Recommendations for a Comprehensive Seagrass Monitoring Plan for the Peconic Estuary

Prepared for the Peconic Estuary Partnership

on April 24, 2025

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Background

Summary: Seagrasse are an important and declining resource in the Peconic Estuary.

Seagrasses are important underwater plants that provide valuable services to coastal communities: they act as shelter and nursery habitat for many species of fishes and invertebrates; they support healthy coastal food webs and sustain productive fisheries; they buffer shorelines against storm surge and prevent coastal erosion; and they sequester significant amounts of carbon. As such, their conservation and restoration are now considered a priority at multiple levels of management, from local to international.

In the Peconic Estuary, the dominant seagrass is currently eelgrass (*Zostera marina*). It is estimated that there were around 8,700 acres of eelgrass in the Peconic Estuary in the 1930s. Recent aerial mapping from 2024 has revealed that this value has dropped to just 785.5 acres, a 7.6% reduction from the last survey in 2014, which mapped 849.7 acres of eelgrass. The historical loss of eelgrass has generally been attributed to declining visibility, which limits the amount of light available for the plant to photosynthesize. Poor water quality has previously been linked to algal blooms (brown tide in the 1980-90s) and to nutrient and sediment pollution. Despite recent improvements in sewage treatment and watershed management, the resource has continued to decline. Rising water temperatures have been identified as a key driver of eelgrass losses across the East Coast and now in the Peconic Estuary. As a result, most meadows are now restricted to areas that are influenced by cooler ocean waters (the eastern part of the Estuary) or in areas that experience groundwater upwelling.

A second species, widgeongrass (*Ruppia maritima*), is present but less widespread and constrained to a few small areas. In 2024, its total extent is estimated at 14.8 acres, while it was undetected in the 2014 mapping. Widgeongrass is considered “weedy” and can tolerate a wide range of conditions. It therefore tends to occupy areas less suitable for eelgrass growth, such as those of low salinity (<20 psu). Widgeongrass populations can be dynamic and their abundance can vary substantially from year-to-year. Thus, this species is less likely to appear reliably each year, interrupting the regular delivery of the key services described above. While the proposed monitoring plan will focus primarily on eelgrass, it recognizes that future conditions may be more enabling for widgeongrass in the system, as has been seen in other western Atlantic estuaries like the Chesapeake Bay.

Objectives

Summary: The monitoring program will provide information on the status and trajectory of the seagrass resource, and context for how and why it may be changing.

An effective and relevant monitoring program for seagrasses in the Peconic Estuary shall provide the following information:

a. The general **status** of the resource throughout the Estuary, including its *extent* and *condition*.

   Extent captures the geographic footprint of the resource (i.e., acreage), while *condition* reflects the properties of the system (e.g., cover, density, canopy height). Since a recent analysis has shown that these components are generally decoupled and do not track one another through time in many seagrass systems worldwide, the monitoring program should ideally measure both concurrently.

   Further, the program should include sites that encompass the range of extent/condition exhibited by seagrass meadows in the Estuary to provide insight into management outcomes and to establish triggers for intervention.

b. The **trajectory** of the resource through space and time. This goal can be achieved by selecting sites throughout the Estuary that are representative of the range of extents and conditions observed; by maintaining continuity with historical data; and by anticipating future changes in the design of the survey (for example, the rise of widgeongrass).

c. **Context** for observed changes by simultaneously collecting environmental covariates that are known to affect the resource, such as light and temperature. These data are critical to provide mechanistic explanations for changes in status and trajectory and to assess the effectiveness of current and future management interventions.

Further, the monitoring program should **adhere to established standards** for survey design, data collection, and reporting that allow for comparisons with other monitoring programs at the local, regional, national (e.g., National Estuaries Program), and international levels (e.g., SeagrassNet).

Finally, the monitoring program should **adaptive and fit-to-purpose**. As new threats are identified and new interventions deployed, the program should revisit these recommendations to adjust the intensity of sampling to capture information needed to adequately characterize the system and its responses. These adjustments may include deploying additional surveys for a limited period outside the permanent monitoring sites to address specific questions or hypotheses.

Extent Monitoring

Summary: Areal surveys will be conducted on regular intervals to quantify the extent of both eelgrass and widegeongrass.

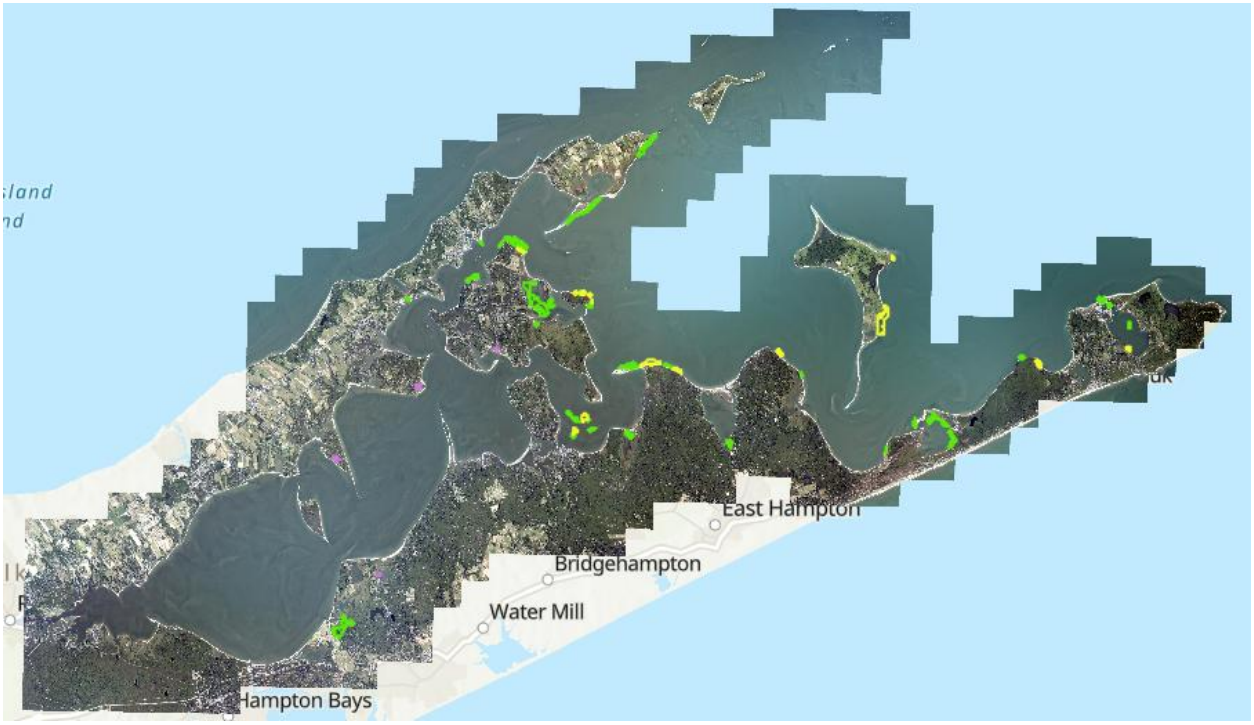


FIGURE 1. MAP OF SEAGRASS EXTENT FROM 2024. GREEN POLYGONS ARE EELGRASS, YELLOW ARE EELGRASS & BOULDERS, AND PURPLE IS WIDGEONGRASS.

Aerial photography acquired in 2024 resulted in a validated map of seagrass extent throughout the Peconic Estuary. As past analysis suggests trends from areal extent and in-water sampling are decoupled in this system, future extent mapping is recommended. The frequency of mapping is set by cost and logistical constraints but should ideally occur more frequently than in the past (i.e., 10 years since the last survey), such as every 3-5 years. The placement of transects for condition monitoring can be used to reduce the number of groundtruthing data points needed to validate future maps.

It is critical to align the frequency and effort with other nearby surveys (e.g., Long Island Sound Study, South Shore Estuary Reserve, Fire Island National Seashore) to promote a comprehensive regional inventory.

Years without aerial photography could be assessed using alternative sources of imagery, such as from satellites, drones, or dropcams, but this will require more investigation in terms of cost and feasibility.

Condition Monitoring - SeagrassNet

Summary: In-water seagrass condition is monitored every year during peak biomass using standardized methods from SeagrassNet.

The Global Ocean Observing System's Essential Ocean Variables for seagrasses recommends any survey record, at minimum, (percent) cover and composition. To maintain continuity with existing data collected in the Peconic Estuary, shoot density should also be included. The SeagrassNet survey protocol considers all these measurements as well as additional variables that are important indicators of the health and function of the system, such canopy height.

SeagrassNet is the largest and longest-running seagrass monitoring program in the world and is now housed at the Center for Coastal Studies in Cape Cod, Massachusetts. It has collected data throughout the region including at Fire Island National Seashore, Long Island Sound (Fisher's Island), Nantucket, and throughout much of southern New England. Further, SeagrassNet maintains its own public-facing database and submission portal and can manage and serve data to the global research community. Thus, SeagrassNet provides the ideal design for monitoring in the Peconic Estuary by incorporating key indicators of seagrass condition, maintaining continuity with legacy datasets, assuming some data curation responsibilities, and coordinating with other regional monitoring programs.

Briefly, the SeagrassNet survey design consists of three 50-m transects placed parallel to shore at shallow, mid-, and deep waters. This design allows for detection of the contraction of meadows at the deep edge due to light limitation and any changes at the shallow edge due to temperature stress. Ideally, transects are fixed in space, but depending on the dynamics of the meadow, transects are other sites have occasionally been relocated to better align with the seagrass resource. Twelve (12) fixed 0.25-m^2 quadrats are placed along the transect line at random intervals for a total of 36 quadrats per survey site. Within each quadrat, the following measurements are taken for each seagrass species present:

- Percent cover in 5% bins (e.g., 0, 5%, 10%, up to 100% cover).
- Average canopy height (ignoring abnormally long blades).
- Shoot density in one 0.0625-m^2 quadrant of the quadrat (for dense meadows, this area can be reduced to limit time underwater).

It is also suggested to take biomass cores outside each quadrat using a 0.0035-m^2 diameter core tube and return to the lab, where the plants are separated into blades, stems, roots and rhizomes and then dried and weighed. However, in areas with logistical constraints or concerns over destructive sampling, biomass cores can be avoided or reduced in replication and frequency (e.g., every other quadrat, or every other year). Eventually, site-specific cover/density-biomass regressions can be computed and used to impute biomass to avoid future destructive sampling.

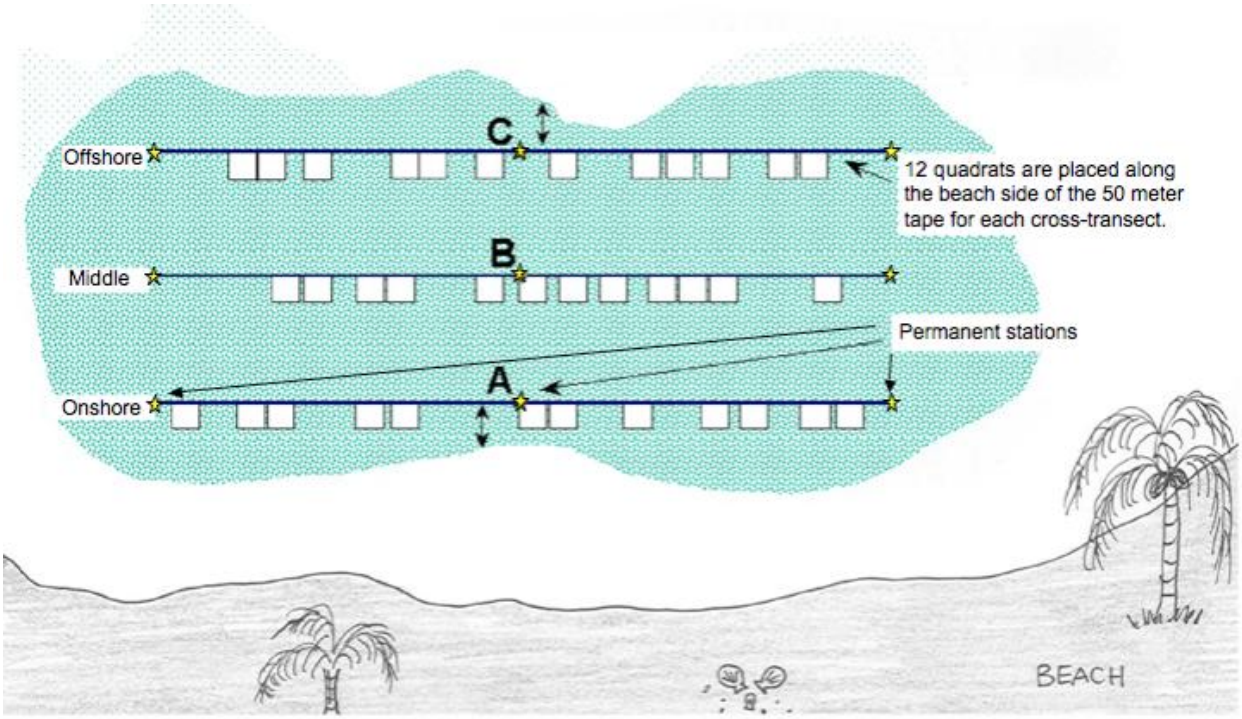


FIGURE 2. SEAGRASSNET SAMPLING DESIGN. TAKEN FROM THE 2015 SEAGRASSNET WORLDWIDE HANDBOOK.

The SeagrassNet Handbook requests that surveys be conducted quarterly but for many sites, this is logistically unfeasible or not very informative, so the newest guidance is to target the season of peak biomass: in the Peconic Estuary, this would be around July to September.

Condition Monitoring – Proposed Sites

Summary: Proposed monitoring sites include 3 sites of high density and stability (Bullhead Bay, Napeague Harbor, Sag Harbor), 3 sites of low density and/or instability (Coecles Harbor, Gardiners Bay, Orient Point), and 1 site dominated by widgeongrass (Cedar Beach Harbor/Nassau Point), for a total of 7 sites.

To promote both the conservation and the recovery of the seagrass resources in the Peconic Estuary, it is recommended that monitoring sites encompass a range of known conditions, from high density and historical stability to low density and instability to provide a comprehensive assessment. Further, to anticipate future changes in seagrass composition in the Estuary, it is recommended to establish a new monitoring site that is currently dominated by widgeongrass to better understand its dynamics.

Map of proposed sites

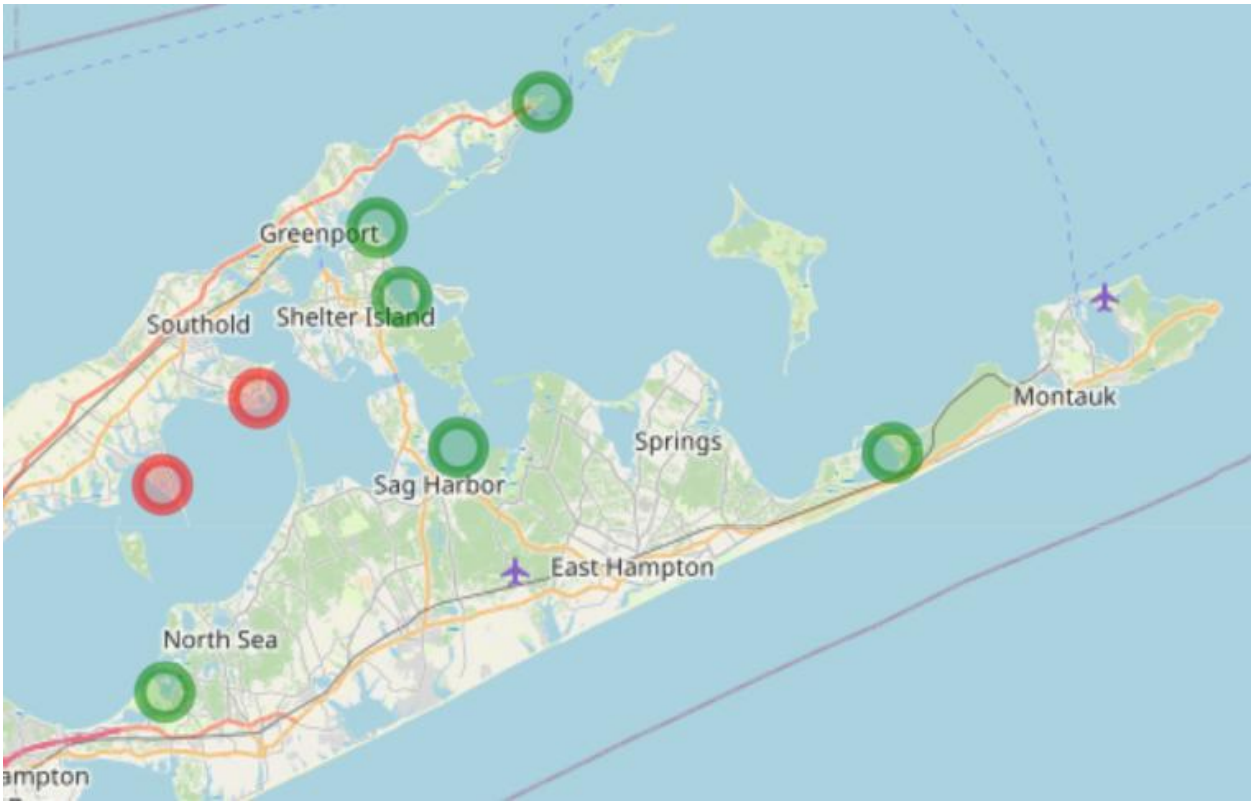


FIGURE 3. SIX PROPOSED EELGRASS MONITORING SITES IN GREEN. ONE OF TWO PROPOSED WIDGEONGRASS MONITORING SITES IN RED.

Bullhead Bay

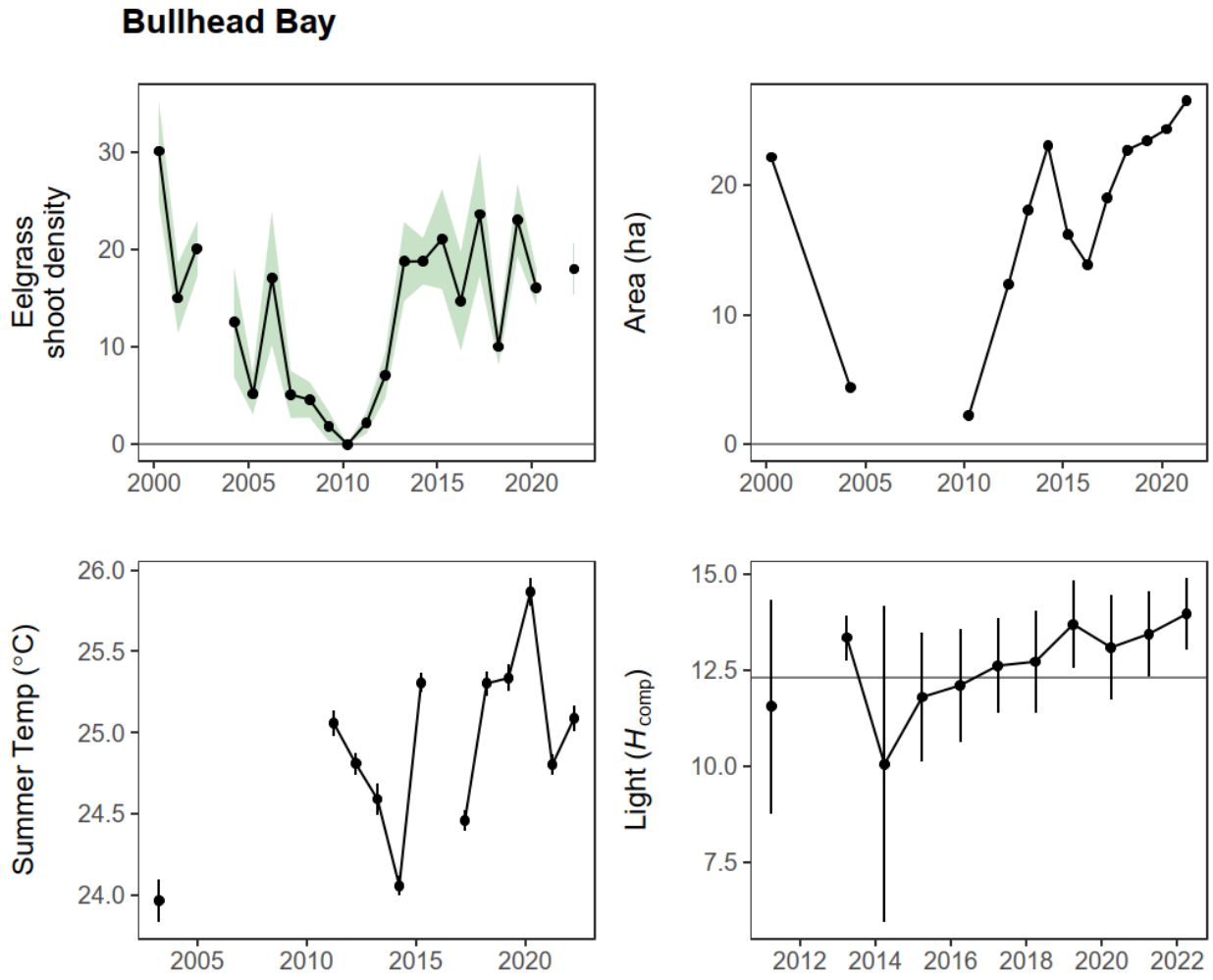
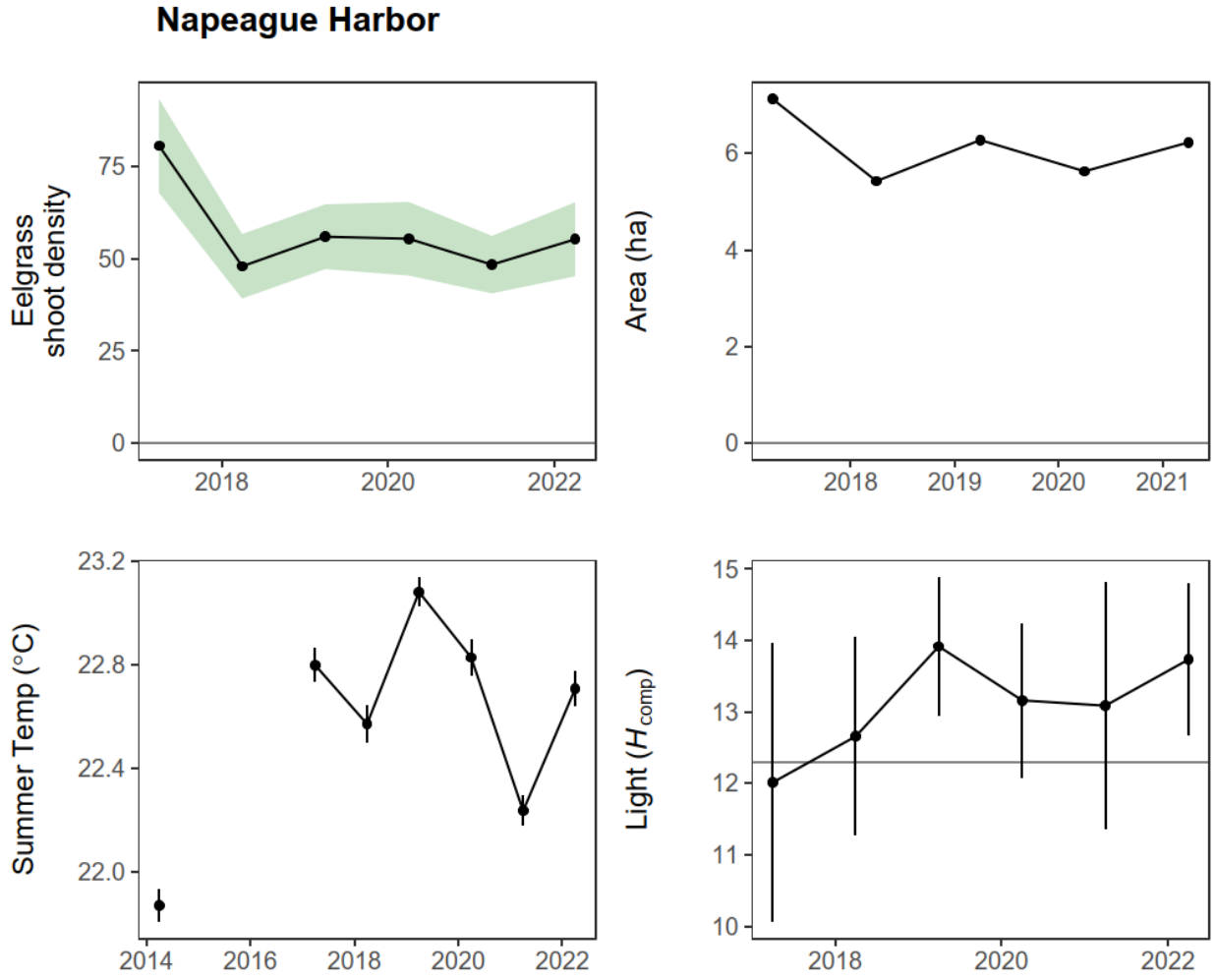


FIGURE 4. HISTORICAL DATA FROM PEP SURVEYS. UPPER LEFT PANEL IS SHOOT DENSITY (PER M^2). UPPER RIGHT PANEL IS ESTIMATES OF EXTENT FROM GOOGLE MAPS (NOT 2014 OR 2024 AERIAL SURVEYS). BOTTOM LEFT IS SUMMERTIME WATER TEMPERATURE. BOTTOM RIGHT IS LIGHT AVAILABILITY (H_{COMP} THRESHOLD IS 12.3 HOURS OF DAYLIGHT TO MEET PHOTOSYNTHETIC DEMANDS BY THE PLANTS, SOLID LINE).

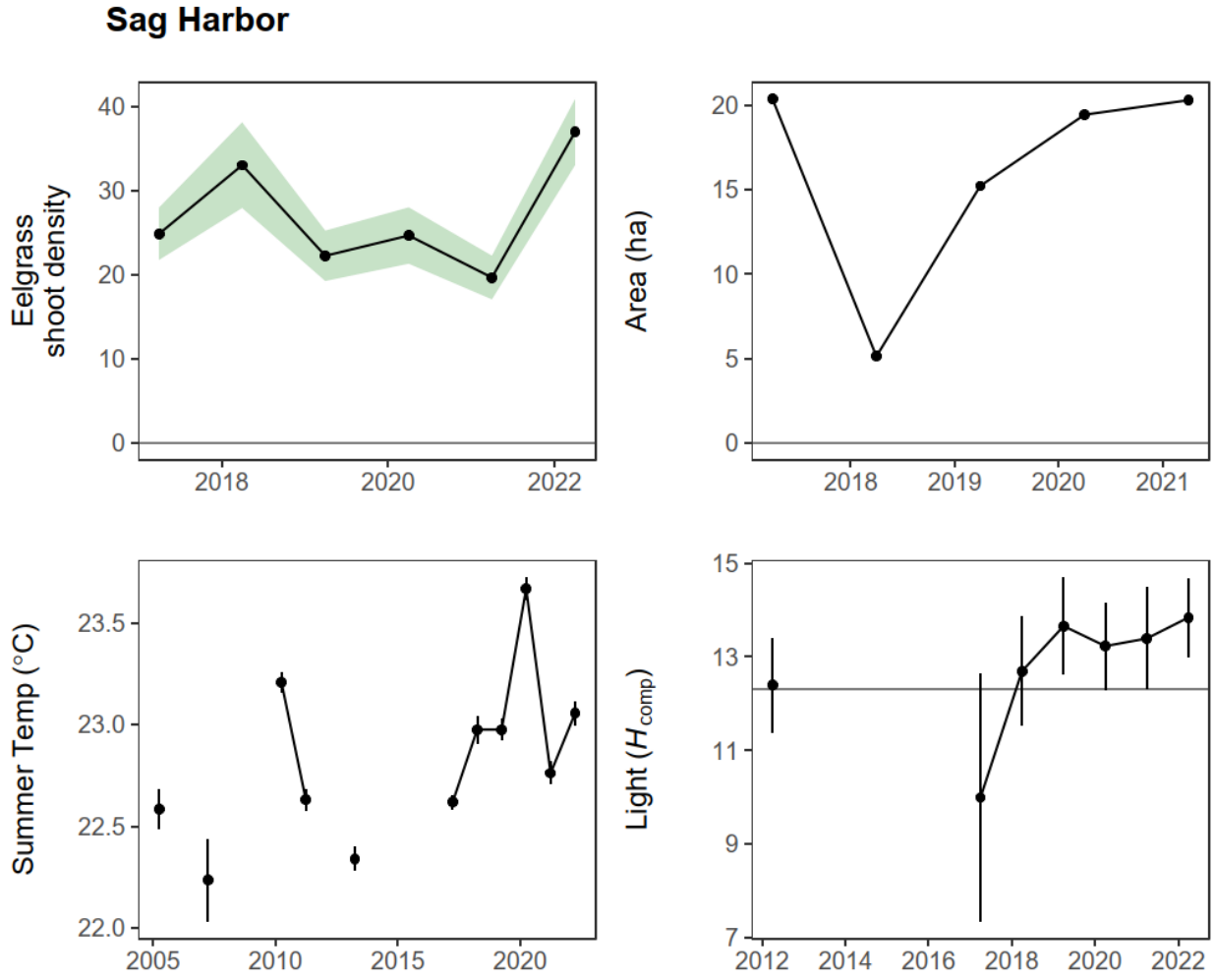
Bullhead Bay has one of the longest histories of monitoring and is the western-most remaining eelgrass meadow in the Peconic Estuary. While its extent and condition has varied over the years (and it nearly disappeared in 2010), the meadow has grown in area and returned to its baseline density as of 2022. While temperatures have increased by nearly +1°C since 2004, the light regime has been improving, with sufficient light available now for photosynthesis during the summer months. As such, Bullhead Bay will be an important barometer for the impact of climate change on seagrasses in the area.

Napeague Harbor



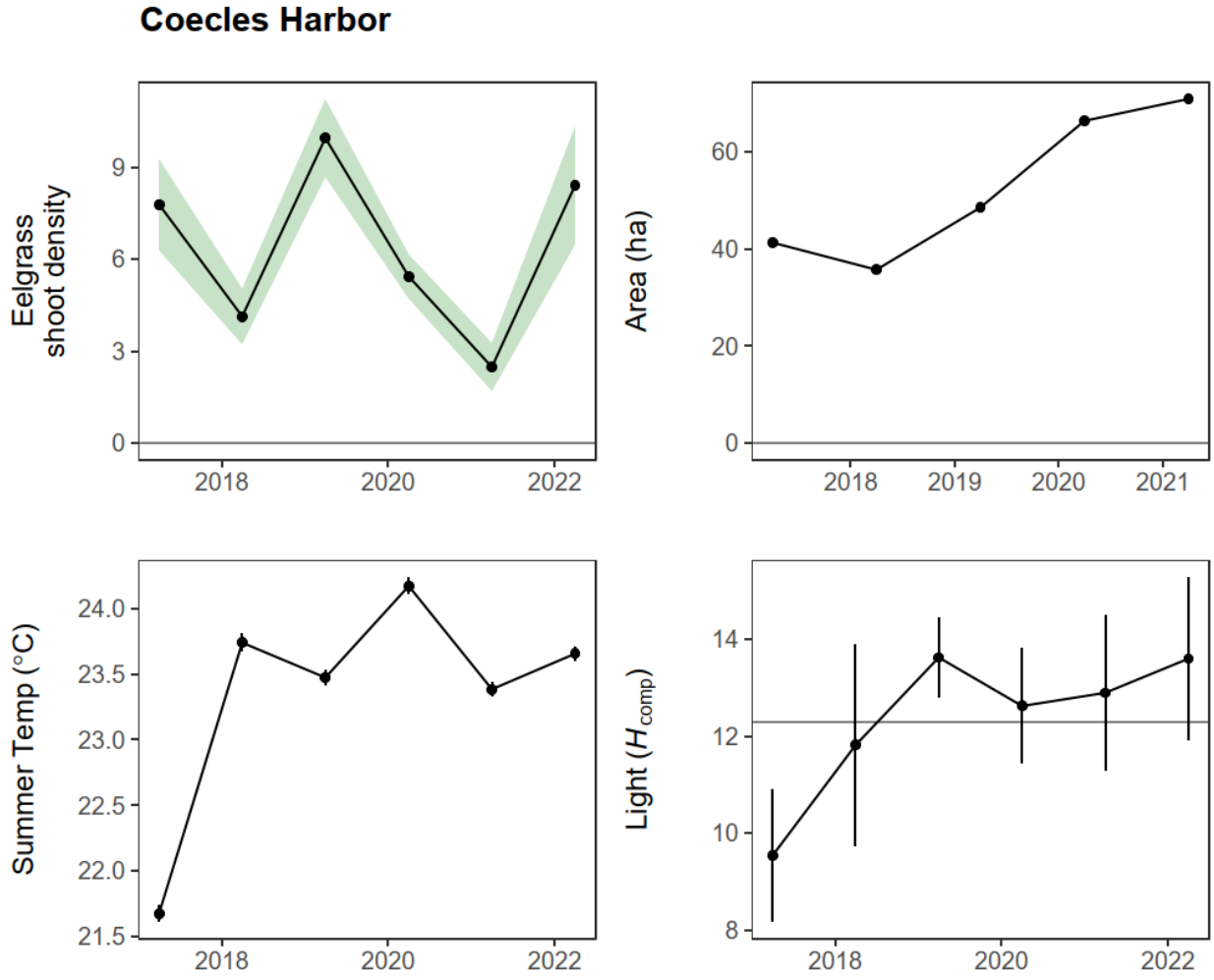
While Napeague Harbor has only been monitored since 2017, it has the highest recorded density of eelgrass shoots anywhere in the Peconic Estuary since 2000. It remains overall cool and as of 2022, has sufficient light to promote photosynthesis. If environmental conditions do not deteriorate, Napeague Harbor is likely to remain one of the more stable and dense meadows in the Estuary.

Sag Harbor



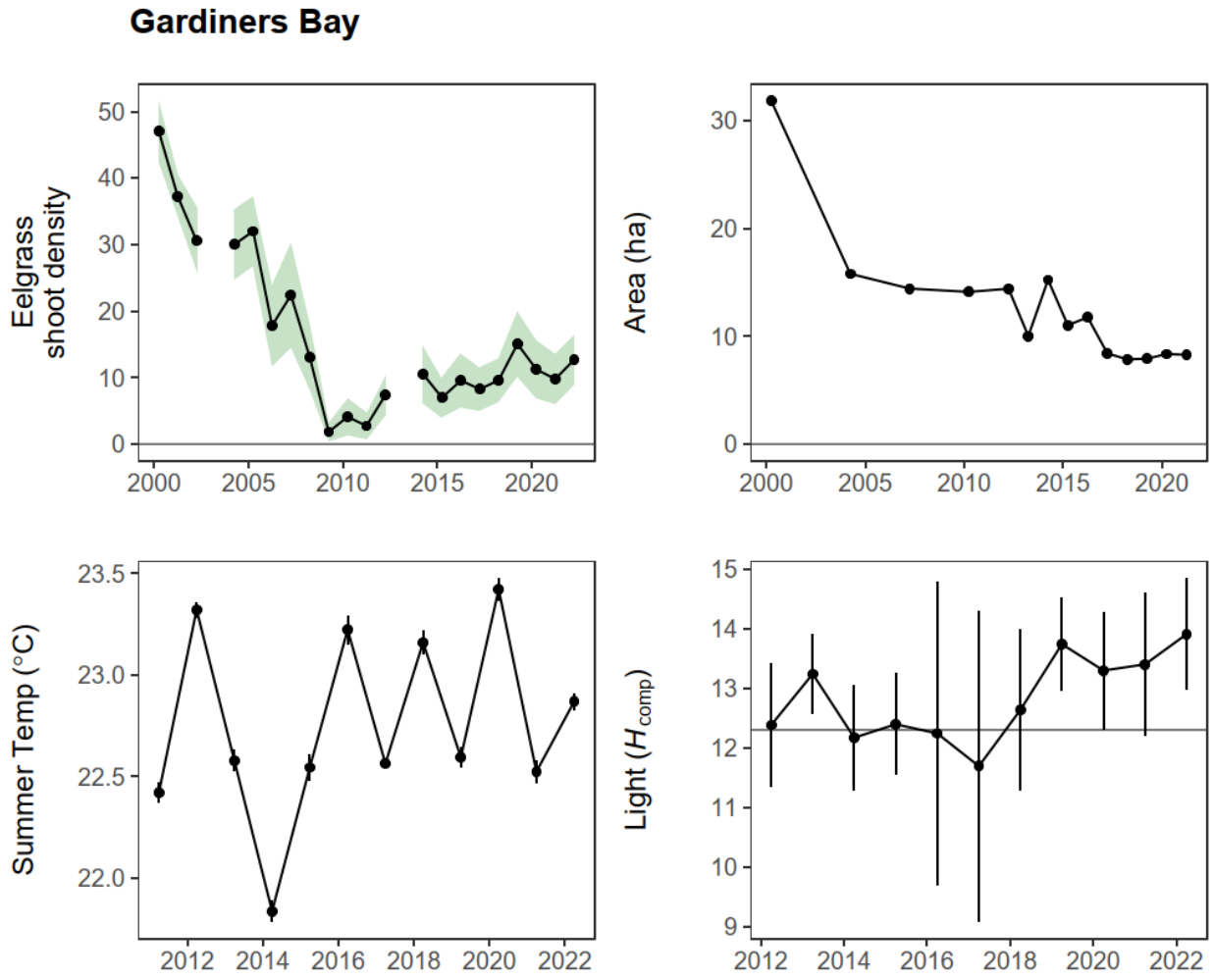
As of 2024, Sag Harbor is comprised of several individual meadows that are unique for being situated farther offshore relative to almost all other meadows in the Peconic Estuary. Further, this area is well-trafficked by boats with a large marina nearby. As such, it is the proposed site of management interventions such as conservation moorings and thus can function as an important sentinel for the resource in the face of human impacts such as anchoring.

Coecles Harbor



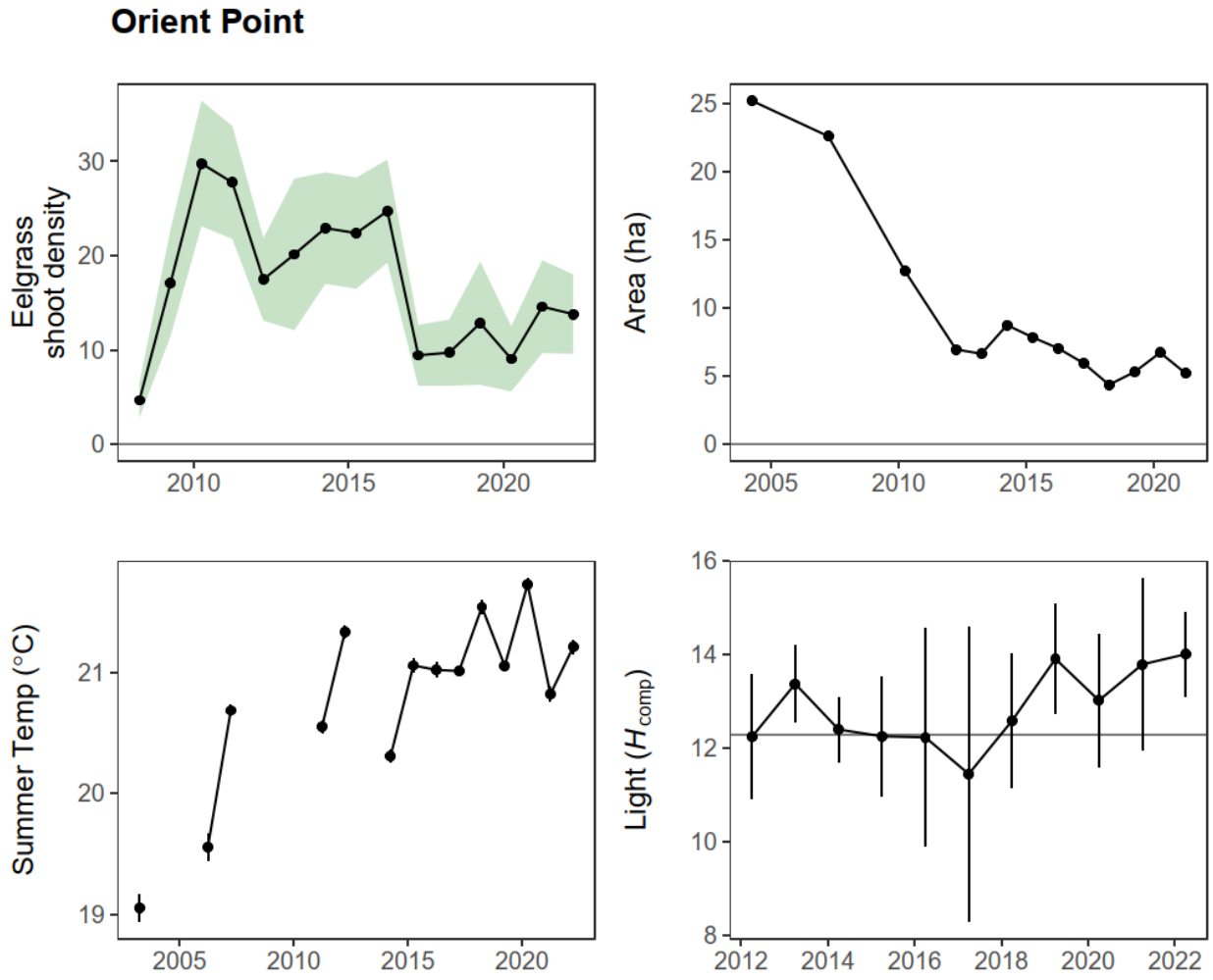
Coecles Harbor possesses one of if not the most extensive and stable eelgrass meadows in the Peconic Estuary. However, it has among the lowest shoot densities recorded, and when coupled with the observation that water temperatures have increased by nearly +2°C since 2017, suggests that Coecles Harbor may be among the more vulnerable meadows in the area, and can function as a sentinel for potential climate impacts.

Gardiners Bay



Gardiners Bay has seen some of the most dramatic losses of shoot density and extent in the Peconic Estuary over the past 20 years, not counting areas that have now become vacant of eelgrass (such as Orient Harbor, Northwest Harbor, Southold Bay, and some areas of Three Mile Harbor). While the temperatures remain relatively cool and sufficient light is available, it remains to be seen whether this area will continue its downward trajectory and why, or if it will rebound in the coming years.

Orient Point



Like Gardiners Bay, Orient Point has witnessed significant reductions in shoot density and extent since the mid-2010s. Understanding why this meadow has declined despite having some of the coolest temperatures in the Estuary is important in identifying critical impacts and deploying effective management interventions.

Cedar Beach Harbor or Nassau Point

Mapping in 2024 revealed several small widgeongrass meadows throughout the Peconic Estuary, including Cedar Beach Harbor, Nassau Point, and North Sea Harbor. Of these, the two former have larger and approximately equal extents. Thus, it is recommended that a monitoring site be established in either Cedar Beach Harbor or Nassau Point, depending on the condition of the meadows (whether they are sufficiently dense to viably establish 3 transects), their relative accessibility, and other logistical constraints.

Past in-water surveys have also observed widgeongrass alongside eelgrass in Bullhead Bay (in 2014) and in Three Mile Harbor (in 2015) despite not being detected in the 2014 aerial surveys. Thus, the proposed sites in Bullhead Bay should pay careful attention for the presence of widgeongrass, which can comingle with eelgrass throughout their shared range.

Environmental Monitoring

Summary: Monitor summertime light and temperature at the SeagrassNet monitoring sites.

The SeagrassNet protocol requires that temperature be recorded at the ends and midpoints of the shallowest and the deepest transects, for a total of 6 loggers at each site. It also suggests placing a logger on the shore to measure air temperature but given the density of comparable weather stations in the area, this is likely unnecessary. It is presently unclear whether this degree of logger replication is necessary, so to save on costs, a single logger at each of the shallowest and deepest transects is likely appropriate. The handbook suggests putting loggers out 2 weeks prior to sampling and to record every 10 minutes. The condition of seagrass on any given day is reflective of the accumulation of stress throughout the growing season, so putting the loggers out for the entire summer (e.g., from May to October) would be most desirable. In this case, having the loggers record once an hour to maximize battery life would be sufficient to create a temperature profile for each site.

The SeagrassNet protocol also recommends using combined temperature and light loggers. As these can be expensive and prone to failure, separate light loggers with less replication may be desirable. For example, having two loggers at each of the shallow and deep transects, with one logger at the surface and one near the bottom to be able to calculate *Kd* (the light attenuation coefficient), a metric that is directly implicated in available light for photosynthesis at the bottom. Since light conditions can vary on a day-to-day basis (for example, following severe winds or precipitation), it is perhaps less important to acquire a running time series of light but rather, to gain a general impression of each site during peak growing season. Thus, light loggers could be placed at a subset of "sentinel" sites or rotated among multiple sites on a shorter basis (e.g., every 2 weeks) to reduce total costs and still acquire relevant data.

Finally, PEP should explore the integrating other data streams on environmental conditions, such as those collected by PEP and partner organizations for water quality and indicators of watershed management (including land use change and specific management actions, such as septic upgrades), or of modeled outputs such as light. Curating a database of complementary environmental monitoring programs will enable more efficient analysis of the drivers of the status and trends of seagrasses in the Peconic Estuary.

Data Recommendations

Summary: Data should be curated and made available on public databases within one year of collection.

It is recommended that all data and metadata (including names and contact information of key personnel) be digitized into a machine-readable flat file (e.g., comma-separated values), curated for quality assurance, and hosted publicly within one year of the surveys being completed. Both local and off-site (e.g., cloud) backups are recommended in the event of a hard drive or other mechanical failure.

The Stony Brook Geospatial Center already hosts legacy datasets related to seagrass monitoring in the Peconic Estuary, including extent maps and in-water survey data, and is regularly backed-up. Therefore, it is recommended to continue to host all data outputs there. Additionally, SeagrassNet can mirror data pertaining to the in-water surveys of seagrass condition in their public portal, increasing the visibility and utility of the data for the global research community.