monitoring Question 3 (water clarity) and temperature to support eelgrass habitat requirements in the open water estuarine segments. Dissolved oxygen and water temperature monitoring is not currently adequate to determine whether targets are being met in areas supporting fish spawning in rivers and streams.

Next Steps:

Groundwater discharge may be a cooling factor in some persistent eelgrass beds. Maps of these areas may help to identify sites where transplanting could be effective. In 2021, the Monitoring Collaborative will develop maps of water temperature in potential seagrass habitat areas, couple with results of the groundwater transport model to assist with identifying future areas for restoration, and map areas where PAR and water temperature could support eelgrass and focus restoration areas there.

Ongoing climate change may also necessitate changes in water clarity targets to support SAV growth. For example, research in a number of geographic areas (e.g., Chesapeake Bay, Denmark, South Korea) indicates that eelgrass requires higher irradiance levels, and thus greater water clarity, as water temperature rises. On the other hand, recent research in Chesapeake Bay and elsewhere suggests that the higher pCO_2 levels associated with ocean acidification may have a 'fertilizing' effect on eelgrass and several other SAV species by reducing carbon limitation. At present, the potential long-term impacts on SAV of these and other stressors associated with climate change are difficult to assess. The TAC and Monitoring Collaborative will periodically assess the current water quality targets as additional information becomes available.

Current river and stream monitoring is periodic in nature and only done in a few locations; these data are useful for long term trends but not for understanding more immediate impacts on spawning and nursery life stages. By 2023, the Monitoring Collaborative will develop a monitoring plan and initiate water quality monitoring in key rivers and streams.

Sharing, Reporting, and Use of Data

Monitoring data are shared by the PEP partners conducting the monitoring and can be found on the websites managed by the collecting entity, or upon request from the Peconic Estuary Partnership's office.

The PEP partners use monitoring data in reports and presentations to provide information to technical and public audiences regarding progress towards CCMP implementation and to describe the State of the Estuary. In December 2019, the PEP TAC recommended using a simple 'stoplight graphic' to report on water quality targets in the three major management areas of the Peconic Estuary (Report 2019e link). An example of these graphics, based on attainment of the adopted chlorophyll-*a* and Secchi disk targets, is shown in Table 2. Growing season median values are shown for both parameters. Definitions of 'green (meeting target values), yellow (cautionary) and red (failing to meet target values) are provided in Report 2019e link.

Estuary Segment	YY	Median Chla (µg/L)	Median Secchi Depth (ft)
West	1976	22.2	3.5
West	1977	--	6.0
West	1978	--	5.3
West	1979	--	5.0
West	1980	--	--
West	1981	--	--
West	1982	--	--
West	1983	--	--
West	1984	--	--
West	1985	--	2.5
West	1986	--	4.0
West	1987	--	4.0
West	1988	12.6	3.5
West	1989	5.0	7.0
West	1990	4.2	5.0
West	1991	6.0	3.5
West	1992	4.0	4.0
West	1993	3.8	4.5
West	1994	3.5	5.5
West	1995	6.9	4.0
West	1996	7.4	5.5
West	1997	7.8	5.5
West	1998	3.8	5.5
West	1999	3.4	5.5
West	2000	3.2	5.0
West	2001	4.1	5.0
West	2002	3.8	5.5
West	2003	4.3	5.5
West	2004	4.4	5.0
West	2005	3.9	5.5
West	2006	4.8	6.0
West	2007	4.7	6.0
West	2008	4.8	5.5
West	2009	4.3	5.0
West	2010	9.0	5.0
West	2011	4.9	5.0
West	2012	3.9	5.0
West	2013	5.1	7.0
West	2014	3.2	6.0
West	2015	2.6	5.5
West	2016	3.6	4.5
West	2017	6.7	4.0
West	2018	5.4	5.0

Estuary Segment	YY	Median Chla (µg/L)	Median Secchi Depth (ft)
Central	1976	--	--
Central	1977	--	--
Central	1978	--	--
Central	1979	--	--
Central	1980	--	--
Central	1981	--	--
Central	1982	--	--
Central	1983	--	--
Central	1984	--	--
Central	1985	--	--
Central	1986	--	5.0
Central	1987	--	3.5
Central	1988	12.0	4.5
Central	1989	4.6	7.0
Central	1990	3.5	7.0
Central	1991	8.6	3.3
Central	1992	3.2	5.5
Central	1993	3.0	6.5
Central	1994	2.7	7.5
Central	1995	4.8	5.5
Central	1996	3.9	7.5
Central	1997	4.1	7.5
Central	1998	2.6	7.5
Central	1999	2.2	7.5
Central	2000	1.6	7.0
Central	2001	2.4	7.0
Central	2002	3.1	7.0
Central	2003	2.3	11.0
Central	2004	2.5	8.0
Central	2005	1.9	8.0
Central	2006	2.9	10.0
Central	2007	3.8	10.0
Central	2008	2.9	8.0
Central	2009	2.5	8.0
Central	2010	4.5	6.5
Central	2011	2.8	7.5
Central	2012	2.7	6.0
Central	2013	3.1	8.0
Central	2014	2.3	7.0
Central	2015	1.9	7.0
Central	2016	2.4	6.0
Central	2017	3.3	6.0
Central	2018	2.3	6.0

Estuary Segment	YY	Median Chla (µg/L)	Median Secchi Depth (Fft)
East	1976	--	--
East	1977	--	--
East	1978	--	--
East	1979	--	--
East	1980	--	--
East	1981	--	--
East	1982	--	--
East	1983	--	--
East	1984	--	--
East	1985	--	--
East	1986	--	6.5
East	1987	--	5.0
East	1988	7.5	6.0
East	1989	4.5	8.5
East	1990	3.0	8.5
East	1991	5.0	6.0
East	1992	2.5	7.5
East	1993	2.8	7.5
East	1994	2.4	9.0
East	1995	2.9	7.0
East	1996	3.0	10.0
East	1997	3.2	10.0
East	1998	2.1	12.0
East	1999	1.6	11.0
East	2000	1.2	9.0
East	2001	1.9	10.0
East	2002	2.5	8.5
East	2003	2.4	12.0
East	2004	2.8	9.5
East	2005	1.5	11.0
East	2006	2.7	10.0
East	2007	3.3	10.0
East	2008	2.4	10.0
East	2009	2.2	11.0
East	2010	2.8	12.0
East	2011	2.4	10.0
East	2012	2.1	8.0
East	2013	2.4	11.0
East	2014	1.9	9.0
East	2015	1.5	10.0
East	2016	2.2	8.0
East	2017	2.1	8.0
East	2018	2.9	8.0

Table 2. Stoplight graphic summarizing attainment of the proposed Secchi depth and chlorophyll-*a* targets in the three Peconic Estuary reporting zones illustrated in Figure 2 for the years 1976 – 2018. Data source: SCDHS.

As with the example above, information on frequency of *Enterococcus*-based beach closures can be summarized and tracked. An example of this approach is shown in Table 3, for the years 2010 through 2018. Numbers in the table cells represent the number of *Enterococcus*-related beach closures (due to exceedances of the 104 cfu/100 ml criterion) that occurred in a given year. Years with zero closures are shown as green, those with one closure are shown as yellow, and those with more than one closure are shown as red. In this data set the Founders Landing beach stands out as experiencing a substantially larger number of closures than the other locations sampled.

Beach Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	Subtotals
Alberts Landing Beach	0	0	0	0	0	0	0	0	1	1
Camp Blue Bay Beach	0	0	0	0	0	0	0	0	1	1
Camp Quinipet Beach	0	1	0	0	0	2	1	0	1	5
Clearwater Beach	0	0	0	0	0	0	0	0	1	1
Cornell Cooperative Extension Marine Center Beach	0	0	0	0	0	0	0	0	0	0
Crescent Beach - Shelter Island	0	0	0	0	0	0	0	1	0	1
Culloden Shores Beach	0	0	0	0	0	0	0	0	0	0
Devon Yacht Club Beach	0	0	0	0	0	0	1	0	1	2
East Lake Drive Beach	0	0	0	0	0	0	0	0	0	0
Fifth Street Park Beach	0	0	0	0	0	2	0	2	1	5
Fleets Neck Beach	0	1	0	0	0	0	0	0	0	1
Foster Memorial Beach	0	0	0	0	0	0	0	0	0	0
Founders Landing Beach	2	1	1	1	0	0	1	3	1	10
Goose Creek Beach	1	0	1	0	0	0	0	0	0	2
Havens Beach	2	1	0	0	0	0	0	0	0	3
Maidstone Beach	0	0	0	1	0	0	0	0	0	1
Meschutt Beach	0	0	1	0	0	0	1	0	1	3
Nassau Point Causeway Beach	0	1	0	0	0	0	0	1	1	3
New Suffolk Beach	0	1	0	0	0	0	0	0	0	1
Norman E. Klipp Park Beach	0	0	0	0	1	0	0	1	0	2
Perlman Music Camp Beach	0	0	0	0	0	0	1	0	1	2
Pridwin Hotel Beach	1	1	0	0	0	0	0	0	1	3
Shelter Island Heights Beach Club Beach	0	0	1	0	0	0	0	0	1	2
Silver Sands Motel Beach	0	1	0	1	0	0	0	0	2	4
South Jamesport Beach	1	0	1	0	0	0	0	0	2	4
Southampton Peconic Beach & Tennis Club Beach	0	0	0	1	0	0	0	0	0	1
Veteran's Memorial Park Beach	0	1	0	2	0	0	0	0	1	4
Wades Beach	0	0	0	0	0	0	0	1	0	1

Table 3. Frequencies of *Enterococcus*-related Peconic Estuary beach closures for the years 2010 through 2018. Data source: SCDHS.

To encourage the use of open-science methods throughout the National Estuary Programs, the Tampa Bay Estuary Program has offered to develop an open-science package using the Suffolk County surface water database. This package, using the statistical and graphics program R, is capable of providing almost real-time analyses and graphics (including the 'stoplight' graphics shown above). In 2020, interested members of the TAC and other PEP partners will evaluate the use of the Peconic R package to report annual water quality reports.

The PEP partners periodically convene a symposium to summarize status and trends in the Peconic Estuary's environmental condition and provide the science and technical community an opportunity to share state-of-the-art research with each other and the public. The last State of the Estuary conference, held in September 2015, included participation from scientists, resource managers, PEP partners, Town supervisors, citizens, and students from the area. The conference included a presentation (along with a distribution of the Peconic Estuary Program 2015 Action Plan Executive Summary and Recent Accomplishments and Initiatives of the Peconic Estuary Program) from the PEP Program Director on the status of the Peconic Estuary health and partnerships, and presentations from PEP Mini-grant funded water quality improvement programs and the Riverhead Sewage Treatment Plant, which included a site tour. Presented posters included the Long Island Water Quality Impairments, summer 2015 produced by SUNY Stony Brook University and The Nature Conservancy.

Indicators and Measures
The creation, assessment, and reporting of succinct "indicators" for the health of the estuary (that combine information from multiple projects) provide opportunities to showcase improvements as well as recognize and address shortfalls (e.g., Bortone 2005). The monitoring programs and indicators presented in this document (see Table 1) attempt to gauge the cumulative effects of all of the suggested activities within each CCMP Action. An environmental indicator is only useful when supported by an active monitoring program. Not all of the environmental indicators in this Strategy have ongoing monitoring programs, and steps should be enacted to address these areas.

By reporting on the indicators described above within the *Numeric Water Quality Targets* section, PEP and the Monitoring Collaborative partners will continue the assessment to understand changes occurring in the Peconic Estuary and its watershed. The information created from these indicators will demonstrate progress towards the goals of the CCMP and aid in identification of new issues that become critical to the improvement and protection of the Peconic Estuary.

Conclusion
The activities described within this Water Quality Monitoring Strategy identify the data necessary to assess the effectiveness of CCMP actions and describe water quality status and trends. The environmental indicators used by the PEP are expected to be an effective mechanism for evaluating progress and identifying gaps regarding the achievement of significant improvements to the Peconic Estuary.

Decision-makers and the public will be kept informed about the condition of the Peconic Estuary as analyzed through this monitoring program. Also as previously stated, comprehensive sustained long-term sampling and monitoring using existing programs are essential for the continued success of the PEP. Stable funding and commitment from monitoring entities is necessary to ensure PEP's CCMP is effectively implemented for the continued improvement of the Peconic Estuary and its watershed.

References

Arnold, T.M., R.C. Zimmerman, K.A.M. Engelhardt, J.C. Stevenson. 2017. Twenty-first century climate change and submerged aquatic vegetation in a temperate estuary: the case of Chesapeake Bay. Ecosystem Health and Sustainability, 3:7, 1353283 (https://doi.org/10.1080/20964129.2017.1353283)

Bortone, S.A. 2005. The quest for the "perfect' estuarine indicator: an introduction. Pp. 1-3 in S.A. Bortone (ed). Estuarine Indicators. Boca Raton, FL: CRC Press. 531 p.

National Academies of Science. 1990. Managing Troubled Waters: The Role of Marine Environmental Monitoring. Washington DC. The National Academies Press. 125 pp.

National Academies of Sciences, Engineering, and Medicine. 2017. Effective Monitoring to Evaluate Ecological Restoration in the Gulf of Mexico. Washington, DC: The National Academies Press. DOI: 10.17226/23476. 266 pp.

PEP 2019a. Summary of Existing Water Quality Monitoring Programs in the Peconic Estuary and Watershed. Prepared by CoastWise Partners for the Peconic Estuary Partnership.

PEP 2019b. Summary of May 29, 2019 TAC and Monitoring Partners Workshops on Existing Water Quality Monitoring Programs. Prepared by CoastWise Partners for the Peconic Estuary Partnership.

PEP 2019c. Summary of Methods Used to Report Results from Existing Water Quality-Related Monitoring Programs in the Peconic Estuary. Prepared by CoastWise Partners for the Peconic Estuary Partnership.

PEP 2019d. Developing an Updated Reporting Strategy for Water Quality Monitoring Information: Background for Dec. 4, 2019, TAC meeting. Prepared by CoastWise Partners for the Peconic Estuary Partnership.

PEP 2019e. TAC Workshop Summary, Recommended Water Quality Targets and Templates for Reporting Monitoring Results. Prepared by CoastWise Partners for the Peconic Estuary Partnership.

Suffolk County Department of Health Services (SCDHS). 2020. Subwatersheds Wastewater Plan. Prepared by CDM Smith, July 2020. https://suffolkcountyny.gov/Departments/Health-Services/Environmental-Quality#SubWWPlan