Long-Term Eelgrass Monitoring in the Peconic Estuary

Update of Results from the 2017-2019 Eelgrass Monitoring Seasons and Trends

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Presentation Outline

- **Background**
- **Monitoring Program**
- **Results and Trends**
  - **Physical Parameters: Temperature and Light Availability**
  - **Vegetative Analysis: eelgrass shoot density and macroalgae percent cover and species composition**
  - **Eelgrass Coverage**
- **Conclusions**
- **Acknowledgements**

Background

- The PEP CCMP Habitat and Living Resources Management Plan states as one of its objectives, “Develop and carry out an estuary-wide research, monitoring, and assessment program to guide and evaluate management decisions concerning the estuary and to ensure management and policy decisions are based on the best available information.”
- The basic purpose of the long term monitoring program (LTEMP) is to collect data, on a scheduled basis, in order to develop a basic understanding of the ecology of eelgrass (*Zostera marina* L.) in the Peconic Estuary and support management and policy decisions
- The PEP LTEMP is the only long-term dataset on eelgrass in New York waters

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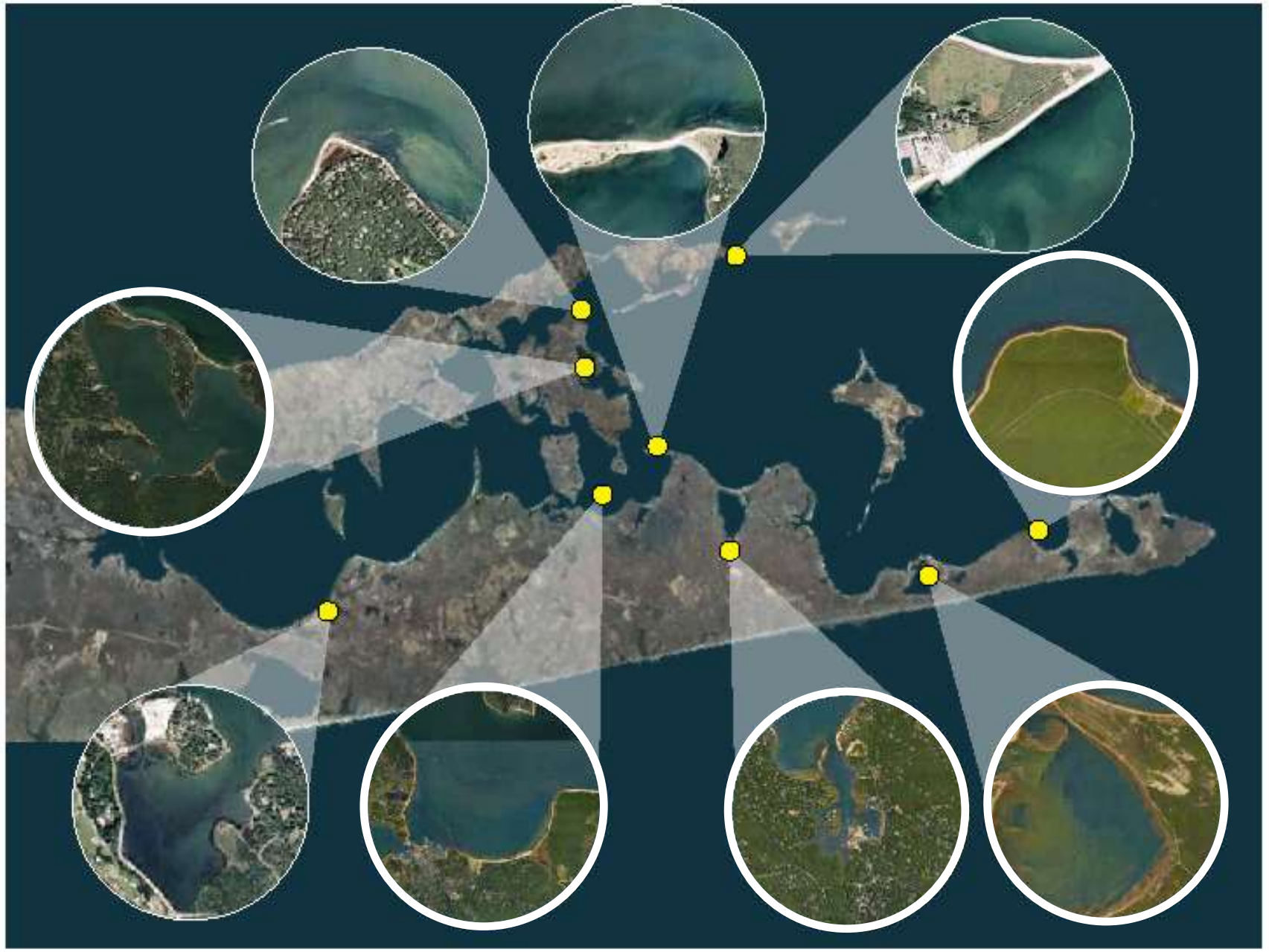
Monitoring Program

- **Currently, the program has nine sites (Bullhead Bay (Southampton), Cedar Point (E. Hampton), Coecles Harbor (Shelter Island), Fort Pond Bay (E. Hampton), Gardiners Bay (Shelter Island), Three Mile Harbor (E. Hampton; new), Napeague Bay (E. Hampton), Orient Point (Southold), and Sag Harbor (E. Hampton, Shelter Island, and Southampton) that are monitored annually.**



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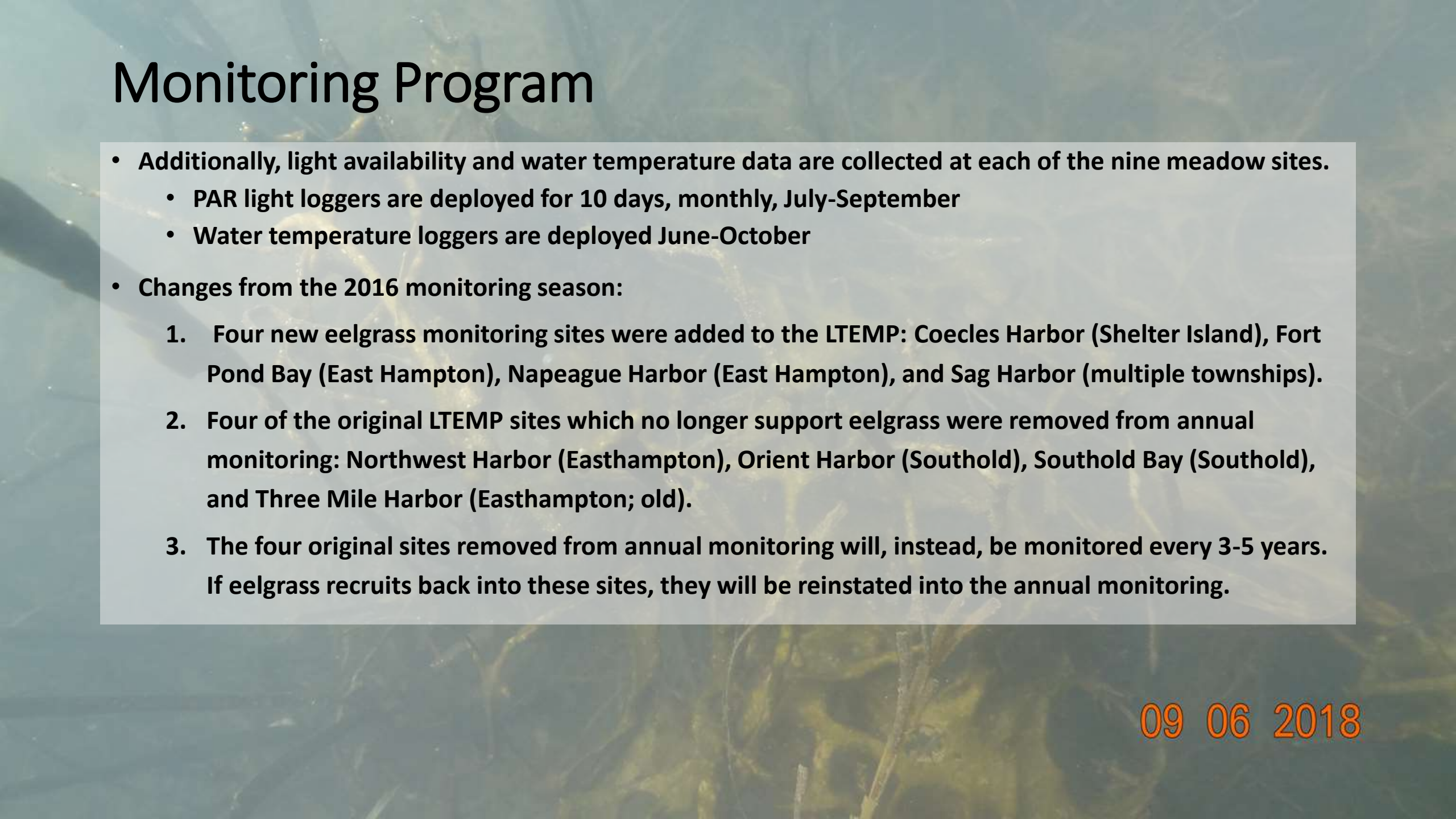
- **Each site has six (6) stations spread throughout the meadow, except for the Gardiners Bay site which has eight (8) stations**
  - **Station center points are set GPS locations that are revisited during annual monitoring visits.**
  - **Sampling is conducted within a 10 meter (33 foot) radius around the station center point.**
- **Eelgrass monitoring is conducted by CCE divers at each station. Divers use 0.10 meter^2 (~1 foot^2) PVC quadrats to sample the parameters below:**
  - **Vegetative Analyses:**
    - **Shoot density and shoot classification (vegetative or flower)**
    - **Macroalgae cover and species composition**
  - **Faunal Analysis**
    - **Species present**
    - **Enumeration of commercially-valuable shellfish species (e.g. clams, scallops, oysters)**
  - **Sediment sample collection, when necessary**
- **Divers also collect video footage of the conditions within each station.**

Monitoring Program

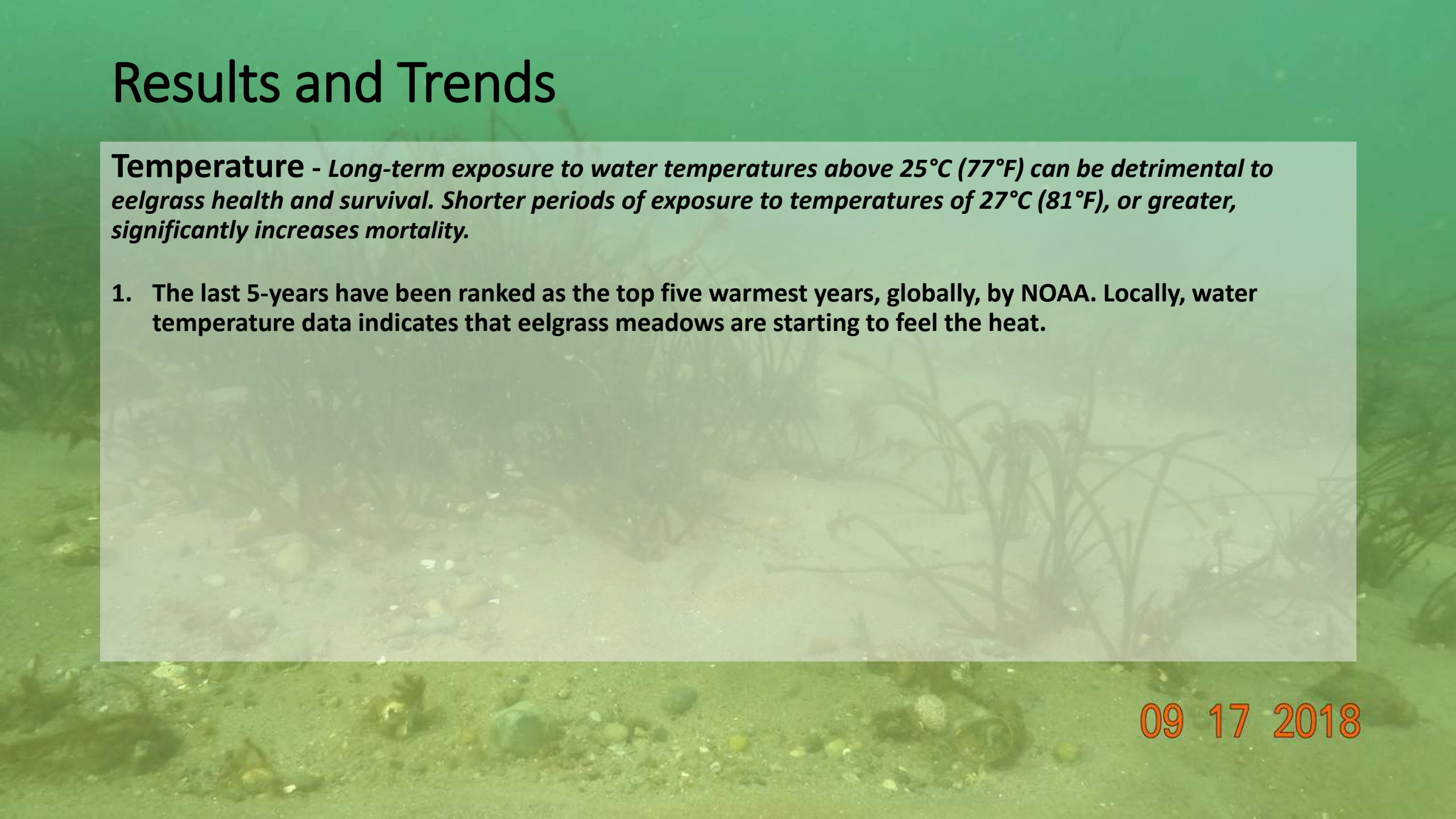
- **Additionally, light availability and water temperature data are collected at each of the nine meadow sites.**
  - **PAR light loggers are deployed for 10 days, monthly, July-September**
  - **Water temperature loggers are deployed June-October**
- **Changes from the 2016 monitoring season:**
  1. **Four new eelgrass monitoring sites were added to the LTEMP: Coecles Harbor (Shelter Island), Fort Pond Bay (East Hampton), Napeague Harbor (East Hampton), and Sag Harbor (multiple townships).**
  2. **Four of the original LTEMP sites which no longer support eelgrass were removed from annual monitoring: Northwest Harbor (Easthampton), Orient Harbor (Southold), Southold Bay (Southold), and Three Mile Harbor (Easthampton; old).**
  3. **The four original sites removed from annual monitoring will, instead, be monitored every 3-5 years. If eelgrass recruits back into these sites, they will be reinstated into the annual monitoring.**



Results and Trends

Temperature - ***Long-term exposure to water temperatures above 25°C (77°F) can be detrimental to eelgrass health and survival. Shorter periods of exposure to temperatures of 27°C (81°F), or greater, significantly increases mortality.***

1. **The last 5-years have been ranked as the top five warmest years, globally, by NOAA. Locally, water temperature data indicates that eelgrass meadows are starting to feel the heat.**



Results and Trends

Water Temperature - Number of 'extreme' temperature days

Meadow	2019		2018		2017		2016		2015		2014		2013		2012		2011		2010	
	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C	Days ≥ 25°C	Days ≥ 27°C
Bullhead Bay	59	43	75	44	49	11	16*	8*	72	25	52	2	50	21	69	29	54	24	52	27
Gardiners Bay	1	0	28	0	0	0	24	0	18	0	0	0	7	0	19	0	4	0	1	0
Cedar Point	0	0	15	0	0	0	1*	0*	2	0	0	0	1	0	ND	ND	2	0	1	0
Orient Point	0	0	0	0	1	1	0	0	0	0	0	0	ND	ND	0	0	0	0	ND	ND
New Three Mile Harbor	34	1	34	1	10	0	39	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Coecles Harbor	36	0	50	9	0	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fort Pond Bay	0*	0*	0	0	2	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Napeague Harbor	13	0	23	0	19	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sag Harbor	16	0	34	0	0	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Incomplete dataset due to lost or failed logger.

Results and Trends

Temperature - ***Long-term exposure to water temperatures above 25°C (77°F) can be detrimental to eelgrass health and survival. Shorter periods of exposure to temperatures of 27°C (81°F), or greater, significantly increases.***

1. **The last 5-years have been ranked as the top five warmest years, globally, by NOAA. Locally, water temperature data indicates that eelgrass meadows are starting to feel the heat.**

2. **Meadows occupying sheltered, shallow embayments should be the most susceptible to rising summer water temperatures. However, this does not seem to always be the case.**

    - **The Bullhead Bay meadow has consistently experienced the warmest water temperatures for the longest periods of time, yet is currently expanding to its year-2000 size.**

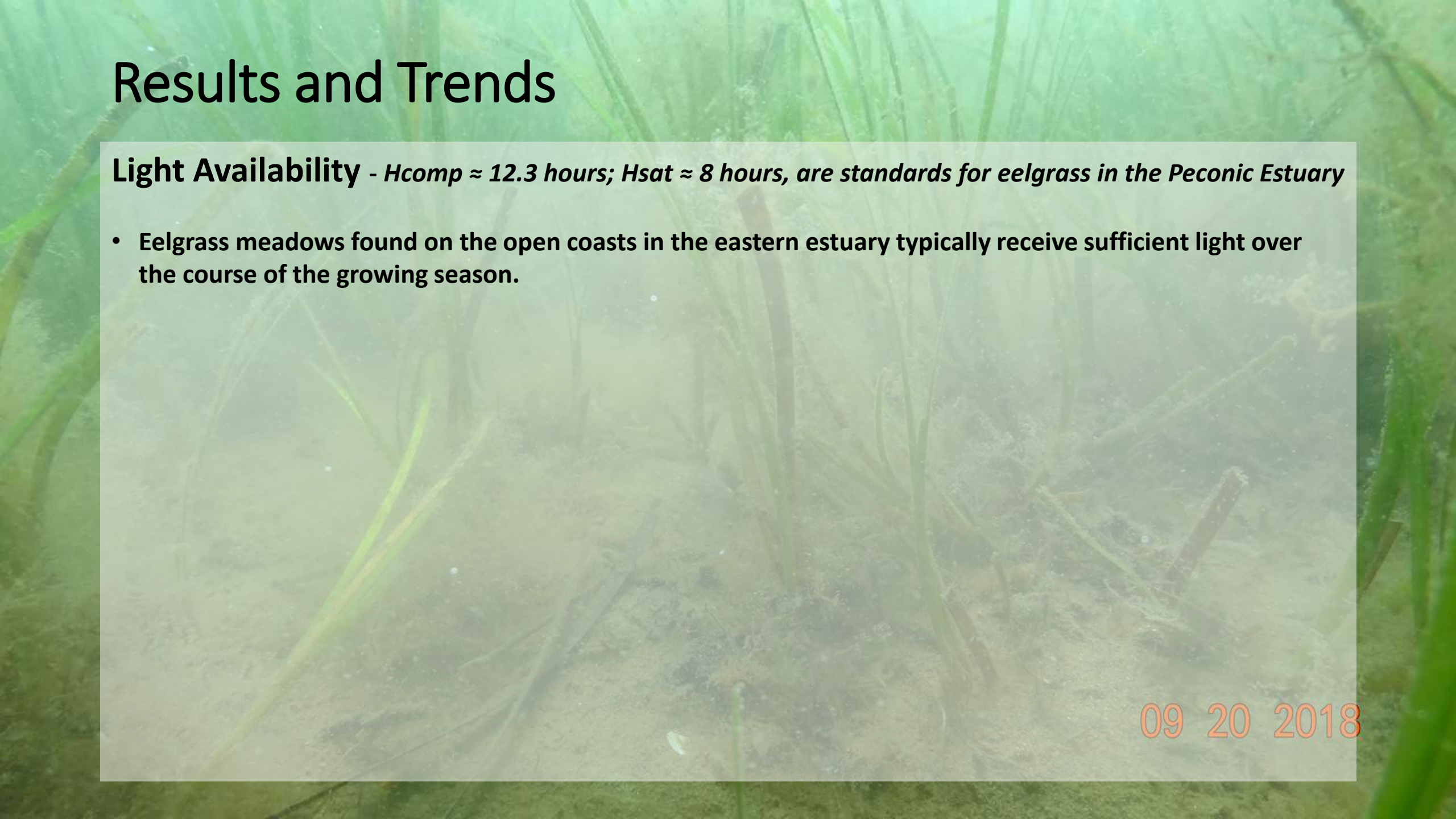
    - **Coecles Harbor and the New Three Mile Harbor meadows are shallow and have relatively low turnover rates, but continue to support relatively healthy eelgrass populations.**

    - **The key to their survival appears to be submarine groundwater discharge (SGD).**

Results and Trends

Light Availability - ***Hcomp ≈ 12.3 hours; Hsat ≈ 8 hours, are standards for eelgrass in the Peconic Estuary***

- **Eelgrass meadows found on the open coasts in the eastern estuary typically receive sufficient light over the course of the growing season.**



Results and Trends

Light Availability – Average hours for Hcomp and Hsat for July-September (2012-2019)

Meadow	2019		2018		2017		2016		2015		2014		2013		2012	
	Hcomp	Hsat	Hcomp	Hsat	Hcomp	Hsat	Hcomp	Hsat	Hcomp	Hsat	Hcomp	Hsat	Hcomp	Hsat	Hcomp	Hsat
Bullhead Bay	13.7 (+1.4)	13 (+5)	12.7 (+0.4)	9.9 (+1.9)	10.5 (-1.8)*	5.5 (-2.5)*	12 (-0.3)	6.3 (-1.7)*	12 (-0.3)	7.2 (-0.8)	9.9 (-2.4)	6.3 (-1.7)	13.4 (+1.1)	9.7 (+1.7)	12 (-0.3)	7.4 (-0.6)
Gardiners Bay	13.8 (+1.5)	13.1 (+5.1)	12.6 (+0.3)	9.9 (+1.9)	11.6 (-0.7)*	7.3 (-0.7)*	12.3 (0)	9.1 (1.1)	12.6 (0.3)	9.5 (1.5)	12.3 (0)	9.5 (+1.5)	13.3 (+1.0)	8.75 (+0.75)	13.1 (+0.8)	9.2 (+1.2)
Cedar Point	13.6 (+1.3)	12.7 (+4.7)	12 (-0.3)*	8.9 (+0.9)*	11.4 (-0.9)	7.3 (-0.7)	12.5 (0.2)	9.3 (1.3)	12.6 (0.3)	9.8 (1.8)	12.3 (0)	9.8 (+1.8)	12.9 (+0.6)*	10.2(+2.2)*	12.5 (+0.2)	8 (0)
Orient Point	13.9 (+5.6)	13.4 (+5.4)	12.8 (+0.5)	9 (+1)	11.3 (-1)	7.6 (-0.4)	12.2 (-0.1)	9.5 (1.5)	12.4 (0.1)	8.9 (0.9)	12.4 (+0.1)	9.8 (+1.8)	13.4 (+1.1)	9.8 (+1.8)	13 (+0.7)	9.2 (+1.2)
New Three Mile Harbor	13.4 (+1.1)	12.2 (+4.2)	12.7 (+0.4)	9.4 (+1.4)	12.3 (0)*	7.7 (-0.3)*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Coecles Harbor	13.6 (+1.3)	12.7 (+4.7)	11.9 (-0.4)	7.2 (-0.8)	8.0 (-4.3)*	2.3 (-5.7)*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fort Pond Bay	13.3 (+1)	12.7 (+4.7)	12.9 (+0.6)	10.2 (+2.2)	11.8 (-0.5)	8.1 (+0.1)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Napeague Harbor	13.6 (+1.3)	12.3 (+4.3)	12.7 (+0.4)	9.3 (+1.3)	12 (-0.3)	7.3 (-0.7)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sag Harbor	13.4 (+1.1)	12.9 (+4.9)	12.7 (+0.4)	9.5 (+1.5)	10.1 (-2.2)	7.1 (-0.9)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Incomplete dataset due to lost or failed logger.

Results and Trends

Light Availability - ***Hcomp ≈ 12.3 hours; Hsat ≈ 8 hours, are standards for eelgrass in the Peconic Estuary***

- **Eelgrass meadows found on the open coasts in the eastern estuary typically receive sufficient light over the course of the growing season.**
- **Light data collected from meadows in sheltered embayments are less likely to meet minimal light requirements…but these meadows continue to survive.**
    - **Reasons for inconsistency between data and reality could include how data is collected (stationary logger at set depth).**
    - **Eelgrass actively adapts to conditions in relatively short periods of time.**
- **The model presented earlier suggests that light may not be as important a factor as previously thought.**

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Results and Trends

Eelgrass Shoot Density

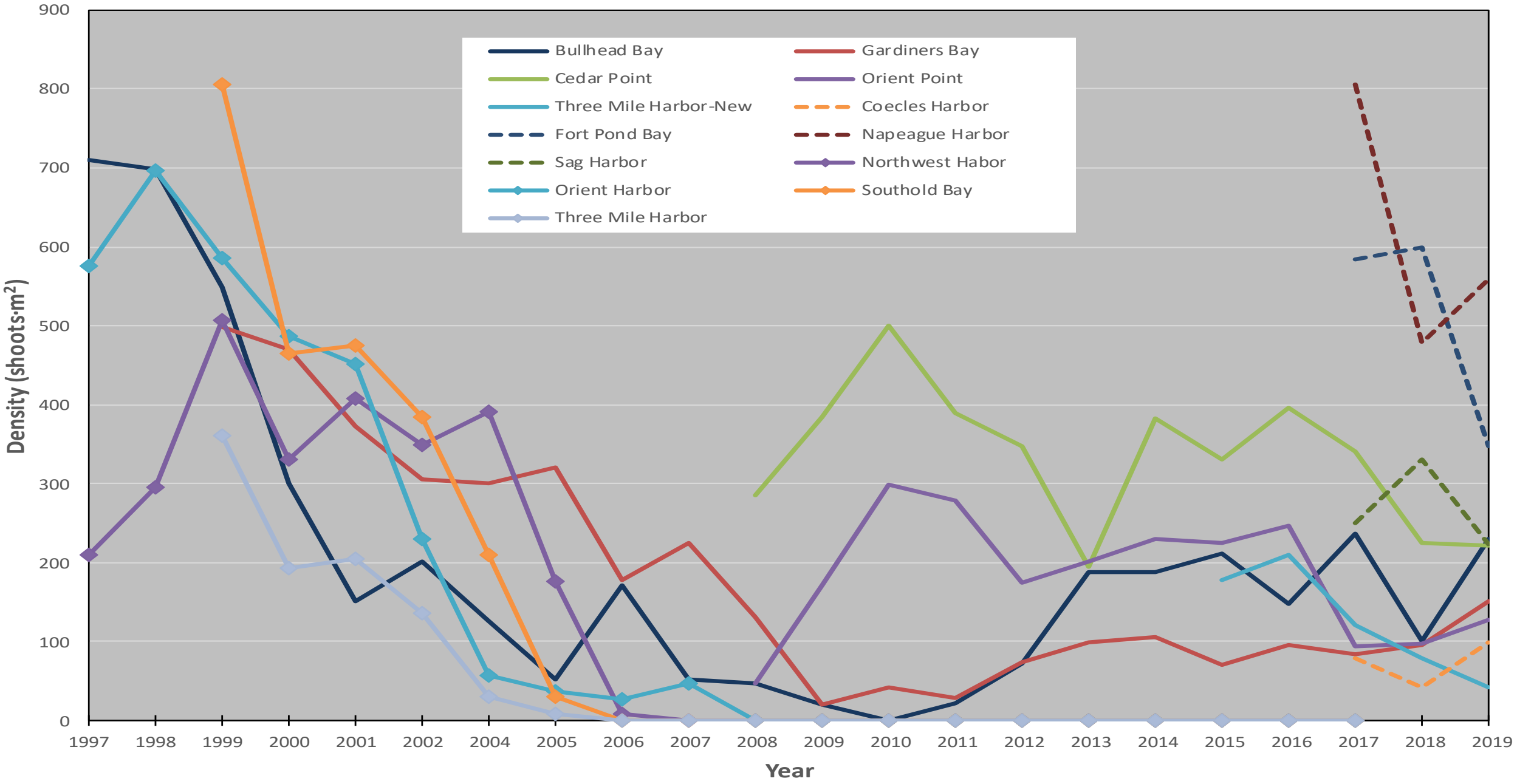
1. **Over the last three seasons (2017-2019), three sites (Bullhead Bay, Gardiners Bay, and Orient Point) recorded a net increase in shoot density, two sites (Coecles and Sag Harbors) showed no net change, and the remaining four sites experienced varied levels of density decline.**

Results and Trends

Eelgrass shoot density - Annual mean eelgrass shoot densities (shoots·m^2) for all monitoring sites from 1997-2019

	SITES												
Year	Bullhead Bay	Gardiners Bay	Northwest Habor	Orient Harbor	Southold Bay	Three Mile Harbor	Cedar Point	Orient Point	Three Mile Harbor-New	Coecles Harbor	Fort Pond Bay	Napeague Harbor	Sag Harbor
1997	710		209	575									
1998	699		296	697									
1999	548	498	507	586	805	361							
2000	301	470	330	487	465	192							
2001	150	372	407	451	475	205							
2002	201	305	349	229	384	135							
2004	126	300	391	56	210	29							
2005	52	320	176	36	30	8							
2006	171	178	8	27	0	0							
2007	51	224	0	47	0	0							
2008	46	131	0	0	0	0	285	47					
2009	19	19	0	0	0	0	385	171					
2010	0	41	0	0	0	0	500	298					
2011	22	28	0	0	0	0	389	278					
2012	71	74	0	0	0	0	348	175					
2013	188	99	0	0	0	0	195	201					
2014	188	106	0	0	0	0	382	229					
2015	211	70	0	0	0	0	331	224	177				
2016	147	96	0	0	0	0	396	247	209				
2017	236	83	0	0	0	0	341	94	120	78	584	806	249
2018	100	96	ND	ND	ND	ND	225	97	79	41	600	479	331
2019	230	151	ND	ND	ND	ND	221	128	42	99	348	559	223

Orange Cells=Year 1 shoot density; Red Cells=Year where shoot density declined from previous year; Green Cells=Year where shoot density increased from previous year; Dark Gray=No significant change.


Bullhead Bay
Cedar Point
Three Mile Harbor-New
Fort Pond Bay
Sag Harbor
Orient Harbor
Three Mile Harbor
Gardiners Bay
Orient Point
Coecles Harbor
Napeague Harbor
Northwest Habor
Southold Bay
Density (shoots·m²)
900
800
700
600
500
400
300
200
100
0
1997
1998
1999
2000
2001
2002
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year

Results and Trends

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2. **Meadow patchiness has increased in the meadows at Gardiners Bay, Cedar Point, Orient Point, Napeague Harbor and Fort Pond Bay.**

    - **Increase in storm events is the likely cause of erosional damage to the meadows in open coast sites.**

    - **The southern extent of Napeague Harbor experiences anthropogenic disturbance from boating and moorings in the shallow meadow.**

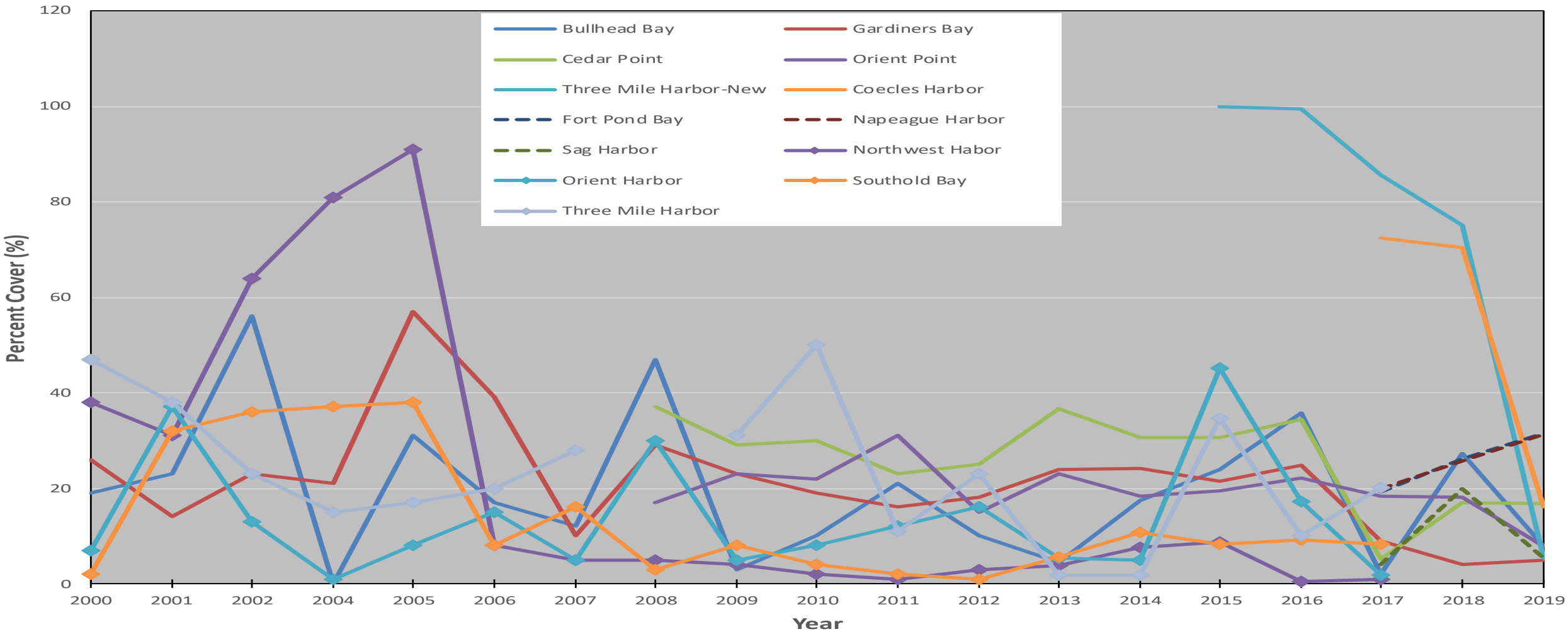
3. **The general trend evident across most of the meadows has been a decline from first reported densities for each site, with exceptions:**

    - **Orient Point (net increase from 2008) and Coecles and Sag Harbors (no significant change)**

    - **The Bullhead Bay meadow was near extinction in 2010, but has undergone a remarkable recovery in both the density and extent of the meadow.**

Results and Trends

Macroalgae Cover - At a glance, the macroalgae cover data looks to be chaotic with no obvious trends.



Results and Trends

Macroalgae Cover

However…

1. **For the meadows in the LTEMP, macroalgae cover has been found to respond to changes in eelgrass density/cover.**
   - **In soft or sandy sediment meadows with minimal hard substrate, significant declines in eelgrass density can result in a corresponding decline in the macroalgae cover at the site.**
   - **In eelgrass meadows on more exposed shore that have coarser substrates, the loss of eelgrass cover can lead to loss of fine sediments, exposure of hard substrates, and alleviation of competition, resulting in an increase in macroalgae cover.**
2. **Collecting data on the macroalgae community in eelgrass meadows provides some valuable data.**
   - **Non-native species have been observed in meadows, including *Grateloupia turuturu*, *Dasysiphonia japonica*, and *Gracilaria vermiculophylla* (needs biomolecular verification)**
   - **Changes in species composition in meadows may indicate environmental changes the meadow is experiencing (e.g. temperature shifts, changes in hydrodynamics, etc.)**

Results and Trends

Areal Coverage (Acreage) Change – Eelgrass meadow delineations based on current year's aerial imagery and groundtruthing. Changes in meadow area greater than 10% are identified with green (increased area) or red (decreased area). No color indicates less than 10% change.

	SITES								
Year	Bullhead Bay	Gardiners Bay	Three Mile Harbor-New	Cedar Point	Orient Point	Coecles Harbor	Fort Pond Bay	Napeague Harbor	Sag Harbor
2000	54.75	78.64	0*	35.2*	7.59*	10.21*	1.45*	15.33*	63.74
2004	10.87	39.03	ND	164.18	62.24	ND	ND	ND	ND
2007	ND**	35.65	ND	224.46	55.8	ND	ND	ND	ND
2010	5.58	34.88	ND	144.96	31.39	ND	ND	ND	ND
2012	30.5	35.62	ND	127.27	17.18	ND	ND	ND	ND
2013	44.65	24.79	ND	96.55	16.4	ND	ND	ND	ND
2014	56.92	37.65	0.72	85.76	21.6	111.67	40.49	21.39	52.4
2015	39.94	27.25	ND	84.8	19.4	ND	ND	ND	ND
2016	34.21	29.08	ND	90.05	19.4	ND	ND	ND	ND
2017	47.0	20.8	0.81	77.1	14.7	102	35.8	17.6	50.3
2018	56.12	19.45	0.67	73.6	10.8	88.4**	14.8**	13.4	12.7**
2019	57.85	19.58	1.19	69.78	13.08	119.77	21.19	15.51	37.55

* Meadows grossly underestimated or missed entirely. **Poor aerial image quality for site resulted in conservative or incomplete delineation.

Bullhead Bay, Southampton

Gardiners Bay, Shelter Island

Conclusions

Temperature

Water temperatures in the Peconic Estuary have been warming.

- **Sites in the eastern estuary have recorded an increasing number of days above critical temperatures.**
- **Meadows in in sheltered bays (Bullhead Bay, Coecles Harbor, Three Mile Harbor) are experiencing longer periods of time above critical temperature and also reporting higher temperatures than before.**
  - **Groundwater appears to be mitigating these temperatures for now, however, with global climate change, increased frequency of drought could result in a lessen of groundwaters impact on the meadows.**
  - **Eelgrass populations may be 'turning on' genes that will help them adapt to warming conditions.**

Light Availability

Light does not appear to be a limiting factor for eelgrass in the Peconic Estuary

- **The model presented today supports this assertion.**
- **Meadows growing in sheltered embayments with a history of low light remain healthy, due to eelgrass's ability to adapt to these conditions.**
- **Inshore migration – deep edges on several meadows have become shallower over time.**
  - **Response to sea level rise.**
  - **Hardened shorelines will have greater influence on meadows in the future.**

Conclusions

Eelgrass

Eelgrass cover in Peconic Estuary has experienced a general decline over the last 20 years; a trend that is being reported globally for seagrasses.

- **Four of the original LTEMP meadows have been lost, and the remaining meadows have seen significant net decline.**
- **Multiple factors are impacting eelgrass health**
  - **Water quality, temperature, climate change, and anthropogenic impacts (e.g. boating, hardened shores) all impact eelgrass populations.**
  - **Increasing frequency and intensity of storms, due to climate change, could prove to be as important an impact on eelgrass meadows as high water temperatures.**
- **Bullhead Bay has shown that eelgrass has the ability to recover from events resulting in large-scale losses to the population.**
  - **Die-off/die-back events could be a way for an eelgrass meadow to 'reset'.**
  - **Recruitment from seed increases genetic diversity in a meadow which has been reported to increase resilience.**
  - **Seedlings are better able to 'turn on' genes to adapt to conditions than adult plants.**

Conclusions

Macroalgae Cover and Species

The macroalgae community may provide insight regarding changes and impacts that may influence the eelgrass meadows in the future.

- **Changes in species composition could indicate evolving conditions at a site.**
  - **An increase in large seaweeds at a site could result from loss of fine sediments due to frequent storms.**
  - **Increases in average water temperatures could favor 'southern species', including non-natives, resulting in displacement of native macroalgae.**
- **The introduction of non-native macroalgae, either human-mediated or natural range expansion, could result in new competitive situations between eelgrass and non-native (e.g. *Gracilaria vermiculophylla*).**

Areal Coverage

Eelgrass meadows, with exceptions, have been declining in overall size since the 2000 survey.

- **Meadow fragmentation/patchiness has increased in many meadows on open shorelines.**
  - **Superstorm Sandy caused significant erosional damage to many meadows that has been continuously exacerbated by the increased frequency of storm events with global climate change.**
  - **Boating activity (prop scars and moorings) within meadows increased fragmentation and provides edges for erosional forces (physical and biological) to act on.**

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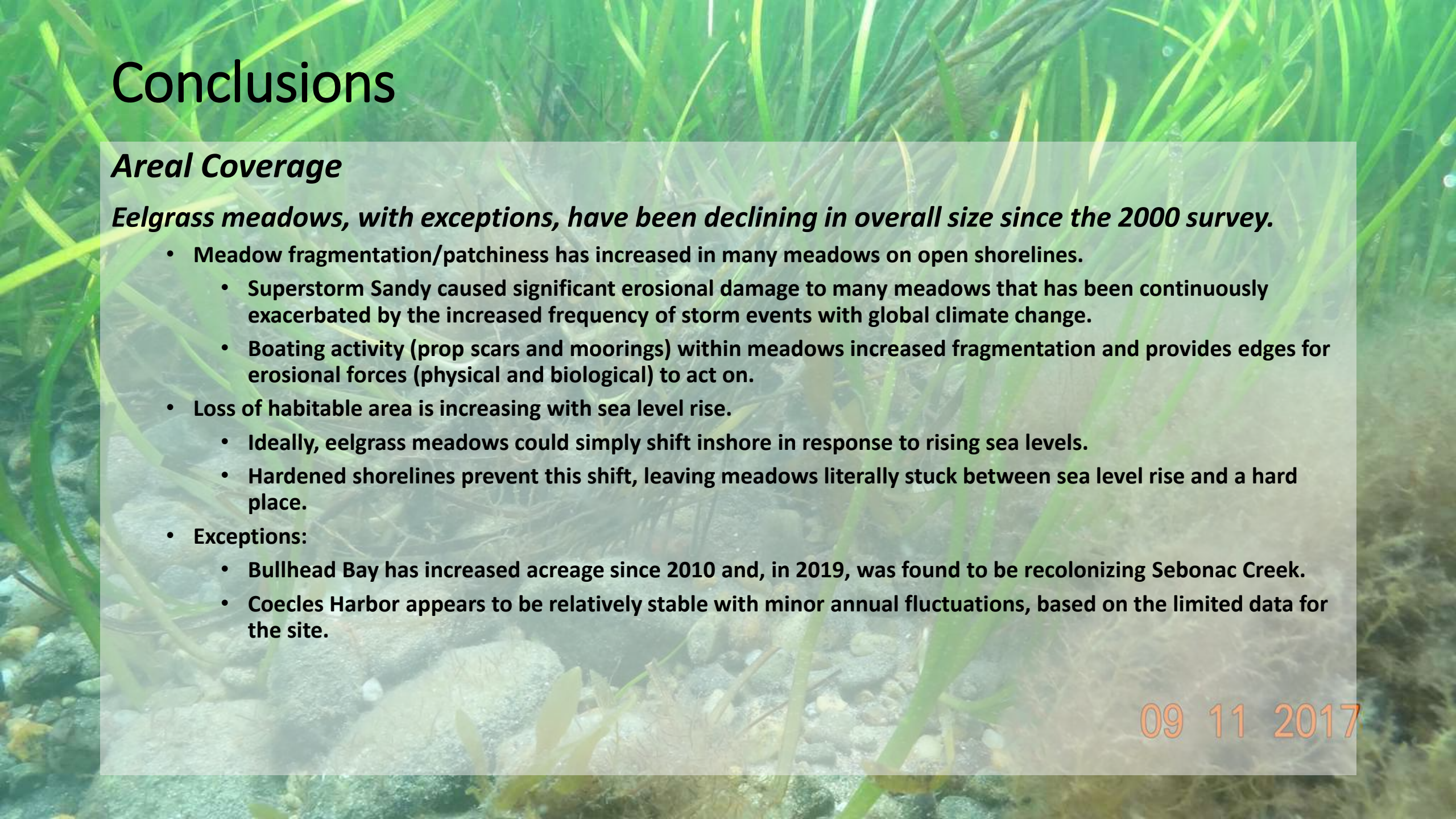
  - **Boating activity (prop scars and moorings) within meadows increased fragmentation and provides edges for erosional forces (physical and biological) to act on.**
- **Loss of habitable area is increasing with sea level rise.**
  - **Ideally, eelgrass meadows could simply shift inshore in response to rising sea levels.**
  - **Hardened shorelines prevent this shift, leaving meadows literally stuck between sea level rise and a hard place.**
- **Exceptions:**
  - **Bullhead Bay has increased acreage since 2010 and, in 2019, was found to be recolonizing Sebonac Creek.**
  - **Coecles Harbor appears to be relatively stable with minor annual fluctuations, based on the limited data for the site.**



Acknowledgements

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Questions?