U.S. Fish & Wildlife Service

2009 Eelgrass Survey for Eastern Long Island Sound, Connecticut and New York

May 2010

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2009 Eelgrass Survey for Eastern Long Island Sound, Connecticut and New York

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Introduction

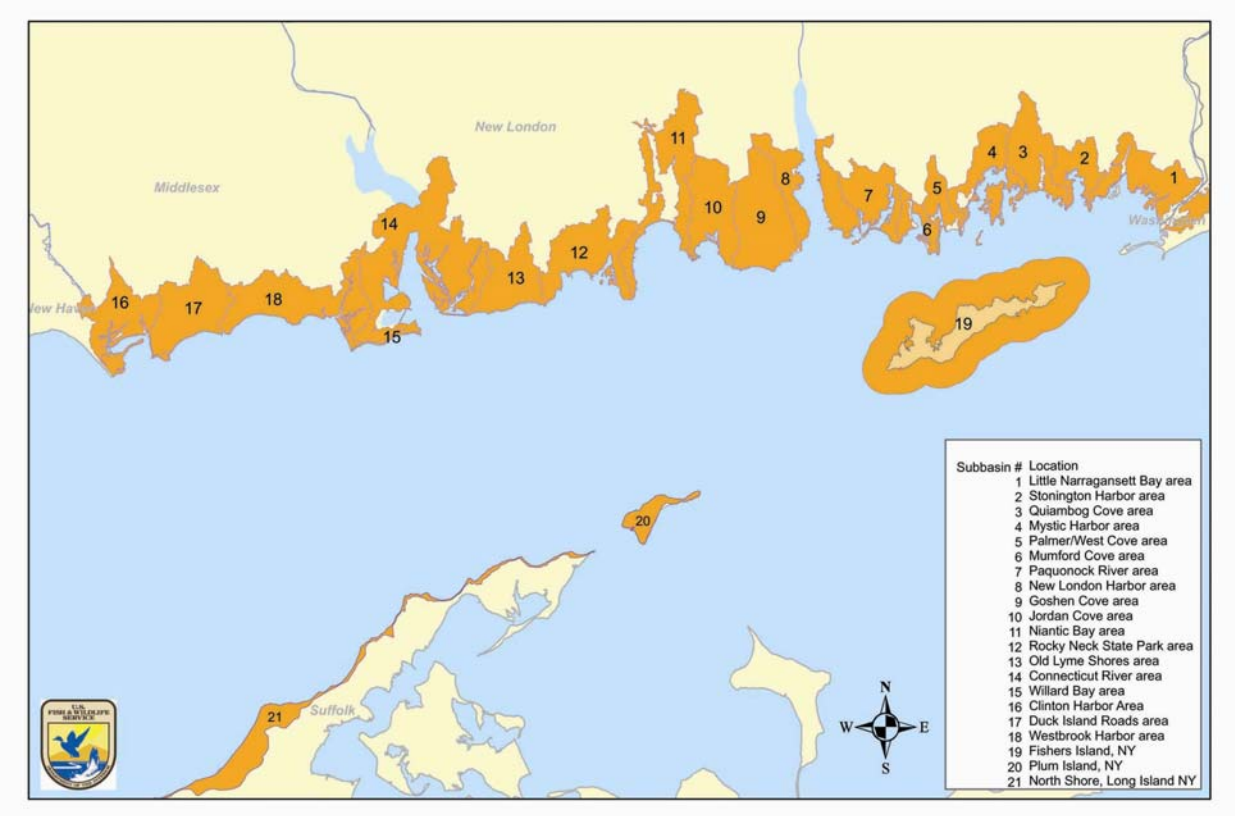
The U.S. Fish and Wildlife Service's National Wetlands Inventory Program (NWI) has conducted eelgrass inventories for the eastern end of Long Island Sound since 2002. To date, three surveys have been conducted: one in 2002, another in 2006, and the most recent in 2009. These inventories were started because the State of Connecticut's Office of Long Island Sound Programs was interested in learning the status of eelgrass beds in 2001 and wanted the beds monitored periodically. Eelgrass beds are vital habitats for marine and estuarine biota. To date, the NWI has produced reports on each of the earlier inventories (Tiner et al. 2003, 2006).

In 2008, the U.S. Environmental Protection Agency provided funding to update this survey. This report outlines the methods used in the survey, summarizes inventory results, compares the findings with the 2006 survey, and provides detailed maps showing the location of eelgrass (*Zostera marina*) beds detected during the 2009 survey.

Study Area

The project area encompasses the eastern end of Long Island Sound, including Fishers Island and the North Fork of Long Island (Figure 1). It includes all coastal embayments and nearshore waters (i.e., to a depth of –15 feet at mean low water) bordering the Sound from Clinton Harbor in the west to the Rhode Island border in the east and including Fishers Island and the North Shore of Long Island from Southold to Orient Point and Plum Island. The study area includes the tidal zone of 18 sub-basins in Connecticut: Little Narragansett Bay, Stonington Harbor, Quiambog Cove, Mystic Harbor, Palmer-West Cove, Mumford Cove, Paquonock River, New London Harbor, Goshen Cove, Jordan Cove, Niantic Bay, Rocky Neck State Park, Old Lyme Shores, Connecticut River, Willard Bay, Westbrook Harbor, Duck Island Roads, and Clinton Harbor, and two areas in New York: Fishers Island and a portion of the North Shore of Long Island.

Figure 1. Location of eelgrass survey study area, with coastal sub-basins identified.



Methods

Acquisition of Aerial Photography

The National Oceanic and Atmospheric Administration's Coastal Change Analysis Program has developed aerial photography specifications for mapping submerged aquatic beds in coastal regions (Dobson et al. 1995). June is the recommended flying time for submersed rooted vascular plants in the Northeast.

The photography for this project was 1:20,000 true color aerial photography captured during low tide on July 14-15, 2009. Figure 1 shows an example of a portion of one aerial photo used in this study.

Eelgrass Database Construction

Aerial photographs were scanned to create digital images for interpretation. Digital imagery was interpreted on-screen by an experienced photointerpreter who delineated eelgrass beds and created a digital database of these beds. Three categories of aquatic beds were initially identified: 1) eelgrass beds, 2) areas where eelgrass beds were suspected to exist, and 3) areas that had aquatic vegetation but not eelgrass. This aquatic bed database was forwarded to field personnel for preparation of maps to review in the field. Based on review comments, aerial photos were re-examined, needed revisions made, and the eelgrass database was finalized. In some cases, very small beds that were identified during the field survey were mapped as points and buffered to yield a polygon of 0.1-acre in size.

Bed density was determined using spectral signatures in the current imagery. The 2006 and 2002 surveys and field observations were used to help identify these signatures in the initial drafts. Field observations from 2009 were then incorporated into the final revision and took precedence over previous density identifications.

Field Work

Field work was performed by Service personnel from the Southern New England Coastal Program Office (SNEP). Ten days were spent in the field verifying locations of potential eelgrass beds during the fall of 2009: October 21, 22, and 26, November 9, 17, 18, 19, and 24, and December 2 and 10. A total of 193 points were inspected: 79 were identified as eelgrass beds. Specific coordinates (latitude/longitude) were recorded using GPS technology. These data were added to the digital database. The entire breadth of individual eelgrass beds was not assessed; several points were evaluated within the mapped beds.

Figure 2. Portion of 2009 true color aerial photo showing eelgrass beds (dark-colored areas) in front of sandy island in the Little Narragansett Bay (enlarged; original scale 1:20,000). Town of Stonington is visible in upper left corner.

Biologists estimated and recorded the density of eelgrass in the beds by eye from the boat or by area observation using an underwater camera. Eelgrass beds were placed in three general cover categories based on relative density of eelgrass leaves derived by visual inspection: high, medium, and low. An underwater video camera mounted on an aluminum pole was used to examine potential eelgrass beds where beds or bottoms were not visible from the boat. The underwater camera was used the majority of time. Exceptions to this were clear shallow waters where the bottom could be easily seen from the boat, very shallow waters where an inflatable dingy was required for access, and other locations where investigators could easily walk in shallow water at low tide and observe the substrate. Where necessary, a view tube (plastic tube about 4 inches in diameter and 3 feet long with clear lens on one end) was used to view the bottom and the presence or absence of eelgrass.

Map Production

Using GIS techniques, 2009 eelgrass bed delineations and field check sites were superimposed on the 2009 digital ortho-imagery. These images served as the base maps for geospatial registration of beds. Two sets of maps were prepared: one showing 2009 beds by plant density and the other showing changes in the beds from 2006-2009. All maps are presented in the Appendix.

Results

Maps

A total of 16 maps (two sets of eight maps) were prepared (Appendix). The study area was divided into eight map areas: 1) Clinton Bay-Westbrook Harbor-Duck Island Roads, 2) Willard Bay-Connecticut River-Old Lyme Shores-Rocky Neck State Park, 3) Fishers Island, 4) Niantic Bay-Jordan Cove-Goshen Cove, 5) New London-Paquonock River-Mumford Cove, 6) Palmer-West Cove-Mystic Harbor-Quiambog Cove, 7) Stonington Harbor-Little Narragansett Harbor, and 8) North Shore (Long Island, New York). The first map of the set shows the distribution of the beds by density (high, medium, and low) in multiple sub-basins, while the second map shows changes (gain, loss, or no change) between 2006 and 2009. The first map also shows the approximate location of field check sites.

Field Review

Nearly two hundred (193) sites were field inspected to verify the presence or absence of eelgrass. Seventy-nine sites were confirmed to have eelgrass; some were multiple sites within a single bed. Fifty-five beds were verified in the field (Table 1). Three additional beds (not visible on the imagery) were added as point beds based on field observations. The latter beds occurred in the Fishers Island waters. (*Note: Time and budget did not allow for all beds to be examined; this was also beyond the project scope of work.*)

Table 1. Number of eelgrass beds in each sub-basin and number verified in 2009; other beds were not field-checked.

Sub-basin Eelgrass	# Beds Mapped	#Beds Verified	Sub-basin	# Beds Mapped	# Beds Verified
Fishers Island (NY)	47*	15	Goshen Cove	6	0
Mystic Harbor	11	3	Palmer-West Cove	2	1
Quiambog Cove	15	7	Stonington Harbor	12	1
Jordan Cove	7	3	New London Harbor	7	1
Niantic Bay	10	2	Duck Island Roads	2	0
Little Narragansett Bay	14	5	Mumford Cove	9	4
Paquonock River	7	1	North Shore (NY)	5	3
Plum Island (NY)	1	1	Rocky Neck State Park	16	7
Connecticut River Area	1	1			

*Includes three beds identified in the field that were not visible on the imagery.

Extent of Eelgrass

A total of 172 eelgrass beds accounting for 1,980 acres were inventoried (Table 4). Figure 3 shows the location of eelgrass beds in the study area as of July 2009. More detailed maps showing the location, size, and shape of these beds in each sub-basin and location of field check sites are presented in the Appendix.

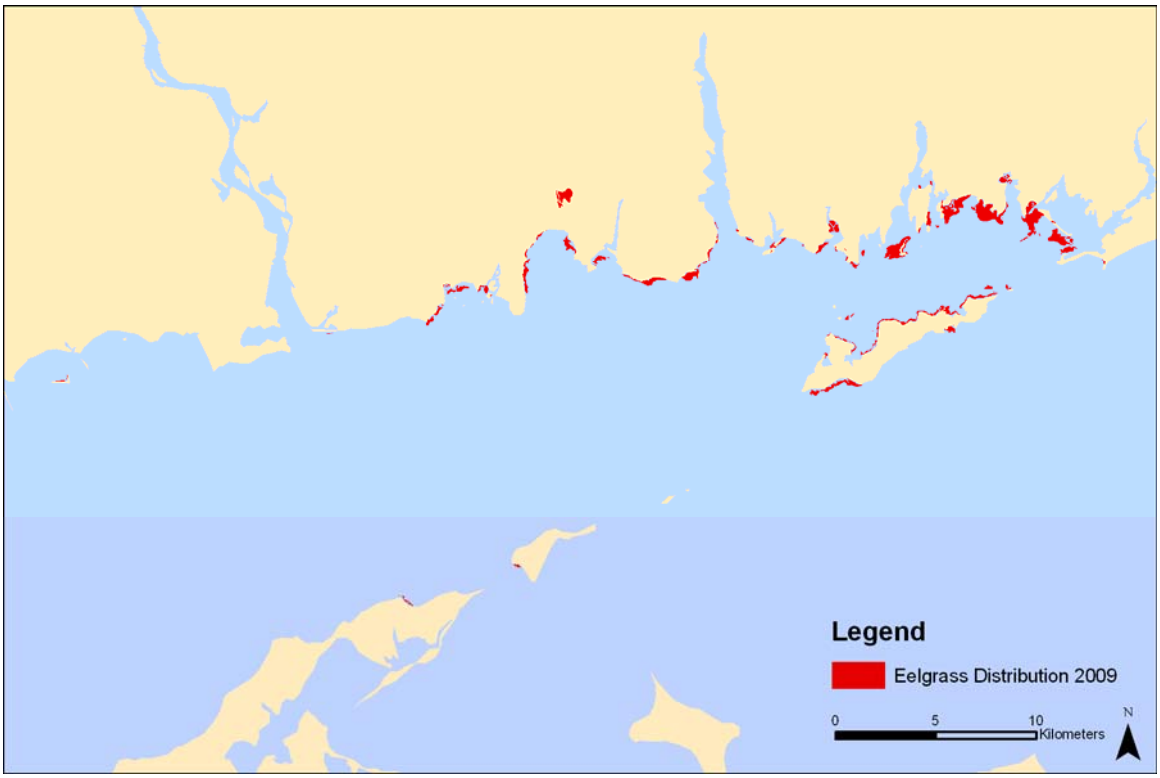
Most (63%) of the sites with eelgrass were estimated to have medium stem density (Table 4). They accounted for nearly 1,209 acres. High density beds totaled 615 acres based on an inventory of 36 such beds. Only 157 acres of low density beds were inventoried.

Seven sub-basins had over 100 acres of eelgrass beds. Quiambog Cove had the most acreage with 407 acres. Two areas had over 300 acres of eelgrass: Fishers Island (346) and Little Narragansett Bay (343), while Niantic Bay had about 212 acres. The remaining sub-basins with more than 100 acres of beds were Mystic Harbor (162), Goshen Cove (124), and Rocky Neck State Park (103).

Table 4. Eelgrass beds in eastern Long Island Sound in 2009. Sites are in Connecticut, except where noted otherwise. *Note: Three beds located in the field but not visible on the image were represented as points and given a value of 0.1 acre each.*

Sub-basin	Acres of High Density (number)	Acres of Medium Density (number)	Acres of Low Density (number)	Total Acres (number)
Little Narragansett Bay	103.9 (2)	177.5 (9)	61.5 (3)	343.0 (14)
Stonington Harbor	--	40.5 (5)	15.2 (7)	55.7 (12)
Quiambog Cove	181.2 (2)	199.3 (10)	26.8 (3)	407.3 (15)
Mystic Harbor	74.2 (4)	83.8 (6)	3.8 (1)	161.7 (11)
Palmer-West Cove	8.5 (1)	14.2 (1)	--	22.7 (2)
Mumford Cove	3.1 (1)	76.3 (7)	2.7 (1)	82.1 (9)
Paquonock River	7.5 (1)	14.0 (5)	2.6 (1)	24.1 (7)
New London Harbor	21.6 (3)	12.0 (4)	--	33.5 (7)
Goshen Cove	--	124.4 (6)	--	124.4 (6)
Jordan Cove	0.4 (1)	38.0 (6)	--	38.4 (7)
Niantic Bay	43.9 (2)	167.9 (8)	--	211.9 (10)
Rocky Neck State Park	8.8 (4)	64.0 (7)	29.9 (5)	102.7 (16)
Connecticut River Area	--	--	2.1 (1)	2.1 (1)
Duck Island Roads	--	--	6.4 (2)	6.4 (2)
Fishers Island, NY	149.0 (11)	191.3 (33)	5.6 (3)	345.9 (47)
North Shore, NY	5.0 (3)	5.5 (2)	--	10.5 (5)
Plum Island, NY	7.6 (1)	--	--	7.6 (1)
Total	614.7 (36)	1,208.7 (109)	156.6 (27)	1,980.0 (172)

Figure 3. General distribution of eelgrass in eastern Long Island Sound based on a 2009 survey by the U.S. Fish and Wildlife Service.



Comparison with Earlier Surveys

When comparing 2009 findings (Table 3) with 2006 survey results (Table 4), we see that a total of four fewer beds and 46 less acres of eelgrass beds were detected in 2009. Table 5 highlights changes in total acreage and number of eelgrass beds for the sub-basins since the initial survey back in 2002. From 2006-2009, eelgrass acreage increased in six sub-basins compared to gains recorded in 11 sub-basins from 2002-2006. Ten sub-basins lost eelgrass from 2006-2009, while only five lost acreage from 2002-2006. The largest acreage gain was found in Little Narragansett Bay where 60 new acres established. This increase accounted for 53 percent of the net gains experienced by the six sub-basins (+114.2 acres). Two other areas with substantial acreage gains of more than 20 acres were Fishers Island and Mystic Harbor. While Mumford Cove experienced the largest loss of eelgrass from 2002-2006 (11-acre loss), eelgrass acreage increased there by seven acres from 2006-2009. A new bed about two acres in size was detected at Griswold Point at mouth of the Connecticut River. Loss of eelgrass was greatest in Niantic Bay where 57 acres disappeared. This is more than the combined loss of the next two sub-basins with substantial losses: Goshen Cove and Quiambog Cove. Other sub-basins losing more than 10 acres of eelgrass were Stonington Harbor, North Shore (NY), and Palmer-West Cove. From 2006-2009, a net loss of four beds was detected. The more significant finding was a loss of 12 beds in the Rocky Neck State Park which may be worthy of further investigation by resource managers.

Table 4. Eelgrass beds in eastern Long Island Sound in 2006. Sites are in Connecticut, except where noted otherwise. (Source: Tiner et al. 2007)

Sub-basin	**Acres of High Density (number)**	**Acres of Medium Density (number)**	**Acres of Low Density (number)**	**Total Acres (number)**
Little Narragansett Bay	0	283.0 (11)	0	283.0 (11)
Stonington Harbor	0	66.7 (11)	4.1 (1)	70.8 (12)
Quiambog Cove	65.5 (2)	343.7 (12)	18.7 (2)	427.9 (16)
Mystic Harbor	73.8 (4)	37.9 (4)	29.1 (4)	140.8 (12)
Palmer-West Cove	0	34.9 (4)	0	34.9 (4)
Mumford Cove	0	75.2 (8)	0	75.2 (8)
Paquonock River	20.9 (2)	4.4 (2)	1.9 (1)	27.2 (5)
New London Harbor	0.1 (1)	24.3 (5)	10.1 (2)	34.5 (8)
Goshen Cove	0.4 (1)	142.5 (6)	9.2 (1)	152.1 (8)
Jordan Cove	0	36.8 (3)	0	36.8 (3)
Niantic Bay	0	267.0 (12)	1.9 (1)	268.9 (13)
Rocky Neck State Park	7.9 (1)	86.1 (22)	16.5 (5)	110.5 (28)
Duck Island Roads	0	0	6.4 (2)	6.4 (2)
Fishers Island, NY	4.1 (12)	190.4 (25)	6.8 (5)	201.3 (42)
North Shore, NY	0	18.1 (2)	6.8 (1)	24.9 (3)
Plum Island, NY	0	9.5 (1)	0	9.5 (1)
Total	172.7 (23)	1,620.5 (128)	111.5 (25)	1,904.7 (176)

Table 5. Differences in eelgrass survey results 2002 to 2006 to 2009. + indicate gains and – losses.

Sub-basin	2002-2006 Acreage Change	2002-2006 Change in # of Beds	2006-2009 Acreage Change	2002-2009 Change in # of Beds
Little Narragansett Bay	-2.8	-2	+60.0	+3
Stonington Harbor	+28.0	+4	-15.1	-0-
Quiambog Cove	+70.7	+6	-20.6	-1
Mystic Harbor	+61.9	-0-	+20.9	-1
Palmer-West Cove	+0.1	-2	-12.2	-2
Mumford Cove	-11.0	-1	+7.0	+1
Paquonock River	-2.9	-1	-3.1	+2
New London Harbor	+3.9	+1	-0.9	-1
Goshen Cove	-4.9	-0-	-27.7	-2
Jordan Cove	-6.5	-4	+1.7	+4
Niantic Bay	+130.2	-1	-57.0	-3
Rocky Neck State Park	+7.7	-0-	-7.7	-12
Connecticut River Area	-0-	-0-	+2.1	+1
Duck Island Roads	+5.3	-0-	-0-	-0-
Fishers Island, NY	+7.8	+11	+22.5*	+5
North Shore, NY	+9.2	+1	-14.4	+2
Plum Island, NY	+9.5	+1	-1.9	-0-
Total	+306.2	+12	-46.4*	-4

*Two large beds totaling 122.1 acres on the south side of Fishers Island could be seen on the 2009 imagery while they were not visible on 2006 imagery due to environmental conditions. Field inspections in 2006 had located robust beds in this area and recorded their occurrence as points since the beds could not be accurately delineated on the imagery. Consequently, for the 2009 report, we did not treat this acreage as a gain because robust beds were noted in this area in 2006 and their boundaries could not be established.

Recommendations for Future Surveys

While the current procedures have offered a consistent, repeatable means of monitoring eelgrass, it would be interesting to compare seasonal imagery – June imagery (recommended time for eelgrass mapping in the Northeast by Dobson et al. 1995) versus late August to early October imagery. Water clarity and atmospheric conditions (lack of haze) tend to be better in the fall. The State of New Hampshire acquired aerial photos in late August for its eelgrass survey (Short and Trowbridge 2003). The use of late August to early October photography if processed quickly might still allow sufficient time for field work, especially if done immediately after imagery is acquired. Although field work for the present study was conducted into December, signs of eelgrass senescence were noted by mid-October. During the next survey, it would be interesting to capture aerial photography in both June and September of the same year to evaluate any differences in beds and photo-interpretability.

The use of helicopter surveys to collect low-cost imagery and verify beds may be worth investigating as a pilot study. Helicopters can cover much ground in a short period and timing could be tailored to the best conditions for eelgrass bed observation (low tide) and for accessing sites where boat access requires costly travel time. Also if successful and cost effective, it would make it possible to monitor eelgrass status on an annual basis. This should work well, especially since we've already constructed a geospatial eelgrass database for eastern Long Island Sound and a laptop with the existing data and imagery can be taken on the trip and used for reference and analysis. Capturing video images via conventional aircraft is another possibly low-cost option for acquiring basic data.

A final option to improve the results is to conduct a pilot study to evaluate the advantages that larger scale imagery would offer in terms of bed detection and estimating bed density. Acquisition of larger scale photos (1:12,000) or high-resolution digital imagery would make for interesting comparison with current techniques.

Summary

The 2009 survey located 172 eelgrass beds in eastern Long Island Sound totaling 1,980 acres. Seven sub-basins had over 100 acres of eelgrass beds, with Quiambog Cove having the most acreage (407 acres). Two areas had over 300 acres of eelgrass: Fishers Island (346) and Little Narragansett Bay (343), while Niantic Bay had about 212 acres. Three other sub-basins possessed more than 100 acres of beds: Mystic Harbor (162), Goshen Cove (124), and Rocky Neck State Park (103). Only three eelgrass beds were found from the Old Lyme Shores sub-basin to Clinton Harbor: one two-acre bed at Griswold Point (a new bed) and two small pre-existing beds (totaling 6.4 acres) associated with the Duck Island breakwater. From 2006-2009, eelgrass acreage increased in six sub-basins, while ten sub-basins lost eelgrass. One sub-basin (Duck Island Roads) had no change in its two pre-existing beds. The largest acreage gain was found in Little Narragansett Bay where 60 new acres were established, whereas Niantic Bay experienced the greatest loss (57 acres). Two large beds totaling 122 acres on the south side of Fishers Island were delineated during this survey. They were not visible on the 2006 imagery, but field inspections that year detected robust beds in the area. Their locations had to be recorded as points since the beds could not be outlined on the imagery. We did not report this acreage as a gain since substantial beds were there in 2006, but their boundaries simply could not be delineated on the imagery.

Acknowledgments

Funding for this project was provided by the U.S. Environmental Protection Agency, Office of Ecosystem Protection, Region I. Mark Tedesco was project officer for EPA. Ralph Tiner was the principal investigator for U.S. Fish and Wildlife Service (Service) and was responsible for study design, coordination, and report preparation. Nicole Fuhrman and Matthew Fields of Virginia Tech's Conservation Management Institute (CMI), while Kevin McGuckin of CMI constructed the digital database, performed GIS analysis, and prepared maps and figures included in this report. The Service's Southern New England Estuary Program (SNEP) was responsible for field review of potential eelgrass beds, with Andrew MacLachlan and Tom Halavik taking lead roles in this effort, and assisted by Neil Anthes and Grace Lentini. Aerial photography was acquired and converted to digital images by James W. Sewall Company, Old Town, Maine. Gina Jones (Service) prepared the cover for this report.

References

Dobson, J.E., E.A. Bright, R.L. Ferguson, D.W. Field, L.L. Wood, K.D. Haddad, H. Iredale III, J.R. Jensen, V.V. Klemas, R.J. Orth, and J. P. Thomas. 1995. NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, DC. NOAA Technical Report NMFS 123. (http://www.csc.noaa.gov/crs/lca/proto2.html#c4p1)

Short, F. and P. Trowbridge. 2003. UNH eelgrass (Zostera marina) monitoring program. Quality assurance project plan. Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH and State of New Hampshire, Department of Environmental Services, Concord, NH.

Tiner, R., H. Bergquist, T. Halavik, and A. MacLachlan. 2003. Eelgrass Survey for Eastern Long Island Sound, Connecticut and New York. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. National Wetlands Inventory report. 14 pp. plus Appendices. (http://library.fws.gov/Wetlands/eelgrass_report_v2.pdf)

Tiner, R., H. Bergquist, T. Halavik, and A. MacLachlan. 2007. 2006 Eelgrass Survey for Eastern Long Island Sound, Connecticut and New York. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. National Wetlands Inventory report. 24 pp. plus Appendix.

Appendix.

Pairs of maps showing distribution of eelgrass beds in 2009 and changes since the 2006 survey

Clinton Harbor/Westbrook Harbor/Duck Island Roads Sub-basins

Willard Bay/Connecticut River/Old Lyme Shores/Rocky Neck State Park Sub-basins

Fishers Island

Goshen Cove/Jordan Cove/Niantic Bay Sub-basins

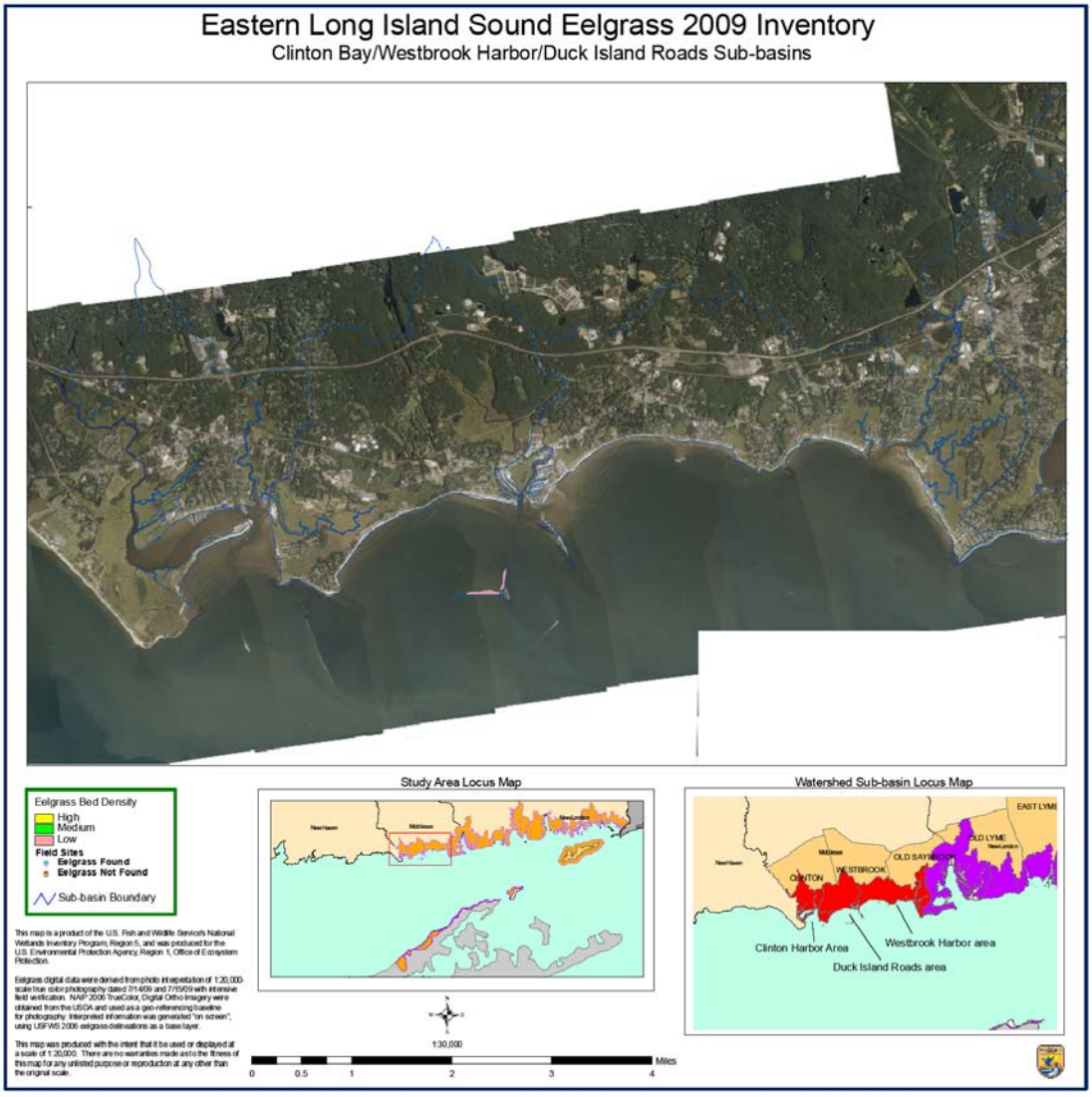
New London Harbor/Paquonock River/Mumford Cove Sub-basins

Palmer-West Cove/Mystic Harbor/Quiambog Cove Sub-basins

Stonington Harbor/Little Narragansett Bay Sub-basins

North Shore, Long Island (Orient Point and Plum Island area)

Note: The maps have been reduced to fit in this report; readers may enlarge them as necessary.

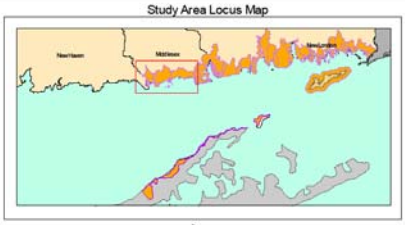

Eastern Long Island Sound Eelgrass 2009 Inventory
Clinton Bay/Westbrook Harbor/Duck Island Roads Sub-basins
Eelgrass Bed Density
High
Medium
Low
Field Sites
Eelgrass Found
Eelgrass Not Found
Sub-basin Boundary
This map is a product of the U.S. Fish and Wildlife Service's National Wetlands Inventory Program, Region 5, and was produced for the U.S. Environmental Protection Agency, Region 1, Office of Ecosystem Protection.
Eelgrass digital data were derived from photo interpretation of 1:20,000-scale true color photography dated 7/14/09 and 7/15/09 with intensive field verification. NAIP 2006 TrueColor, Digital Ortho Imagery were obtained from the USDA and used as a geo-referencing baseline for photography. Interpreted information was generated "on screen", using USFWS 2006 eelgrass delineations as a base layer.
This map was produced with the intent that it be used or displayed at a scale of 1:20,000. There are no warranties made as to the fitness of this map for any unlisted purpose or reproduction at any other than the original scale.
Study Area Locus Map
Watershed Sub-basin Locus Map
EAST LYME
OLD LYME
OLD SAYBROOK
WESTBROOK
CLINTON
Clinton Harbor Area
Westbrook Harbor area
Duck Island Roads area
1:30,000
0
0.5
1
2
3
4
Miles

Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

Clinton Bay/Westbrook Harbor/Duck Island Roads Sub-basins

Eelgrass Status
- Gain
- No Change
- Loss
- Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

1:30,000

0 0.5 1 2 3 4 Miles

This map is a product of the U.S. Fish and Wildlife Service's National Wetlands Inventory Program, Region 5, and was produced for the U.S. Environmental Protection Agency, Region 1, Office of Ecosystem Protection.

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Eastern Long Island Sound Eelgrass 2009 Inventory

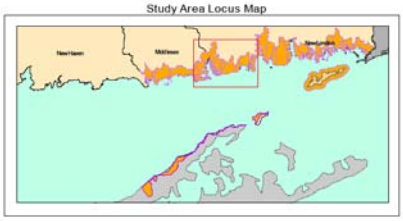
Willard Bay/Connecticut River/Old Lyme Shores/Rocky Neck State Park area Sub-basins

Eelgrass Bed Density
- High
- Medium
- Low

Field Sites
- Eelgrass Found
- Eelgrass Not Found

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

1:30,000

0 0.5 1 2 3 4 Miles

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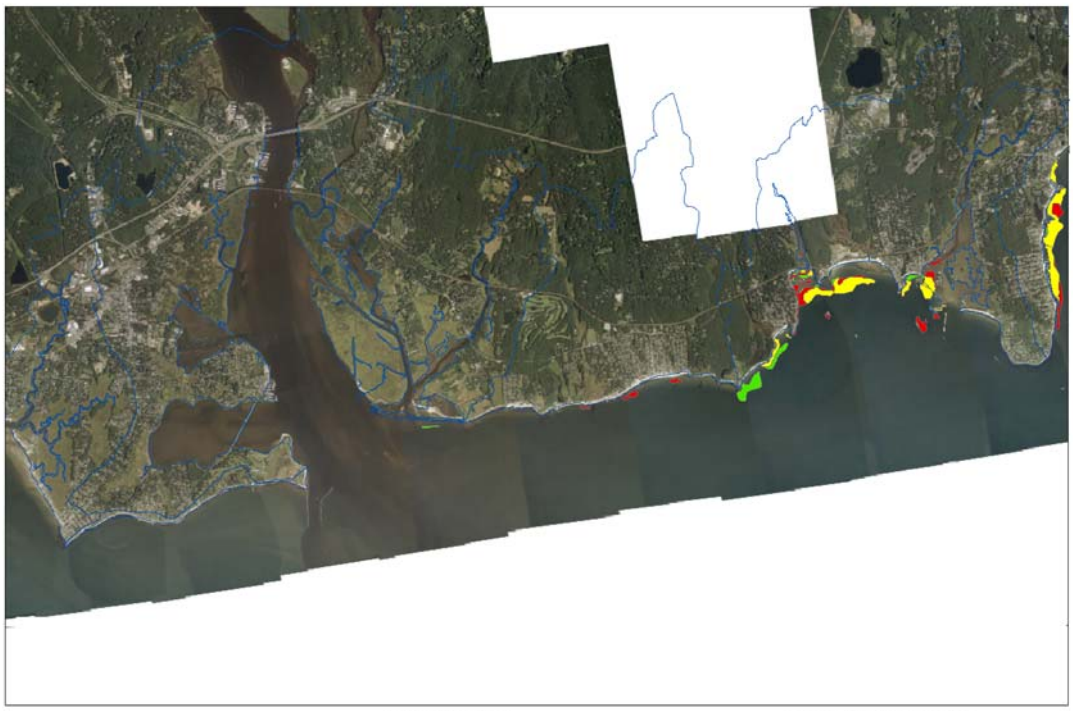
Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

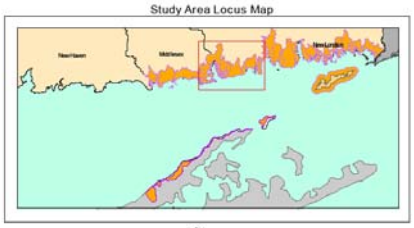
Willard Bay/Connecticut River/Old Lyme Shores/Rocky Neck State Park area Sub-basins



Eelgrass Status
- Gain
- No Change
- Loss

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

1:30,000

0 0.5 1 2 3 4 Miles

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Eelgrass digital data were derived from photo interpretation of 1:20,000-scale true color photography dated 7/14/09 and 7/15/09 with intensive field verification. NAIP 2006 TrueColor, Digital Ortho Imagery were obtained from the USDA and used as a geo-referencing baseline for photography. Interpreted information was generated "on screen", using USFWS 2006 eelgrass delineations as a base layer.

This map was produced with the intent that it be used or displayed at a scale of 1:30,000. There are no warranties made as to the fitness of this map for any unlisted purpose or reproduction at any other than the original scale.

Eastern Long Island Sound Eelgrass 2009 Inventory

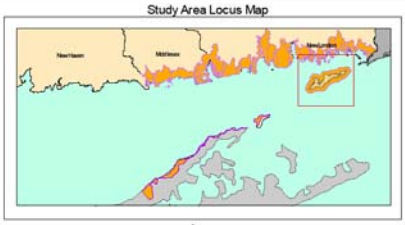
Fishers Island, New York

Eelgrass Bed Density
- High
- Medium
- Low

Field Sites
- **Eelgrass Found**
- **Eelgrass Not Found**

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

1:20,000

0 0.5 1 2 Miles

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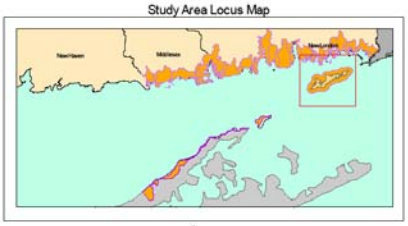
Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

Fishers Island, New York

Eelgrass Status
- Gain
- No Change*
- Loss
- Sub-basin Boundary

* Bed reported only by points in 2006 due to imagery limitations, but treated in 2009 as no change

Study Area Locus Map



Watershed Sub-basin Locus Map

1:20,000

0 0.5 1 2 Miles

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Eelgrass digital data were derived from photo interpretation of 1:20,000-scale true-color photography dated 7/14/06 and 7/15/09 with intensive field verification. NAIP 2006 TrueColor, Digital Ortho Imagery were obtained from the USDA and used as a geo-referencing baseline for photography. Interpreted information was generated "on screen", using USFWS 2006 eelgrass delineations as a base layer.

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Eastern Long Island Sound Eelgrass 2009 Inventory

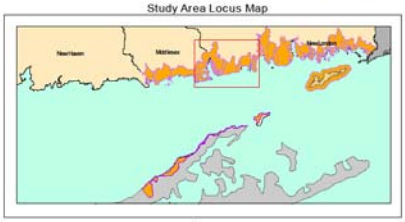
Niantic Bay/Jordan Cove/Goshen Cove area Sub-basins

Eelgrass Bed Density
- High
- Medium
- Low

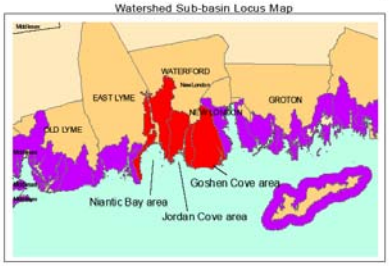
Field Sites
- **Eelgrass Found**
- **Eelgrass Not Found**

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map



1:20,000

0 0.5 1 2 Miles

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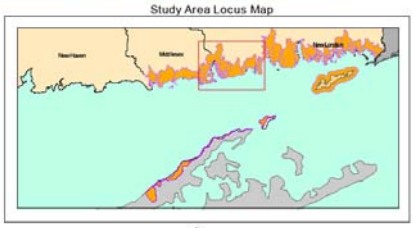
Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

Niantic Bay/Jordan Cove/Goshen Cove area Sub-basins

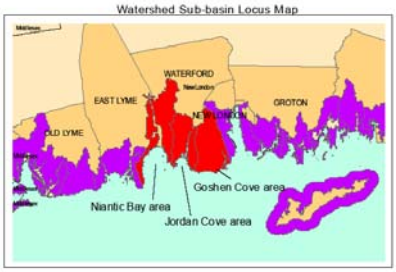
Eelgrass Status
- Gain
- No Change
- Loss

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map



1:20,000

0 0.5 1 2 Miles

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Eastern Long Island Sound Eelgrass 2009 Inventory

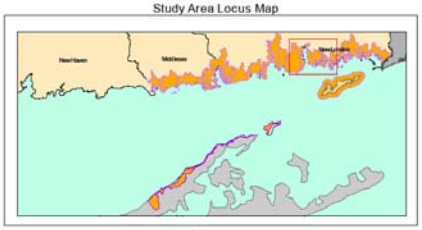
New London/Paquonock River/Mumford Cove area Sub-basins

Eelgrass Bed Density
- High
- Medium
- Low

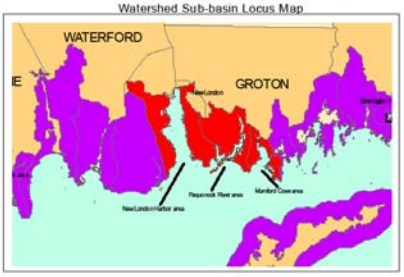
Field Sites
- Eelgrass Found
- Eelgrass Not Found

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map



1:20,000

0 0.5 1 2 Miles

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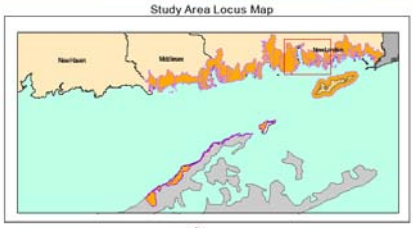
Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

New London/Paquonock River/Mumford Cove area Sub-basins

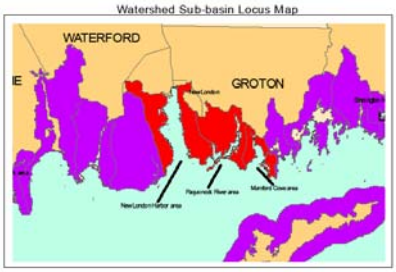
Eelgrass Status
- Gain
- No Change
- Loss

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

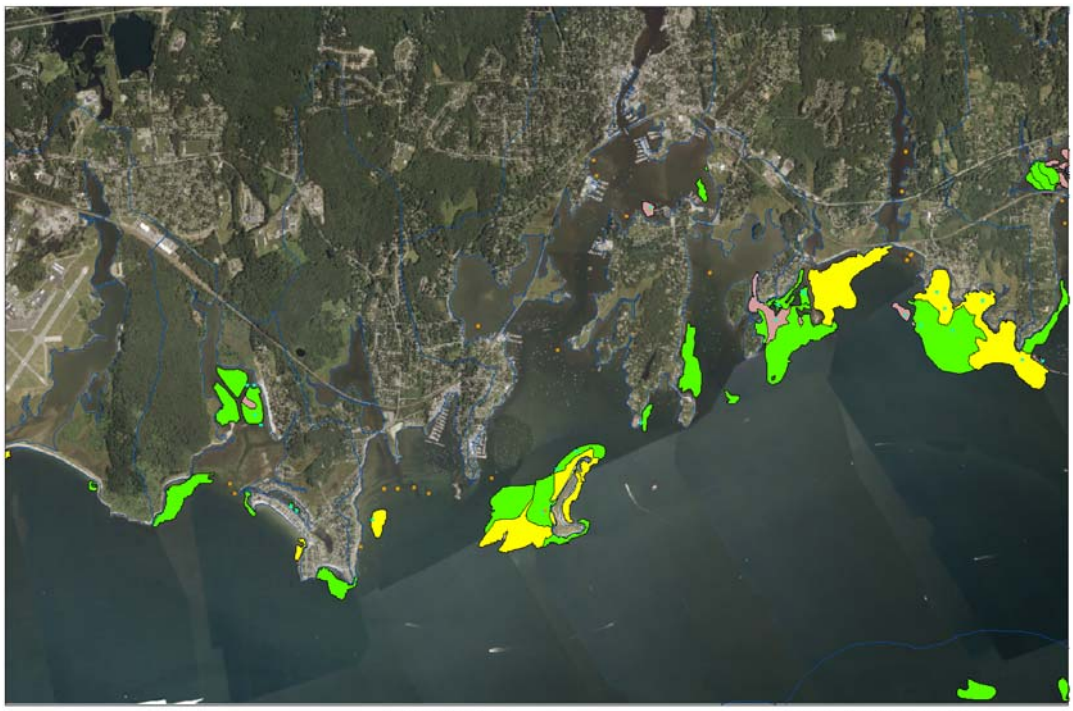


1:20,000

0 0.5 1 2 Miles

Eastern Long Island Sound Eelgrass 2009 Inventory

Palmer-West Cove/Mystic Harbor/Quiambog Cove area Sub-basins

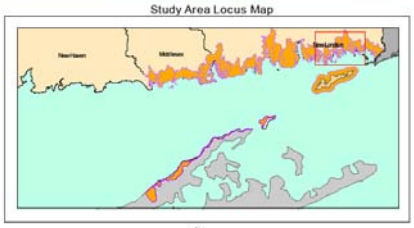


Eelgrass Bed Density
- High
- Medium
- Low

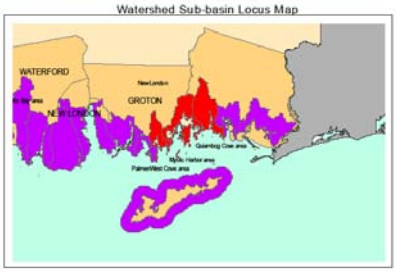
Field Sites
- **Eelgrass Found**
- **Eelgrass Not Found**

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map



1:20,000

0 0.5 1 2 Miles

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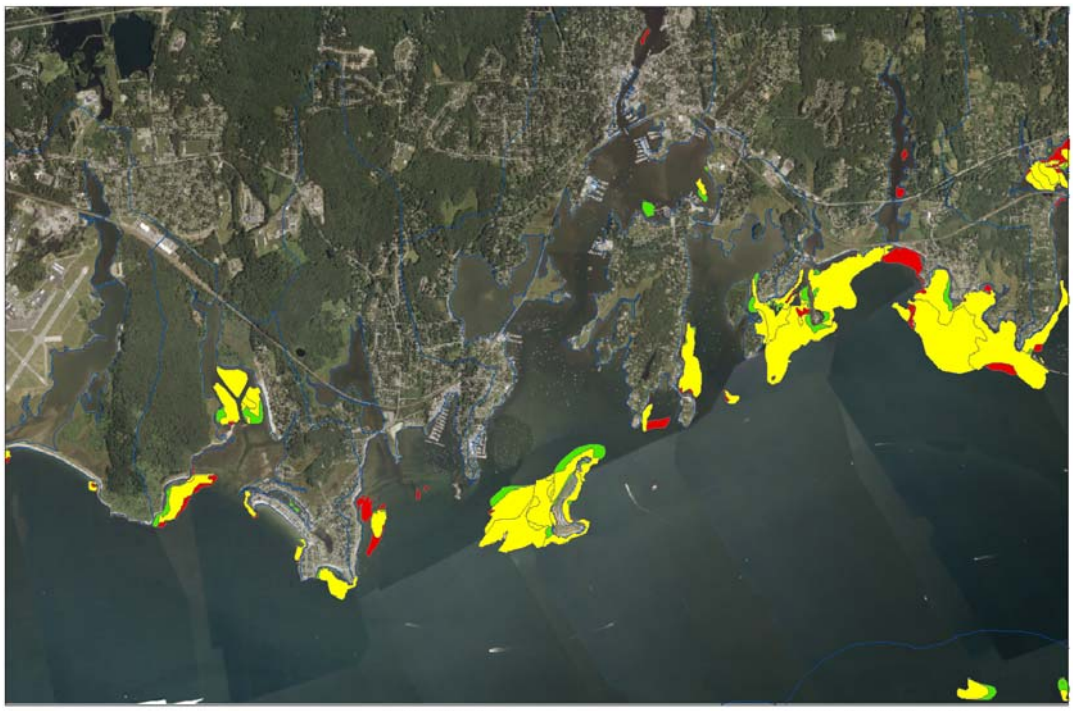
Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

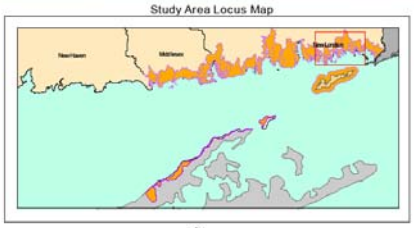
Palmer-West Cove/Mystic Harbor/Quiambog Cove area Sub-basins



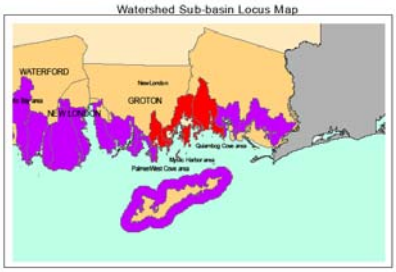
Eelgrass Status
Gain
No Change
Loss

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map



1:20,000

0 0.5 1 2 Miles

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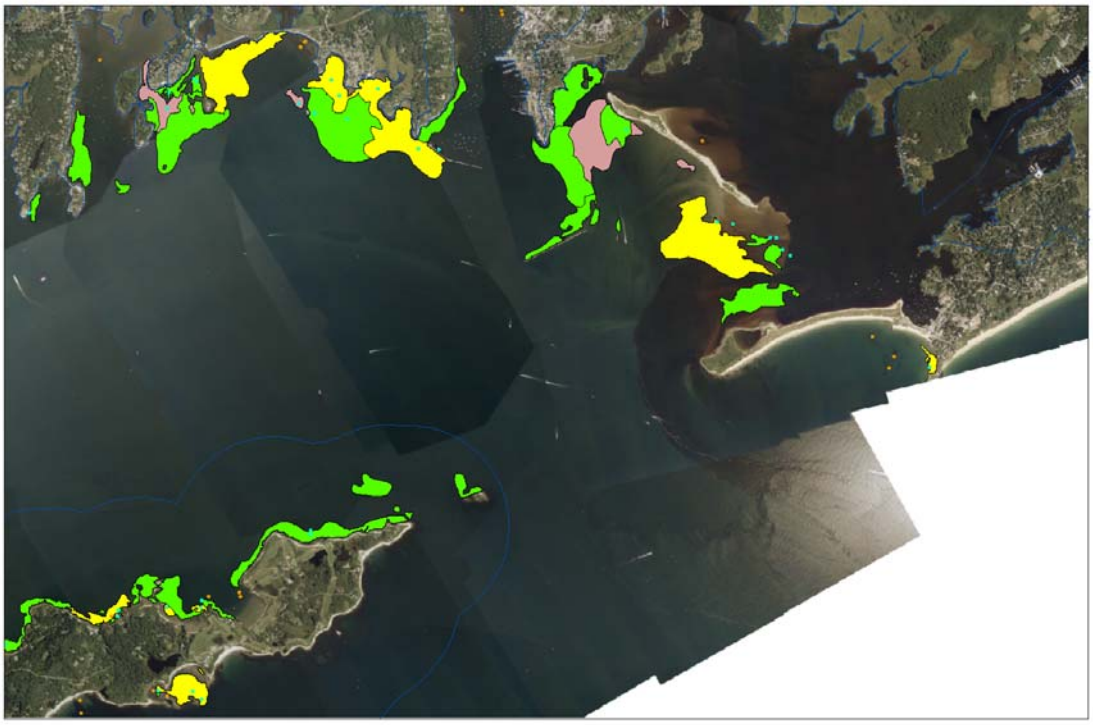
Eastern Long Island Sound Eelgrass 2009 Inventory

Stonington Harbor/Little Narragansett Harbor area Sub-basins

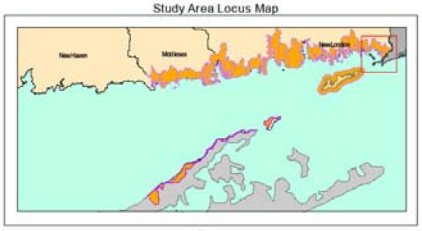


Eelgrass Bed Density
- High
- Medium
- Low

Field Sites
- Eelgrass Found
- Eelgrass Not Found

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

1:20,000

0 0.5 1 2 Miles

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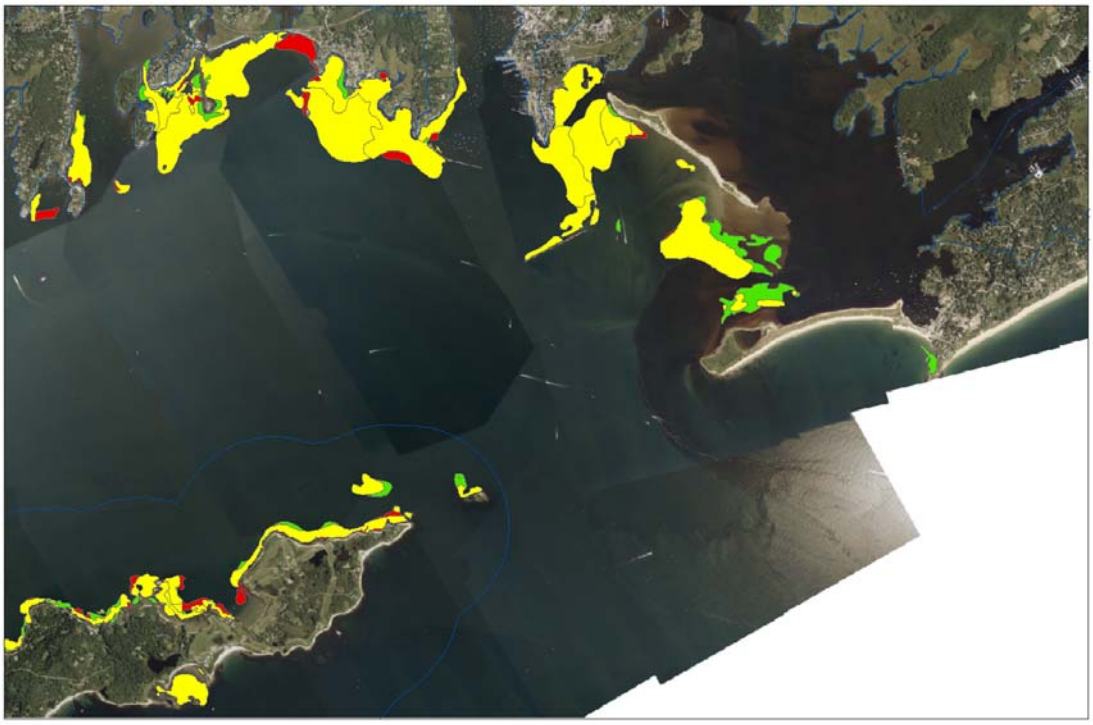
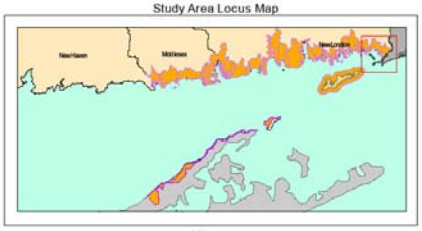
Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

Stonington Harbor/Little Narragansett Harbor area Sub-basins



Eelgrass Status
- Gain
- No Change
- Loss
- Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

1:20,000

0 0.5 1 2 Miles

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Eastern Long Island Sound Eelgrass 2009 Inventory

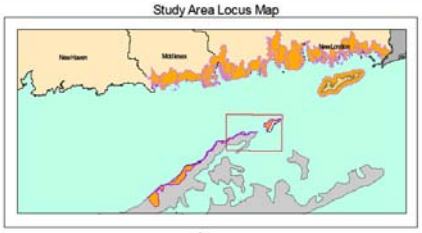
North Shore, Long Island, New York

Eelgrass Bed Density
- High
- Medium
- Low

Field Sites
- Eelgrass Found
- Eelgrass Not Found

Sub-basin Boundary

Study Area Locus Map



Watershed Sub-basin Locus Map

1:25,000

0 0.5 1 2 Miles

*Note: Map shows full extent of beds identified.

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Eastern Long Island Sound Eelgrass 2006 - 2009 Change in Distribution

North Shore, Long Island, New York

Eelgrass Status
- Gain
- No Change*
- Loss

Sub-basin Boundary

*Note: Map shows full extent of beds identified.

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Eelgrass digital data were derived from photo interpretation of 1:20,000-scale true color photography dated 7/14/09 and 7/15/09 with intensive field verification. NAIP 2006 TrueColor, Digital Ortho Imagery were obtained from the USDA and used as a geo-referencing baseline for photography. Interpreted information was generated "on screen", using USFWS 2006 eelgrass delineations as a base layer.

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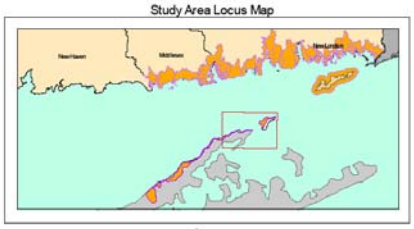
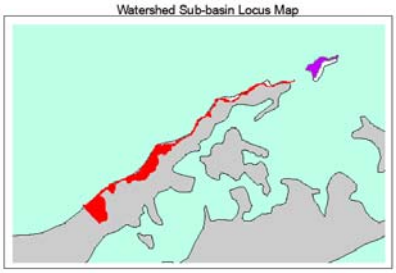
Study Area Locus Map



Watershed Sub-basin Locus Map



1:25,000

0 0.5 1 2 Miles

U.S. Fish & Wildlife Service
http://www.fws.gov

May 2010