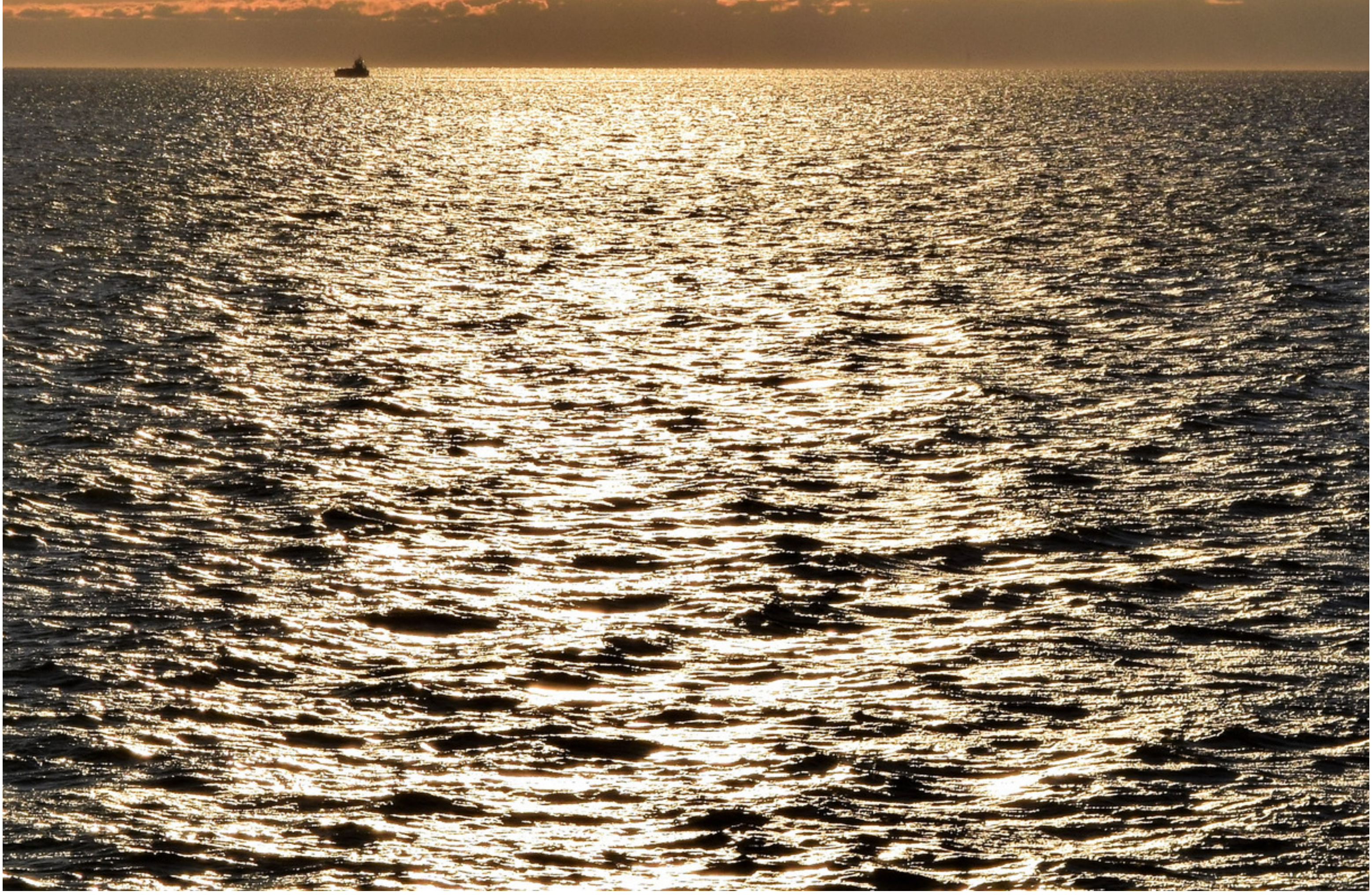
LONG ISLAND SOUND BLUE PLAN 2019

LONG ISLAND SOUND
BLUE PLAN
Sustainable Ecosystems - Compatible Uses

The following is an extract from Appendix 2 of the Final Draft Version of the Blue Plan (version 1.2 dated September 2019) describing the process to create Ecologically Significant Areas (ESAs)



Long Island Sound
Blue Plan

Report presented by the:

Connecticut Department of
Energy and Environmental Protection

Version 1.2
September 2019

Long Island Sound Blue Plan

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The following is an extract from Appendix 2 of the Final Draft Version of the Blue Plan (version 1.2 dated September 2019) describing the process to create Ecologically Significant Areas (ESAs)

Appendix 2. Ecologically Significant Areas: Supplemental Information and Maps

Appendix 1: Table of Contents

Appendix Figures

Appendix Tables

1. Introduction

This appendix is primarily serving to present the full set of ESA results including data and maps for all 14 criteria. It also includes the complete set of ESA Layer Construction Tables. The Appendix starts with filling in some of the details of the "ESA Approach, Rationale and Methodology" section 3.4a of the Blue Plan document. For this portion, it is meant to be used as a companion to section 3.4a.

2. ESA Approach, Rationale and Methodology

The following additional notes are added to Section 3.4a: Designation of Ecologically Significant Areas:

a. Methodology: Procedural Process

i. Blue Plan Ecological Characterization Work Team (ECWT):
As part of beginning development of the Blue Plan in 2016 by the Blue Plan Advisory Committee and CT DEEP, the ECWT was formed to give direction and provide output for all ecological aspects of the Blue Plan formation process. This was a bi-state group that generally met by conference call on a monthly basis. Its members included Sylvain De Guise, William Gardella, Mary-beth Hart, Leah Schmalz, Karen Chytalo, Melissa Albino-Hegeman, Victoria O'Neill, Brian Thompson, David Blatt, Sheryll Jones, Kevin O'Brien, Ian Yue and Emily Hall. Nathan Frohling served as the team lead. It provided the structure for how to move forward and eventually be able to identify ESAs. It was the core team for overseeing and contributing to preparation of the ecological elements of Inventory.

ii. Diagram of the ESA Process:
The following diagram (Figure 2a-1) graphically depicts the basic ESA process that was followed:

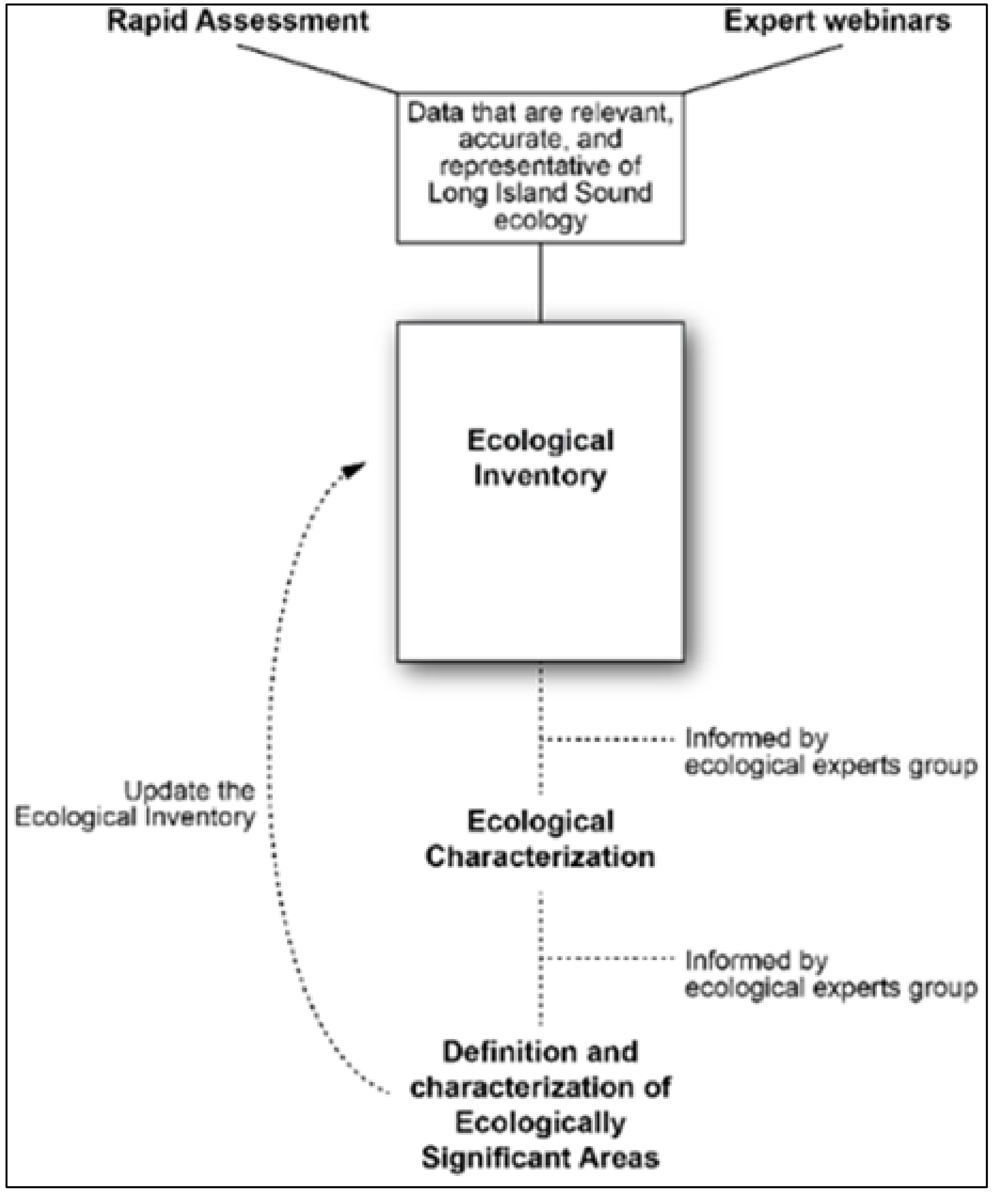

Figure 2a-1 Ecologically Significant Area designation process.

iii. *Ecological Characterization:*

The Ecological Characterization (EC) process was used in preparation for and as an active part of the effort to identify the ESAs. A by-product of the EC effort was a stand-along document called the Ecological Characterization Summary (ECS). Although this does not capture the history of the full process of EC, it does capture key parts of the broader set of information used to identify ESAs that the ESAs alone may leave out.

The Ecological Characterization Summary catalogs and present a more complete picture of the map products used for developing the ESAs. Map products noted and shown in the EC stem from using data references in the Inventory. The EC work also includes map product development work – that is, additional map products developed by utilizing the data referenced in the Inventory to generate particular results or insights not yet portrayed or available. For example, Terrain Ruggedness Index (TRI) is a model/process that was used with existing data sources in the Inventory to create a critical component of "Seafloor Complexity." Seafloor Complexity is one of the factors that make up ESA, however, such a map product or data layer had to be produced, it did not exist in the Inventory even though the data used by the model is referred to in the Inventory. Also, because the ESA are intended to represent the most significant areas, typically the top 20%, to only show the 20% areas does not allow the underlying 80% to be seen. The EC helps show the broader story, the 100%. Being able to see this full picture may be important in many contexts including use and implementation of Blue Plan policy.

iv. *The Ecological Experts Group (EEG):*

A major activity critical to the success of identifying ESA was the formation of the "Ecological Experts Group (EEG)" which was completed in March 2018. This body of marine ecologists, researchers and other ecological experts provided the scientific horsepower along with the Consultant and Blue Plan leadership to form and carryout the ESA process. This group was formed from the Ecological "Interested Parties". The EEG members were invited by the CT DEEP Commissioner and contributed considerable voluntary time. The EEG participated in 2 webinars and 4 day-long workshops in addition to numerous one on one contacts as of December 2018. The members were selected based on their area of expertise to assure there was sufficient coverage of the range of ecological topics to be addressed. They were also selected to assure a high level of credibility to the process. The EEG continues to serve in process of review and revision of the identified ESA.

v. *Endorsement:*

The EEG in their November 30th, 2018 day-long workshop expressed unanimous support for the ESA that had been developed at that point in time including the definitions of ESA Criteria. It was recognized that this endorsement was to be followed up with a few agreed on updates, particularly for the fish results. Although the EEG was deeply immersed in identifying the ESA, achieving consensus of the EEG on the draft ESA results was not easy but was achieved. Endorsement by the EEG has been informally recognized within the Blue Plan process as the most critical "party" to assure the validity of the ESA.

vi. *Review by Scientists and the Public:*

During 2018 there were multiple communications with scientists and experts outside the EEG that assisted in moving the ESA process forward. At the end of 2018 a series of formal presentations of the draft ESA were made to the larger body of Ecological "Interested Parties" and the public. Specifically, two webinars to over 50 scientists were held. Additional data sources were reported by the scientists (that have since been integrated), constructive input offered, and general support expressed for the draft ESA. Three public meetings were held with attendance totaling approximately 60 people, one at the UConn Avery Point Campus, one at Stony Brook University School of Marine and Atmospheric Sciences and one at Bridgeport City Hall, CT. In addition to many questions and comments, general support was expressed.

b. Methodology: Technical Process

i. *ESA Criteria:*

The following shows the connection between the natural resource categories of the Inventory and the ESA Criteria:

Plants

- Seaweed/Algae: Considered, did not emerge as an ESA
- Submerged Aquatic Vegetation (SAV): included as an ESA
- Phytoplankton: Considered, did not emerge as an ESA see Zooplankton below

Animals

- Birds: included as an ESA
- Fish: included as an ESA
- Marine mammals & Sea Turtles: both included as an ESA
- Zooplankton: Considered, did not emerge as an ESA. Data and information for both Phyto and Zooplankton were reviewed and discussed. Both forms of plankton are critical to the ecology of LIS, are at the base of the food chain and a fundamental expression of “productivity” which is a pillar ESA Criteria. The challenge was identifying meaningful criteria and a clear, defensible rationale for selecting areas as ecologically significant - one area over another. In this case, “most” or “highest” is not necessarily an appropriate metric for ecological integrity or even balance (i.e. water quality considerations). Plankton may be an important and more viable category for the next iteration of ESA
- Marine Invertebrates & Benthic Fauna: included as an ESA within different ESA Criteria

Environmental Characteristics

- Water Chemistry/Quality: Considered, did not emerge as an ESA as discussed above.
- Meteorology: Considered, did not emerge as an ESA as discussed above.
- Physical Oceanography: Considered, did not emerge as an ESA as discussed above.

Habitats Physical

- Geology/Sediments/Topography: included as an ESA within different ESA Criteria
- Bathymetry: included as an ESA within different ESA Criteria

Habitats Biological

- Species Persistence Areas: included as an ESA, especially for fish

Habitats Ecological

- Seafloor Complexity: included as an ESA
- Ecological Marine Units: Considered, but not needed to convey as an ESA
- Habitat Classes/Units: included as an ESA within different ESA Criteria
- Benthic: included as an ESA within different ESA Criteria
- Water Column: included as an ESA within different ESA Criteria (e.g. fish)

ii. *Framework for Translating Data and Criteria into ESA:*

With draft ESA Criteria in hand, the EEG, ECWT and E & C Enviroscape identified a framework for how ESAs would be synthesized and presented, even before all datasets were assembled. Other state and regional ocean plans were studied including and beyond New England regarding such a framework (e.g. The Draft Summary of Marine Life Data and Approaches to define Ecologically Important Areas and Measure Ocean Health produced by the Northeast Regional Ocean Plan (2014) was used). The following is a diagram (Figure 2a-2) used to communicate about the Framework:

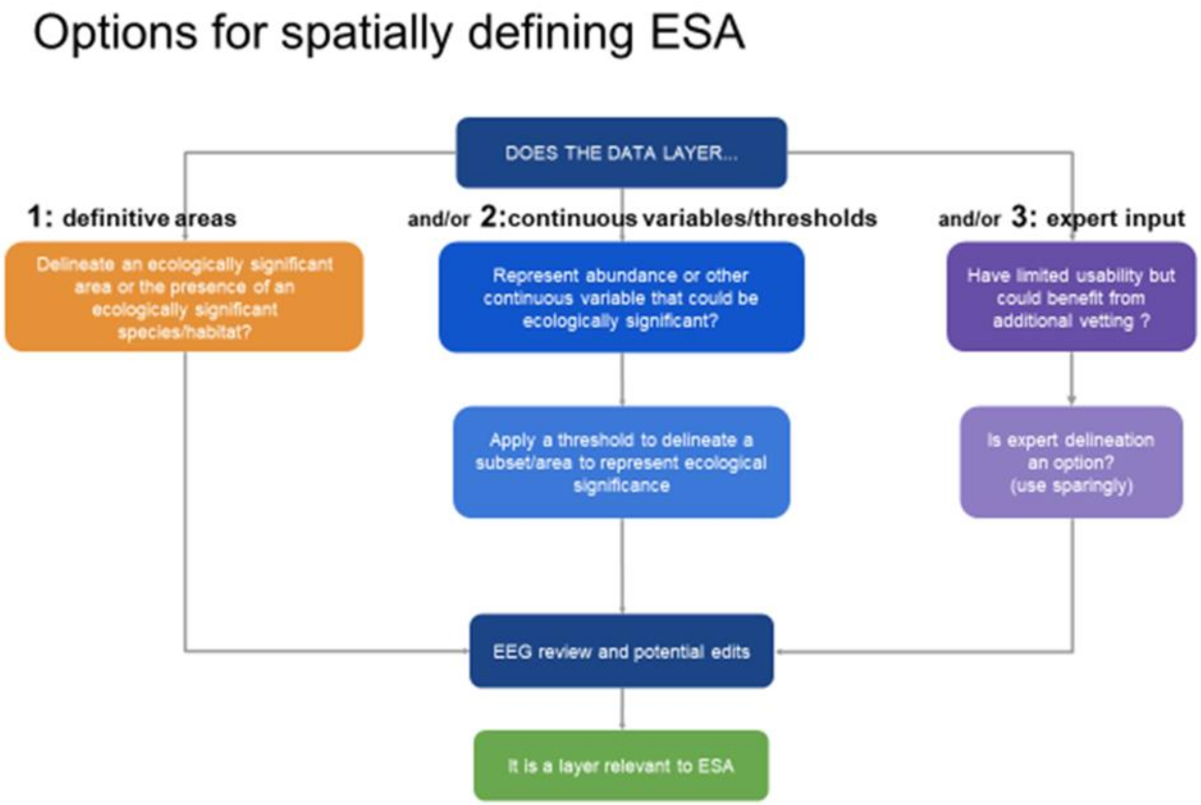

Figure 2a-2 Framework for Spatially Identifying ESAs.

iii. *Technical Steps:*

There are 12 technical steps that have been outlined to generally describe how the ESAs were identified and depicted on maps:

1. Identify datasets; most were identified in the Blue Plan Inventory; there was a need to address data gaps in the Inventory, notably for birds and sea turtles. See “ESA Results” below.
2. Obtain the datasets; many are publicly available and downloadable, but some are held by private entities (e.g., Mystic Aquarium, Riverhead Foundation) or not easily downloaded online (e.g., CT DEEP Marine Fisheries data) but were obtained and used for the ESA.
3. Map the full extent of each dataset in a Geographic Information System: ArcGIS 10.5. Almost all datasets were already provided in geospatial format, but some were tabular and needed to be plotted on a map (e.g., lobster projected thermal refuge)
4. Some datasets required analysis (e.g., buffering of point observations to create “areas”, calculation of metrics like total abundance, complexity, or richness) and synthesis (e.g., modeling predicted bird occurrences using environmental variables). Simple analyses like buffering were done using ArcGIS; more complex analyses and map algebra were done using R (coding language) in R Studio (a software/program used to implement it). Resulting outputs were either polygon or raster datasets.
5. Re-project each dataset to a common geographic coordinate system so each dataset or layer can be seen, analyzed, and depicted interchangeably.
6. Convert each dataset into a common raster grid with 8-meter pixel size. This means the finest resolution of data was at or larger than an 8-meter square (point data was buffered to be visible) and datasets with lower resolution were converted into the 8-meter system so all maps could be linked and interchangeable with both the overall geographic coordinate system and the internal data pixel size.
7. Clip each dataset to Long Island Sound’s boundary (essentially the shoreline).
8. Iterative EEG review and discussion of each individual ESA criterion definition and the associated dataset(s) to determine: if the available data sufficiently represent the ecological components described by the ESA criteria, if the data could be logically subset to identify ESAs, if the resulting map matched their expectations given their individual experience and expertise. The EEG weighed in at each step to provide review and suggest addition or different datasets. Examples: additional high resolution bathymetry data for Fisher’s Island Sound were added after the seafloor complexity map was drafted to improve depictions of seafloor complexity; locations of oyster seed beds (“natural beds”) were added to the managed shellfish criterion; additional years and seasons were added to the fish criterion after consultation with the EEG and CT DEEP Marine Fisheries.

9. For each criterion (or sub-criteria), identify preliminary subsets for what represents “ecologically significant”. For several datasets, the full distribution (i.e., anywhere the ecological component occurred) was deemed ecologically significant; for example, submerged aquatic vegetation, coastal wetlands or cold water corals. In cases where the dataset showed various levels of abundance or numbers of species present, the EEG opted to select the top quintile of the data distribution as “ecologically significant”.
10. Within each criterion, overlay all of the relevant contributing data to display a single coverage of an ESA. For example, buffered points of hard bottom observations, buffered points of wrecks and obstructions, hard bottom polygons (broader hard bottom areas than point observations), and the top 20% of complex seafloor grid cells (the most complex) are all overlaid to represent the ESA coverage for the hard bottom and complex seafloor criterion. The draft ESA map for hard bottom and complex seafloor shows all of these datasets merged together and represents areas where the ESA criterion for hard bottom and complex seafloor are present or absent. A user can click on an area where it is present and determine if that location contains a hard bottom observation, a wreck or obstruction, a hard bottom polygon, and/or a highly complex seafloor grid cell.
11. Once each of the ESA criterion layers have been completed, the ESAs have been identified. The single or multiple sources used to make the given ESA criterion (and associated map layer) are all turned into presence/absence – that is, a place either has the ESA or not for that criterion. These are the final ESA maps for each criterion. The next step is for purposes of seeing how it all adds up. To see which and how many ESAs may exist in any given 8-meter square, the ESA layers are stacked up, overlaid or “rolled-up” together. A roll-up map was made for the ESAs within each of the two ESA Criteria “pillars” (2-maps) and for all ESAs together (1-map). These represent the “minimum number of ESA’s” as noted above given the limitations of data. A user can click on an area and determine which combination of ESA criteria overlap in any given place.
12. Where possible, code was written in R using R Studio to accelerate steps 5-7 and 9-11 so that draft products could be quickly updated with additional data, different thresholds, or different summary/roll-up methods. Geotiffs were exported from R and imported into ArcGIS 10.5. All of the visualization of ESA maps was done using ArcGIS 10.5.

2. ESA Results

a. Introduction

The full set of ESA results follows. These include the table of all the ESA Criteria with associated descriptions and list of supporting data sources (Table 2a-1). The 14 individual ESA criteria and associated ESA layers are then presented, prefaced by a summary of the relevant overarching Criteria Pillar. For each ESA criterion, a short narrative of its ecological significance is included followed by descriptions of the principal, underlying data and associated maps used to form the ESA layer.[34] These maps are the building blocks that are combined to 1) show how the underlying layers overlap and 2) create a presence/absence layer that depicts the final map for the given ESA criterion. Next, a synthesis of all the 14 ESA criteria is presented that shows the overlay and density of all the ESAs when seen together. Finally, the full set of ESA Layer Construction Tables is presented.

It is again noted that the Ecological Characterization Summary is an important part of the full ESA documentation. As a stand-along document, it is not included in this Appendix.

i. Map Viewer:

Please note that the ESA maps are available to view and navigate through the Blue Plan Map Viewer. The viewer allows the user to zoom in for details, to unpack the layers to see which ESAs are present in a particular area, or to view which layers overlap within a single ESA criterion.

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[34] "ESA layers" refers to the maps of ESA that are used to depict the ESA criteria. ESA criteria are the written descriptions of the ESA and because they point to the "ideal" ESA, they are often more comprehensive and/or specific than the maps (and underlying data) are able to provide.

ii. ESA Criteria Table

Table 2a-1 ESA criteria supporting datasets, and descriptions. Mapped data layers can be found in Appendix 2 and in a LIS Blue Plan mapping portal. Some ESA sub-criteria do not have associated datasets, but descriptions have been included so that these areas may be recognized in policy and designated if spatial information is provided in the future.

ESA Criteria	Supporting Datasets	Description
Areas with rare, sensitive, or vulnerable, species, communities, or habitats		
Hard bottom and complex sea floor	• Long Island Sound Ecological Assessment (LISEA) hard bottom (pts) • USGS Surficial sediment map, gravel areas (polys) • Long Island Sound Mapping and Research Collaborative (LISMaRC) Phase II SEABOSS hard bottom observations (pts) • Terrain Ruggedness Index (top quintile) • Wrecks and obstructions (pts)	Areas of hard bottom are characterized by exposed bedrock or concentrations of boulder, cobble, pebble, gravel, or other similar hard substrate distinguished from surrounding sediments and provide a substrate for sensitive sessile suspension-feeding communities and associated biodiversity. Complex seafloor is a morphologically rugged seafloor characterized by high variability in neighboring bathymetry around a central point. Biogenic reefs and man-made structures, such as artificial reefs, wrecks, or other functionally equivalent structures, may provide additional suitable substrate for the development of hard bottom biological communities. Areas of hard bottom and complex seafloor are areas characterized singly or by any combination of hard seafloor, complex seafloor, artificial reefs, biogenic reefs, or wrecks and obstructions.
Areas of submerged aquatic vegetation	Seagrass surveys from 2002, 2006, 2009, 2012, 2017 (polys)	Areas where submerged aquatic vegetation, e.g., eelgrass (Zostera marina), etc., are present or have been found to be present in the past.

Endangered, threatened, species of concern, or candidate species listed under state or federal ESA, and their habitats	• Atlantic sturgeon gear restriction areas (polys) • Atlantic sturgeon and shortnose sturgeon high and medium use areas (polys) • Atlantic sturgeon migratory corridor (polys) • Predicted summer occurrence of roseate tern (raster) • Connecticut Natural Diversity Database approximate locations of endangered, threatened, species of concern (polys) • Connecticut Critical Habitats (estuarine, polys) • New York rare plants and rare animals (polys) • New York Significant Natural Communities (polys) • New York Significant Coastal Fish and Wildlife Habitats (polys) • US Endangered Species Act Critical Habitat for Atlantic sturgeon (polys)	The species listed by federal or state statutes (e.g., the US Endangered Species Act, the CT Endangered Species Act, the NY Endangered Species Act) as endangered, threatened, species of concern, or candidates for listing, and their associated habitats, recognizing that detailed spatial data depicting the distribution and abundance for these marine species in Long Island Sound are potentially unavailable.
Areas of cold water corals	LISMaRC Phase I and Phase II cold water coral observations near Stratford Shoals and eastern LIS (polys)	Areas where cold-water corals have been observed or where habitat suitability or other scientific models predict they occur.

Coastal wetlands[35]	National Wetlands Inventory, clipped to Long Island Sound Study boundary (polys)	According to Connecticut General Statute (CGS) 22a-29: "Those areas which border on or lie beneath tidal waters, such as, but not limited to banks, bogs, salt marshes, swamps, meadows, flats, or other low lands subject to tidal action, including those areas now or formerly connected to tidal waters, and whose surface is at or below an elevation of one foot above local extreme high water; and upon which may grow or be capable of growing some, but not necessarily all, of [a list of specific plant species found in CGS section 22a-29(2)].
ESA Criteria	**Supporting Datasets**	**Description**
Areas of high natural productivity (HNP), biological persistence, diversity, and abundance, including areas important for supporting or exhibiting such features, relative to the following characteristics or species.[36]		
Cetaceans (marine mammals)	• Cetacean density models for the US Atlantic Coast, Duke University Marine Geospatial Ecology Lab, for species with predictions in LIS (raster)	Areas where cetaceans occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support cetaceans (e.g. particular feeding areas, nursery grounds).

[35] Although Coastal Wetlands are within the Long Island Sound Blue Plan "Area of Interest", Blue Plan policies do not apply to areas landward of the 10-foot contour. Therefore, while considered Ecologically Significant Areas, Coastal Wetlands and any associated existing statues or policies relevant to Coastal Wetlands are not within the scope of Long Island Sound Blue Plan policies and performance standards.

[36] Areas where natural productivity, biological persistence, diversity, and abundance are high, as well as migratory sanctuaries, stopovers and corridors, nesting areas, feeding areas, and nursery grounds for cetaceans, pinnipeds, sea turtles, marine birds, fish, mobile invertebrates, sessile-mollusk-dominated communities, managed shellfish beds, and soft-bottom benthic communities.

	• Expert participatory mapping (polys; P. Comins, Connecticut Audubon Society, 1/4/19)	
Pinnipeds (seals)	• NOAA Environmental Sensitivity Index seal concentration areas (polys) • Expert participatory mapping included in the Blue Plan Inventory (polys)	Areas where pinnipeds occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support pinnipeds (e.g. particular haul-out locations, feeding areas).
Sea turtles and other reptiles	• Northern diamondback terrapin probability of occurrence (polys) • Locations of 2018 coastal CT sea turtle strikes (pts) • Live sea turtle stranding's, rescues, and in-water observations, Riverhead Foundation for Marine Research and Preservation (pts) • Live sea turtle strandings and rescues, Mystic Aquarium (pts)	Areas where sea turtles and other reptiles occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support sea turtles and other reptiles (e.g. particular feeding areas, nesting grounds, hibernation areas).
Birds	• Seabird occurrence models, University of Connecticut (raster) • Expert participatory mapping (polys; P. Comins, Connecticut Audubon Society, 1/4/19)	Areas where birds are abundant or diverse including feeding areas; areas of high bird productivity including nesting areas.

Fish	• Persistently productive places for fish (polys; LISEA high weighted persistence) • Areas of high fish abundance and concentration (polys; CT DEEP Marine Fisheries Long Island Sound Trawl Survey, 1995-2004 and 2005-2014, spring and fall data for species caught in >5 tows)	Areas of high weighted fish persistence and high fish abundance and concentration.
Mobile invertebrates	• Areas of high mobile invertebrate biomass and concentration (polys; CT DEEP Marine Fisheries Long Island Sound Trawl Survey, 1995-2004 and 2005-2014, spring and fall data for crabs, lobster, squid, and horseshoe crab) • Horseshoe crab predicted spawning beaches (polys) • American lobster projected thermal refuge (polys)	Areas of high mobile invertebrate (e.g., lobster, other crustaceans, squid) abundance and concentration.
Sessile-mollusk-dominated communities	LISMaRC Phase I and Phase II observations of Slipper shell (*Crepidula fornicata*) aggregations and blue mussel (*Mytilus edulis*) aggregations near Stratford Shoals and eastern LIS (polys)	Areas where wild, natural sessile-mollusk-dominated communities occur.

Managed shellfish beds	• Oyster seed beds (CT Natural Shellfish Beds) (polys) • CT Recreational Shellfish Beds (polys) • CT State-managed Shellfish Beds (polys) • CT Town-managed Shellfish Beds (polys)	Locations of commercial and recreational shellfishing harvest areas, including shellfish restoration activities and areas closed to shellfishing.
Soft-bottom benthic communities	*Adequate data not available*	Areas of soft-bottom seafloor communities where natural productivity, biological persistence, diversity, and/or abundance of marine flora and fauna are high, as well as areas of soft-bottom seafloor communities known to support important life history or important ecological functions of mobile species (e.g., migratory stopovers and corridors, feeding areas, and nursery grounds).
Zooplankton	*Adequate data not available*	Not an ESA criterion at this time, but noted for ecological relevance to productivity.

b. Criteria Pillar 1: Areas with rare, sensitive, or vulnerable species, communities, or habitats

The first set of criteria considered by the EEG encompass the concepts of "special", "sensitive", and "unique" that were articulated in the statute definition. In naming this set of criteria the EEG attempted to avoid using words that could be considered to be value-laden. The criteria in this category correspond to similar components of ecological importance identified by other ocean planning and management efforts. For example, these criteria match the components "Areas of vulnerable marine resources" and "Areas of rare marine resources" that were described by the Northeast and Mid-

Atlantic regional ocean plans. Some of the criteria in this category match directly to the twelve "Special, Sensitive, or Unique (SSU) Resources" described in the Massachusetts Ocean Plan, such as the MA hard or complex seafloor and eelgrass SSUs.

The ecological components in this category play critical roles in the Long Island ecosystem but are rare or particularly vulnerable to disturbance and/or environmental change. Many already confer special protection via local, state, and federal regulations.

i. **Criterion 1: Hard bottom and complex seafloor**

Definition: Areas of hard bottom are characterized by exposed bedrock or concentrations of boulder, cobble, pebble, gravel, or other similar hard substrate distinguished from surrounding sediments and provide a substrate for sensitive sessile suspension-feeding communities and associated biodiversity. Complex seafloor is a morphologically rugged seafloor characterized by high variability in neighboring bathymetry around a central point. Biogenic reefs and man-made structures, such as artificial reefs, wrecks, or other functionally equivalent structures, may provide additional suitable substrate for the development of hard bottom biological communities. Areas of hard bottom and complex seafloor are areas characterized singly or by any combination of hard seafloor, complex seafloor, artificial reefs, biogenic reefs, or wrecks and obstructions.

Significance of Hard bottom and complex seafloor

Areas of hard bottom and complex seafloor are known to attract a variety of mobile organisms like fish and seabirds and serve as attachment sites for sessile creatures such as corals, anemones, sponges, and tube-building worms, which in-turn create additional structure and complexity that attracts and shelters marine organisms. Species diversity tends to be higher in areas of complex seafloor when compared to adjacent homogeneous seafloor, and this relationship also influences ecosystem functioning and increases ecosystem efficiency (Zeppilli, Pusceddu, Trincardi, & Danovaro, 2016). The hard bottom and complex seafloor criterion is a proxy for all of these characteristics and components. Multiple datasets were required to characterize hard and complex seafloor.

Hard bottom component

The EEG described "hard bottom" as any substrate coarser than "very coarse sand" on the Wentworth grain size scale, which is equivalent to particles greater than 2 mm in size, and includes granules, pebbles, and cobbles (collectively called "gravel"), as well as boulders. Outcrops of bedrock are also considered hard bottom. Any locations where hard bottom occurred were considered ecologically significant and contributed to the summary map of hard and complex seafloor ESA. The following data sources and associated maps each contributed to depicting the extent of known hard bottom in LIS. They were combined into one map (Figure 2a-3) to create the hard bottom portion of the overall Hard bottom and complex seafloor ESA criterion.

The Nature Conservancy's Long Island Sound Ecological Assessment (LISEA) known occurrences of hard bottom

The LISEA known occurrences of hard bottom map integrates data several sources (below). The resulting layer is a point dataset depicting the locations of hard bottom. The maps and data can be accessed via The Nature Conservancy's Conservation Gateway (The Nature Conservancy, 2017).

- USGS usSEABED database - scientific measurements of seafloor type and grain size
- USGS East Coast Sediment Texture Database - scientific measurements of seafloor type and grain size
- NOAA Electronic Nautical Chart data - notations on charts of bottom type

USGS Long Island Sound Surficial Sediment map

This map represents sediment types in Long Island Sound by polygons, interpreted by USGS scientists from bottom samples, bottom photography, and side scan sonar data. The map and data were published in an academic journal (Poppe, Knebel, Mlodzinska, Hastings, & Seekins, 2000)and in a USGS open file report (US Geological Survey, 2000).

Long Island Sound Mapping and Research Collaborative (LISMaRC) Phase II SEABOSS hard bottom observations

LISMaRC, as part of the Long Island Sound Habitat Mapping Initiative, characterized seafloor type in eastern Long Island Sound in 2017 (LISS, 2017). Locations described as gravel and coarser seafloor types were included in the criterion map. These unpublished data were provided by Dr. Christian Conroy, University of Connecticut.

Figure 2a-3 integrates the datasets for hard bottom and shows the extent of hard bottom that contributes to the Hard bottom and complex seafloor ESA Criterion. The points have a 160 meter buffer so they are visible.

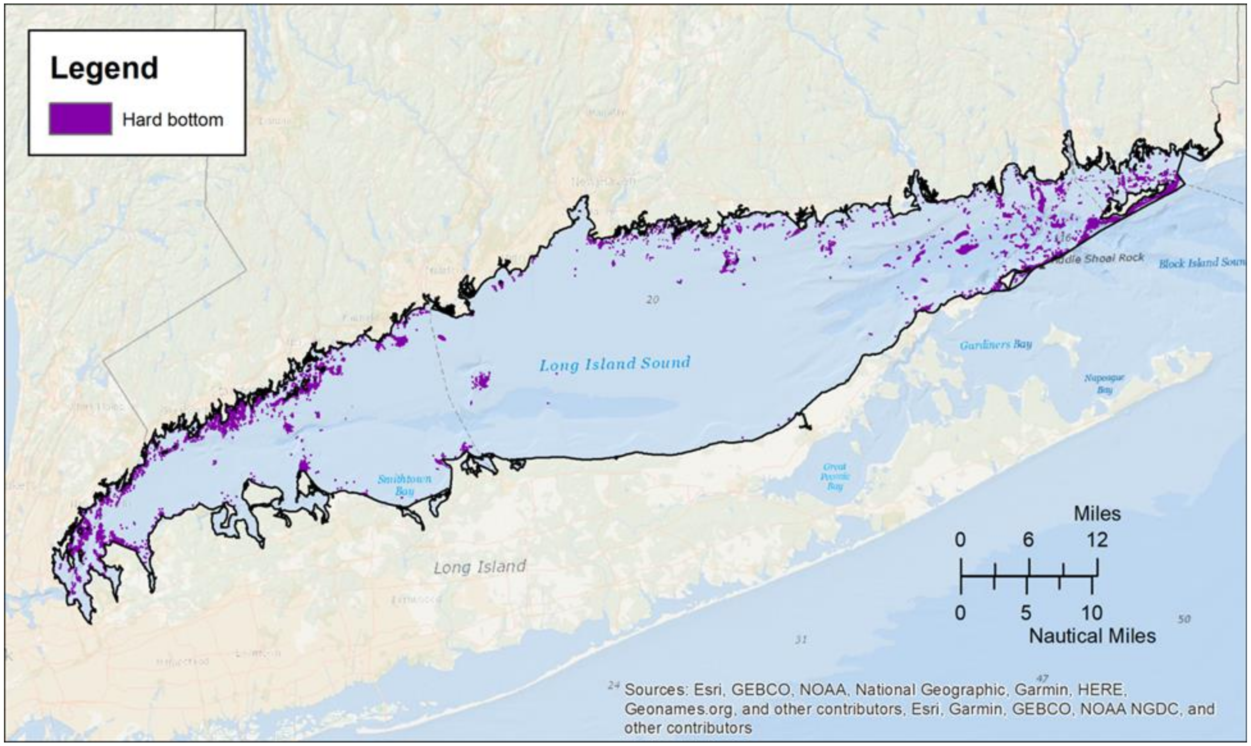

Figure 2a-3 The extent of hard bottom in Long Island Sound mapped from the Long Island Sound Ecological Assessment (LISEA), USGS Long Island Sound surficial sediment map, and Long Island Sound Mapping and Research Collaborative SEABOSS surveys.

Complex seafloor component

The EEG identified areas of complex seafloor using the Terrain Ruggedness Index (TRI) (Riley, DeGloria, & Elliot, 1999). The TRI metric reflects the difference between the depth at each point on the seafloor and the depth of the points surrounding it. Complex seafloor has greater differences between focal points and their surroundings (which equals higher TRI), whereas featureless seafloor has smaller differences between focal points and their surroundings (which equals lower TRI). The data required to calculate TRI are full-coverage bathymetry, or depth, data. A composite bathymetry dataset with a horizontal resolution of 8 meters was created for Long Island Sound by mosaicking the most recent federal and local datasets from the NOAA National Ocean Service. Data sources including high-resolution multibeam survey data wherever available (ranging in resolution from 0.5m to 8m), and the NOAA Coastal Relief Model data (83m resolution) where high-resolution data were not available. The mosaic resolution of 8m was chosen to optimize the detail conveyed by the highest resolution datasets in the final bathymetry map. TRI was calculated at the scale of a single pixel (8m) and so the resulting TRI map has a resolution of 8m. In order to identify ESA for complex seafloor, the EEG classified the data into quintiles and extracted the top quintile (top 20%) as ecologically significant (Figure 2a-4).

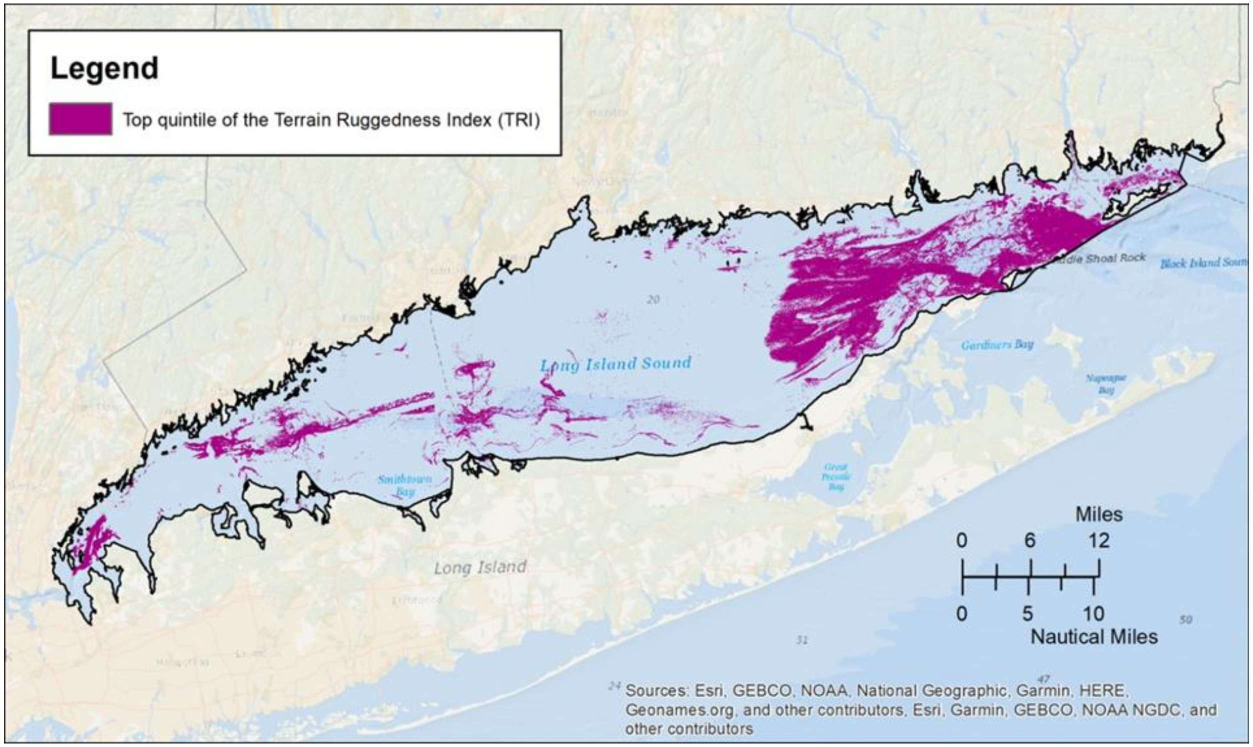

Figure 2a-4 The top quintile of the Terrain Ruggedness Index (TRI) calculated at 8-meter resolution for Long Island Sound.

Wrecks and obstructions component

The EEG included wrecks and obstructions in the map of hard bottom and complex seafloor. Wrecks tend to serve as artificial reefs, and obstructions can include boulders or other hard bottom not delineated in geologic maps. The NOAA Automated Wreck and Obstruction Information System was clipped to Long Island Sound for inclusion in this criterion map. Any locations where wrecks and obstructions occurred were considered ecologically significant (Figure 2a-5). These also have a 160 meter buffer to be visible.

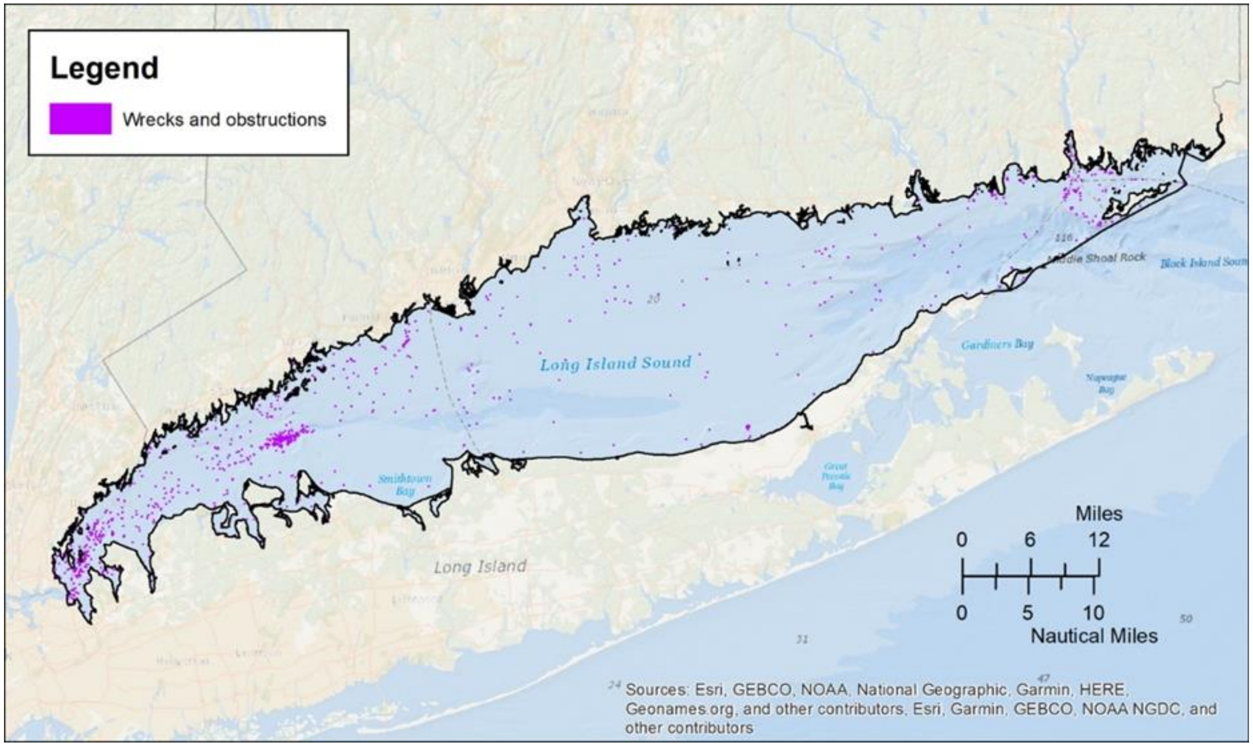

Figure 2a-5 Locations of wrecks and obstructions in LIS from the NOAA Automated Wreck and Obstruction Information System.

Integration of components

Each of the datasets described above (hard bottom, complex seafloor, wrecks and obstructions) were mapped together to represent the full extent of hard bottom and complex seafloor. Figure 2a-6 shows the number of overlaps in those datasets. Figure 2a-7 also shows all of the datasets dissolved together to show a single presence/absence layer of Ecologically Significant Areas for hard and complex seafloor. Figure 2a-7 shows the final ESA hard bottom and complex seafloor map.

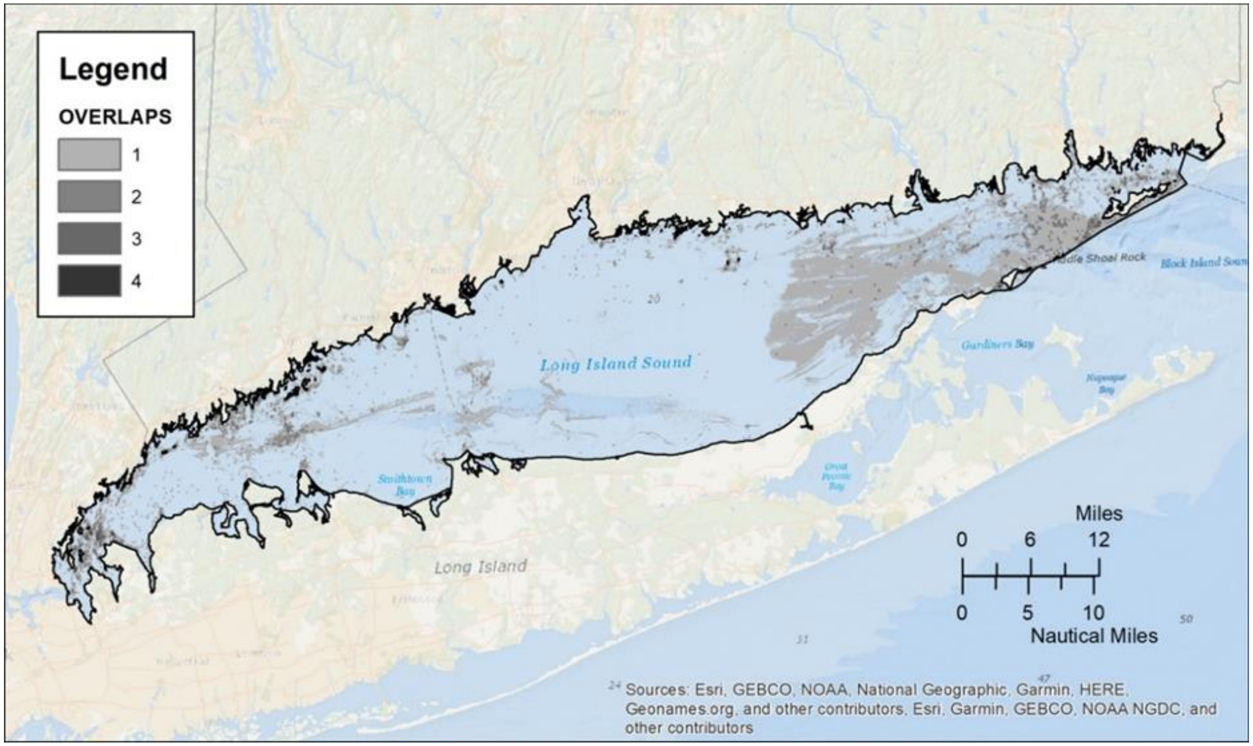

Figure 2a-6 Overlaps among each of the input datasets representing the hard bottom and complex seafloor criterion.

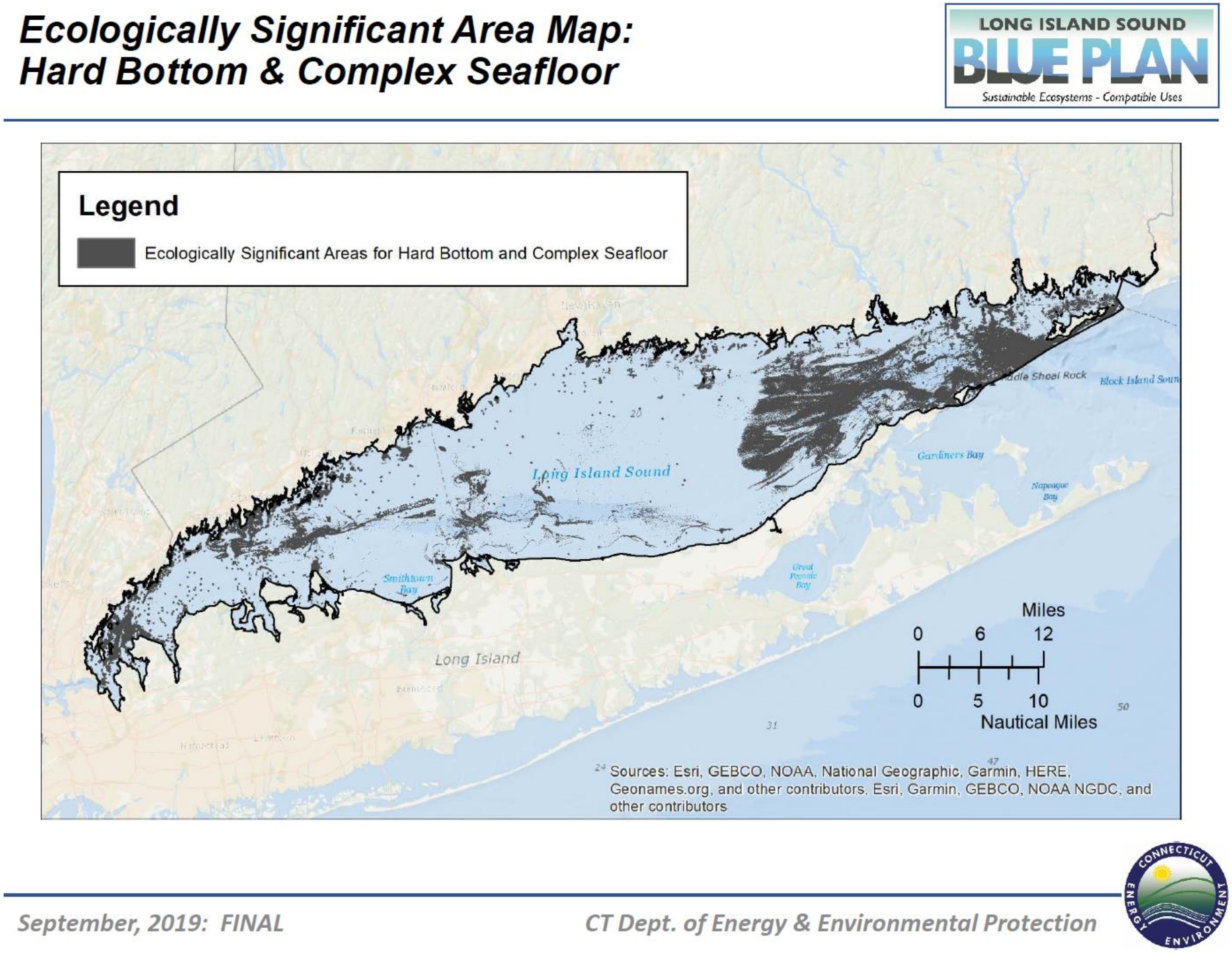

Figure 2a-7 Final ESA map for Hard Bottom and Complex Seafloor.

Updates and potential future work
Additional seafloor observations from the Long Island Sound Seafloor Mapping Initiative and similar projects will improve the identification of both hard bottom and complex seafloor in this criterion. Additional high-resolution multibeam bathymetry surveys by these projects and/or federal agencies will also improve the identification of complex seafloor.

ii. **Criterion 2: Areas of submerged aquatic vegetation**
Definition: Areas where submerged aquatic vegetation, e.g., eelgrass (Zostera marina), etc., are present or have been found to be present.

Significance of submerged aquatic vegetation (SAV):
Submerged aquatic vegetation refers to rooted, vascular plants that occur in the shallow waters of Long Island Sound. Species such as eelgrass can form large, dense meadows that serve as important nursery habitat for fish and shellfish species. Connecticut Public Act 02-50, Section 4 states that the Commissioner of Environmental Protection shall adopt regulations, in accordance with chapter 54 of the general statutes, to protect and restore eelgrass, including the protection of existing eelgrass beds from degradation, the development of a restoration plan to restore eelgrass and the periodic monitoring of the effectiveness of such measures to protect and restore eelgrass.

Delineation of SAV Areas:
Although eelgrass has historically been found throughout Long Island Sound, its current distribution is limited to the eastern Sound (Latimer, Tedesco, Yarish, Stacey, & Garza, 2014). The EEG discussed whether or not to include historical eelgrass data in the delineation of ESA as a way to acknowledge that eelgrass can often be restored or regrow naturally into areas of historical distribution when water quality and other environmental conditions improve. However, the decision to include multiple years of eelgrass survey results ultimately reflected the need to offset the high variability in the results of each survey that result from the high natural spatial/temporal variability in eelgrass meadow extent itself and the high variability inherent in the survey methods (Dr. Jamie Vaudrey, personal communication, December 11, 2018). A multi-year composite map more accurately portrays recent eelgrass distribution.

The US Fish and Wildlife Service National Wetland Inventory mapped eelgrass in Long Island Sound in 2002, 2006, 2009, 2012, and 2017. Each of these datasets can be downloaded from the CT DEEP GIS website (CT DEEP, 2019).

Integration of datasets:

Each of the five years of eelgrass survey datasets described above were mapped together to represent the recent extent of submerged aquatic vegetation. Figure 2a-8 shows all of the datasets dissolved together to show a single presence/absence layer of an ESA for submerged aquatic vegetation, which is spatially limited to eastern Long Island Sound (Figure 2a-9).

Ecologically Significant Area Map: Submerged Aquatic Vegetation

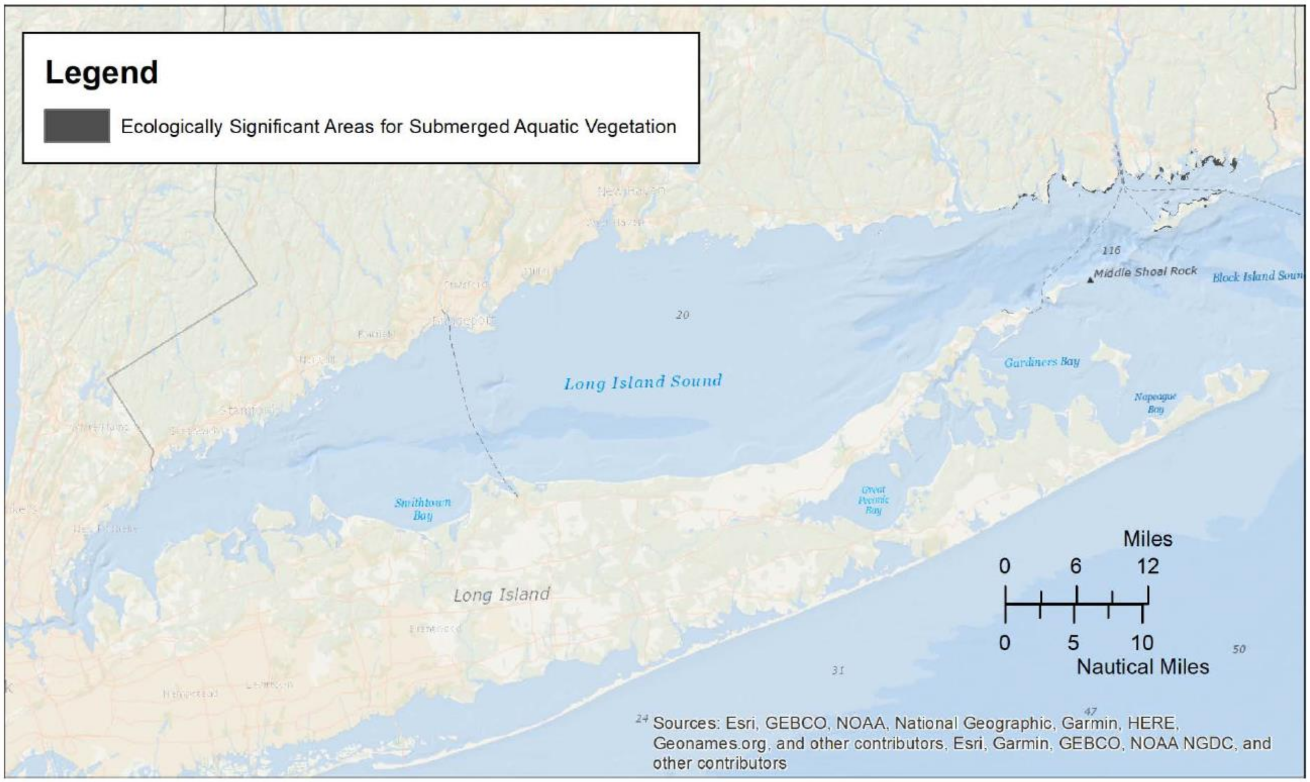

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Figure 2a-8 Final ESA map for Submerged Aquatic Vegetation. Note: The Long Island Sound boundary is removed in this map to more clearly depict submerged aquatic vegetation features. Figure 2a-9 shows the eastern Sound in detail to better discern submerged aquatic vegetation features.

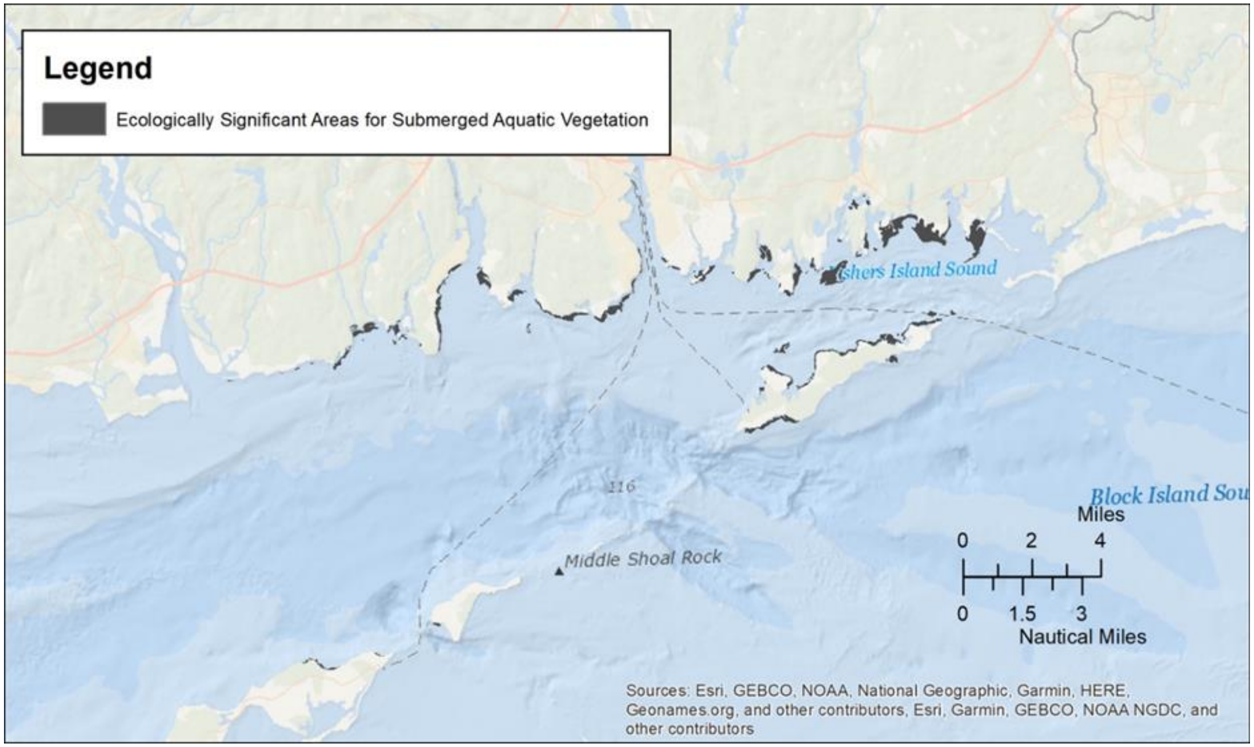

Figure 2a-9 Zoomed-in map showing the extent of the ESA for submerged aquatic vegetation. Note: The Long Island Sound boundary is removed in this map to more clearly depict submerged aquatic vegetation features.

Updates and potential future work

As discussed above, the natural spatial and temporal variability in eelgrass meadows necessitates frequent updates of these data to accurately reflect current conditions. Additionally, eelgrass habitat suitability models that combine physical and biological environmental conditions with observations of eelgrass to predict eelgrass occurrence, could be used as an input for this criterion that would identify areas that could potentially be ecologically important for eelgrass.

iii. **Criterion 3: Endangered, threatened, species of concern, or candidate species listed under state or Federal Endangered Species Act and their habitats**

Definition: *The species listed by federal or state statutes (e.g., the US Endangered Species Act, the CT Endangered Species Act, the NY Endangered Species Act) as endangered, threatened, species of concern, or candidates for listing, and their associated habitats, recognizing that detailed spatial data depicting the distribution and abundance for these marine species in Long Island Sound are potentially unavailable.*

Significance of Criterion 3:

The marine life represented by this criterion, by their special status of being endangered, threatened, etc., are significant because of that status. That significance is already recognized officially. This criterion is also a clear representation of the meaning of Criteria Pillar 1.

Components/data sources for Criterion 3:

This criterion relates to species that are protected by existing state and/or Federal regulations and laws, as well as species being considered by the Secretary of Commerce for listing as an endangered or threatened species, but not yet the subject of a proposed rule (i.e., candidate species). The EEG indicated that the data required to fully characterize this criterion would consist minimally of species occurrence data, but also could include abundance data and/or habitat maps for each individual endangered, threatened, species of concern, and candidate species found to occur in Long Island Sound. However, for most of these species, this level of data and information is currently unavailable. Species listed under the Connecticut Endangered Species Act were used as the basis for this criterion because the New York Endangered Species Act is relevant to both Long Island Sound and the New York Bight ecosystem, which is fundamentally different from Long Island Sound. The listed species that are expected to occur within Long Island Sound are shown in Table 2a-2. Federal species of concern and candidate species are also included in Table 2a-2. The following data sources and associated maps serve as components of the ESA for Criterion 3.

Table 2a-2 Connecticut Endangered Species Act-listed species occurring within Long Island Sound, where SC means Species of Special Concern, T means Threatened Species, and E means Endangered Species.

Common name	Scientific name	CT Status	NY Status	Federal Status
Mammals				
Harbor porpoise	*Phocoena phocoena spp. phocoena*	SC	SC	
Birds - Loons, Shorebirds, Terns, and others				
Common loon	*Gavia immer*	SC	SC	
Common tern	*Sterna hirundo*	SC	T	
Least tern	*Sternula antillarum*	T	T	
Piping plover	*Charadrius melodus*	T	T	T
Roseate tern	*Sterna dougalii*	E	E	E
Upland sandpiper	*Bartramia longicauda*	E	T	
American oystercatcher	*Haematopus palliatus*	T		
Eskimow curlew	*Numenius borealis*	SC		
Fish				
Atlantic bluefin Tuna	*Thunnus thynnus*			SC
Atlantic halibut	*Hippoglossus*			SC
Atlantic sturgeon	*Acipenser oxyrinchus*	E	E	E
Atlantic wolffish	*Anarhichas lupas*			SC

Blueback herring	*Alosa aestivalis*	SC		
Cusk	*Brosme*			SC; Candidate Species
Dusky shark	*Carcharhinus obscurus*			SC
Porbeagle shark	*Lamna nasus*			Candidate
Rainbow smelt	*Osmerus mordax*			SC
River herring (Alewife and Blueback herring)	*Alosa pseudoharengus and Alosa aestivalis*			SC
Sand tiger shark	*Carcharius taurus*	SC		SC
Shortnose sturgeon	*Acipenser brevirostrum*	E	E	E
Reptiles - sea turtles and brackish turtles				
Atlantic green sea turtle	*Chelonia mydas*	T	T	T
Atlantic ridley	*Lepidochelys kempii*	E	E	E
Leatherback sea turtle	*Dermochelys coriacea*	E	E	E
Loggerhead sea turtle	*Caretta*	T	T	E
Northern diamondback terrapin	*Malaclemys terrapin*	SC		

For three of the five endangered species, Atlantic sturgeon, shortnose sturgeon, and roseate tern, datasets at the individual species level were available for inclusion in the maps for this criterion. Several of the other threatened or special concern species are characterized spatially in other ESA criteria (e.g., harbor porpoise, diamondback terrapin). However, for this criterion, state endangered species spatial databases were used to characterize Ecologically

Significant Areas for these non-endangered species. One limitation of the state spatial databases is that they are focused on the coast and coastal habitats even though many of the endangered, threatened, and species of concern have open-water distributions. Individual layers for the endangered sturgeon species and roseate tern partly address this limitation.

Atlantic sturgeon and shortnose sturgeon

CT DEEP Marine Fisheries provided several datasets relevant to these two sturgeon species. First, they provided a layer that delineates the sturgeon migratory corridor in the Sound. Second, the provided the boundaries of areas where certain fishing gears (e.g., otter trawl, beam trawl, sink or anchored gillnet) are restricted to protect Atlantic sturgeon. Lastly, areas of high and medium sturgeon use were identified from the CT DEEP Marine Fisheries Long Island Sound Trawl Survey (LISTS). The sturgeon migratory corridor, the gear restriction areas, and the medium and high use areas were all considered ecologically significant (Figure 2a-10). For more detail on LISTS and its methods, see the Fish criterion.

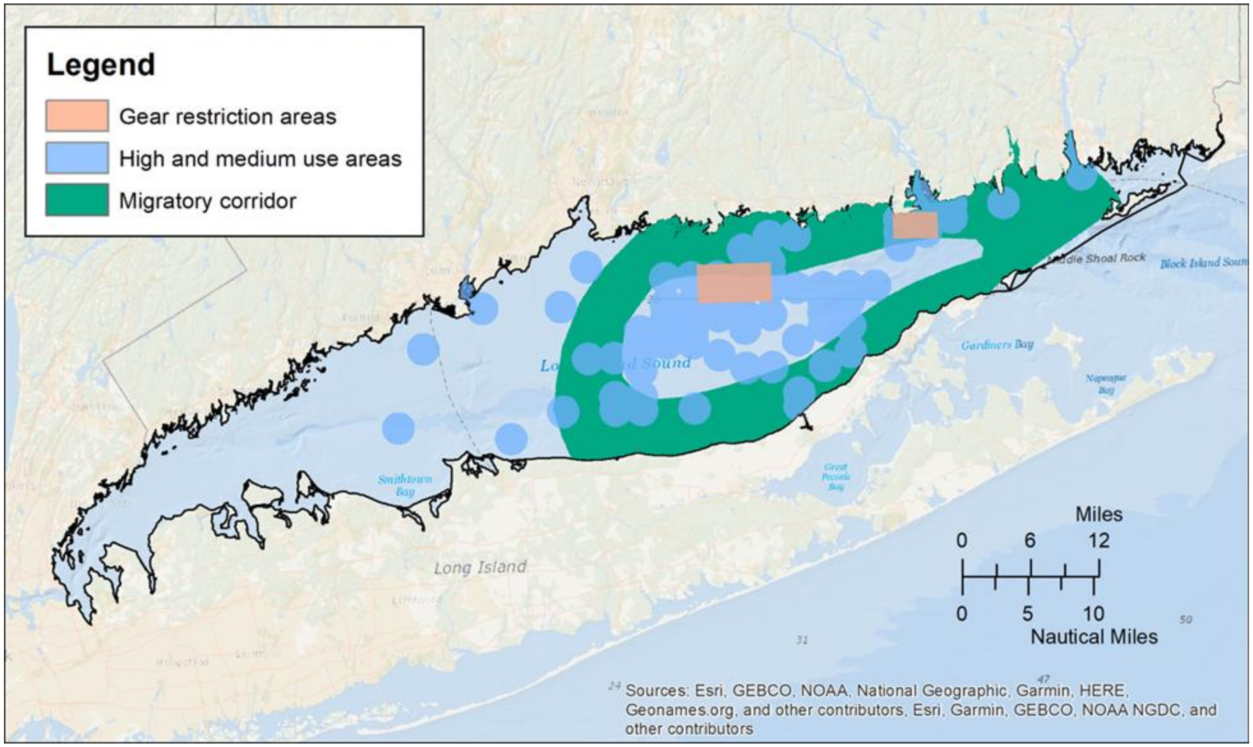

Figure 2a-10 Data layers relevant to Atlantic and shortnose sturgeon ESA including Atlantic sturgeon gear restriction areas, high and medium use sturgeon areas, and Atlantic sturgeon migratory corridor from CT DEEP Marine Fisheries.

Roseate tern

A summer (May - September) predicted occurrence map for roseate tern was provided by the University of Connecticut. All areas where roseate tern was predicted to be present were considered ecologically significant (Figure 2a-11). For more detail on this layer, see the Birds criterion.

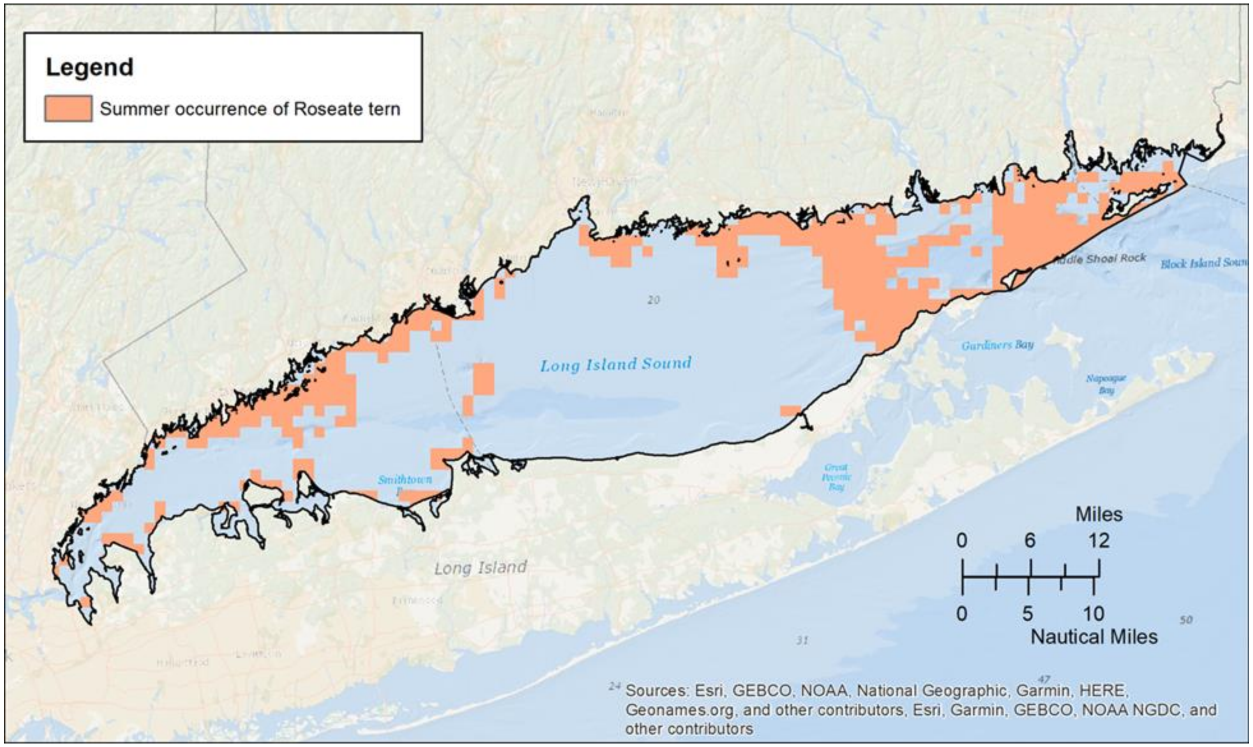

Figure 2a-11 Predicted summer occurrence of roseate tern in LIS.

Connecticut Natural Diversity Database

The [Connecticut Natural Diversity Database] maintains maps that represent approximate locations of endangered, threatened and special concern species and significant natural communities in Connecticut, compiled from CT DEEP staff, scientists, conservation groups, and landowners (Figure 2a-12) (CT DEEP, 2019). The data are updated approximately every 6-months and are meant to serve as a pre-screening tool to identify potential impacts to state-listed species. The Connecticut Natural Diversity Database was updated in December 2018, and are available for download on the [CT DEEP GIS website] (CT DEEP, 2019).

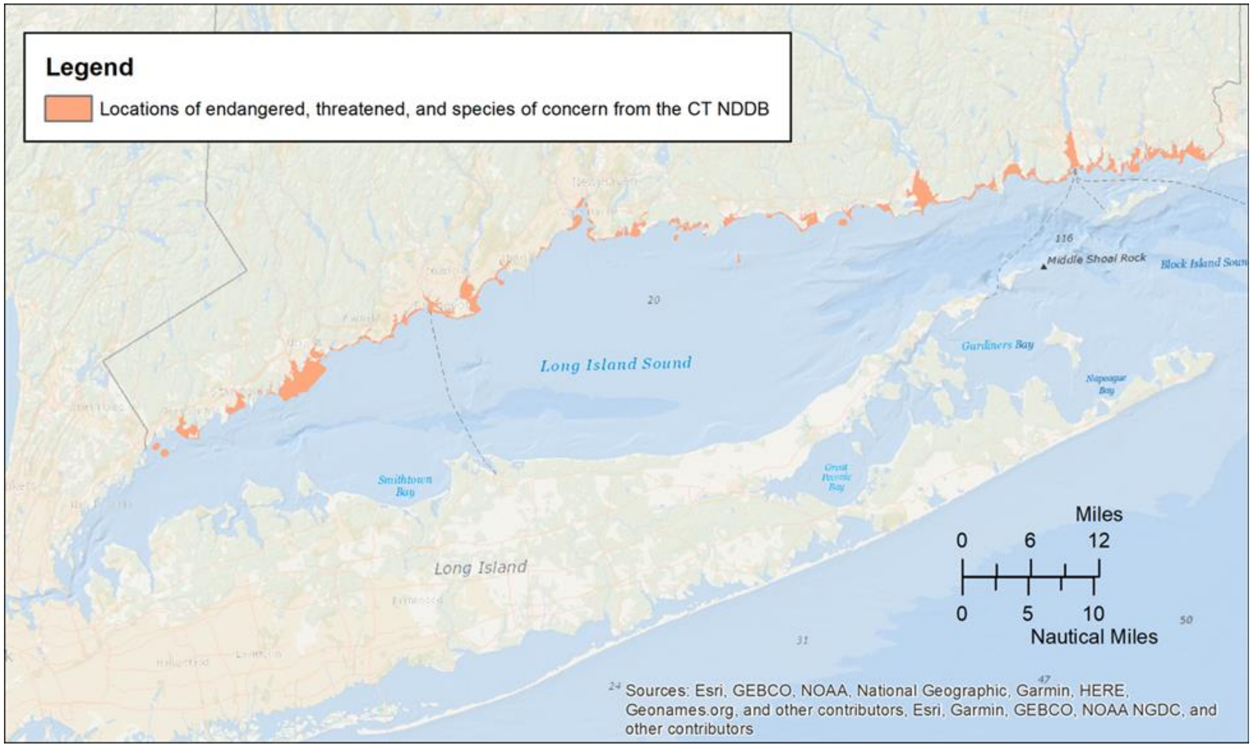

Figure 2a-12 Approximate locations of endangered, threatened, and special concern species and significant natural communities in Long Island Sound, as reflected in the Connecticut Natural Diversity Database (CT NDDB). Note: The Long Island Sound boundary is removed in this map to more clearly depict features.

Connecticut Critical Habitats

Connecticut Critical Habitats provides the identification and distribution of a subset of important wildlife habitats identified in the Connecticut Comprehensive Wildlife Conservation Strategy. Critical Habitats in estuarine environments were extracted from the full dataset for mapping in the Long Island Sound (Figure 2a-13). The full dataset is available for download on the CT DEEP GIS website (CT DEEP, 2019).

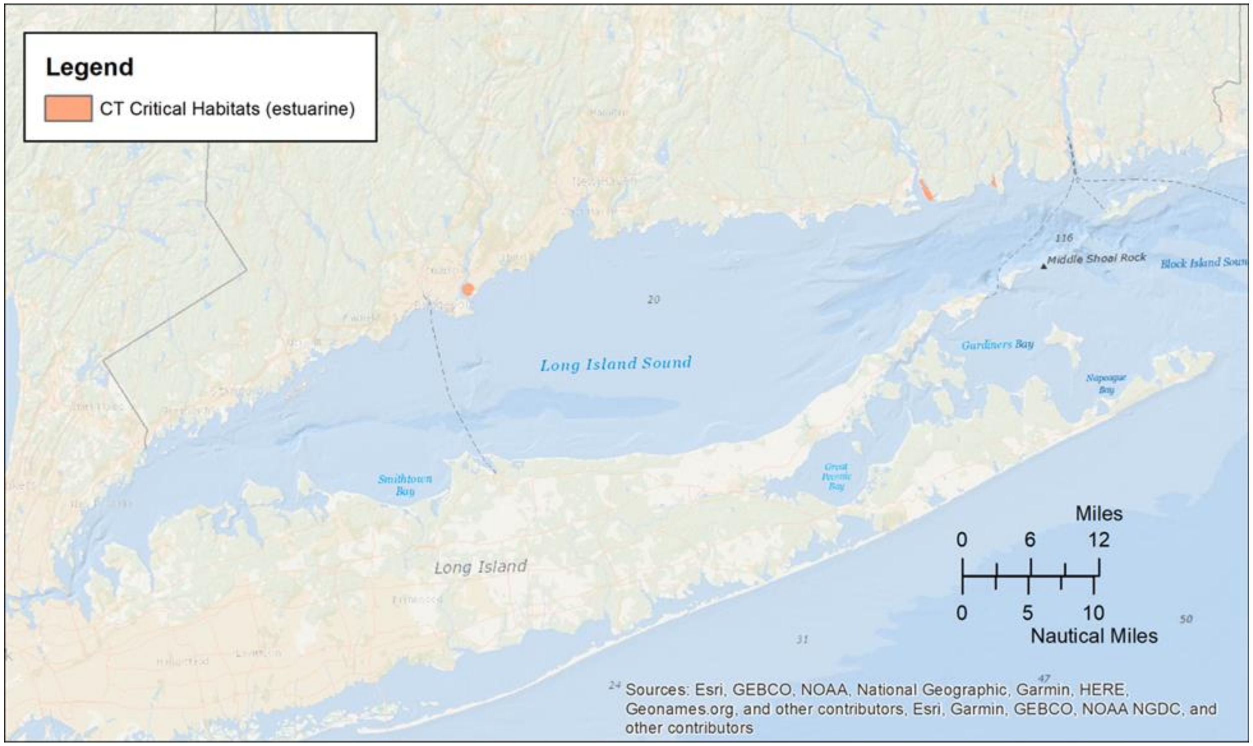

Figure 2a-13 Connecticut Critical Habitats in estuarine environments within Long Island Sound. Polygons are located on the north shore of the Sound. Note: The Long Island Sound boundary is removed in this map to more clearly depict features.

New York Rare Plants and Rare Animals

The New York Natural Heritage Program actively surveys rare animal species, including those listed as threatened, endangered, and of species concern by the state (Figure 2a-14). The data can be accessed via the New York State Department of Environmental Conservation [Environmental Resource Mapper](#) (NY DEC, 2019).

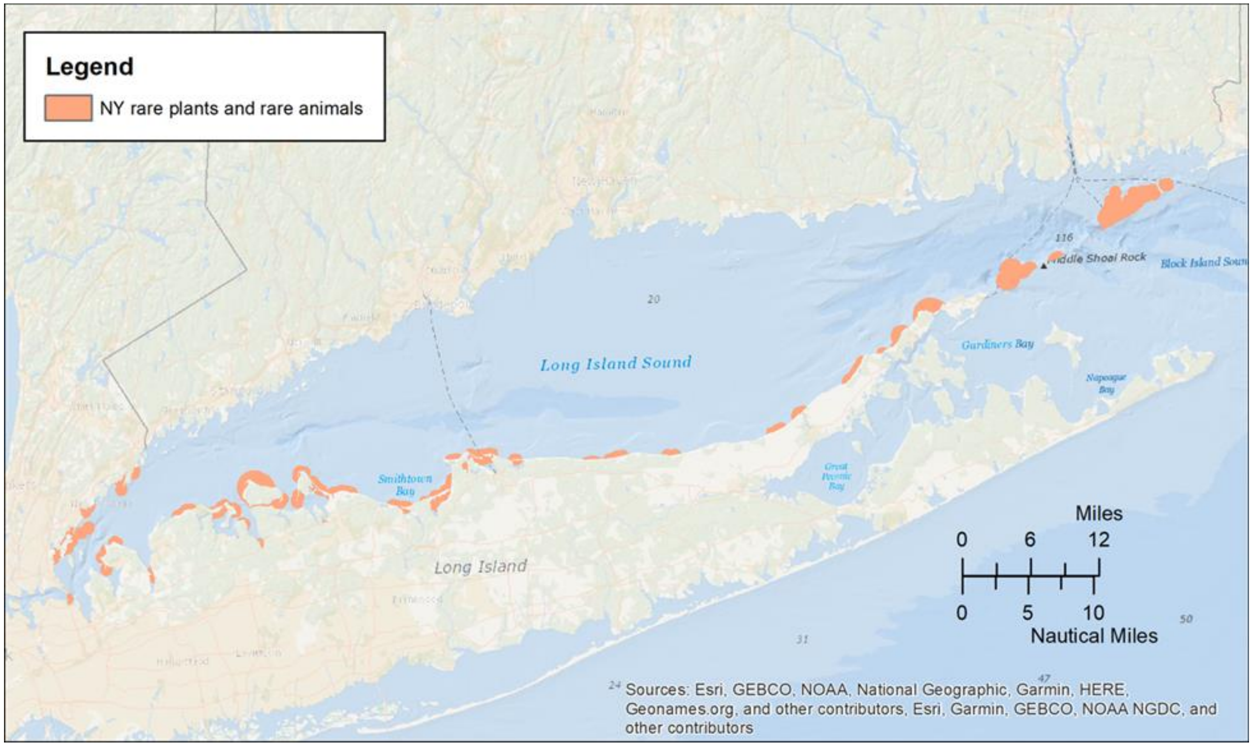

Figure 2a-14 Approximate locations of rare plants and animals in New York waters of LIS from the New York Department of Environmental Conservation. Note: The Long Island Sound boundary is removed in this map to more clearly depict features.

New York Significant Natural Communities

The New York Natural Heritage Program maintains a database of locations of rare or high-quality wetlands, forests, grasslands, ponds, streams, and other types of habitats, ecosystems, and ecological areas (Figure 2a-15). Because some significant natural communities contain rare plants and/or rare animals, there is some overlap between this layer and the New York Rare Plants and Rare Animals layer. The data can be accessed via the New York State Department of Environmental Conservation Environmental Resource Mapper (NY DEC, 2019).

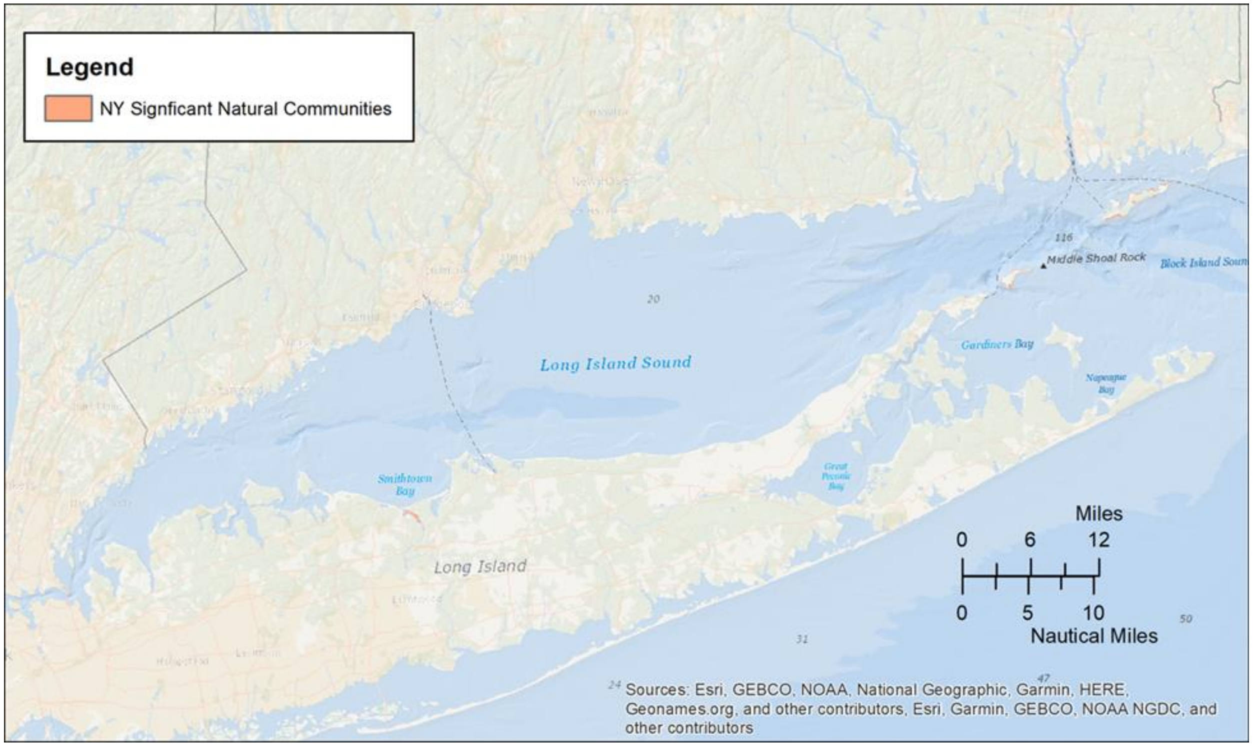

Figure 2a-15 Locations of New York Significant Natural Communities, on the Long Island shore of the Sound. Note: The Long Island Sound boundary is removed in this map to more clearly depict features.

New York Significant Coastal Fish and Wildlife Habitats

New York State Significant Coastal Fish and Wildlife Habitats (NY Office of Planning and Development, 2019) have been designated and mapped by the New York Department of State, after recommendation by the New York Department of Environmental Conservation, which applied a rating system (Ozard, 1984) to identify and rate the habitats (Figure 2a-16). Generally, the habitats must: be essential to the survival of a large portion of a particular fish or wildlife population; support populations of species which are endangered, threatened or of special concern; support populations having significant commercial, recreational, or educational value; or exemplify a habitat type which is not commonly found in the State or in a coastal region.

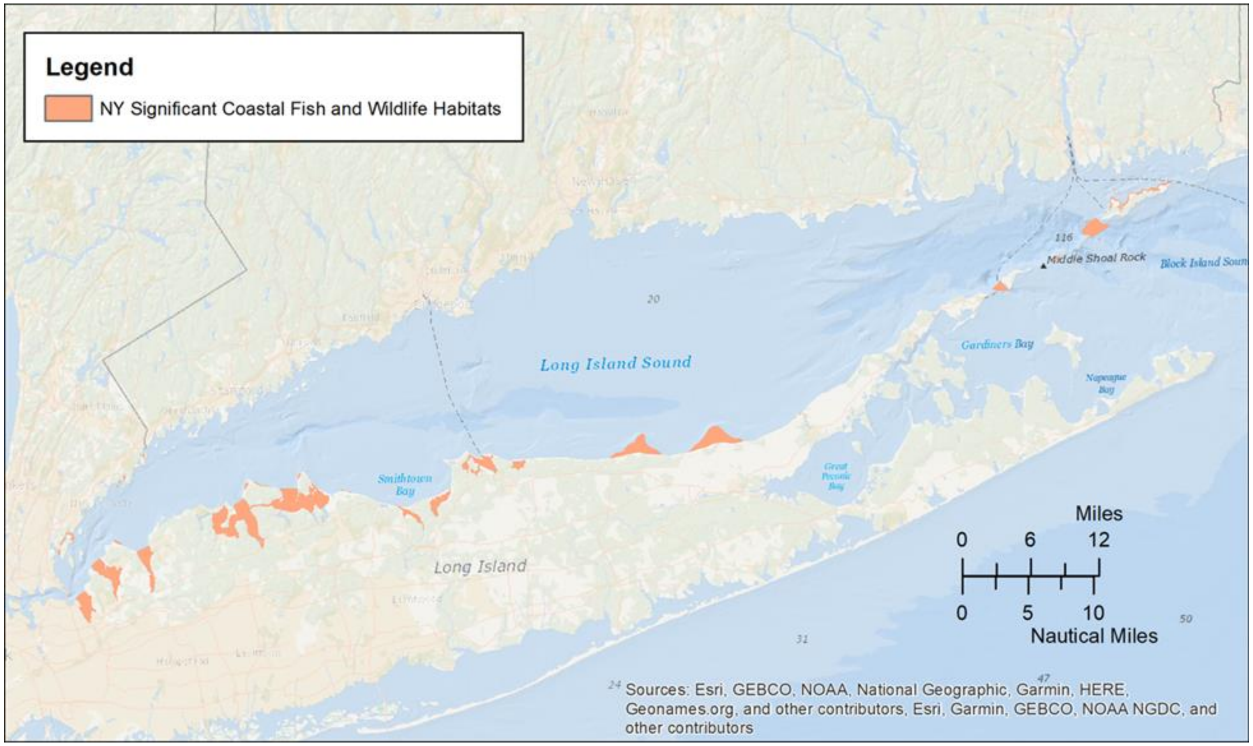

Figure 2a-16 Locations of New York Significant Coastal Fishing and Wildlife Habitats. Note: The Long Island Sound boundary is removed in this map to more clearly depict features.

US Endangered Species Act Critical Habitats

One of the six federally endangered species known to occur in Long Island Sound (Table 2a-2) has Critical Habitat spatially defined under the US Endangered Species Act by the NOAA Greater Atlantic Region Fisheries Office (GARFO) Protected Resources Division (NOAA Fisheries, 2017). Atlantic sturgeon Critical Habitat is defined for Connecticut River and Housatonic River segments (Figure 2a-17). The other endangered species known to occur in Long Island Sound do not have Critical Habitats defined under the US Endangered Species Act. The NOAA GARFO Protected Resources Division developed and maintains the ESA Section 7 Mapper, which allows users to identify any Critical Habitats and protected species present in a project action area (Fisheries, 2019).

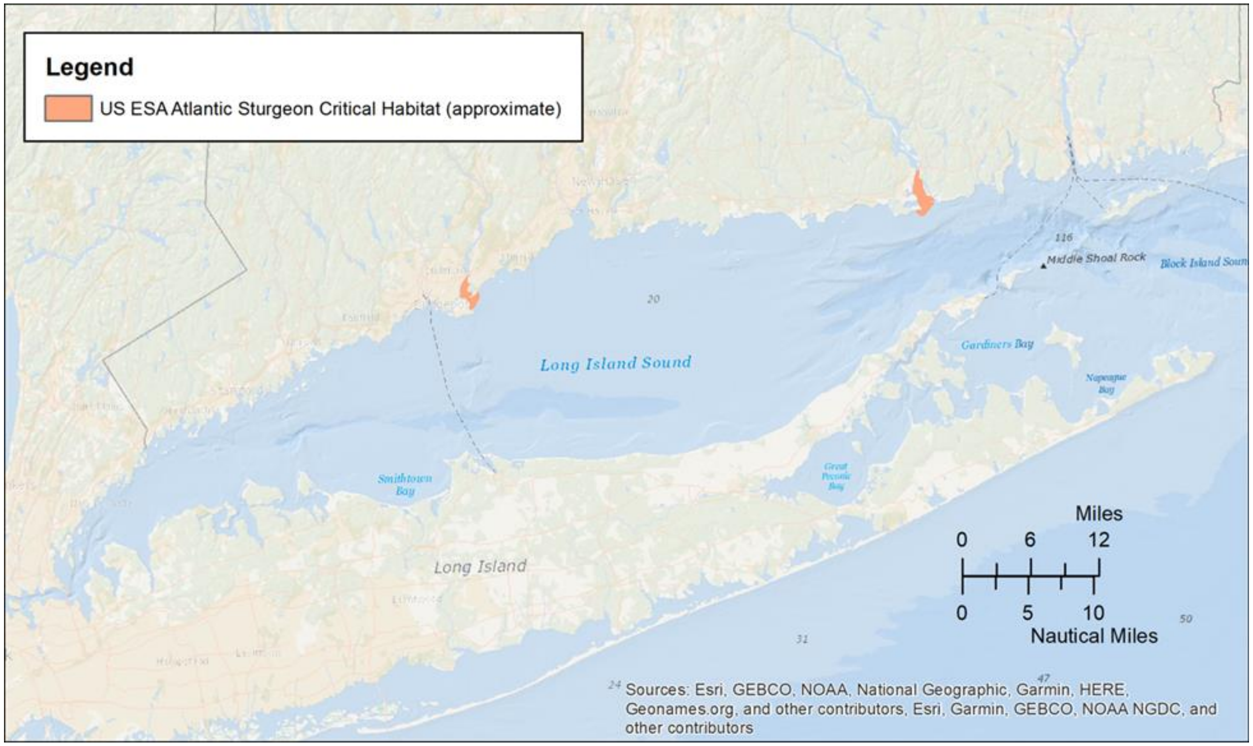

Figure 2a-17 Approximate location of Critical Habitats delineated for Atlantic sturgeon under the US Endangered Species Act (US ESA). The river segments affected by this regulation have been buffered to increase visibility on this map and in the Ecologically Significant Areas analysis. Note: The Long Island Sound boundary is removed in this map to more clearly depict features.

Integration of components/data sets

Each of the datasets described above were mapped together to represent the extent of endangered, threatened, species of concern, or candidate species listed under state or Federal Endangered Species Act and their habitats. Figure 2a-18 shows the number of overlaps in those datasets. Figure 2a-19 shows all of the datasets dissolved together to show a single presence/absence layer of ESA for endangered, threatened, species of concern, or candidate species listed under state or Federal Endangered Species Act and their habitats.

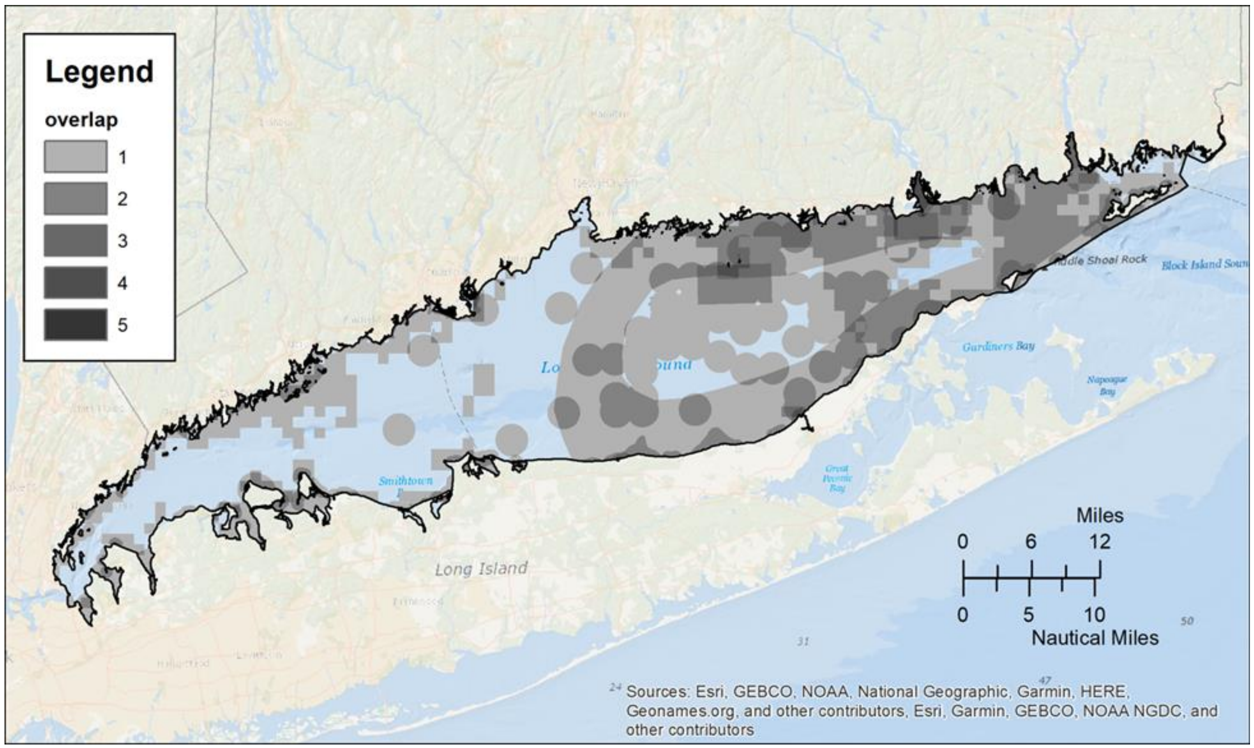

Figure 2a-18 Overlaps among each of the input components/datasets representing Criterion 3: Ecologically Significant Areas for Endangered, threatened, species of concern, or candidate species listed under state or Federal Endangered Species Act and their habitats.

Ecologically Significant Area Map: Endangered, Threatened, and Species of Concern

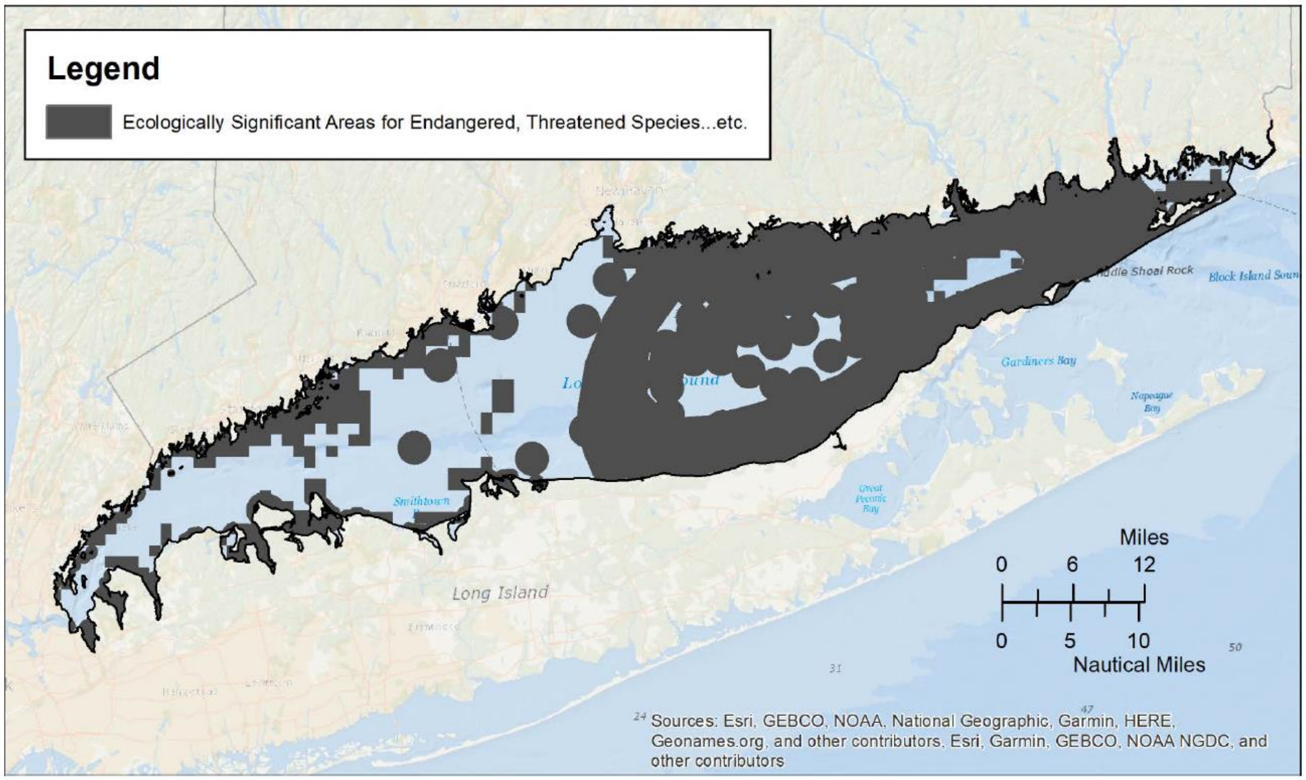

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Figure 2a-19 Final ESA map for the Endangered, threatened, species of concern, or candidate species listed under state or federal Endangered Species Act and their habitats.

Updates and potential future work
Additional species-specific layers depicting the occurrence of endangered, threatened, species of concern, and candidate species will improve this criterion. Specifically, characterizations of protected species in open water, versus in coastal habitats, are particularly needed.

iv. **Criterion 4: Cold water corals**
Definition: Areas where cold-water corals have been observed or where habitat suitability or other scientific models predict they occur.

Significance of Cold water corals
Cold water corals are colonial animals similar to tropical reef corals, but many species don't require sunlight for survival. Because they catch food from the surrounding water, they are usually found in areas with higher current speeds, including on ledges and mounds. There are stony cold water corals and soft cold water corals. A common species of stony cold water coral in New England, the northern star coral (*Astrangia poculata*), can house symbiotic zooxanthellae, as tropical corals do, and can survive in a variety of water depths. In general, cold water corals are slow-growing and fragile, meaning they are vulnerable to physical disturbance. Invertebrates and fish are attracted to cold water coral aggregations for food and shelter. Additionally, Cold water corals are a visibly unique expression of a healthy, thriving marine ecosystem; they are a direct example of the ecological character of the Sound the Blue Plan is seeking to sustain.

Data sources for Cold water corals
There have been no comprehensive surveys of cold water coral distribution and abundance in Long Island Sound. However, the Long Island Sound Mapping and Research Collaborative (LISMaRC), through the Long Island Sound Seafloor Mapping Initiative, have mapped the occurrence of *Astrangia poculata* at discrete sampling locations near Stratford Shoals and eastern Long Island Sound. These observations create an incomplete picture of where ESA for cold water corals exist. First, while each survey area is shown on the map at its true size, cold water corals likely only exist in a fraction of each survey area. In other words, cold water corals only needed to be found to occur once within the entire survey area for that survey area to be included as ecologically significant. Second, it is important to reiterate that simply because the ESA maps do not indicate presence of cold water corals in other areas of the Sound, they do not reflect their absence - they merely indicate the lack of survey effort in those parts of the Sound. Only survey areas

where cold water corals have been observed (anywhere within the survey area) are considered ecologically significant (Figure 2a-20).

Ecologically Significant Area Map: Cold Water Corals

LONG ISLAND SOUND BLUE PLAN
Sustainable Ecosystems - Compatible Uses

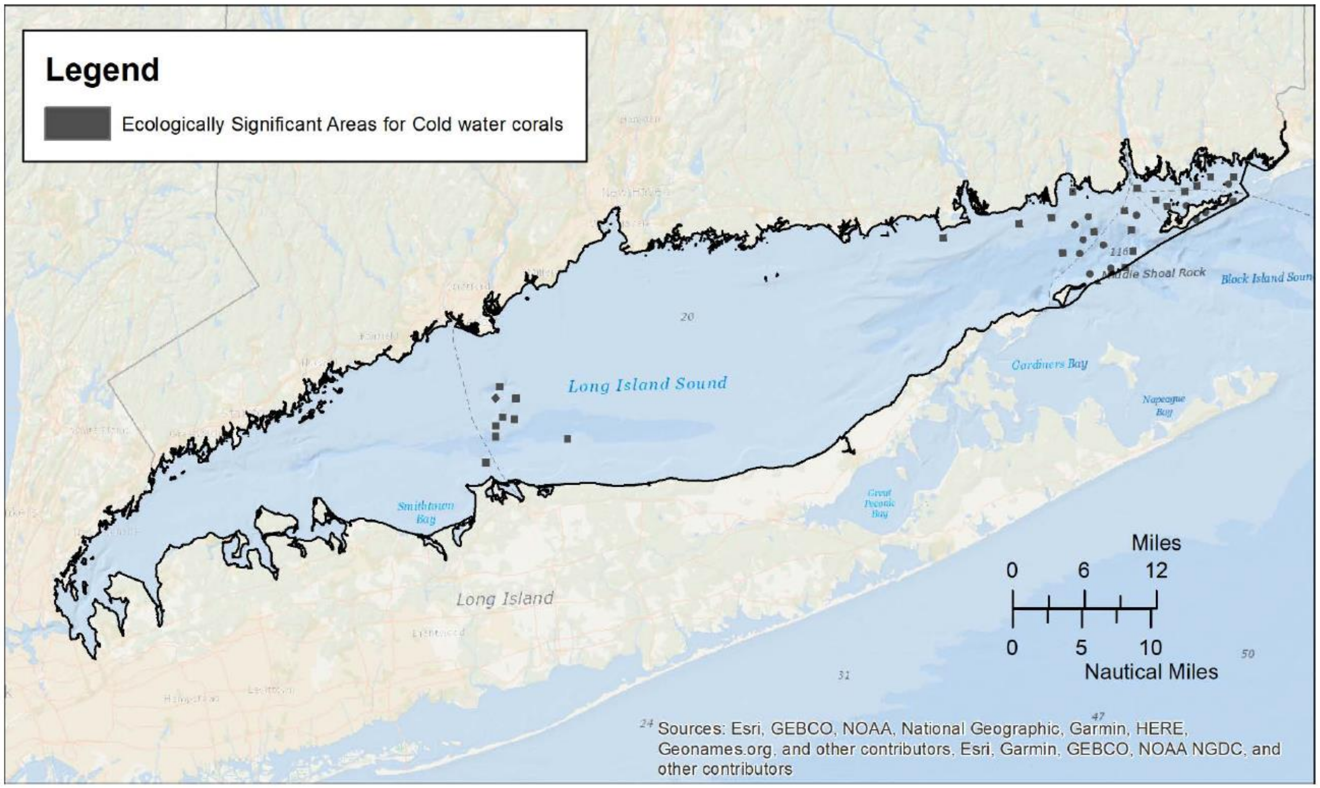

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Figure 2a-20 Final ESA map of cold water corals.

Updates and potential future work

It is plausible to assume that with additional analysis, a habitat suitability model for cold water corals in Long Island Sound could be developed. The benefit of using a habitat suitability model is that an existing and limited set of observations could be used to predict habitat suitability across the entire Long Island Sound, rather than rely on a piece-meal sampling approach that may never sample every Long Island Sound habitat. This type of model would use combinations of physical and biological features of the marine environment, along with known locations of cold water corals, to predict where cold water corals might occur throughout the entire Sound. The EEG's definition for this criterion explicitly included the results of habitat suitability models as adequate inputs for characterizing this criterion.

v. **Criterion 5: Coastal wetlands**

Definition: According to Connecticut General Statute (CGS) 22a-29: "Those areas which border on or lie beneath tidal waters, such as, but not limited to banks, bogs, salt marshes, swamps, meadows, flats, or other low lands subject to tidal action, including those areas now or formerly connected to tidal waters, and whose surface is at or below an elevation of one foot above local extreme high water; and upon which may grow or be capable of growing some, but not necessarily all, of [a list of specific plant species found in CGS section 22a-29(2)].

Significance of Coastal wetlands

Coastal Wetlands serve multiple ecological purposes and have been identified as one of the most important natural communities of LIS. They serve as nursery grounds and nesting habitat for many species, and also provide ecosystem services such as wave attenuation and nutrient cycling. Since coastal wetlands tend to occur in environments landward of the 10-foot contour, Blue Plan policies, which apply seaward of the 10-foot contour, are not expected to apply to coastal wetland habitats. However, as discussed in section 3.4a, the EEG included these coastal habitats in the ESA framework because of their importance as supporting habitats for the Long Island Sound ecosystem.

Data Sources for Coastal wetlands

The EEG used National Wetlands Inventory data, clipped to the Long Island Sound Study boundary, to depict coastal wetlands for this criterion. Figure 2a-21 shows a single presence/absence layer of ESA for coastal wetlands.

Ecologically Significant Area Map: Coastal Wetlands

LONG ISLAND SOUND BLUE PLAN
Sustainable Ecosystems - Compatible Uses

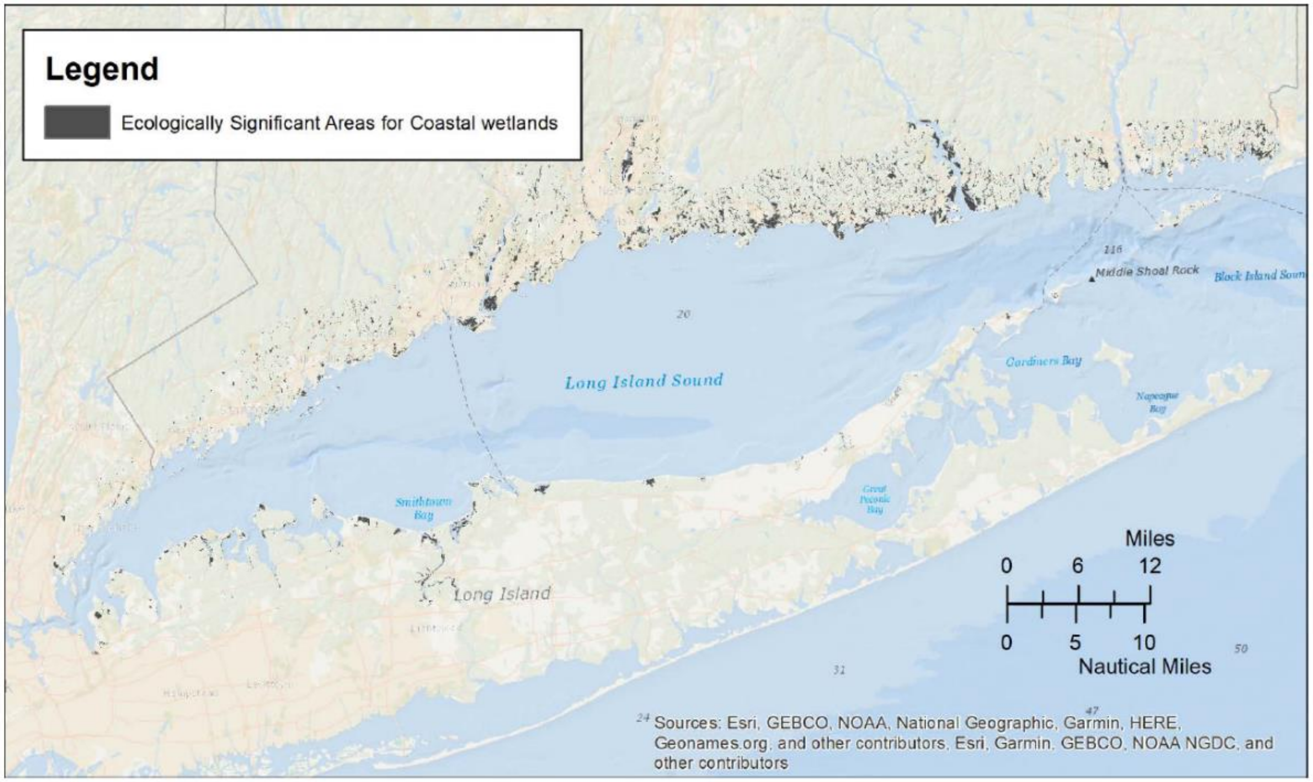

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Figure 2a-21 Final ESA map of coastal wetlands. Note: The Long Island Sound boundary is removed in this map to more clearly depict coastal wetland features.

Updates and potential future work

Like any other coastal biological feature, coastal wetland extent is naturally variable and highly susceptible to human development and disturbance. For these reasons, data from the most recent coastal wetland surveys should continue to be integrated into this criterion.

c. Criteria Pillar 2: Areas of high natural productivity, biological persistence, diversity, and abundance, including areas important for supporting or exhibiting such features, relative to the following characteristics or species (see footnote 28 above for complete title)

The second set of criteria considered by the EEG expand on the concept of "productive" places articulated in the statute. From an ecological perspective, productivity refers to the processes of reproduction and growth. If organisms throughout the ecosystem grow and reproduce to their potential, the ecosystem is considered balanced and efficient. This balance is important for the provisioning of ecosystem services on which humans depend. Productivity as a set of processes is difficult to measure, so ecologists often use abundance, and other metrics like diversity and persistence, to understand productivity. Furthermore, the places where behaviors that allow organisms to be productive, such as feeding areas, nesting areas, nursery grounds, and migratory routes were considered important to include in this category. The EEG decided to take a taxa-based approach to gather data on these topics because the data were usually collected and presented by species group or at the taxa level. The criteria within this category are similar to the components of ecological importance identified by the Northeast and Mid-Atlantic regional ocean planning efforts "Areas of high productivity", "Areas of high diversity", and "Areas of high abundance". The Massachusetts Ocean Plan also took a taxa-based approach for several of its SSUs, including important fish resources and colonial waterbirds important nesting habitat, among others.

The broad taxonomic categories used to organize these data can potentially mask or obscure relevant spatial patterns in individual species or groups of species within a taxon. Species within a taxonomic group have diverse behaviors, life history traits, and habitat requirements, and so it could be necessary, once at the project-scale, to drill into underlying datasets to better understand how Ecologically Significant Areas for individual species could be captured by the taxonomic group's ESA, or not.

i. Criterion 6: Cetaceans

Definition: Areas where cetaceans occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support cetaceans (e.g. particular feeding areas, nursery grounds).

Significance of Cetaceans

Cetaceans include whales, dolphins, and porpoises. Porpoises, specifically the harbor porpoise, are the most common cetacean inhabitant of Long Island Sound (Dr. Robert Kenney, personal communication, December 5, 2018). The harbor porpoise is a species of Special Concern in the state of Connecticut. Some whale species, such as humpback whales, have been more commonly observed in recent years in western Long Island Sound. However, since large whales have not historically been observed in the Sound, they are not listed as endangered species in Connecticut. Many large whales retain protection by the federal Endangered Species Act wherever they occur in US waters. All cetacean species are also protected by the US Marine Mammal Protection Act. Cetaceans are susceptible to human activities, particularly boat strikes and entanglement.

Data Sources for Cetaceans

Duke University Cetacean Models

To map cetacean occurrence in the Sound, the EEG used the same datasets being used for regional ocean planning in the Northeast and Mid-Atlantic - Duke University Marine Geospatial Ecology Lab cetacean density models (Curtice, Cleary, Shumchenia, & Halpin, 2018) (Roberts, et al., 2016) (Roberts, Mannocci, & Halpin, 2016-2017). These data were accessed via the Northeast Ocean Data Portal (NROC, 2019). Predicted density maps were available for eleven cetacean species or species guilds with coverage in Long Island Sound. Several of those maps were annual averages whereas others were monthly predictions. For the species with monthly predicted densities, the twelve months were averaged to create an annual summary layer for each species. The eleven annual summary layers were added up to reflect the predicted total annual average density of cetaceans in the Sound. The EEG selected the area in the eastern Sound where 5 or more individuals of any species were predicted to occur on an annual basis as ecologically significant (Figure 2a-22). In this area, densities of harbor porpoise were predicted to be the highest of any other species; very low densities were predicted in this area for the remaining cetacean species.

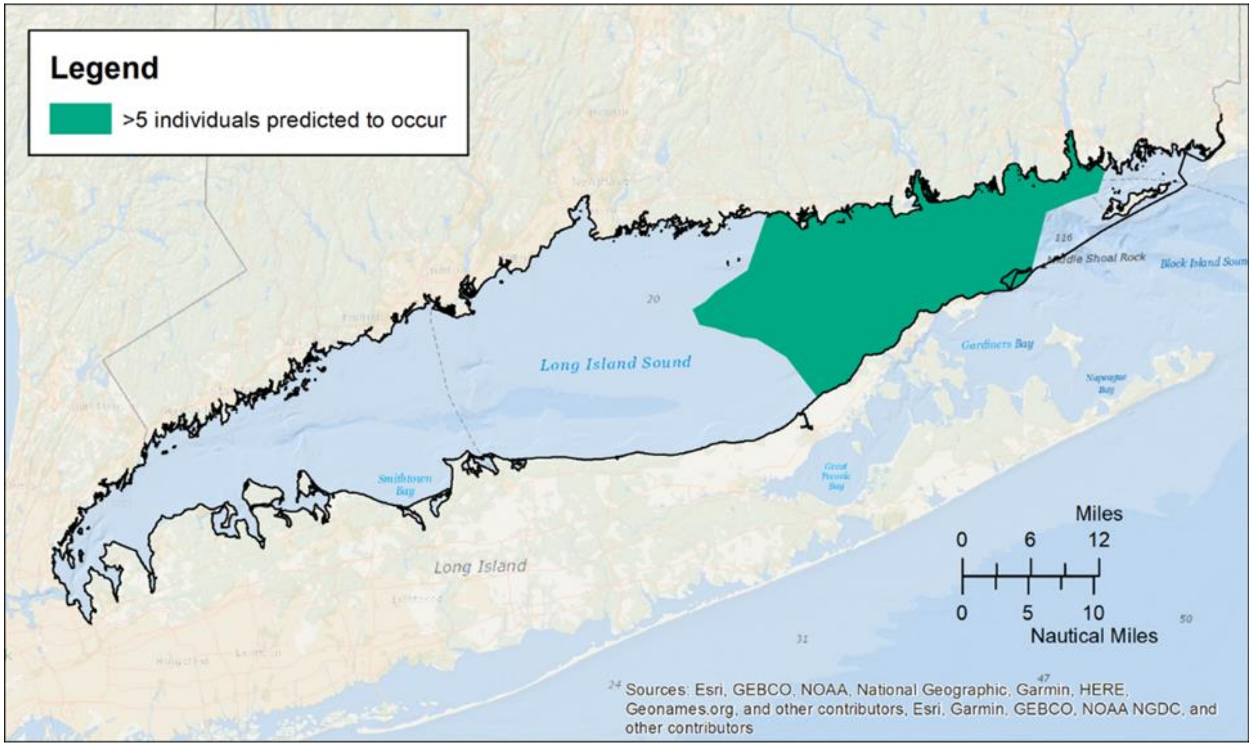


Figure 2a-22 Area where greater than 5 individual cetaceans (of any species) are predicted to occur annually in LIS, extracted from the Duke Marine Geospatial Ecology Lab's cetacean density models for the US Atlantic Coast.

Expert Participatory Mapping

After reviewing the draft area selected by the EEG that was derived from the Duke University Cetacean Models, experts recommended that the ESA for cetaceans be amended to include an area where humpback whales had been recently observed in western Long Island Sound. On January 3, 2019, Patrick Comins, Executive Director of the Connecticut Audubon Society, delineated this area off of New Rochelle, NY, for inclusion as an ESA (Figure 2a-23).

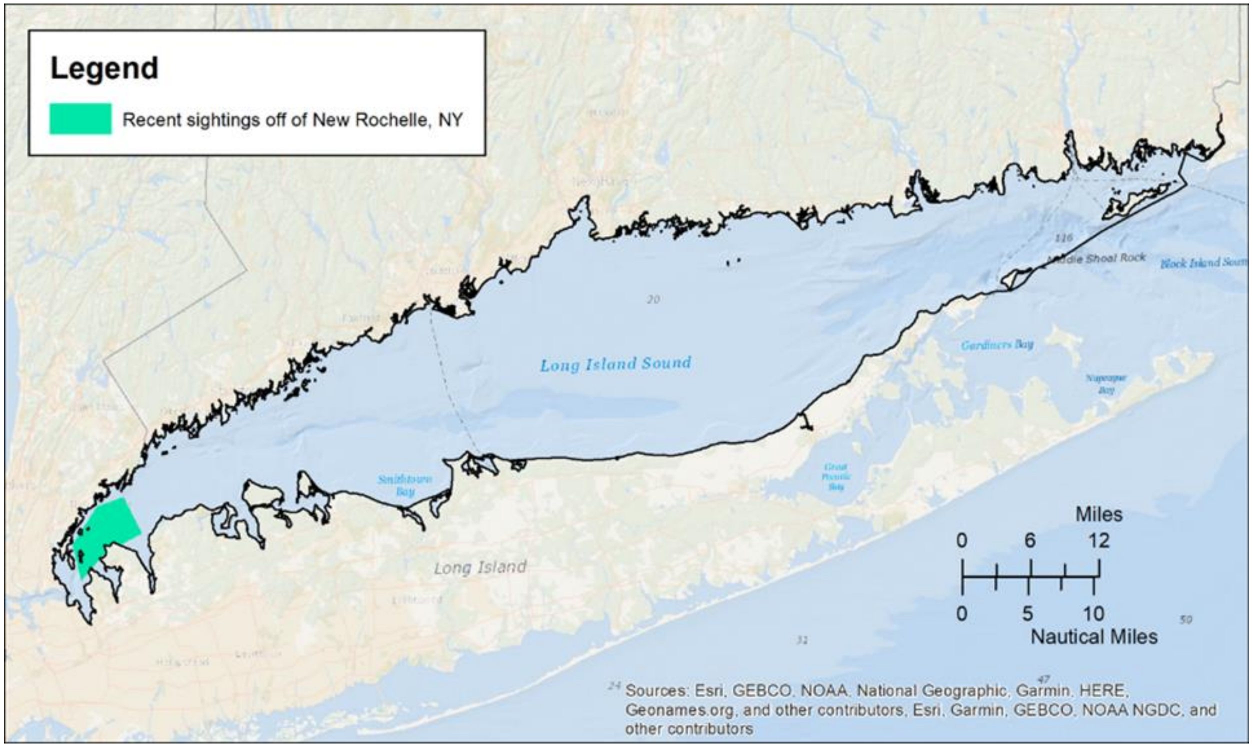
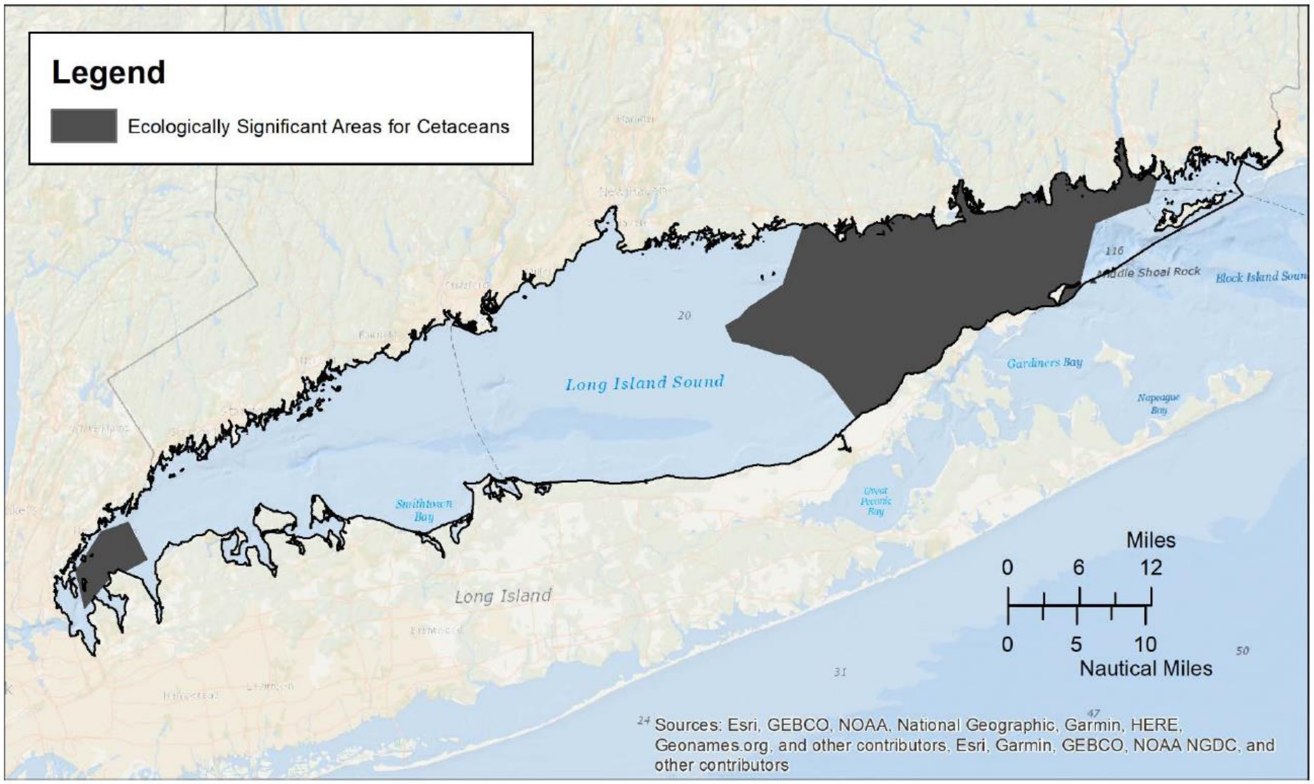


Figure 2a-23 Area identified through expert participatory mapping depicting recent sightings of humpback whales in western LIS.

Integration of information sources

Each of the datasets described above were mapped together to areas where cetaceans occur in higher concentrations and/or particular significant areas. Figure 2a-24 shows both datasets together on the same map of the ESA for cetaceans.

Ecologically Significant Area Map: Cetaceans (e.g., whales, dolphins, porpoises)



September, 2019: FINAL *CT Dept. of Energy & Environmental Protection*

Figure 2a-24 Final ESA map of cetaceans.

Updates and potential future work

The occurrence of some large whale species in the western Sound has increased very recently. For this reason, and due to shifting environmental conditions that may be driving these new patterns, additional data collected by citizens, conservation organizations, and whale-watching groups should be considered as supporting information for this criterion.

ii. **Criterion 7: Pinnipeds**

Definition: *Areas where pinnipeds occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support pinnipeds (e.g. particular haul-out locations, feeding areas).*

Significance of Pinnipeds

Pinniped species found on Long Island (including outside LIS) include Harbor, Grey, Harp, Hooded, and Ringed seals. Although no seal species have protected status under the Connecticut Endangered Species Act, they are protected federally by the US Marine Mammal Protection Act. Like cetaceans, seals are susceptible to boat strikes and entanglement.

Data sources for Pinnipeds

As a result of the science webinars and outreach that supported the Inventory, a data layer representing important areas for seals, including haul-out sites, was developed. The NOAA Environmental Sensitivity Index (ESI) map of seal haul-out sites was used as a starting point. Using participatory mapping, experts identified and/or augmented areas on the ESI map to create a more up-to-date and accurate map of Ecologically Significant Areas for pinnipeds. The resulting map was included in the Blue Plan Inventory and used by the EEG to map the ESA for pinnipeds (Figure 2a-25). Additional expert input to delineate pinniped concentration areas near Hungry Point on Fishers Island was obtained during the Blue Plan draft review process and is also represented in Figure 2a-25.

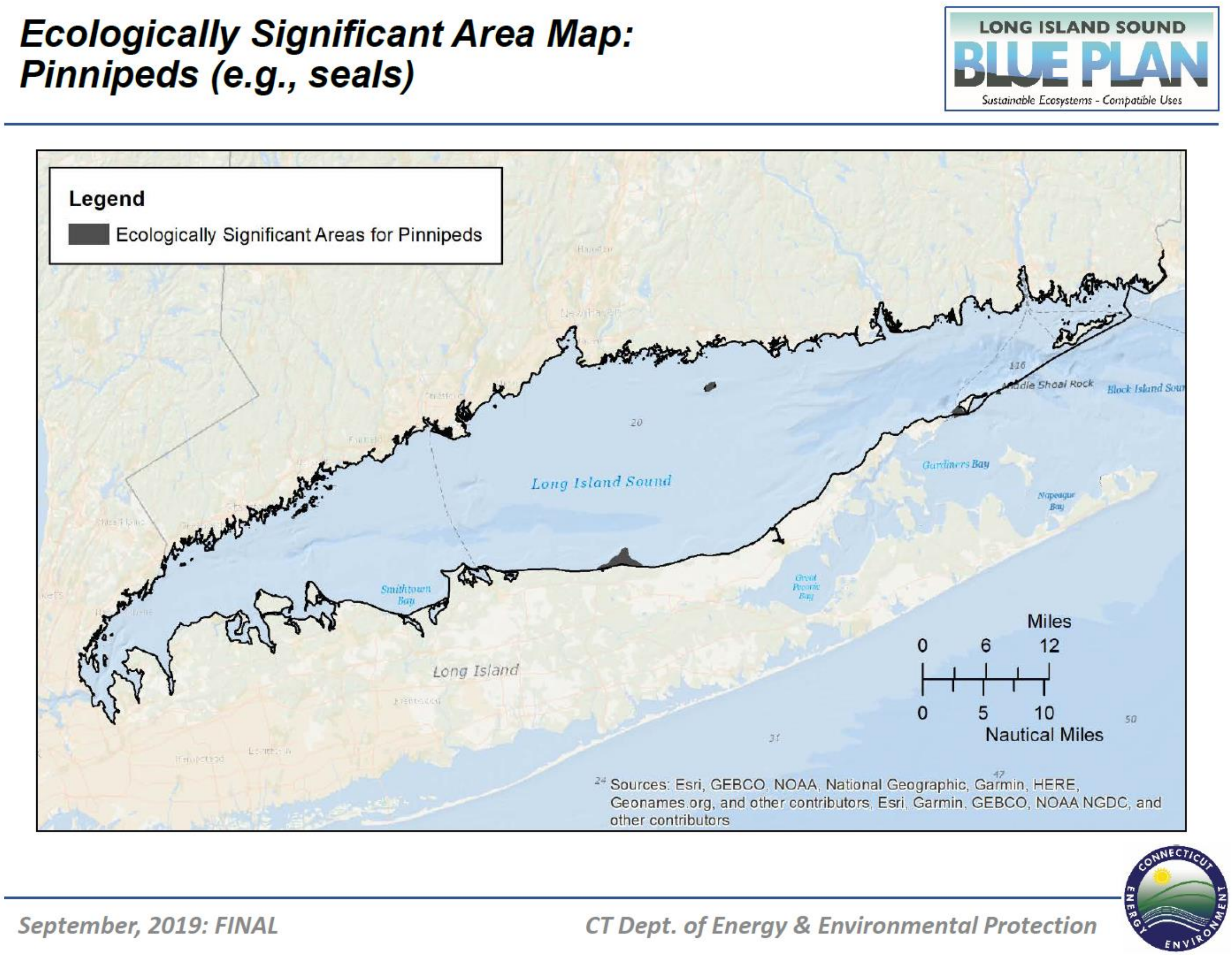


Figure 2a-25 Final ESA map for Pinnipeds. Note: The Long Island Sound boundary is removed in this map to more clearly depict areas where pinnipeds occur in higher concentrations.

Updates and potential future work

When compared with the locations of haul-out sites, relatively little is known about the spatial patterns of seals' use of the waters of Long Island Sound for activities like feeding, migrating, etc. Therefore, future work could focus on improving spatial representations of these activities. In addition, the population of seals has increased in the Sound in recent years, and so frequent updates may be required to continue to accurately depict the ESA for seals.

iii. **Criterion 8: Sea turtles and other reptiles**

Definition: Areas where sea turtles and other reptiles occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support sea turtles and other reptiles (e.g. particular feeding areas, nesting grounds, hibernation areas).

Significance of Sea turtles and other reptiles

The criterion "Sea turtles and other reptiles" includes sea turtle species common in the Sound such as Loggerhead, Kemp's Ridley, and Green, as well as a different species of turtle, the Northern diamondback terrapin (CT DEEP, 2019). Diamondback terrapins are not sea turtles but are more similar to terrestrial and aquatic turtle species. They are a species of Special Concern in Connecticut. Diamondback terrapins live in coastal habitats where fresh and salt water meet, and often hibernate in muddy habitats like coastal marshes and wetlands. This behavior makes diamondback terrapins particularly susceptible to coastal construction and dredging activities via habitat disturbance and direct mortality. Sea turtles are extremely vulnerable to boat strikes as they swim and drift slowly at the water surface. Loggerhead (threatened), Green (threatened), and Leatherback (endangered) sea turtles are protected by the Connecticut Endangered Species Act as well as the US Endangered Species Act. Leatherback sea turtles are not common in the Sound. In recent years, there have been several documented boat strikes of Green and Loggerhead sea turtles that resulted in severe injury or mortality.

Data sources for Sea turtles and other reptiles

Northern diamondback terrapin probability of occurrence

During the 2018 science review webinars on Ecologically Significant Areas, experts sharing information with the EEG regarding available diamondback terrapin spatial data, which had been lacking in the draft ESA maps. Even though diamondback terrapin habitat is not expected to overlap with the Blue Plan policy area, the data are included as ecologically significant. The available data was compiled by the Conserve Wildlife Foundation of New Jersey and is available via the North Atlantic Landscape Conservation Cooperative website (Conservation Biology Institute, 2016)and the USGS. The point layer represents documented occurrences of the northern diamondback terrapin between 2000-2012 from Massachusetts to Virginia, provided by the Diamondback Terrapin Working Group. The map depicts the predicted probability of occurrence on a 0 - 1 scale, with 0.7722 being the highest possible value. A threshold of 0.3188 was generated by the modeling program (Maxent) and is considered a relatively conservative threshold that has been used as an indicator for suitable habitat in other studies. The EEG selected occurrences above the 0.3188 threshold to include as the ESA (Figure 2a-26).

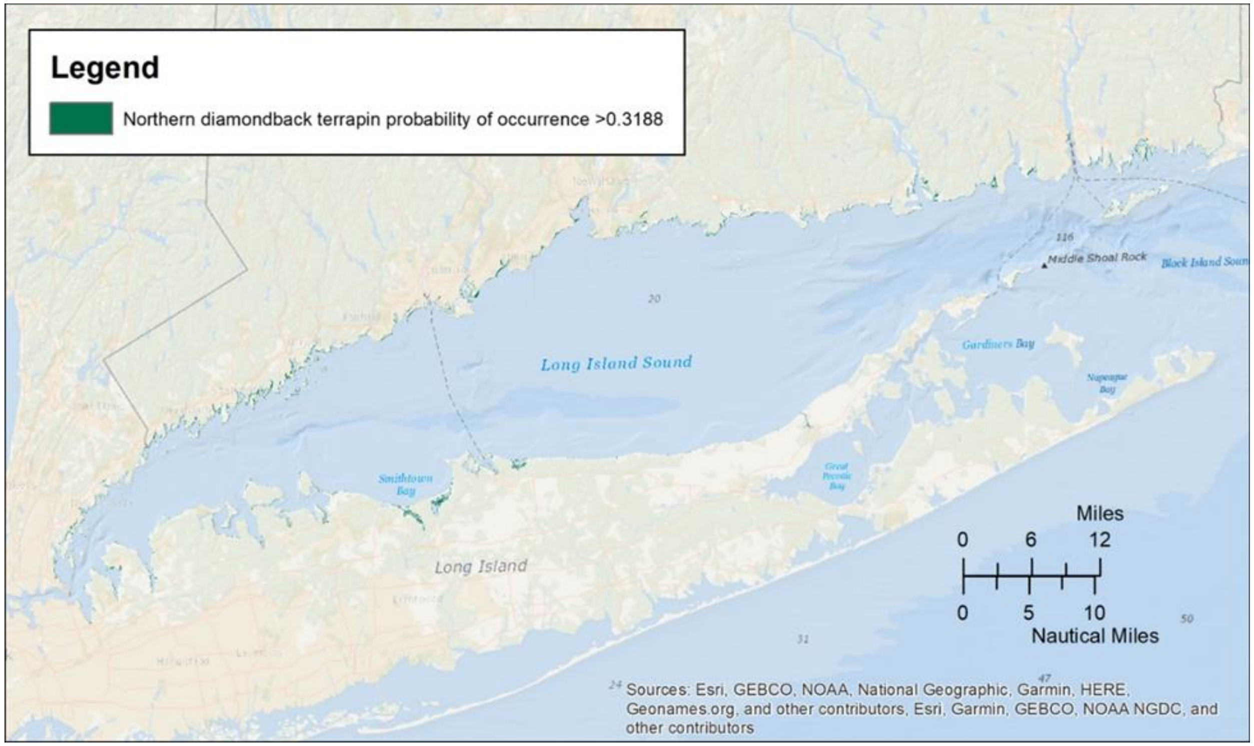


Figure 2a-26 Areas where Northern diamondback terrapin probability of occurrence is greater than 0.3118. Note: The Long Island Sound boundary is removed in this map to more clearly depict these areas.

Sea turtle live strandings and recent mortality events

The EEG investigated several sea turtle datasets described in the Blue Plan Inventory for use in identifying the ESA. The EEG recommended the use of recent verified live strandings, rescues, and in-water observations to reflect places where sea turtles were actively using Sound habitats. The records of these point locations were obtained from Mystic Aquarium (Mystic Aquarium, 2016) (for the CT coast) and the Riverhead Foundation for Marine Research and Preservation (Riverhead Foundation, 2018) (for the Long Island coast). These datasets may be available from each entity upon request. In addition, the point locations of three 2018 boat-strike mortality events in the Stratford area were included in the ESA map (Figure 2a-27).

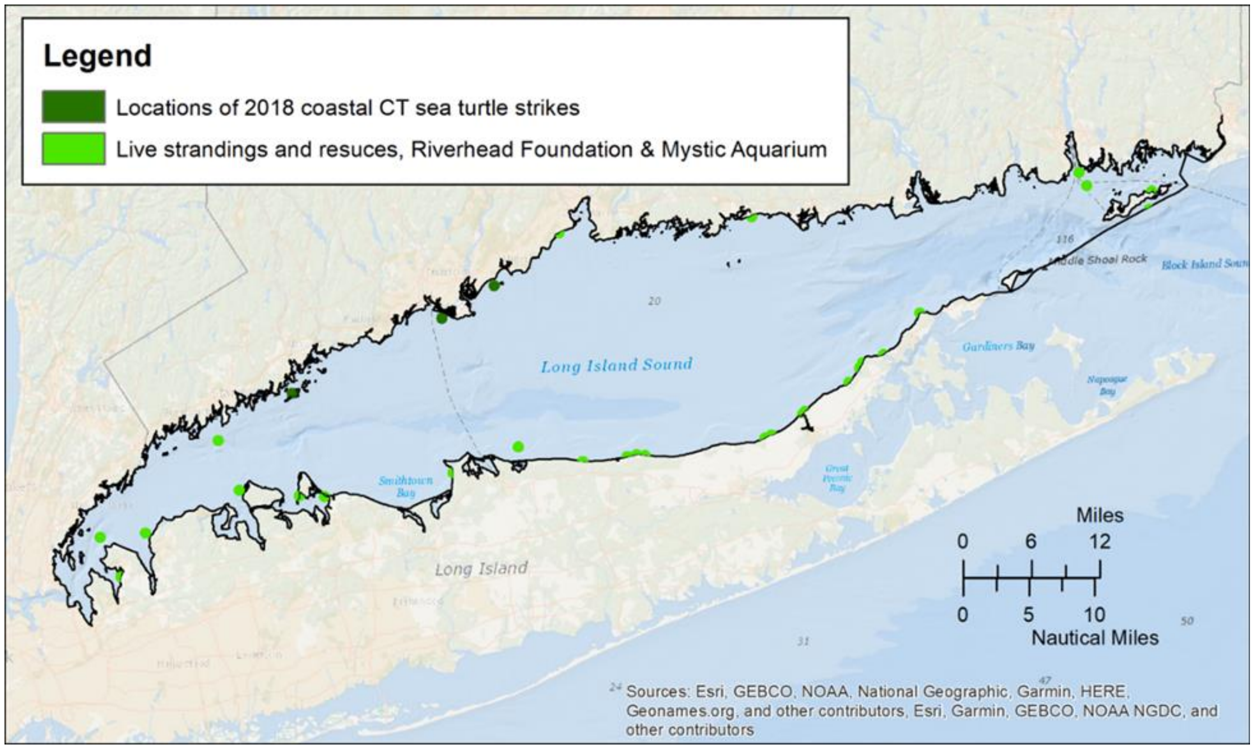


Figure 2a-27 Locations of 2018 coastal Connecticut sea turtle strikes and live sea turtle strandings and rescues from the Riverhead Foundation and Mystic Aquarium

Integration of data sets

Each of the datasets described above were mapped together to represent the extent of Ecologically Significant Areas for sea turtles and other reptiles. Figure 2a-28 shows all of the datasets dissolved together to show a single presence/absence layer of ESA for sea turtles and other reptiles.

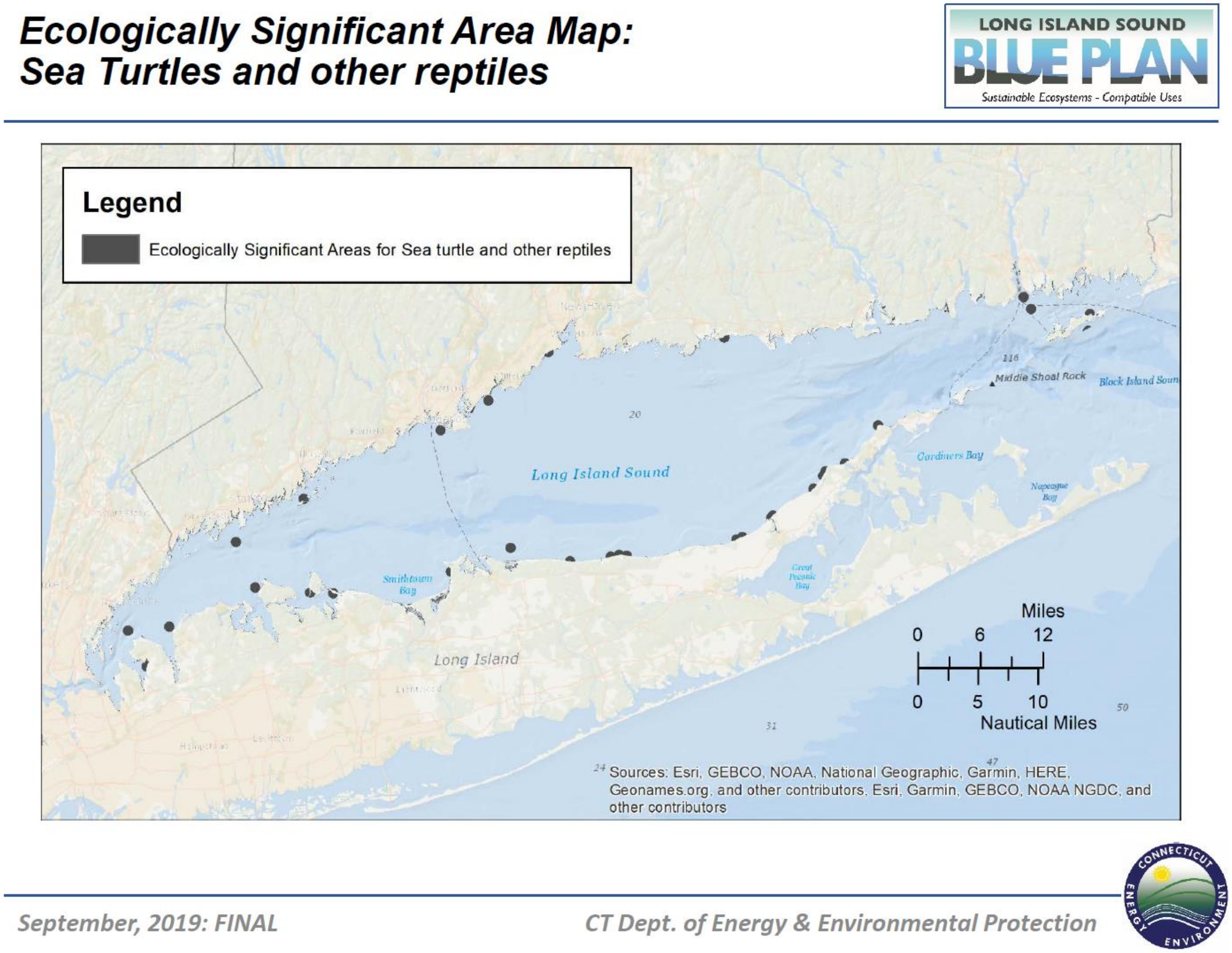


Figure 2a-28 Final ESA map of Sea Turtles and other Reptiles. Note: The Long Island Sound boundary is removed in this map to more clearly depict these areas.

Updates and potential future work

Changing environmental conditions may be influencing sea turtle use of the Sound, and updates should be made frequently enough to capture significant changes in occurrence.

iv. **Criterion 9: Birds**

Definition: Areas where birds are abundant or diverse including feeding areas; areas of high bird productivity including nesting areas.

Significance of Birds

This criterion focuses on seabird species that are expected to use the open-water habitats of Long Island Sound (i.e., within the Blue Plan policy boundary). Many of these seabird species use the Sound for feeding, nesting, and/or as a migratory stopover, and therefore use both open-water and coastal habitats. Other more strictly-coastal bird species (including some endangered, threatened, and species of concern) use the Sound, but these habitats may be outside of the Blue Plan policy area. Because of the range of behaviors and habitats in this species group, it will likely be necessary to examine data at the species-level to best understand any potential conflicts between birds and human activities.

The roseate tern is endangered in the state of Connecticut and the entire US. The third largest roseate tern colony in North America exists in Connecticut at Falkner Island, where approximately 175 to 200 pairs of terns breed every year (CT DEEP, 2019). Roseate terns' nesting habitats are vulnerable to human activities that cause physical disturbances in coastal areas, like recreation or development. Human activities have greatly reduced available nesting habitat for roseate terns. See the section on Endangered, Threatened, Species of Concern, and Candidate Species for a list of protected coastal birds and seabirds.

Data and Information Sources for Birds

Seabird occurrence models

At the time of EEG formation, there were no Sound-wide maps of seabird occurrence. However, the Blue Plan Inventory described the eBird Database, which contains thousands of records of seabird observations in multiple seasons in Long Island Sound. Valerie Steen, a University of Connecticut (UConn) postdoctoral fellow working with

EEG member Chris Elphick, used the eBird Database and several environmental datasets from the Blue Plan Inventory (e.g., bathymetry, eelgrass) to create maps of predicted seabird occurrence in Long Island Sound. Separate models were constructed for 7 species' summer (May - September) occurrence and 23 species' winter (October - April) occurrence (Table 2a-3). Five species had both summer and winter occurrence maps. A simple evaluation of the models' performance indicated that although the patterns depicted in the output maps were better than relying on anecdotal information, they could be improved if more data were available (both seabird observations and environmental/habitat covariates). Unpublished presence/absence maps were generated for each species and incorporated by the EEG for this criterion.

Table 2a-3 Species for which predicted presence/absence maps were available and included in the Birds criterion.

Summer	**Winter**
• Common tern • Double-crested cormorant • Great black-backed gull • Herring gull • Laughing gull • Ring-billed gull • Roseate tern	• American black duck • Black scoter • Bonaparte's gull • Brant • Bufflehead • Common eider • Common goldeneye • Common loon • Double-crested cormorant • Great black-backed gull • Great cormorant • Greater scaup • Herring gull • Horned grebe • Laughing gull • Lesser scaup • Long-tailed duck • Northern gannet • Red breasted merganser • Red throated loon

	• Ring-billed gull • Surf scoter • White-winged scoter

Presence/absence maps for the 7 summer species were overlaid and summed to create a summer species richness map. The presence/absence maps for the 23 winter species were also overlaid and summed to create a winter species richness map. Each richness map was classified into quintiles and the top quintile of each was considered part of the ESA (Figure 2a-29).

Participatory mapping

After reviewing the draft areas selected by the EEG that were derived from the UConn models, experts recommended that ESA for birds be amended to include additional areas, including, for example, staging, nesting, and foraging areas in summer, and roosting, foraging, and wintering areas in winter. On January 3, 2019, Patrick Comins, Executive Director of the Connecticut Audubon Society, delineated these areas (Figure 2a-30).

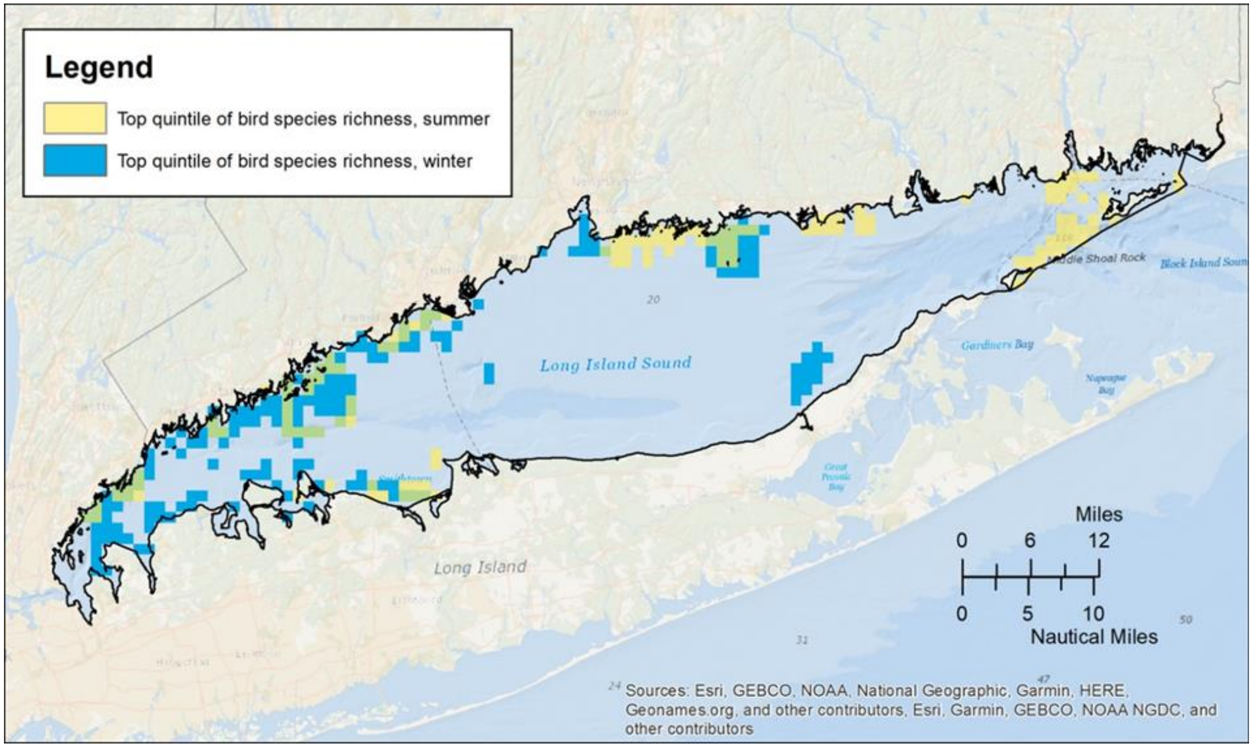


Figure 2a-29 Top quintile maps for both summer and winter predicted species richness for birds, from University of Connecticut preliminary models. The summer areas (yellow) are partially transparent to better show where summer areas overlap with winter areas.

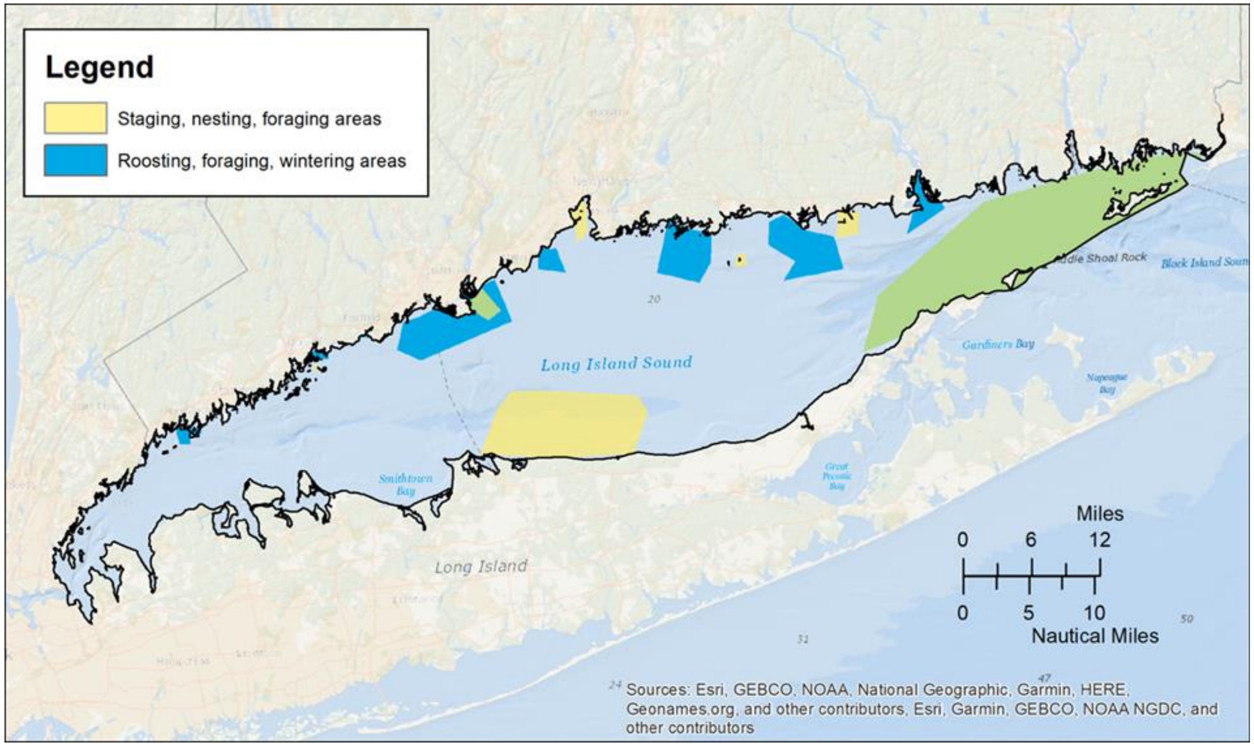


Figure 2a-30 Areas important to bird staging, nesting, foraging, roasting, and wintering identified through expert participatory mapping. The summer staging, nesting and foraging areas (yellow) are partially transparent to better show where these areas overlap with roosting, foraging, and wintering areas. The Race appears green because it is where roseate and common terns forage in summer, and is also an important wintering area for razorbills (Patrick Comins, personal communication, 1/3/19).

Integration of data and information

The datasets described above were mapped together to represent the extent of Ecologically Significant Areas for birds. Figure 2a-31 shows all of the datasets dissolved together as a single presence/absence layer of ESA for birds.

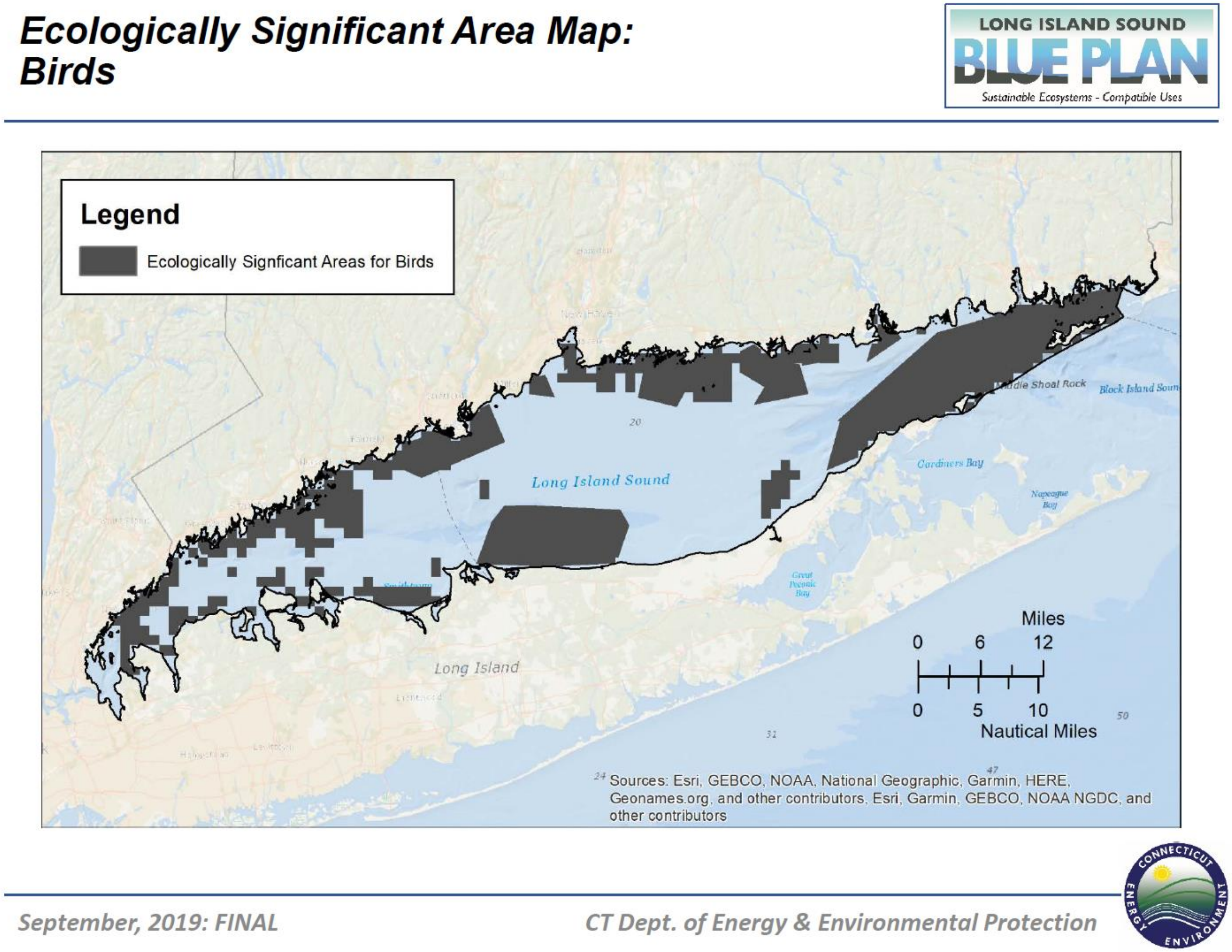


Figure 2a-31 Final ESA map for Birds.

Updates and potential future work

The data that inform this criterion could be improved by additional vetting or evaluation of the model outputs; increasing the quantity of data (both observations and numbers of environmental/habitat variables) used by the models to improve predictions; and additional or repeated participatory mapping by experts to highlight areas that may be changing with regard to bird aggregations or overall bird occurrence.

v. **Criterion 10: Fish**

Definition: Areas of high weighted fish persistence and high fish abundance and concentration.

Significance of Fish:

The fish criterion includes pelagic and demersal vertebrate fish species. Fish are key components of the Long Island Sound ecosystem, and are critical to both human and animal food webs. In addition to fishing pressure, fish community composition in Long Island Sound is influenced by climate and environmental change. Since 1998, the fish community has transitioned to a single community adapted to higher temperatures, from a state where distinct winter-spring and summer-autumn communities existed prior to 1998 (Howell & Auster, 2012). There are likely other species-specific and functional-group-specific trends that are also relevant to management and decision-making that should be considered on a case-by-case basis. In an effort to characterize Ecologically Significant Areas for fish in a simplified, but not oversimplified way, the EEG considered metrics of persistence and abundance for species using water column habitats (i.e., diadromous and pelagic species), and seafloor habitats (i.e., demersal species). Both types of metrics use data derived from the CT DEEP Marine Fisheries Long Island Sound Trawl Survey (LISTS), which occurs in spring and fall of each year since 1984 (CT DEEP, 2019). The LISTS divides the Sound into about three hundred 1x2 nautical-mile grid cells and uses a stratified-random survey design. The survey design relies on the stratum assigned to each 1x2 nautical mile area and weights the number of samples per stratum by the amount of stratum-specific area available for sampling. Strata are 12 combinations of three bottom types and four depth intervals. Although LISTS data are representative of the entire Sound at the stratum level, there are some areas that cannot be effectively sampled by bottom trawl (e.g., The Race, shoals, reefs and trenches). Since strata are not uniformly distributed throughout the sound and sites are not equally available to the sample gear, not all grid cells have been sampled equally over time (Figure 2a-32). Biomass has been recorded since 1992. All of the data for this criterion are reported using the 1x2 nautical mile site grid, even though LISTS methodology does not require a tow be conducted within the confines of a grid cell provided it is conducted in the correct stratum.

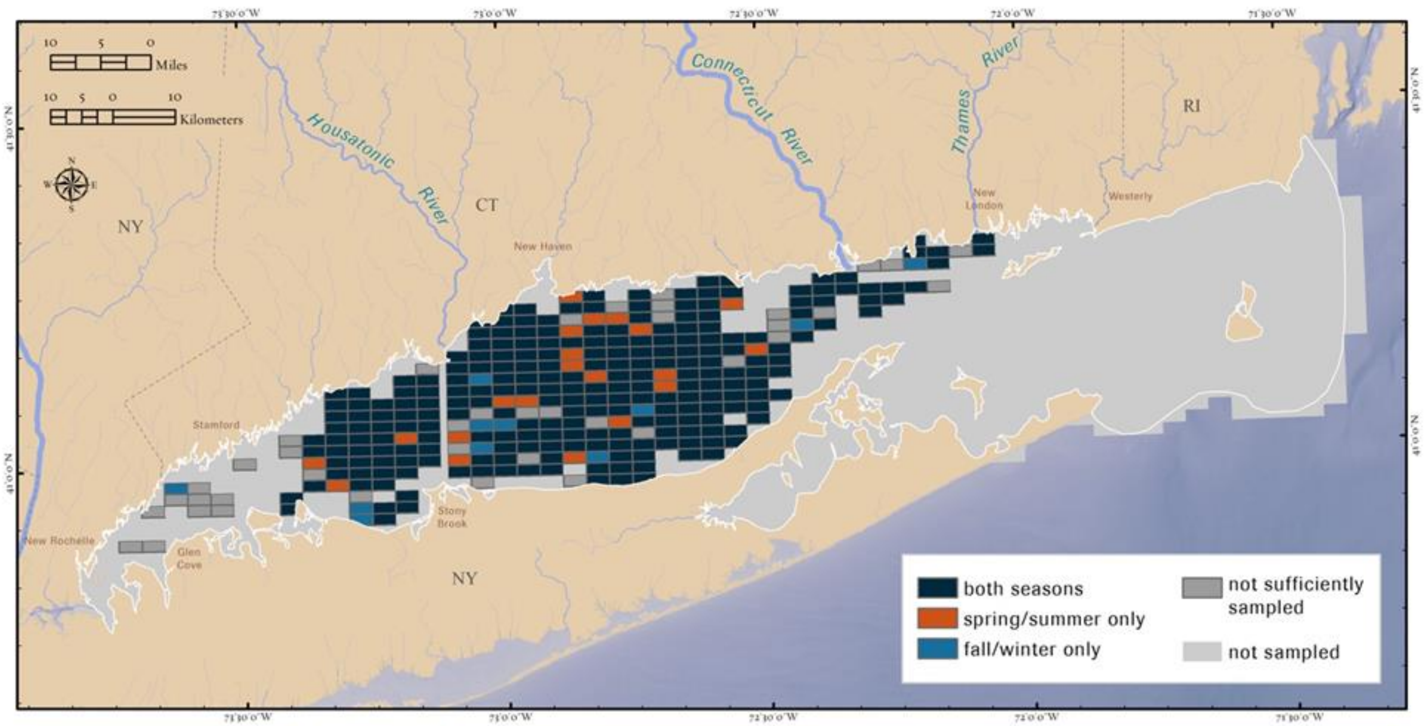


Figure 2a-32 Grid cells sampled by the Connecticut DEEP Marine Fisheries Long Island Sound Trawl Survey (1984-2009). Map credit: The Nature Conservancy, Long Island Sound Ecological Assessment. TNC considered grid cells that did not have survey points in at least two of three periods (1984-1992, 1993-2001, 2002-2009) to be insufficiently sampled for their weighted persistence analyses.

Data sources and Methodologies for Fish

Persistently productive places for fish

The Long Island Sound Ecological Assessment (LISEA) identified persistently productive areas for fish using 26 years of LISTS data (1984-2009). These places have the highest number of species that have persisted there for the longest period (i.e., throughout each period of the LISTS, or 3 periods totaling 26 years at the time of the assessment) and each of these species have been detected at a frequency higher than expected, from just under 1 standard deviation to over 2 standard deviations above the mean. These persistently productive places for each species were aggregated into persistently productive places for fish functional groups: diadromous, pelagic, and demersal species (Table 2a-4). The maps and data showing persistently productive places for each functional group can be accessed via The Nature Conservancy's Conservation Gateway (The Nature Conservancy, 2017). From these maps, the following criteria were applied to identify Ecologically Significant Areas:

Diadromous species

- Grid cells of Diadromous species in the highest weighted persistence category
- Grid cells where both Pelagic and Diadromous species are in the second highest weighted persistence category overlap

  Pelagic species
- Grid cells of Pelagic species in the highest weighted persistence category
- Grid cells where both Pelagic and Diadromous species are in the second highest weighted persistence category overlap

Demersal species

- Grid cells in the highest LISEA weighted persistence category for each of the Demersal species functional groups (Elasmobranchs, Gadids, Pleuronectids, Structure-oriented, Other)
- Grid cells where 3 or more of the 5 Demersal species functional groups are in the second highest LISEA weighted persistence category overlap

Table 2a-4 Species and functional groups considered in the LISEA persistence analysis.

Functional group	**Species**	**Subgroup**
Demersal	Barndoor skate Dipturus laevis	Elasmobranch
Demersal	Clearnose skate Raja eglanteria	Elasmobranch
Demersal	Little skate Leucoraja erinacea	Elasmobranch
Demersal	Roughtail stingray Dasyatis centroura	Elasmobranch
Demersal	Smooth dogfish Mustelus canis	Elasmobranch
Demersal	Spiny dogfish Squalus acanthius	Elasmobranch

Functional group	**Species**	**Subgroup**
Demersal	Winter skate Leucoraja ocellata	Elasmobranch
Demersal	Atlantic cod Gadus morhua	Gadids
Demersal	Fourbeard rockling Enchelyopus cimbrius	Gadids
Demersal	Haddock Melanogrammus aeglefinus	Gadids
Demersal	Pollock Pollachius virens	Gadids
Demersal	Red hake Urophycis chuss	Gadids
Demersal	Silver hake Merluccius bilinearis	Gadids
Demersal	Spotted hake Urophycis regia	Gadids
Demersal	Fourspot flounder Paralichthys oblongus	Pleuronectids
Demersal	Hogchoker Trinectes maculatus	Pleuronectids
Demersal	Smallmouth flounder Etropus microstomus	Pleuronectids
Demersal	Summer flounder Paralichthys dentatus	Pleuronectids
Demersal	Windowpane flounder Scophthalmus aquosus	Pleuronectids
Demersal	Winter flounder Pseudopleuronectes american	Pleuronectids
Demersal	Yellowtail flounder Pleuronectes ferrugineus	Pleuronectids
Demersal	Black sea bass Centropristes striata	structure oriented
Demersal	Cunner Tautogolabrus adspersus	structure oriented
Demersal	Oyster toadfish Opsanus tau	structure oriented
Demersal	Rock Gunnel Pholis gunnellus	structure oriented
Demersal	Scup Stenotomus chrysops	structure oriented
Demersal	Tautog Tautoga onitis	structure oriented
Demersal	American sand lance Ammodytes americanus	Other: misc.
Demersal	Atlantic silverside Menidia	Other: misc.
Demersal	Atlantic croaker Micropogonias undulatus	Other: misc.
Demersal	Bigeye Priacanthus arenatus	Other: misc.
Demersal	Spot Leiostomus xanthurus	Other: misc.
Demersal	Striped searobin Prionotus evolans	Other: misc.
Demersal	Conger eel Conger oceanicus	Other: misc.
Demersal	Dwarf goatfish Upeneus parvus	Other: misc.
Demersal	Fawn cusk-eel Lepophidium profundorum	Other: misc.

Functional group	Species	Subgroup
Demersal	Feather blenny Hypsoblennius hentz	Other: misc.
Demersal	Goosefish/monkfish Lophius americanus	Other: misc.
Demersal	Grubby Myoxocephalus aeneus	Other: misc.
Demersal	Lined seahorse Hippocampus erectus	Other: misc.
Demersal	Longhorn sculpin Myoxocephalus octodecemspin	Other: misc.
Demersal	Lumpfish Cyclopterus lumpus	Other: misc.
Demersal	Naked goby Gobiosoma bosci	Other: misc.
Demersal	Northern kingfish Menticirrhus saxatilis	Other: misc.
Demersal	Northern Pipefish Syngnathus fuscus	Other: misc.
Demersal	Northern Puffer Sphoeroides maculatus	Other: misc.
Demersal	Northern Searobin Prionotus carolinus	Other: misc.
Demersal	Northern Sennet Sphyraena borealis	Other: misc.
Demersal	Northern Stargazer Astroscopus guttatus	Other: misc.
Demersal	Ocean Pout Macrozoarces americanus	Other: misc.
Demersal	Planehead Filefish Monacanthus hispidus	Other: misc.
Demersal	Red Cornetfish Fistularia petimba	Other: misc.
Demersal	Red Goatfish Mullus auratus	Other: misc.
Demersal	Sea Raven Hemitripterus americanus	Other: misc.
Demersal	Seasnail Liparis atlanticus	Other: misc.
Demersal	Short Bigeye Pristigenys alta	Other: misc.
Demersal	Striped Burrfish Chilomycterus schoepfi	Other: misc.
Demersal	Striped Cusk-Eel Ophidion marginatum	Other: misc.
Demersal	Weakfish Cynoscion regalis	Other: misc.
Diadromous	Alewife Alosa pseudoharengus	
Diadromous	American eel Anguilla rostrata	
Diadromous	American shad Alosa sapidissima	
Diadromous	Atlantic salmon Salmo salar	
Diadromous	Atlantic sturgeon Acipenser oxyrinchus	
Diadromous	Atlantic tomcod Microgadus tomcod	
Diadromous	Blueback herring Alosa aestivalis	

Functional group	Species	Subgroup
Diadromous	Gizzard shad Dorosoma cepedianum	
Diadromous	Hickory shad Alosa mediocris	
Diadromous	Rainbow smelt Osmerus mordax	
Diadromous	Sea lamprey Petromyzon marinus	
Diadromous	Striped bass Morone saxatilis	
Diadromous	White perch Morone americana	
Pelagic	Atlantic bonito Sarda	
Pelagic	Atlantic herring Clupea harengus	
Pelagic	Atlantic mackerel Scomber scombrus	
Pelagic	Atlantic menhaden Brevoortia tyrannus	
Pelagic	Banded rudderfish Seriola zonata	
Pelagic	Bay anchovy Anchoa mitchilli	
Pelagic	Bigeye scad Selar crumenophthalmus	
Pelagic	Blue runner Caranx crysos	
Pelagic	Bluefish Peprilus triacanthus	
Pelagic	Crevalle jack Caranx hippos	
Pelagic	Gray triggerfish Balistes capriscus	
Pelagic	Lookdown Selene vomer	
Pelagic	Mackerel scad Decapterus macarellus	
Pelagic	Moonfish Selene setapinnis	
Pelagic	Rough scad Trachurus lathami	
Pelagic	Round herring Etrumeus teres	
Pelagic	Round scad Decapterus punctatus	
Pelagic	Sandbar shark Carcharhinus plumbeus	
Pelagic	Sharksucker Echeneis naucrates	
Pelagic	Spanish mackerel Scomberomorus maculatus	
Pelagic	Striped anchovy Anchoa hepsetus	
Pelagic	Yellow jack Caranx bartholomaei	

Areas of high fish abundance and concentration

CT DEEP Marine Fisheries provided LISTS data to the EEG to identify areas of high fish abundance and concentration. The data included the natural log of the mean abundance per grid cell for each species for spring and fall in the following date ranges: 1995-2004 and 2005-2014. Only species caught in more than 5 tows in any of the seasons in each date range were included. Species were assigned to either water column (which included diadromous and pelagic) or demersal (which included demersal and epibenthic) (Table 2a-5) functional groups and group total mean abundance was calculated for each season in each date range. The two decades of data were each used to find high fish abundance (instead of just one combined period) for several reasons. The EEG believed the most recent decade is particularly important to see, especially given the dynamics in fish distribution. Combining the two decades would have diluted that clarity and there were other statistical challenges as well. DEEP Marine Fisheries believed that 1995-2004 decade was important to use, in part so a larger portion of the broader abundance record could be captured. All parties agreed that using the first decade (before 1995) would be less relevant because of the significant shift in fish distribution that occurred in 1997. This resulted in 8 individual abundance layers. Layers were classified by quintiles and the top quintile of each layer was considered an ecologically significant area of high fish abundance and concentration.

Table 2a-5 Fish species present in greater than 5 tows in any of the seasons and date ranges for the Long Island Sound Trawl Survey between 1995 and 2014.

Water column		**Seafloor**	
Common name	Scientific name	Common name	Scientific name
Alewife	*Alosa pseudoharengus*	Atlantic sturgeon	*Acipenser oxyrinchus*
American shad	*Alosa sapidissima*	Tautog	*Tautoga onitis*
Atlantic silverside	*Menidia*	Black sea bass	*Centropristis striata*
Atlantic herring	*Clupea harengus*	Clearnose skate	*Raja eglanteria*
Bay anchovy	*Anchoa mitchilli*	Atlantic cod	*Gadus morhua*

Blueback herring	*Alosa aestivalis*	Conger eel	*Conger oceanicus*
Bigeye scad	*Selar crumenophthalmus*	Cunner	*Tautogolabrus adspersus*
Bluefish	*Pomatomus saltatrix*	Fourspot flounder	*Paralichthys oblongus*
Blue runner	*Caranx crysos*	Glasseye snapper	*Priacanthus cruentatus*
Butterfish	*Peprilus triacanthus*	Goosefish	*Lophius americanus*
Crevalle jack	*Caranx hippos*	Grubby	*Myoxocephalus aeneus*
Planehead filefish	*Monacanthus hispidus*	Haddock	*Melanogrammus aeglefinus*
Hickory shad	*Alosa mediocris*	Hogchoker	*Trinectes maculatus*
Atlantic menhaden	*Brevoortia tyrannus*	Inshore lizardfish	*Synodus foetens*
Atlantic mackerel	*Scomber scombrus*	Little skate	*Leucoraja erinacea*
Moonfish	*Selene setapinnis*	Northern kingfish	*Menticirrhus saxatilis*
Northern sennet	*Sphyraena borealis*	Northern red shrimp	*Pandalus montagui*
Pollock	*Pollachius virens*	Ocean pout	*Macrozoarces americanus*
Round scad	*Decapterus punctatus*	Scup	*Stenotomus chrysops*
Rough scad	*Trachurus lathami*	Northern pipefish	*Syngnathus fuscus*
Short bigeye	*Pristigenys alta*	Fourbeard rockling	*Enchelyopus cimbrius*
Spiny dogfish	*Squalus acanthias*	Red hake	*Urophycis chuss*
Striped anchovy	*Anchoa hepsetus*	Rock gunnel	*Pholis gunnellus*
Striped bass	*Morone saxatilis*	American sand lance	*Ammodytes americanus*
Yellow jack	*Caranx bartholomaei*	Striped cusk-eel	*Ophidion marginatum*
		Longhorn sculpin	*Myoxocephalus octodecemspinosus*
		Summer flounder	*Paralichthys dentatus*

	Smooth dogfish	*Mustelus canis*
	Smallmouth flounder	*Etropus microstomus*
	Spotted hake	*Urophycis regia*
	Spot	*Leiostomus xanthurus*
	Sea raven	*Hemitripterus americanus*
	Striped searobin	*Prionotus evolans*
	Oyster toadfish	*Opsanus tau*
	Atlantic tomcod	*Microgadus tomcod*
	Winter flounder	*Pseudopleuronectes americanus*
	Silver hake	*Merluccius bilinearis*
	White perch	*Morone americana*
	Weakfish	*Cynoscion regalis*
	Windowpane flounder	*Scophthalmus aquosus*
	Winter skate	*Leucoraja ocellata*

Integration of Data and Methodologies

The datasets described above were mapped together to represent the extent of Ecologically Significant Areas for fish. In general, diadromous and pelagic fish were combined under "water column fish species" and "demersal fish species" remained its own category. Areas delineated from ten individual layers were overlaid for this ESA criterion (Table 5). Because of the particular detail available in the datasets for this criterion, and the importance of seasonality and long-term trends in the fish communities of Long Island Sound, Ecologically Significant Areas for fish have been visualized using each of the 10 layers separately (see Table 2a-6; Figures 33 to 42). Figure 43 shows the number of overlaps in each of the 10 fish components. Figure 44 shows all of the datasets dissolved together to show a single presence/absence layer of ESA for fish. Figure 44 also represents the final Ecologically Significant Area for the Fish criterion.

Table 2a-6 The ten individual data layers that contributed to the fish criterion.

Data layer description	**Maps**
Demersal fish species high weighted persistence (LISEA), 1984-2009	2a-33
Water column fish species high weighted persistence (LISEA), 1984-2009	2a-34
Top quintile of demersal species fall abundance, 1995-2004	2a-35
Top quintile of demersal species spring abundance, 1995-2004	2a-36
Top quintile of demersal species fall abundance, 2005-2014	2a-37
Top quintile of demersal species spring abundance, 2005-2014	2a-38
Top quintile of water column species fall abundance, 1995-2004	2a-39
Top quintile of water column species spring abundance, 1995-2004	2a-40
Top quintile of water column species fall abundance, 2005-2014	2a-41
Top quintile of water column species spring abundance, 2005-2014	2a-42

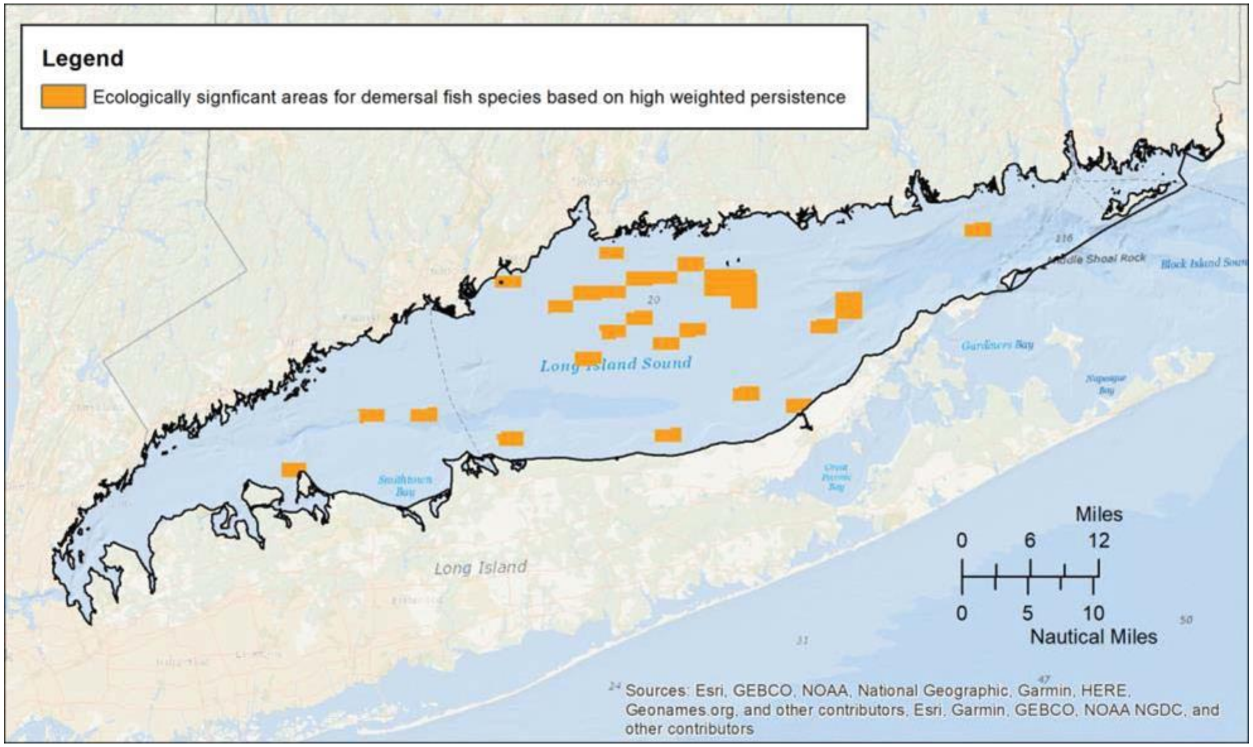


Figure 2a-33 A map showing one component of Ecologically significant areas for fish: areas of high weighted persistence for demersal fish subgroups based on TNC's LISEA

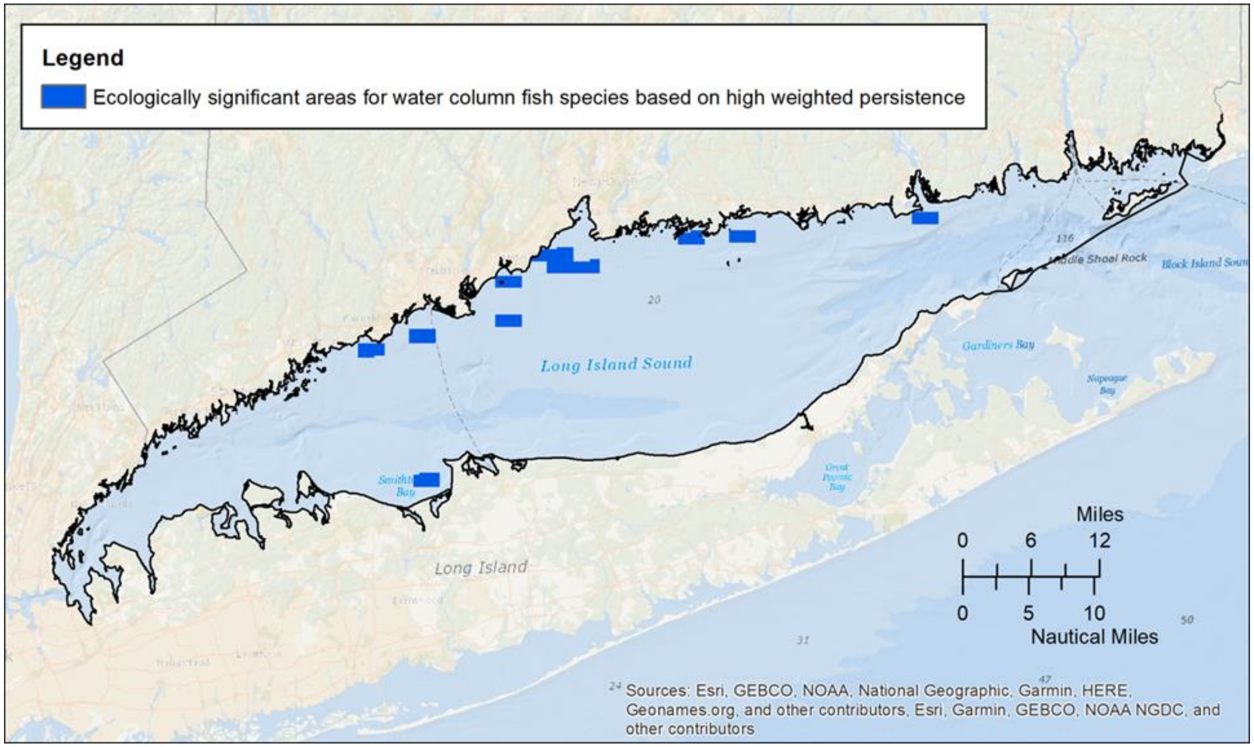


Figure 2a-34 A map showing one component of Ecologically Significant Areas for fish: areas of high weighted persistence for water column (pelagic and diadromous) fish subgroups based on TNC's LISEA.

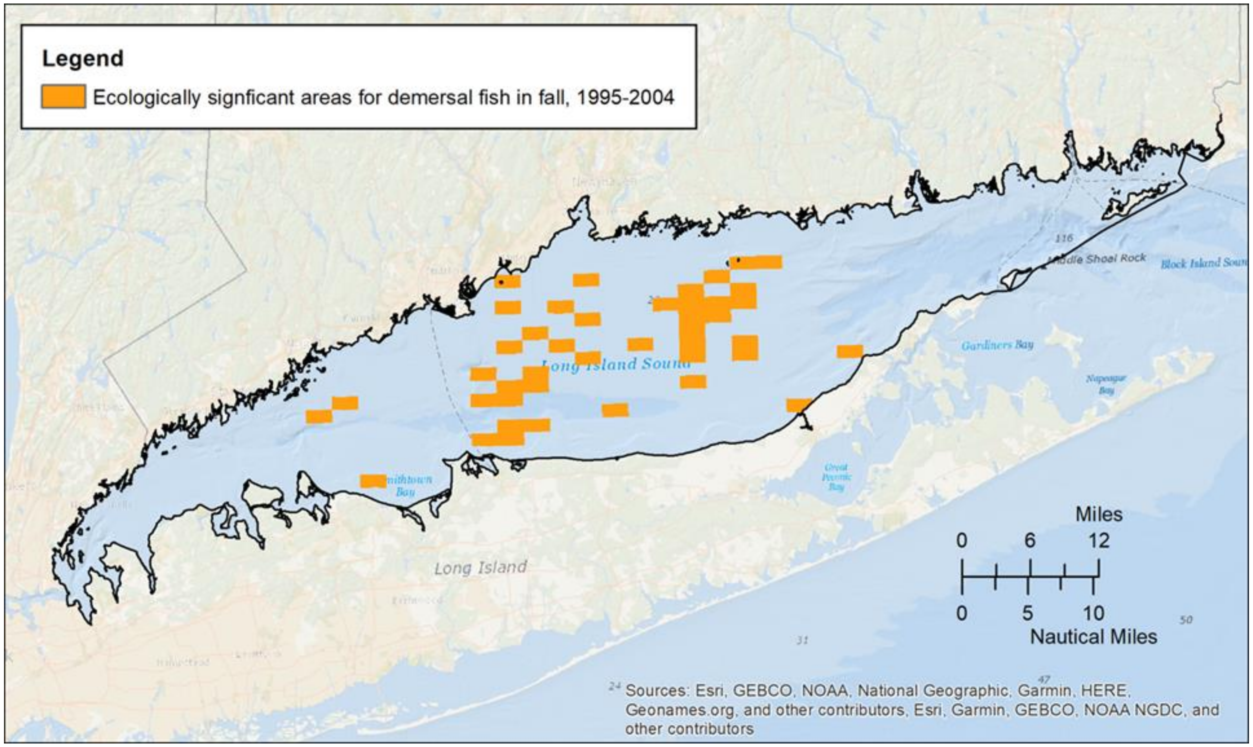


Figure 2a-35 A map showing one component of Ecologically Significant Areas for fish: the top quintile of demersal fish species abundance in fall from LISTS 1995-2004.

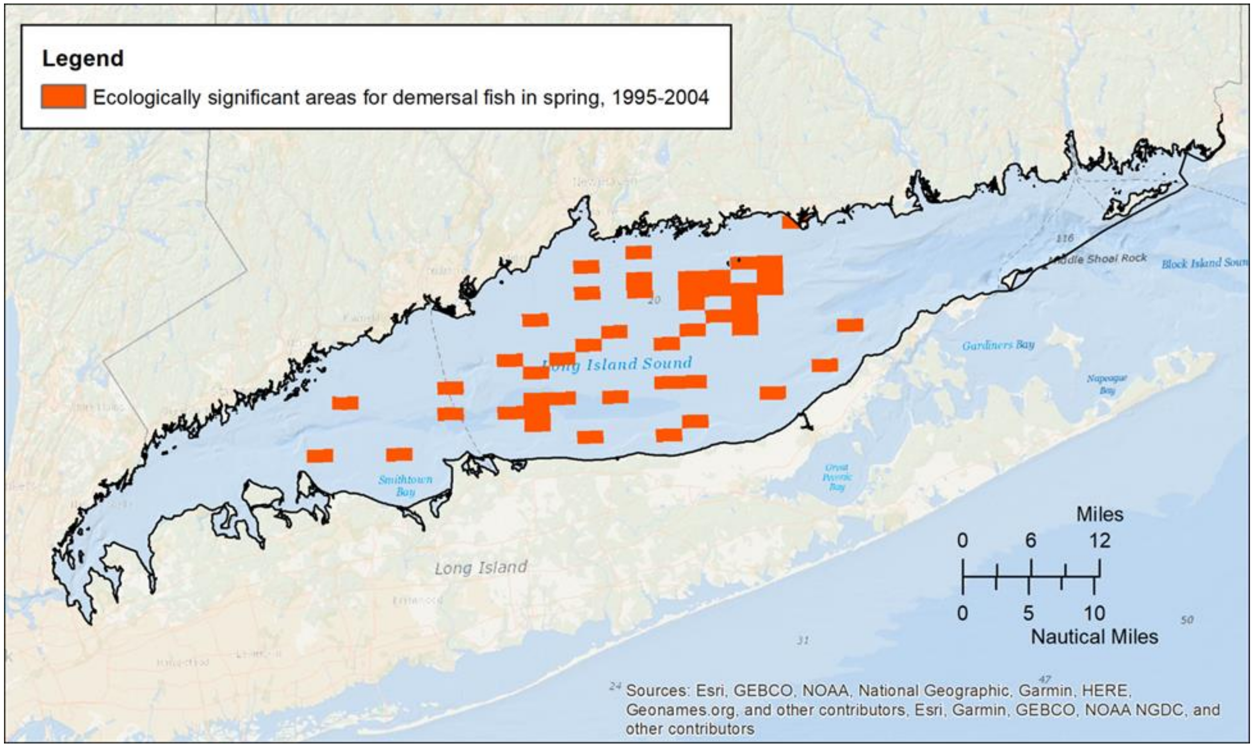


Figure 2a-36 A map showing one component of Ecologically Significant Areas for fish: the top quintile of demersal fish species abundance in spring from LISTS 1995-2004.

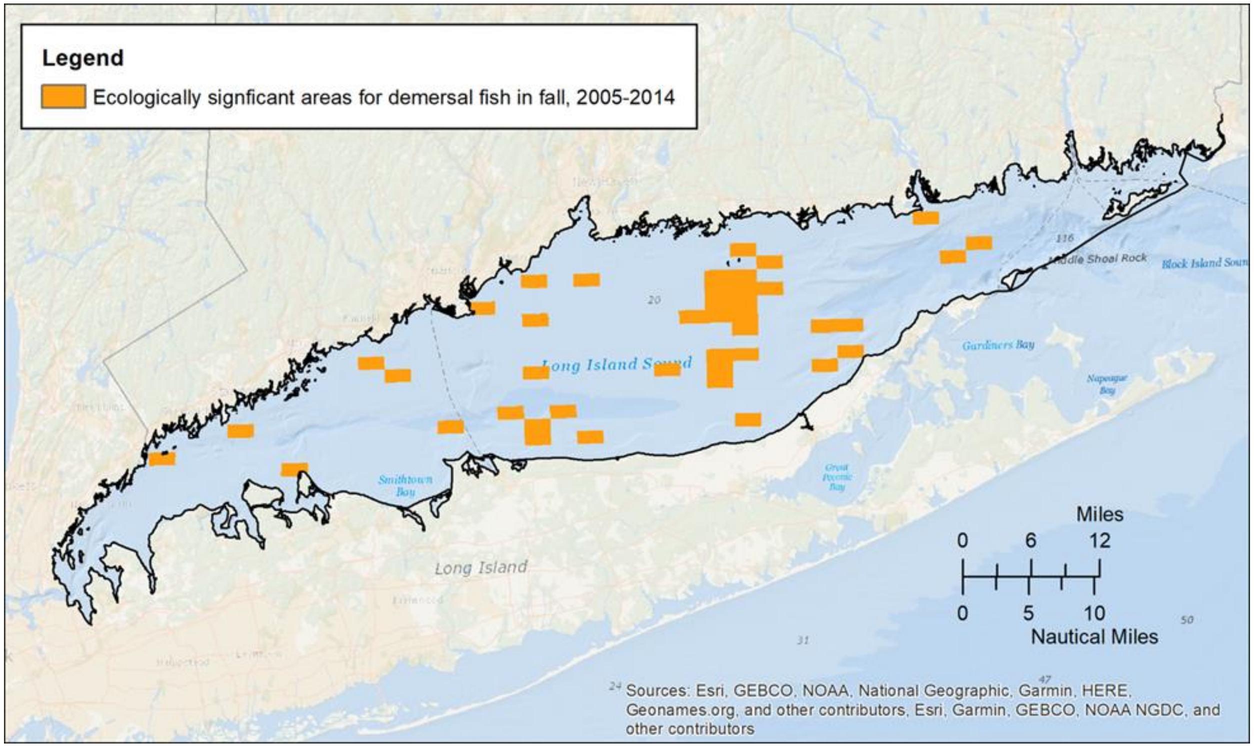


Figure 2a-37 A map showing one component of Ecologically Significant Areas for fish: the top quintile of demersal fish species abundance in fall from LISTS 2005-2014.

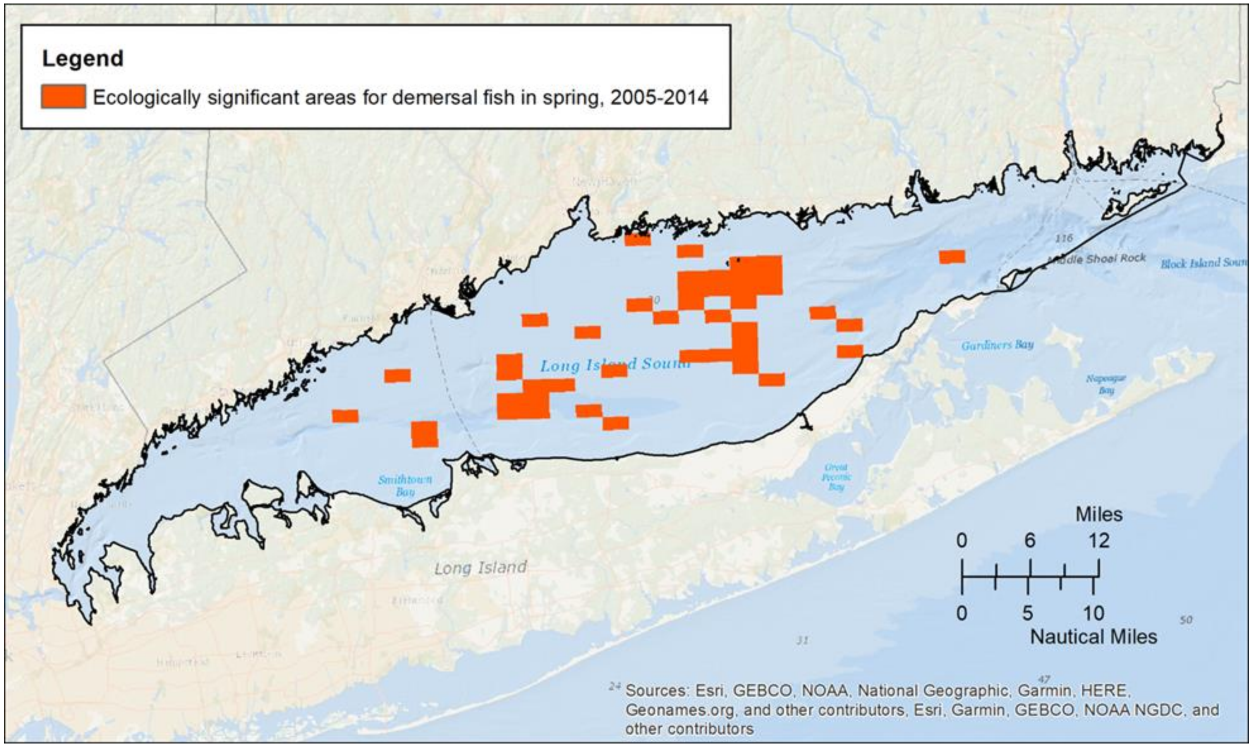


Figure 2a-38 A map showing one component of Ecologically Significant Areas for fish: the top quintile of demersal fish species abundance in spring from LISTS 2005-2014.

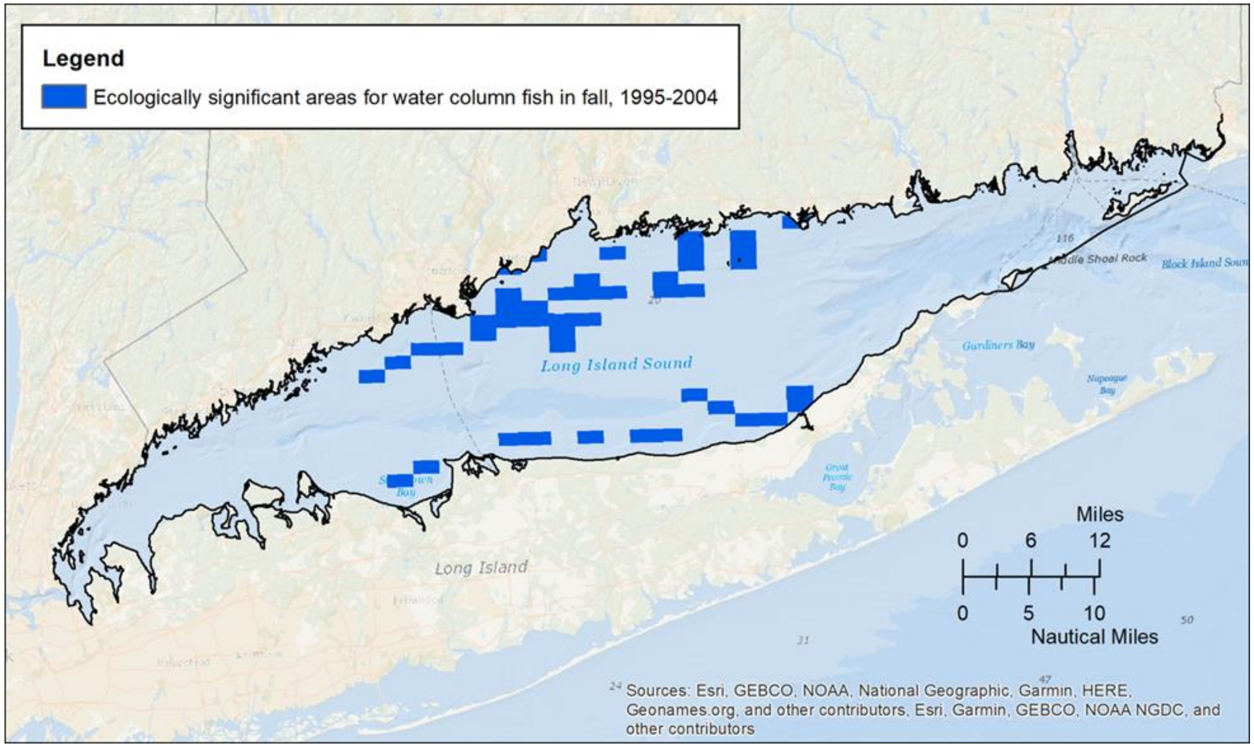


Figure 2a-39 A map showing one component of Ecologically Significant Areas for fish: the top quintile of water column fish species abundance in fall from LISTS 1995-2004.

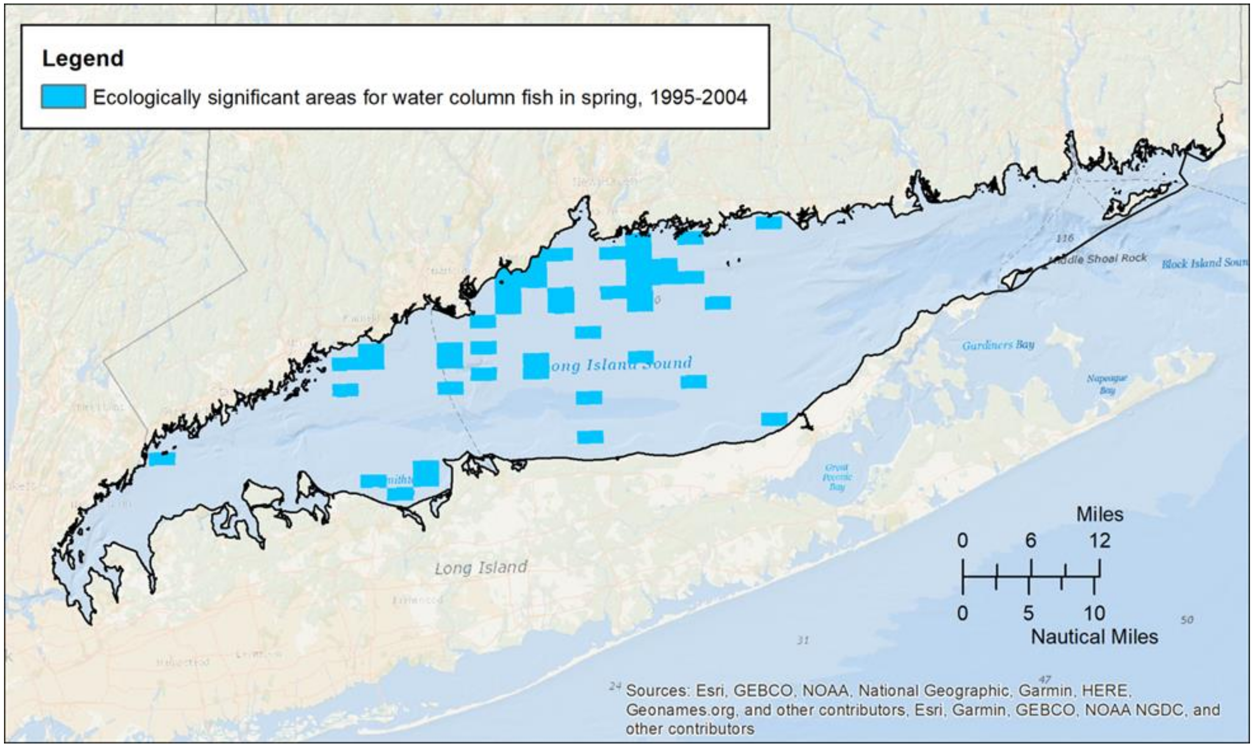


Figure 2a-40 A map showing one component of Ecologically Significant Areas for fish: the top quintile of water column fish abundance in spring from LISTS 1995-2004.

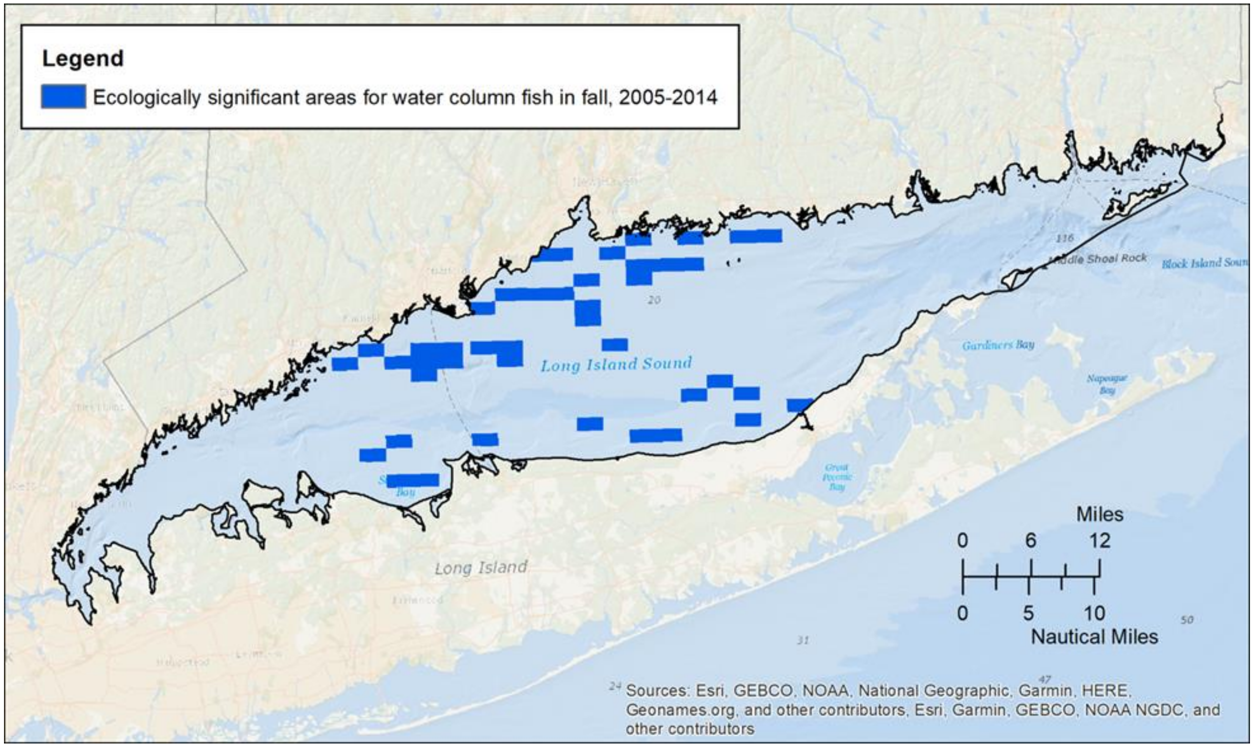


Figure 2a-41 A map showing one component of Ecologically Significant Areas for fish: the top quintile of water column fish species abundance in fall from LISTS 2005-2014.

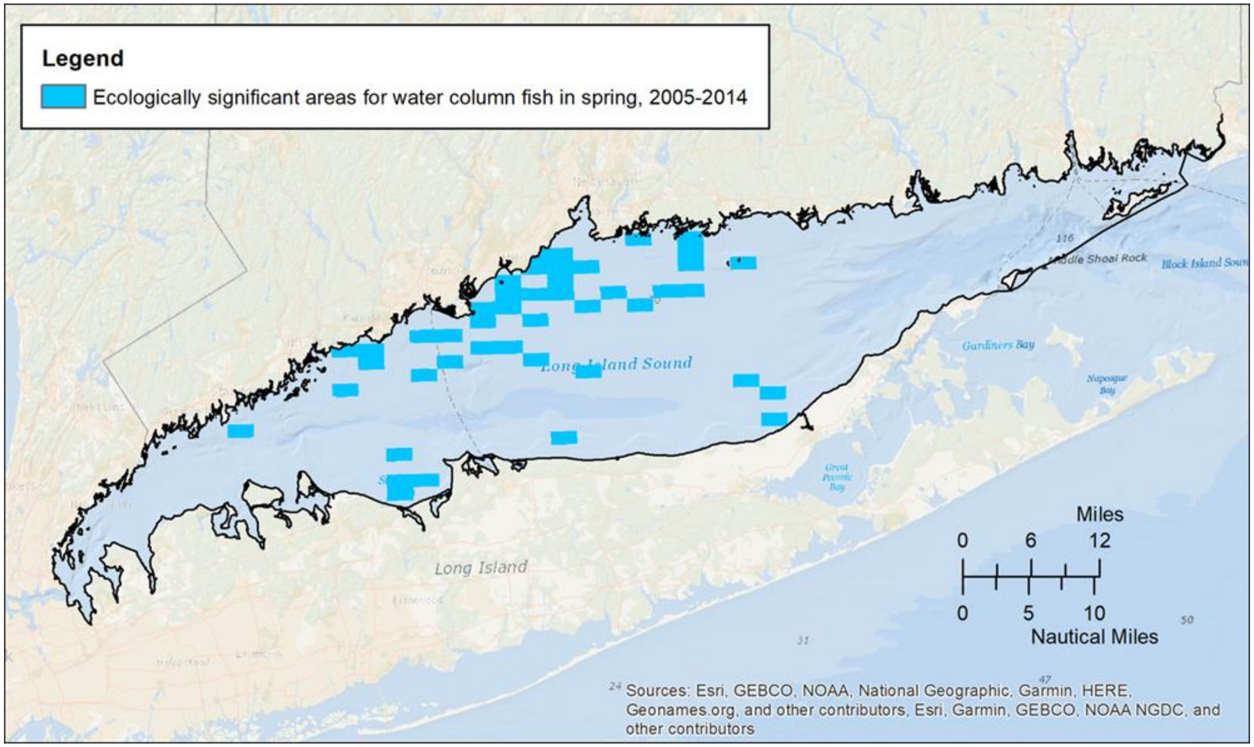


Figure 2a-42 A map showing one component of Ecologically Significant Areas for fish: the top quintile of water column fish species abundance in spring from LISTS 2005-2014.

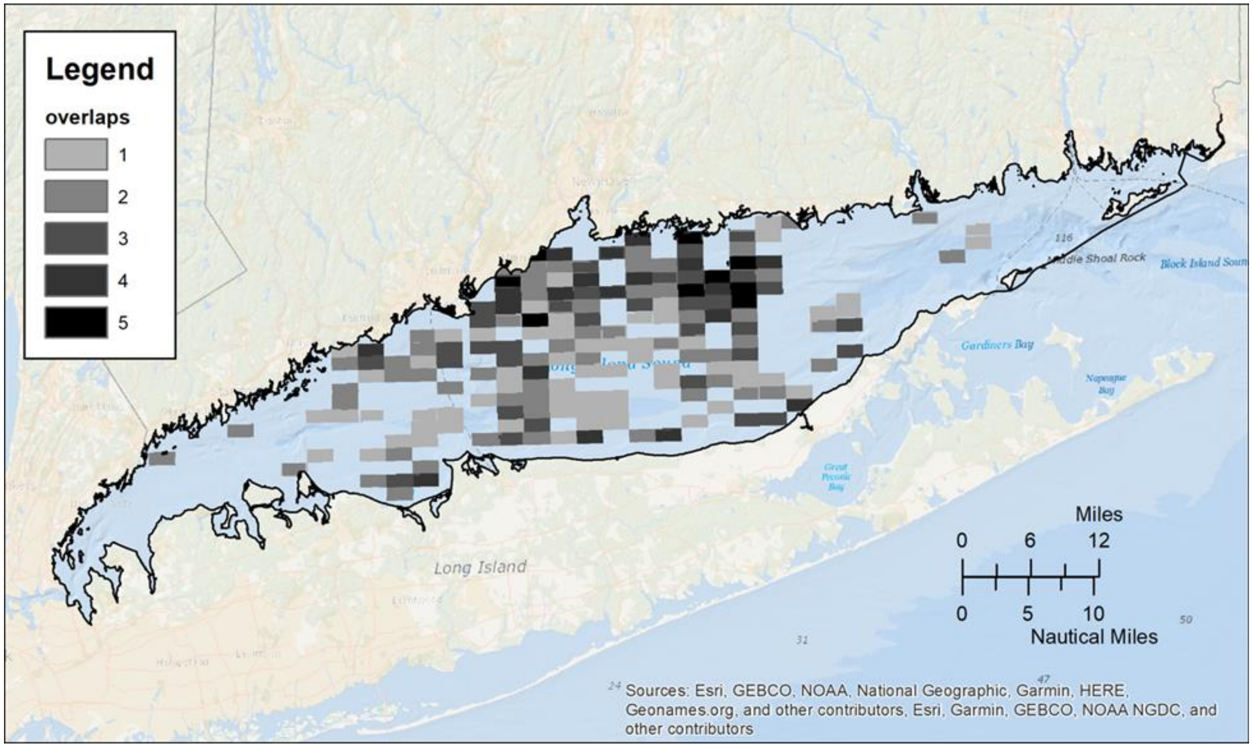


Figure 2a-43 Overlaps among each of the 10 input datasets representing Ecologically Significant Areas for fish species.

Ecologically Significant Area Map: Fish

LONG ISLAND SOUND BLUE PLAN

Sustainable Ecosystems - Compatible Uses

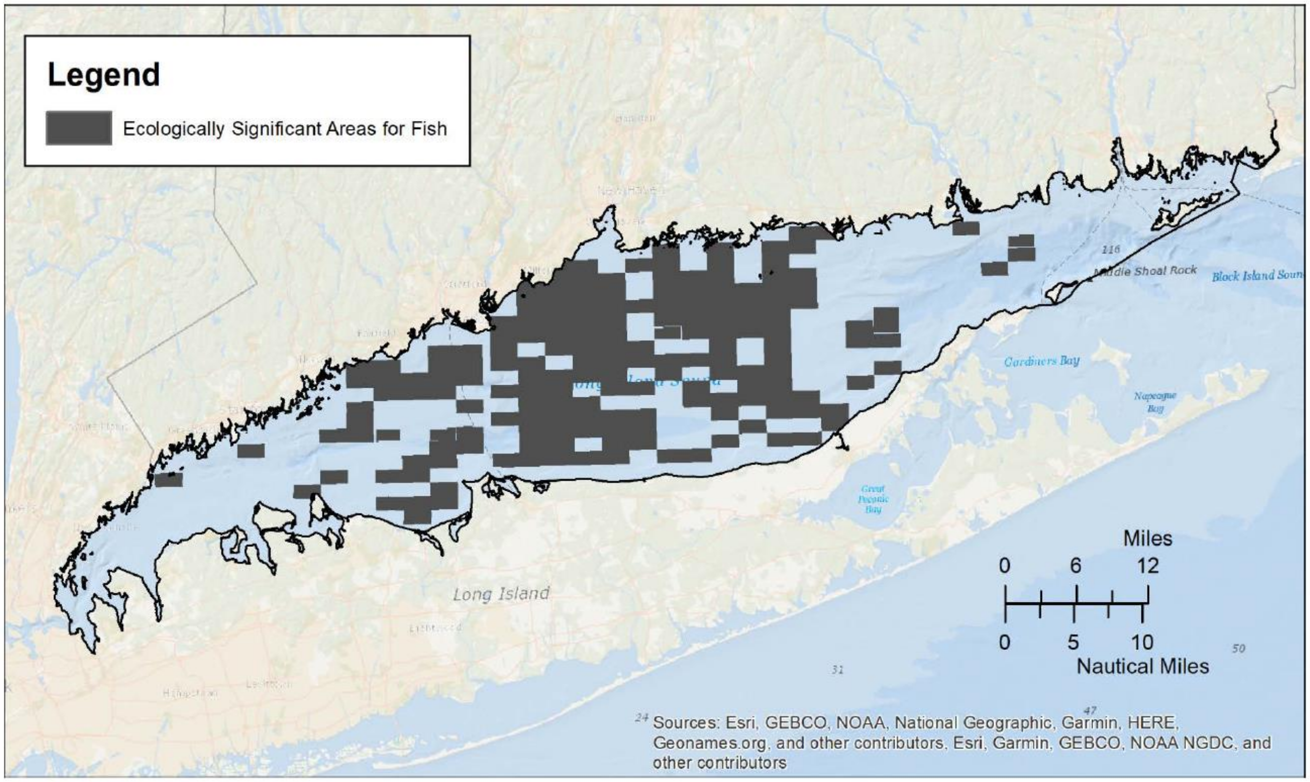


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Figure 2a-44 Final ESA map of Fish

Updates and potential future work

The CT DEEP Marine Fisheries LISTS dataset is a robust, long-term dataset that provides many different opportunities for summarization. Future work could take the form of developing updated persistence products with additional data collected since the LISEA report's analysis that included data up to 2009. Similarly, the abundance products could be updated to include the most recent survey years since 2014. In both types of analyses, additional steps could be taken to highlight the differences in fish communities before and after the observed regime shift of the mid-1990s.

vi. **Criterion 11: Mobile invertebrates**

Definition: Areas of high mobile invertebrate (e.g., lobster, other crustaceans, squid) abundance and concentration.

Significance of Mobile invertebrates

Mobile invertebrates include large benthic crustaceans like lobster and crabs, as well as pelagic invertebrates such as squid. Mobile invertebrates are key components of the Long Island Sound ecosystem as scavengers and detritivores, and are critical to both human and animal food webs. In addition to fishing pressure, mobile invertebrate species in Long Island Sound are influenced by climate and environmental change. American lobster populations in particular have been severely impacted by warming waters. Horseshoe crab populations, on the other hand, have been influenced by the pharmaceutical industry and by human disturbance to nesting beaches.

Data Sources and Components of Mobile invertebrates

To identify Ecologically Significant Areas for mobile invertebrates, the EEG used the CT DEEP Marine Fisheries Long Island Sound Trawl Survey (LISTS) data and the results of existing analyses using this database, for multiple species. Mobile invertebrate species are routinely caught in the LISTS which occurs in spring and fall of each year since 1984. The LISTS divides the Sound into about three hundred 1x2 nautical-mile grid cells and uses a stratified-random survey design. The survey design relies on the stratum assigned to each 1x2 nautical mile area and weights the number of samples per stratum by the amount of stratum-specific area available for sampling. Strata are 12 combinations of three bottom types and four depth intervals. Although LISTS data are representative of the entire Sound at the stratum level, there are some areas that cannot be effectively sampled by the Surveybottom trawl (e.g., The Race, shoals, reefs and trenches). Since strata are not uniformly distributed throughout the sound and sites are not equally available to the sampling gear, not all grid cells have been sampled equally over time (Figure 2a-32). Biomass has been recorded since

1992. All of the data for this criterion are reported using the 1x2 nautical mile site grid, even though LISTS methodology does not require a tow be conducted within the confines of a grid cell provided it is conducted in the correct stratum.

Areas of high mobile invertebrate biomass and concentration

CT DEEP Marine Fisheries provided LISTS data to the EEG to identify areas of high mobile invertebrate abundance and concentration. Marine Fisheries recommended that the biomass of five decapod species (Blue crab, flat claw hermit crab, lady crab, rock crab, and spider crab) be mapped and considered together as a group due to similarities in their biology, habitat preferences, and catchability in the trawl survey (Table 2a-7). Other focal mobile invertebrate species that Marine Fisheries recommended for inclusion in this component were horseshoe crab, American lobster, and long-finned squid (Table 2a-7). For the decapod species group, The data included the natural log of the mean biomass per grid cell for each species for spring and fall in the following date ranges: 1995-2004 and 2005-2014 (biomass was used since these species are weighed but not counted in LISTS). For horseshoe crab, American lobster, and long-finned squid, the data included the natural log of the mean count per grid cell for each species for spring and fall in the following date ranges: 1995-2004 and 2004-2015. For decapods, group total mean biomass was calculated for each season in each date range. For the other three species, total mean abundance (counts) were calculated for each species in each season in each date range. This resulted in 4 biomass layers for decapods and 12 additional abundance layers for the other three species.

Layers were classified by quintiles and the top quintile of each layer were combined and considered an ecologically significant area of high mobile invertebrate biomass and concentration (Table 2a-8). Ecologically significant areas for decapods, horseshoe crab, American lobster, and long-finned squid in fall and spring and each decade were mapped individually (See Table 2a-8; Figures 45-60).

Table 2a-7 Mobile invertebrate species present in greater than 5 tows in any of the seasons and date ranges for the Long Island Sound Trawl Survey between 1995 and 2014.

Species Group	**Common name**	**Scientific name**
Decapods	Blue crab	*Callinectes sapidus*
Decapods	Flat claw hermit crab	*Pagurus pollicaris*
Decapods	Lady crab	*Ovalipes ocellatus*

Decapods	Rock crab	*Cancer irroratus*
Decapods	Spider crab	*Libinia emarginata*
N/A	Horseshoe crab	*Limulus polyphemus*
N/A	American lobster	*Homarus americanus*
N/A	Long-finned squid	*Loligo pealeii*

Table 2a-8 The 16 individual data layers derived from the LISTS data for describing areas of high mobile invertebrate biomass and concentration.

Data layer description	**Maps**
Top quintile of **decapod species** spring biomass, 1995-2004	2a-45
Top quintile of **decapod species** fall biomass, 1995-2004	2a-46
Top quintile of **decapod species** spring biomass, 2005-2014	2a-47
Top quintile of **decapod species** fall biomass, 2005-2014	2a-48
Top quintile of **horseshoe crab** spring abundance, 1995-2004	2a-49
Top quintile of **horseshoe crab** fall abundance, 1995-2004	2a-50
Top quintile of **horseshoe crab** spring abundance, 2005-2014	2a-51
Top quintile of **horseshoe crab** fall abundance, 2005-2014	2a-52
Top quintile of **American lobster** spring abundance, 1995-2004	2a-53
Top quintile of **American lobster** fall abundance, 1995-2004	2a-54
Top quintile of **American lobster** spring abundance, 2005-2014	2a-55
Top quintile of **American lobster** fall abundance, 2005-2014	2a-56
Top quintile of **long-finned squid** spring abundance, 1995-2004	2a-57
Top quintile of **long-finned squid** fall abundance, 1995-2004	2a-58

Top quintile of **long-finned squid** spring abundance, 2005-2014	2a-59
Top quintile of **long-finned squid** fall abundance, 2005-2014	2a-60

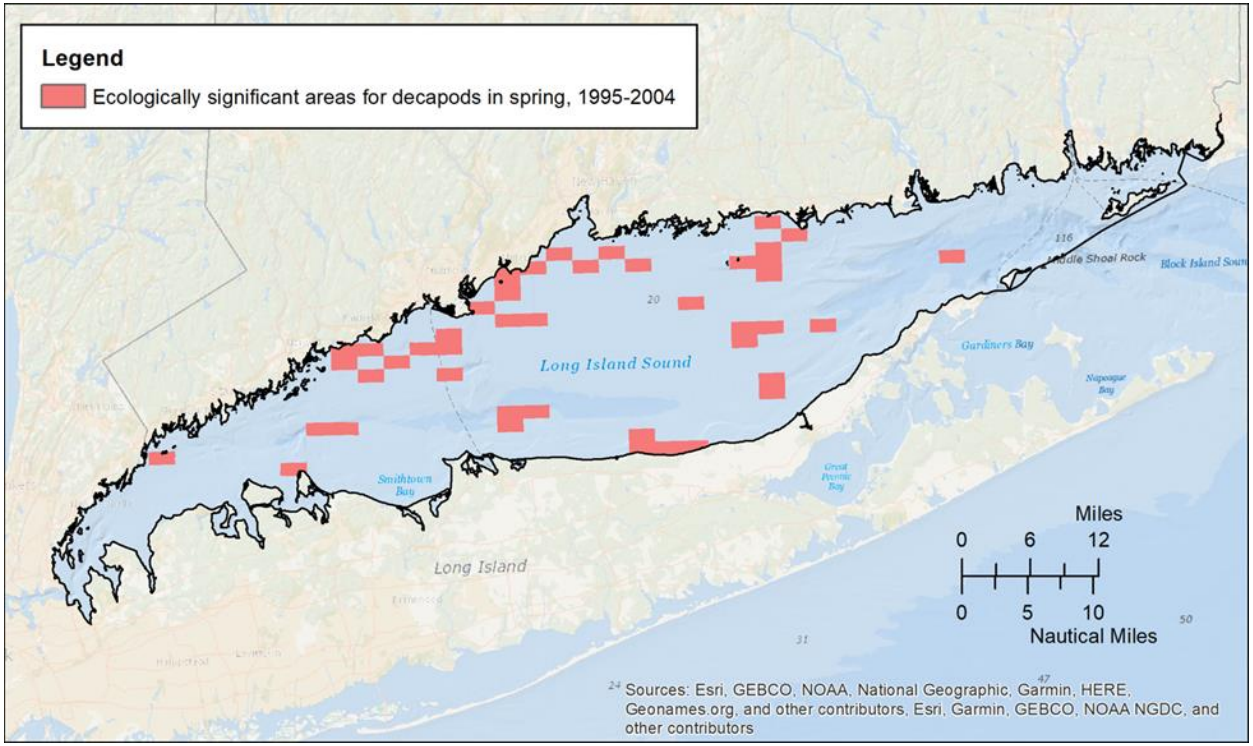


Figure 2a-45 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of decapod species biomass in spring from LISTS 1995-2004.

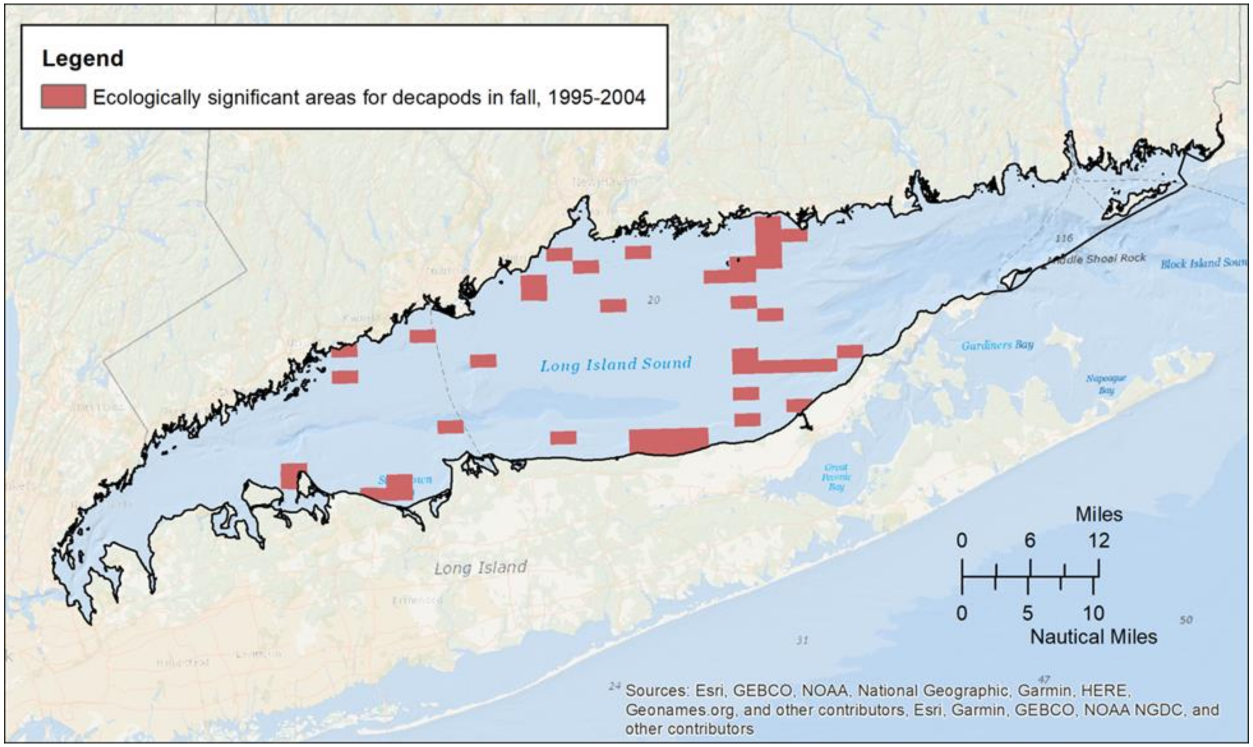


Figure 2a-46 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of decapod species biomass in fall from LISTS 1995-2004.

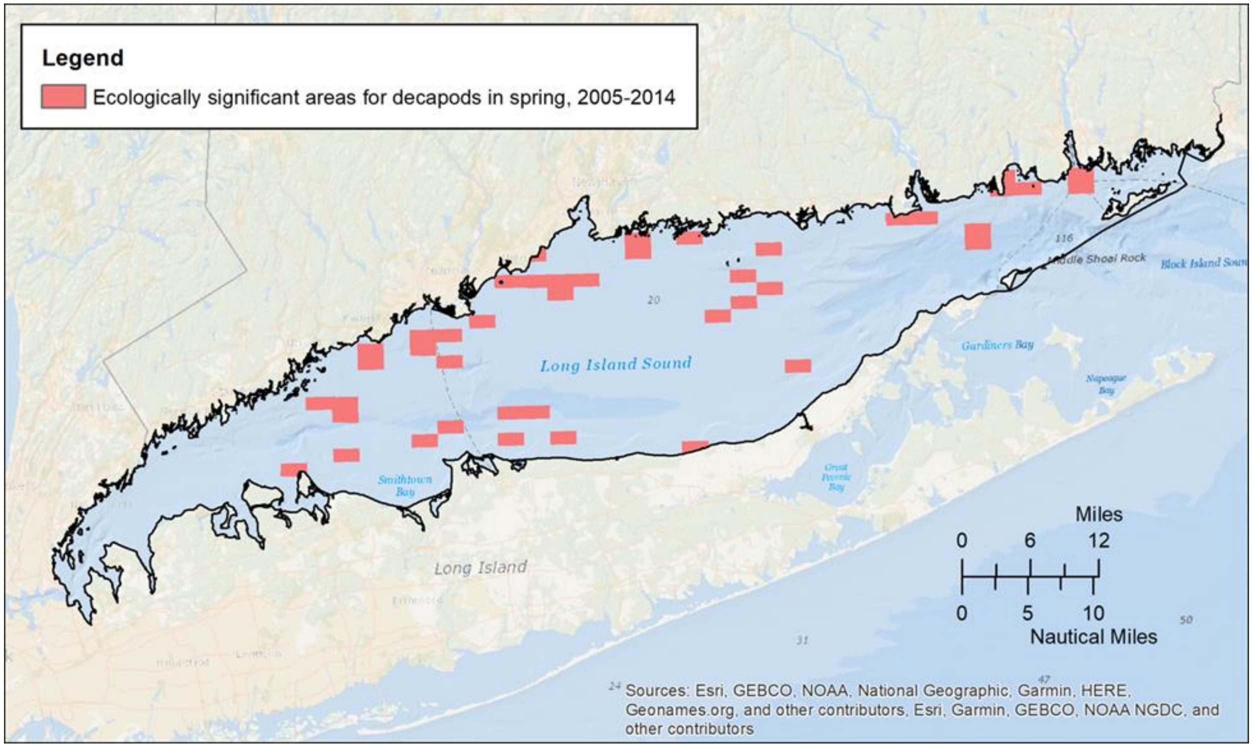


Figure 2a-47 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of decapod species biomass in spring from LISTS 2005-2014.

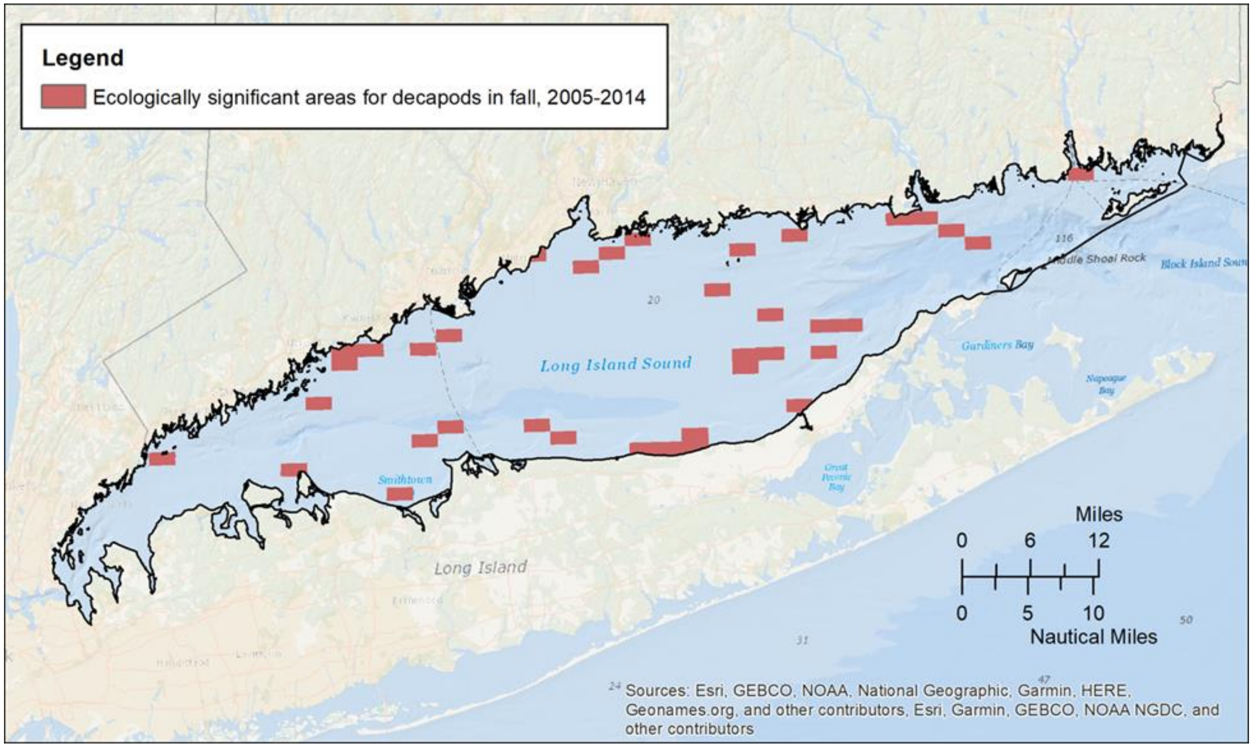


Figure 2a-48 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of decapod species biomass in spring from LISTS 2005-2014.

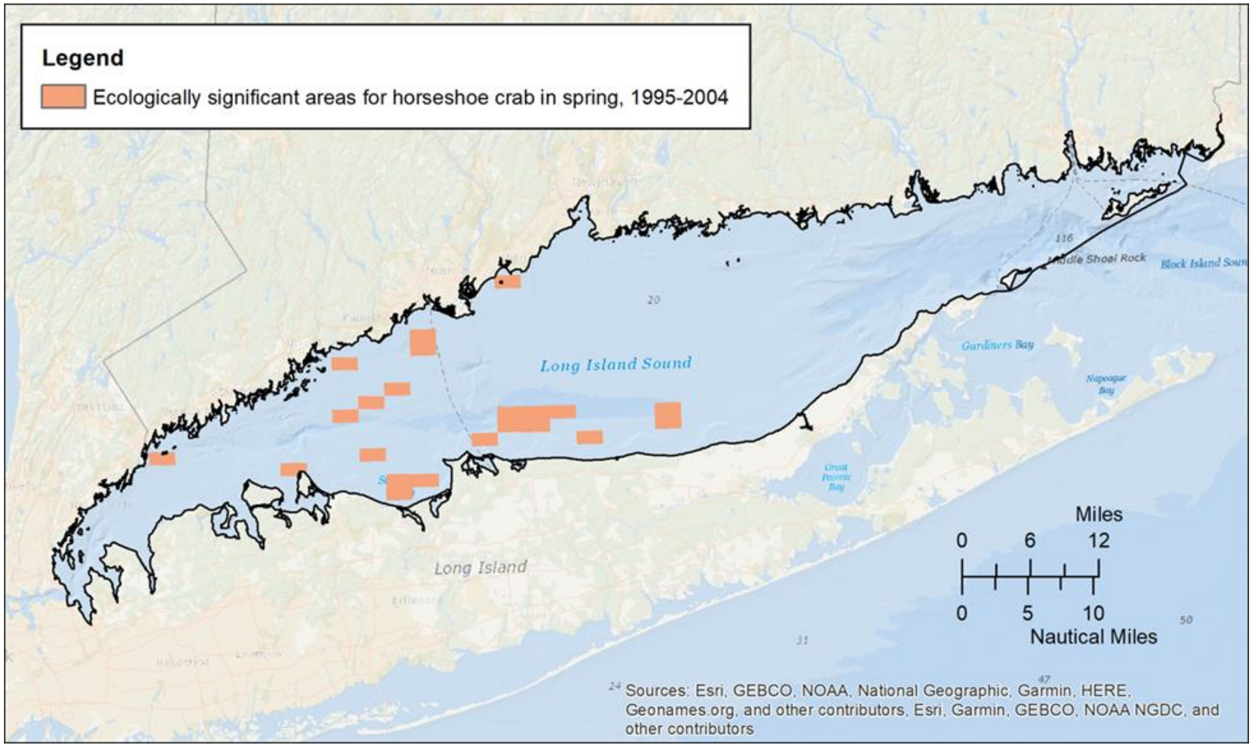


Figure 2a-49 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of horseshoe crab abundance in spring from LISTS 1995-2004.

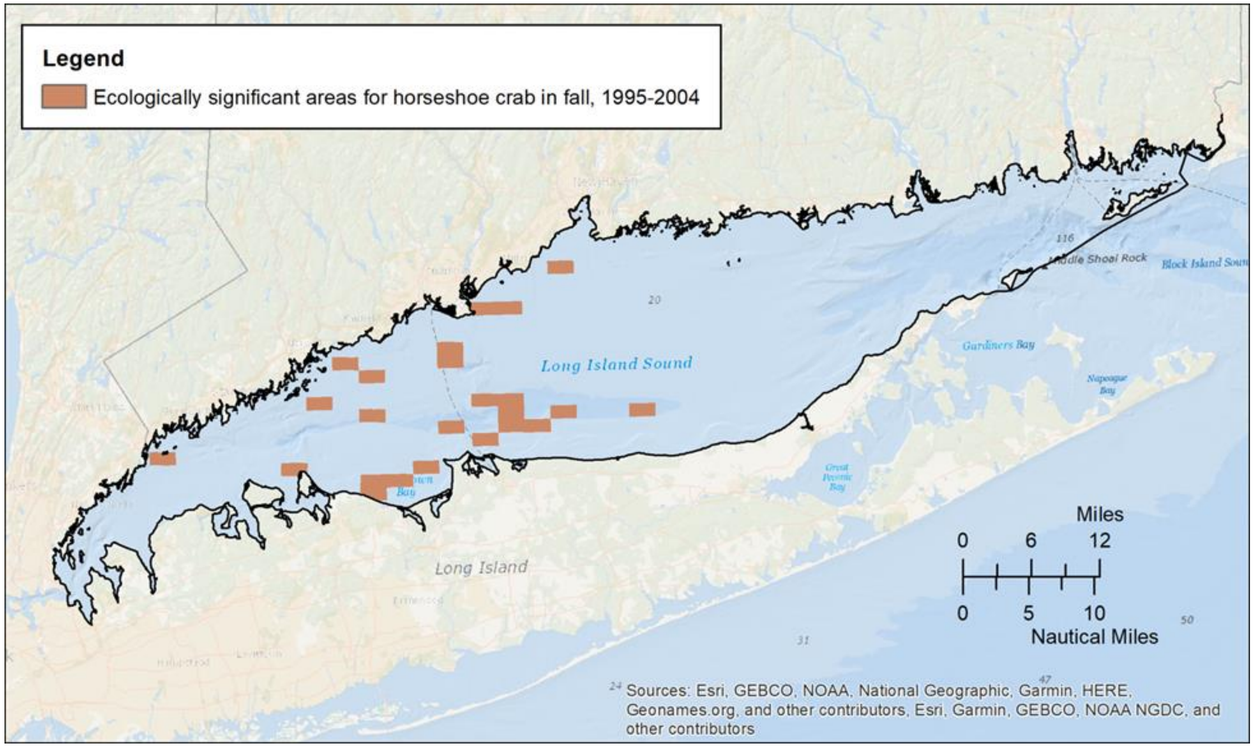


Figure 2a-50 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of horseshoe crab abundance in fall from LISTS 1995-2004.

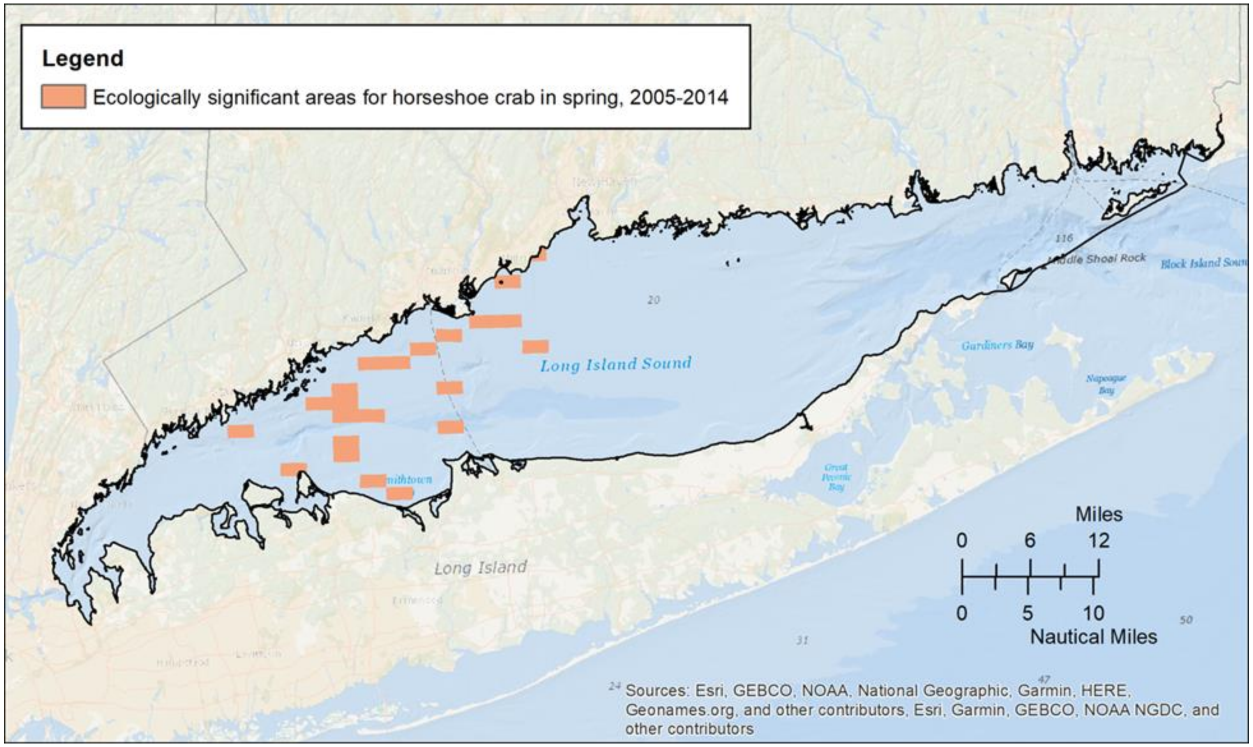


Figure 2a-51 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of horseshoe crab abundance in spring from LISTS 2005-2014.

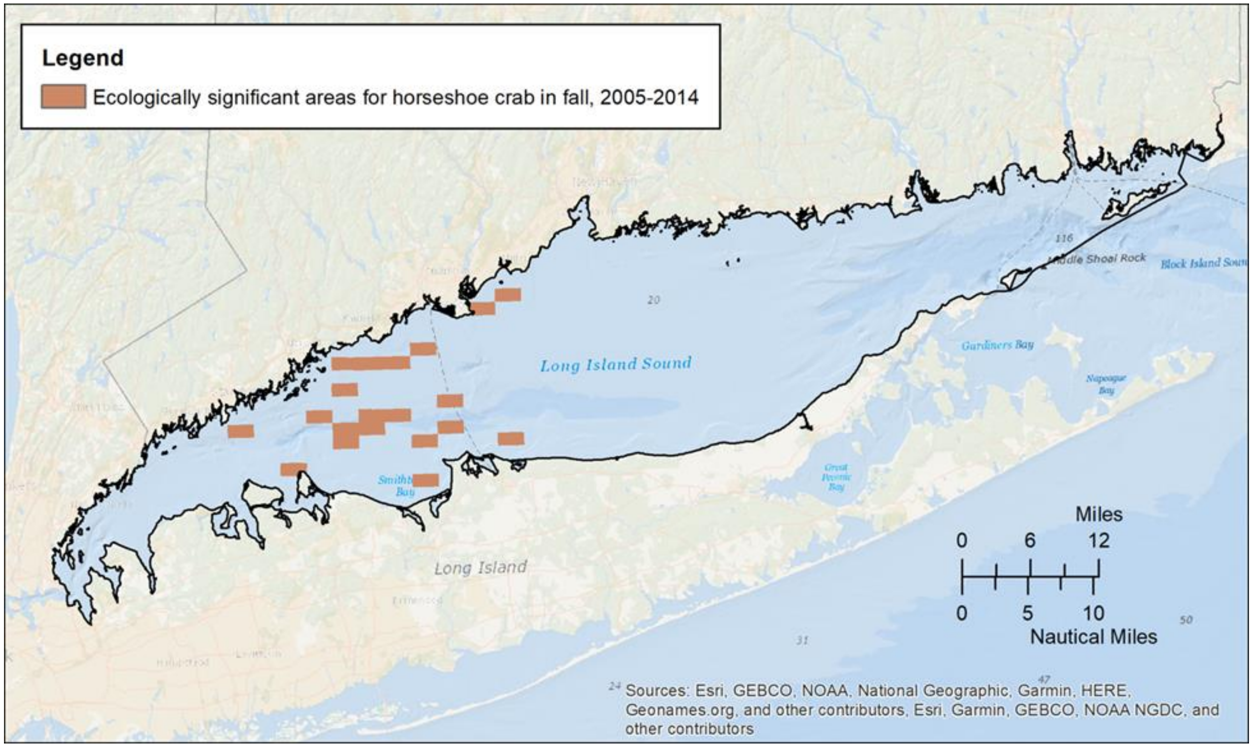


Figure 2a-52 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of horseshoe crab abundance in fall from LISTS 2005-2014.

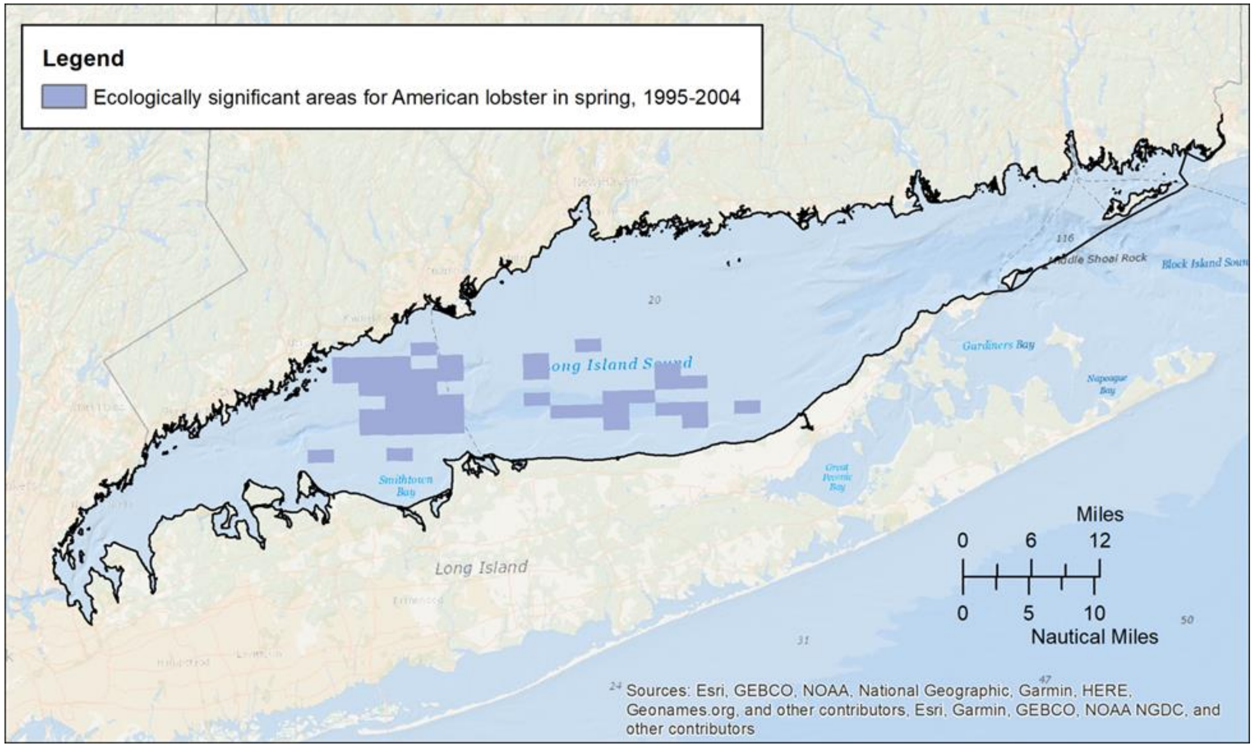


Figure 2a-53 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of American lobster abundance in spring from LISTS 1995-2004.

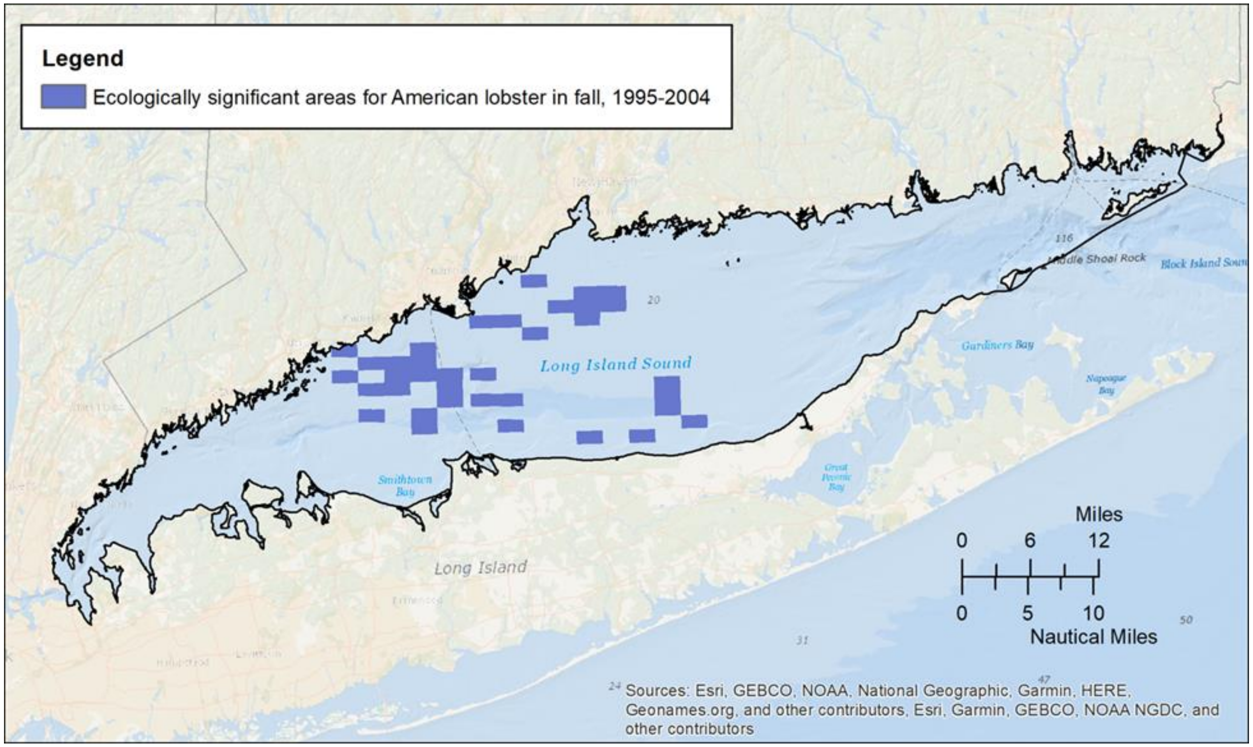


Figure 2a-54 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of American lobster abundance in fall from LISTS 1995-2004.

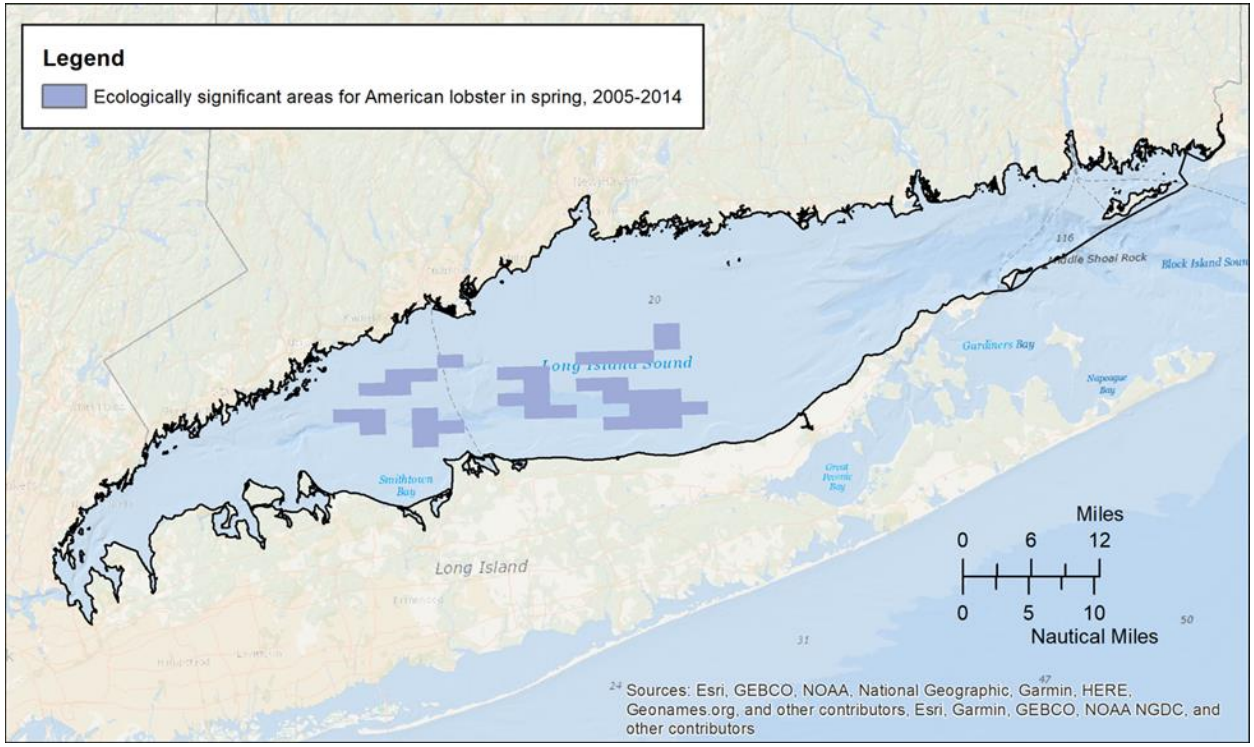


Figure 2a-55 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of American lobster abundance in spring from LISTS 2005-2014.

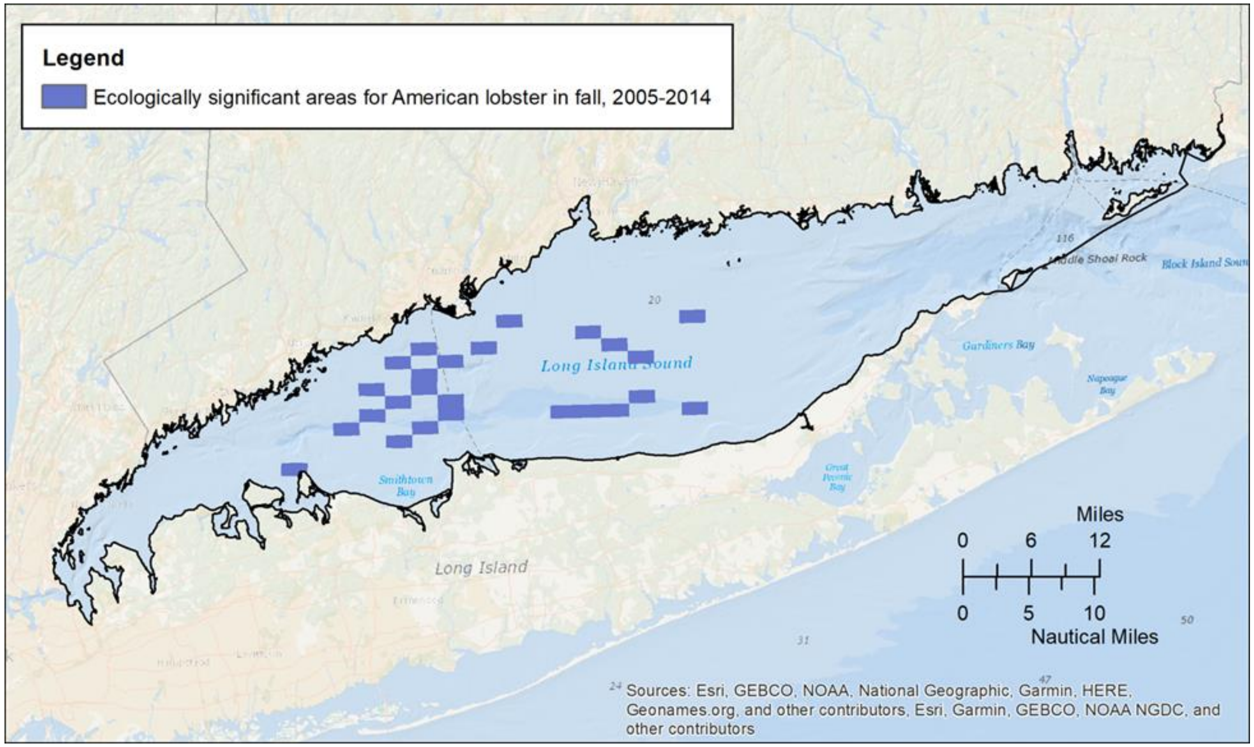


Figure 2a-56 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of American lobster abundance in fall from LISTS 2005-2014.

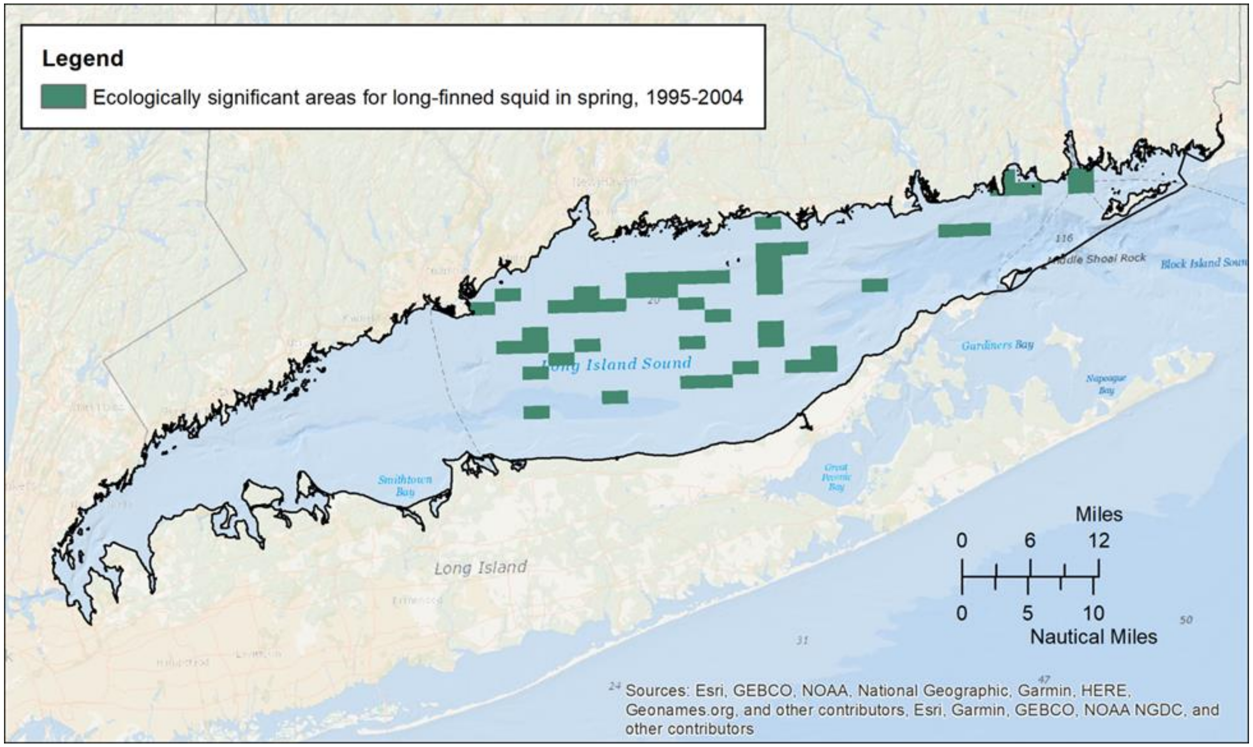


Figure 2a-57 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of long-finned squid abundance in spring from LISTS 1995-2004.

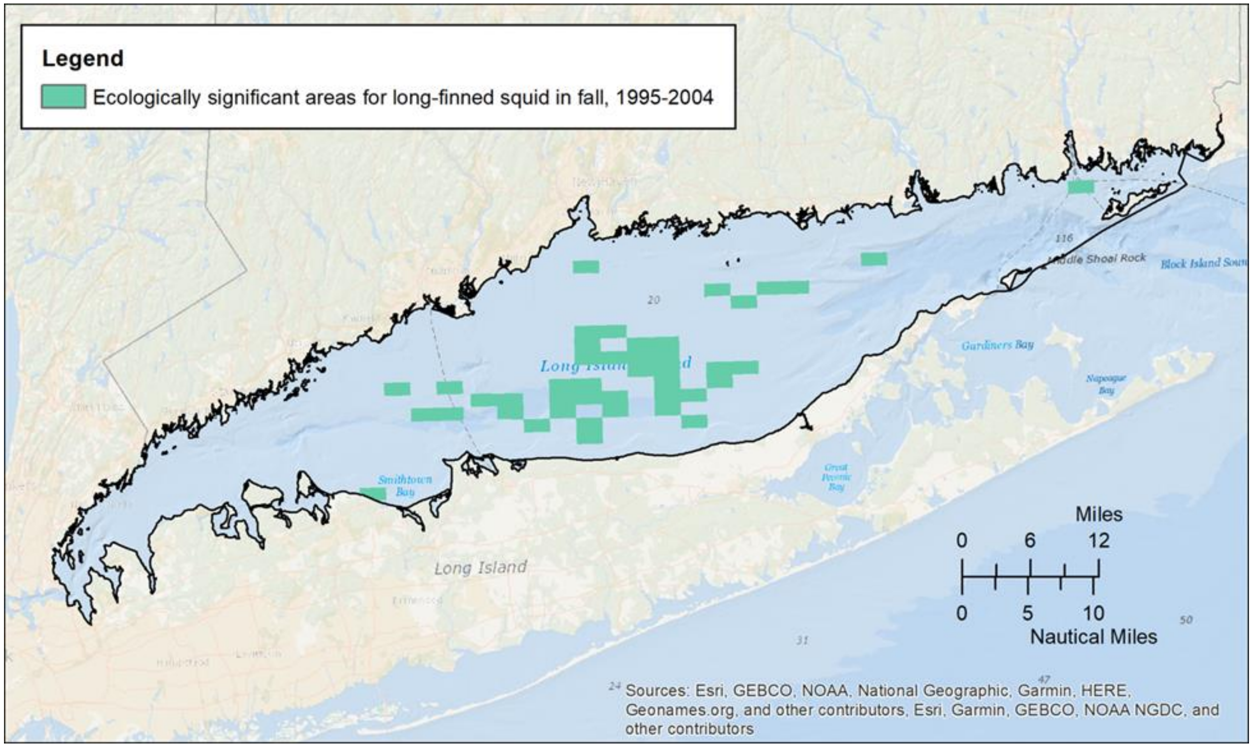


Figure 2a-58 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of long-finned squid abundance in fall from LISTS 1995-2004.

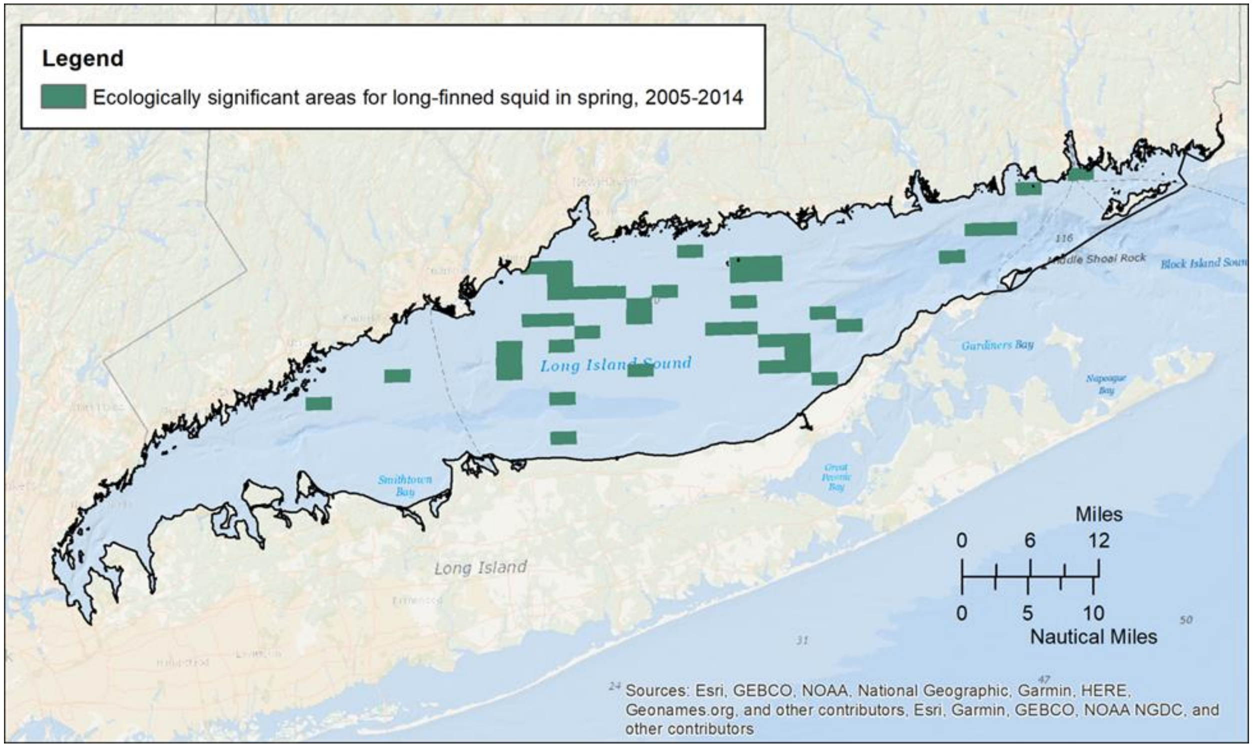


Figure 2a-59 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of long-finned squid abundance in spring from LISTS 2005-2014.

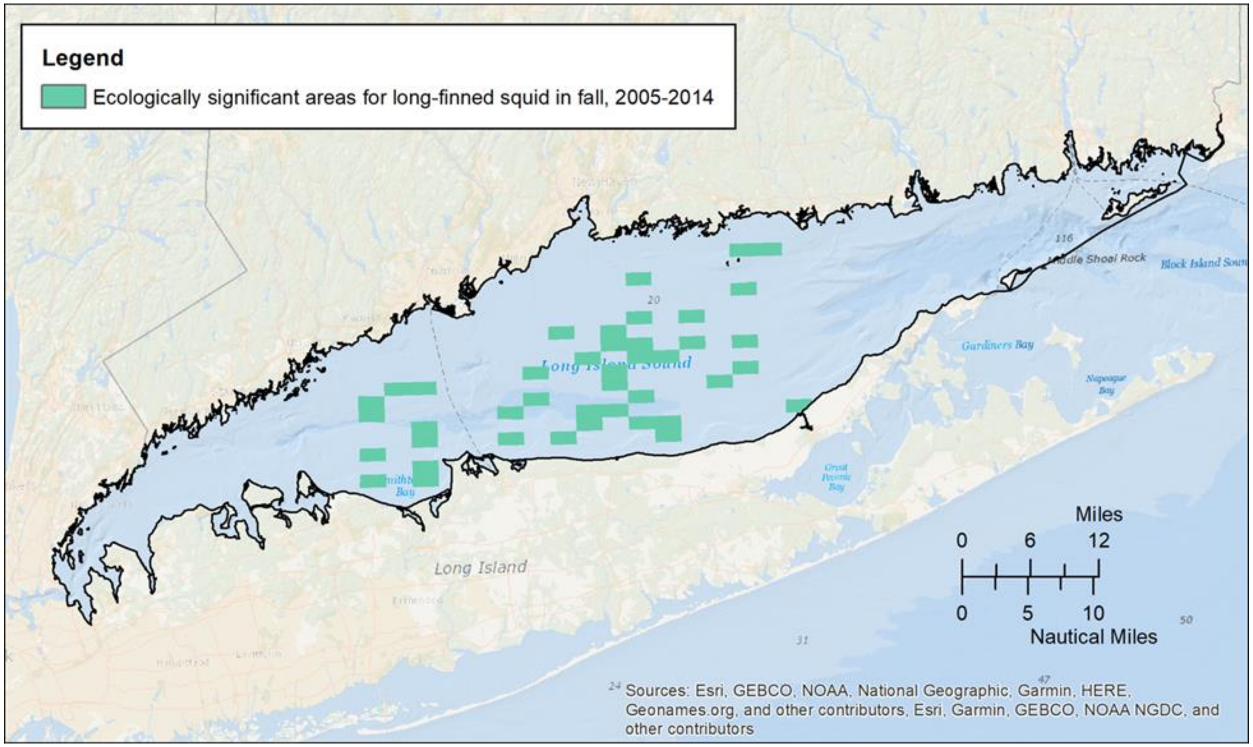


Figure 2a-60 A map showing one component of Ecologically Significant Areas for mobile invertebrates: the top quintile of long-finned squid abundance in fall from LISTS 2005-2014.

Horseshoe crab predicted spawning beaches

Provided by CT DEEP Marine Fisheries, this layer represents predicted horseshoe crab spawning use classifications for Connecticut beaches. These data were included in Connecticut's 2015 Wildlife Action Plan Key Habitats and Communities. High and medium use beaches were considered ecologically significant (Figure 2a-61).

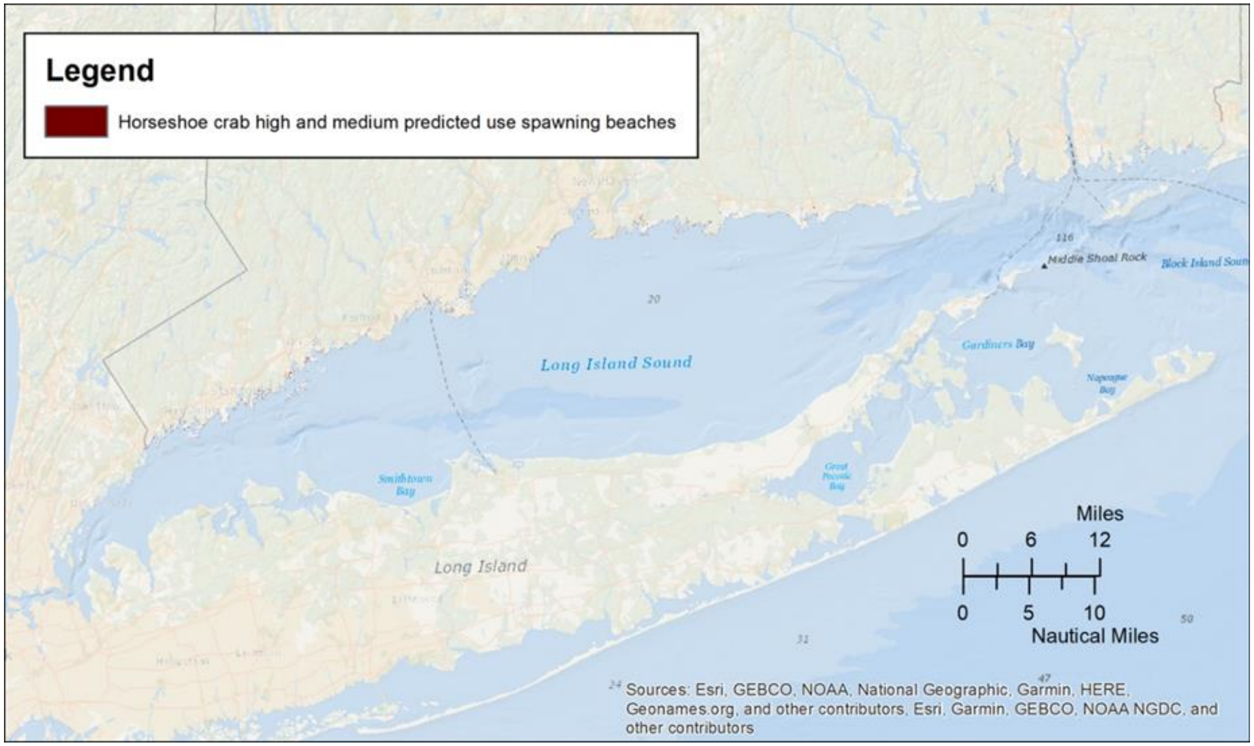


Figure 2a-61 Horseshoe crab predicted spawning beaches. Note: The Long Island Sound boundary is removed in this map to more clearly depict features.

American lobster projected thermal refuge

Provided by CT DEEP Marine Fisheries, this layer represents those LISTS grid cells where projected future temperatures remain within American lobsters' tolerance (between 12-20°C) from July to September for at least 32% of the time. This threshold was chosen because between 2002-2012 temperatures remained between 12-20°C from July to September for ~32% of the time and allowed for some American lobster survival. Development of the thermal refuge layer (Figure 2a-62) required use of a projected temperature layer that corresponded to the LISTS grid, developed by the Stevens Institute.

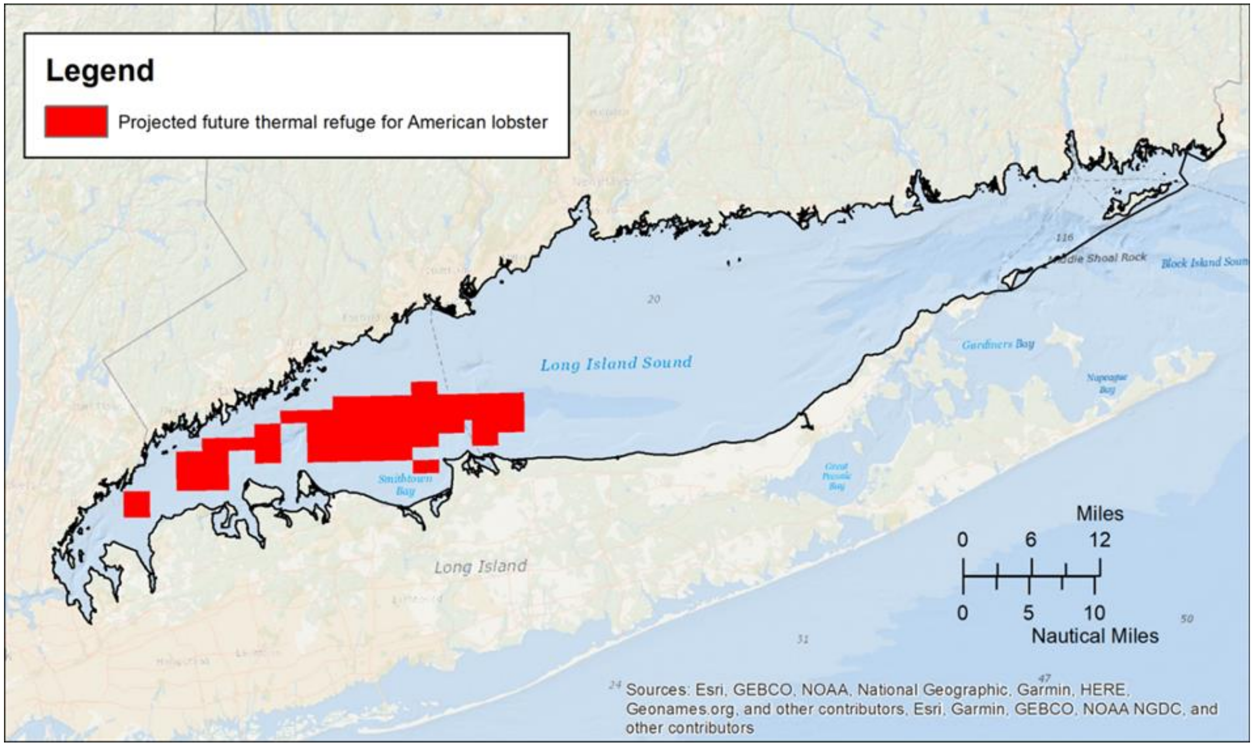


Figure 2a-62 Projected thermal refuge for American Lobster.

Integration of Data and Components

The datasets described above were mapped together to represent the extent of Ecologically Significant Areas for mobile invertebrates. Figure 2a-63 shows the number of overlaps in those datasets. Figure 2a-64 shows those datasets dissolved together to show a single presence/absence layer of ESA for mobile invertebrates.

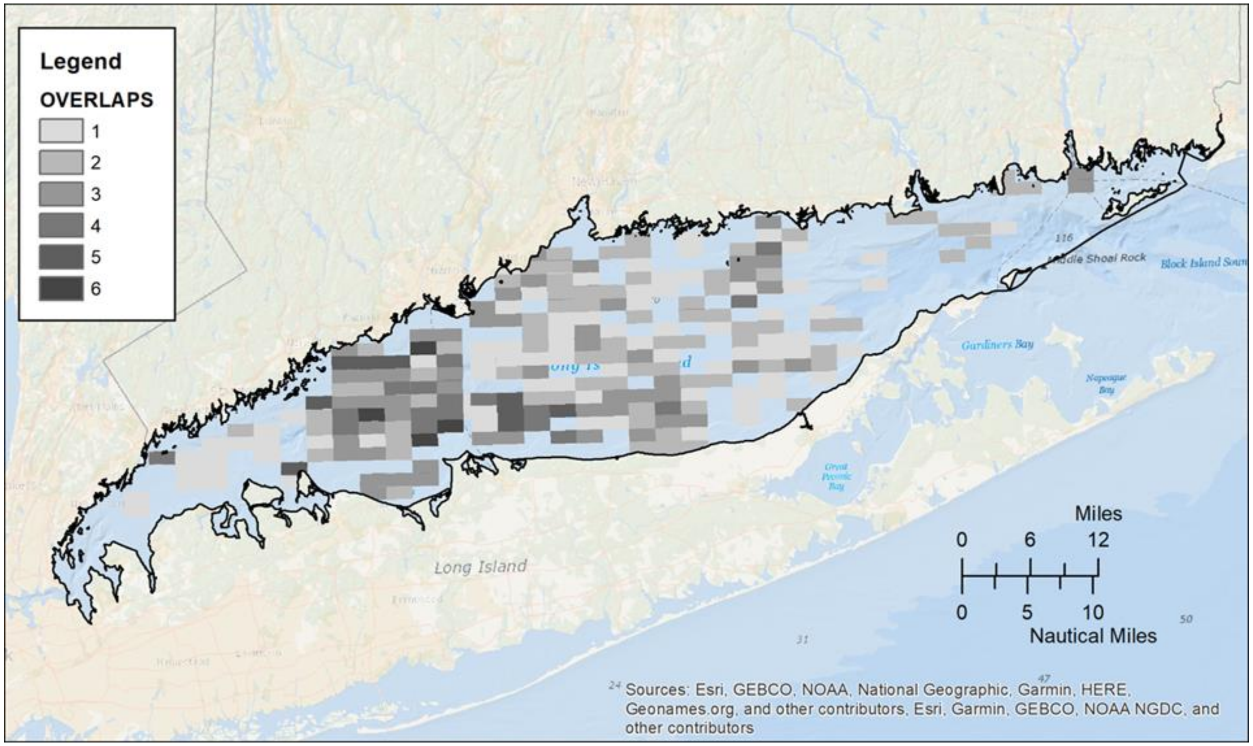


Figure 2a-63 Overlaps in datasets contributing to the mobile invertebrate ESA.

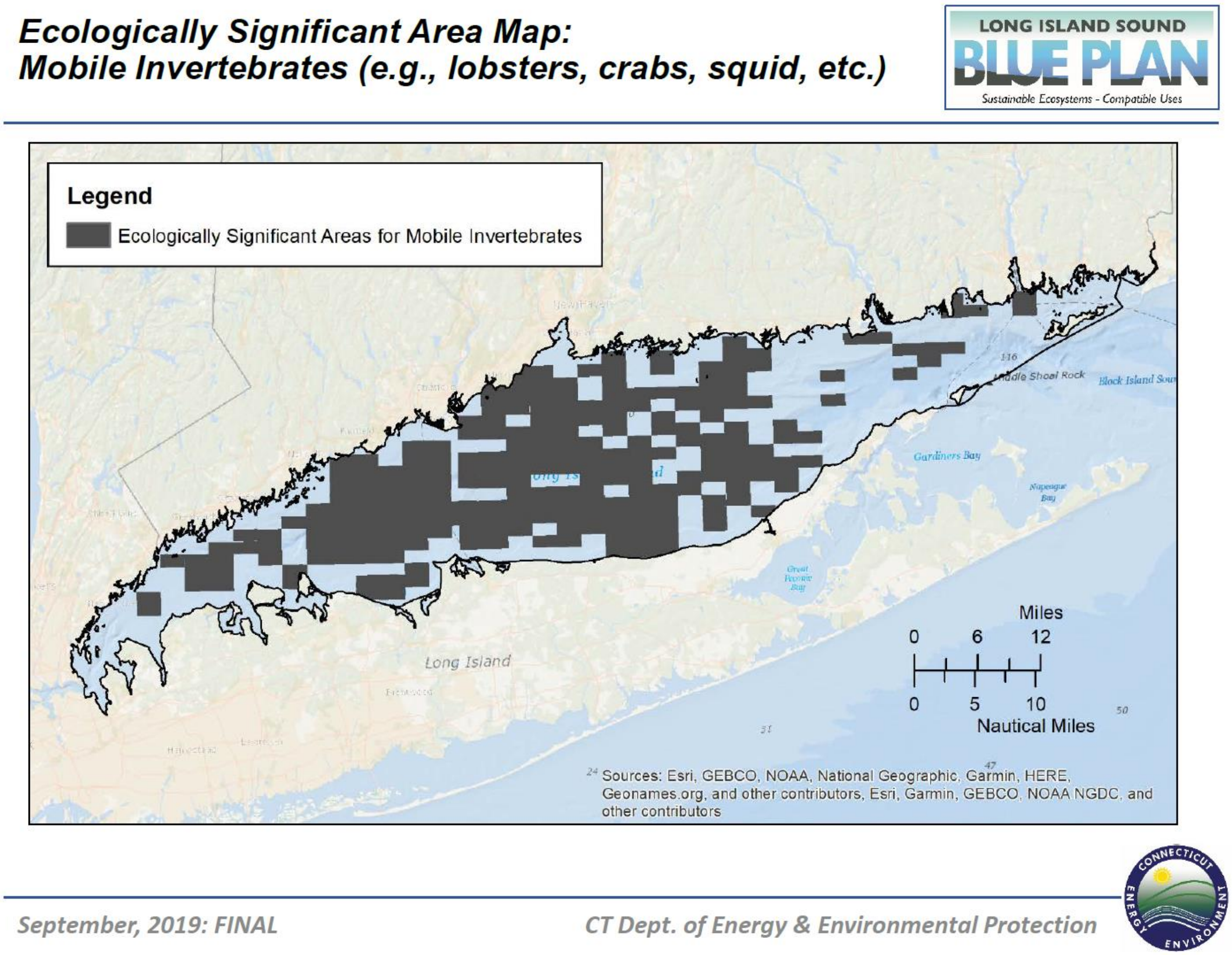


Figure 2a-64 Final ESA map of mobile invertebrates.

Updates and potential future work

The CT DEEP Marine Fisheries LISTS dataset is a robust, long-term dataset that provides many different opportunities for summarization. Future work could take the form of developing updated biomass products with additional data collected since 2014.

vii. **Criterion 12: Sessile-mollusk-dominated communities**

Definition: Areas where wild, natural sessile-mollusk-dominated communities occur.

Significance of Sessile-mollusk-dominated communities

Sessile-mollusk-dominated communities are assemblages of non-mobile gastropods (e.g., slipper shells) and bivalves (e.g., blue mussels, clams) that are not harvested by humans. These communities are anchored by the mollusks, where dead and living shell material can sometimes form reef-like features that forms habitat for encrusting species (e.g., sponges, tube worms) and mobile species (e.g., juvenile fish). Furthermore, as filter-feeders, these communities filter particles and organic matter from the water column and deposit it into the sediment, contributing to the cycling of nutrients in the Sound. Aggregations of sessile mollusks can take years or decades to establish and so are vulnerable to disturbances including physical removal, burial, or smothering.

Components and data sources for Sessile-mollusk-dominated communities

Long Island Sound Mapping and Research Collaborative (LISMaRC) Phase I and II SEABOSS observations

There have been no comprehensive surveys of sessile-mollusk-dominated communities in Long Island Sound. However, the Long Island Sound Mapping and Research Collaborative (LISMaRC), through the Long Island Sound Seafloor Mapping Initiative, have mapped the occurrence of several sessile mollusk species at discrete sampling locations near Stratford Shoals and eastern Long Island Sound. The species observations used in maps for this criterion include the common slipper shell (*Crepidula fornicata*) and blue mussels (*Mytilus edulis*). In 2012 and 2013, the percent cover of slipper shells and blue mussels was documented in the Stratford Shoals area. Survey areas with >50% cover of slipper shells and blue mussels were considered ecologically significant. In 2017, the presence and absence of slipper shells and blue mussels was documented in eastern Long Island Sound. Survey areas with slipper shells or blue mussels present were considered ecologically significant. The combined observations of slipper shells are shown in Figure 2a-66 and the combined observations of blue mussels are shown in Figure 2a-67.

These observations create an incomplete picture of where ESA for sessile-mollusk-dominated communities exist. First, while each survey area is shown on the map at its true size, sessile-mollusk-dominated communities likely only exist in a fraction of each survey area. In other words, these communities only needed to be found to occur once within the entire survey area for that survey area to be included as ecologically significant. Second, it is important to reiterate that simply because the ESA maps do not indicate presence of sessile-mollusk-dominated communities in other areas of the Sound, they do not reflect their absence - they merely indicate the lack of survey effort in those parts of the Sound. Only survey areas where sessile-mollusk-dominated communities have been observed (anywhere within the survey area) are considered ecologically significant.

Expert participatory mapping

After reviewing the draft areas selected by the EEG that were derived from the LISMaRC data, experts recommended that ESA for sessile-mollusk-dominated communities be amended to include additional areas. On January 3, 2019, Patrick Comins, Executive Director of the Connecticut Audubon Society, delineated additional areas for slipper shell aggregations and blue mussel aggregations for inclusion as ESA (Figure 2a-68).

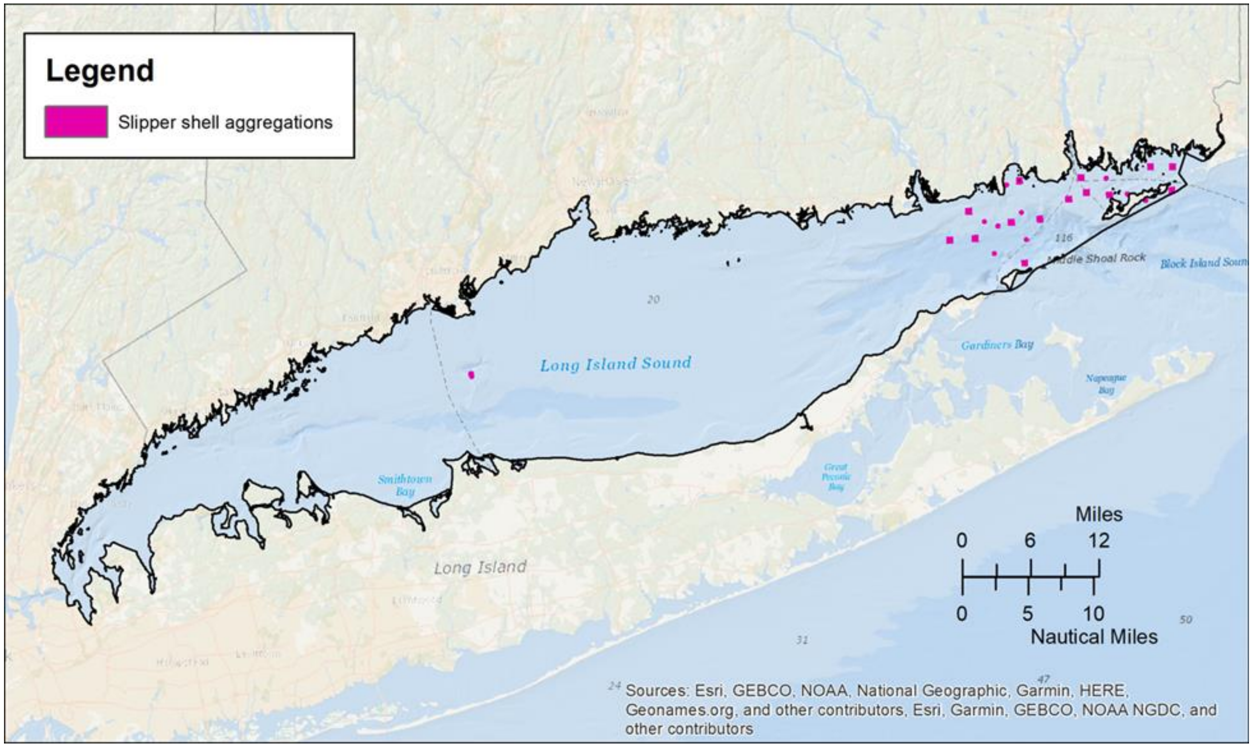


Figure 2a-65 Observations of slipper shell aggregations near Stratford Shoals and in eastern LIS.

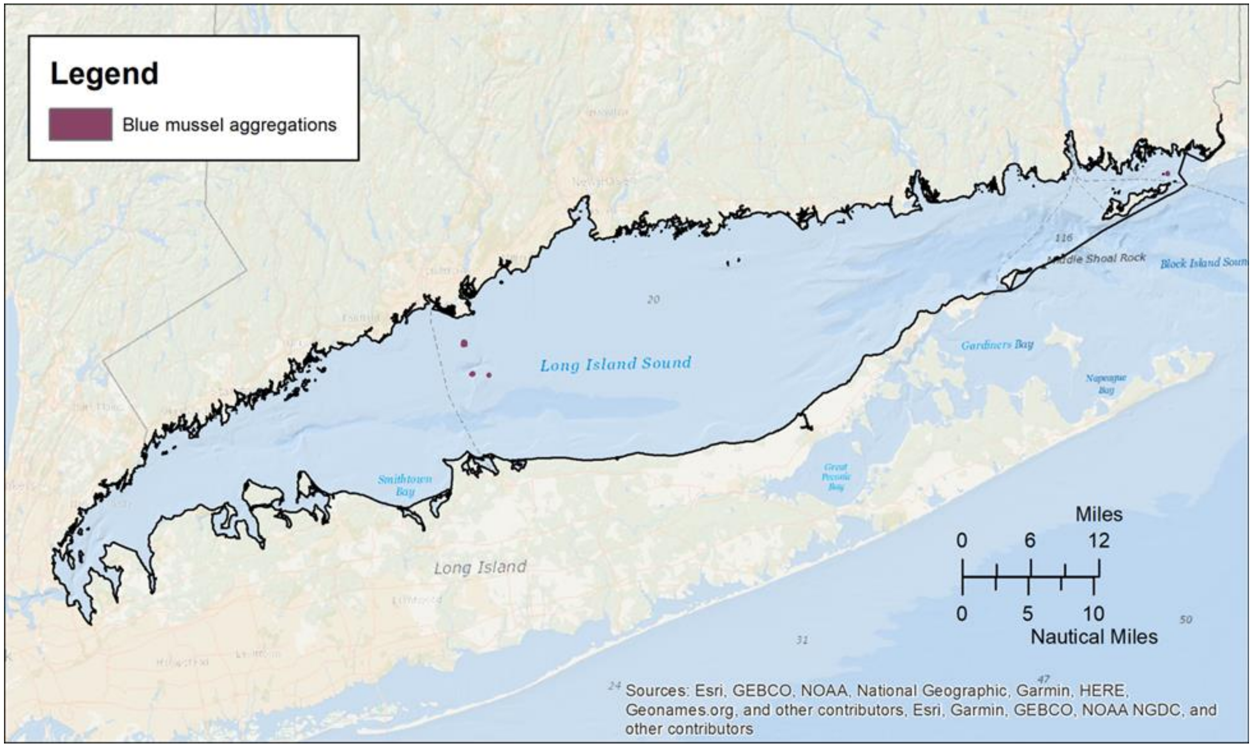


Figure 2a-66 Observations of blue mussel aggregations near Stratford Shoals and in eastern LIS.

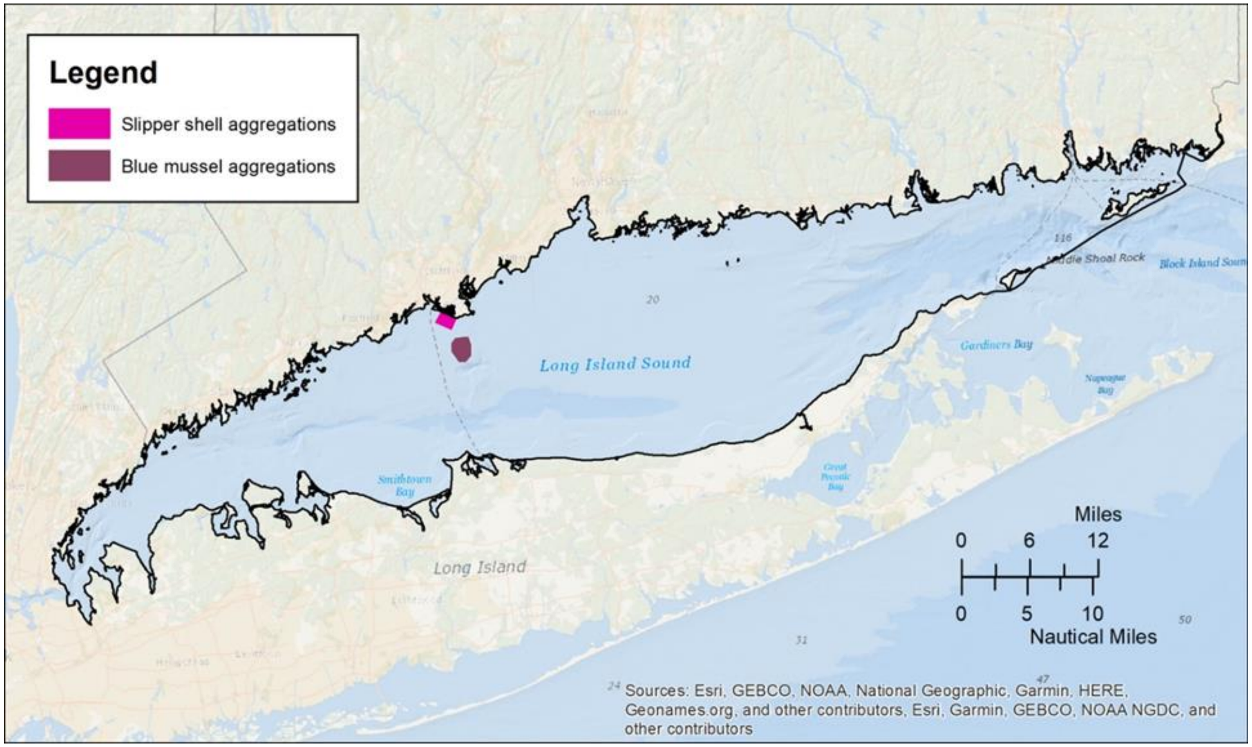
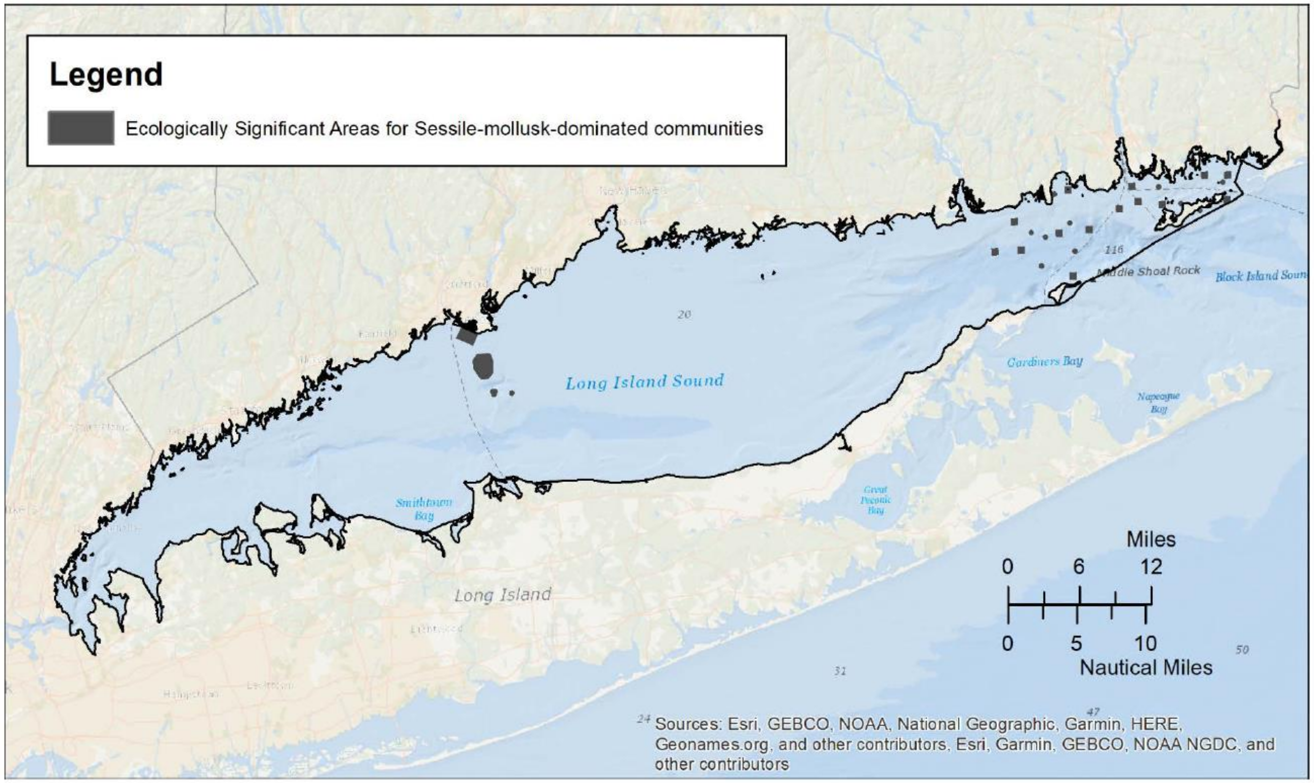


Figure 2a-67 Aggregations of slipper shells and blue mussels delineated by expert participatory mapping.

Integration of components and data sources

The datasets described above were mapped together to represent the extent of Ecologically Significant Areas for sessile-mollusk-dominated communities. Figure 2a-69 shows those datasets dissolved together to show a single presence/absence layer of ESA for sessile-mollusk-dominated communities.

Ecologically Significant Area Map: Sessile/Mollusk Communities (e.g., mussels, clams, etc.)



September, 2019: FINAL   CT Dept. of Energy & Environmental Protection

Figure 2a-68 Final ESA map of Sessile-mollusk-dominated communities.

Updates and potential future work

Additional observations of sessile-mollusk-dominated communities would improve the maps for this criterion. As with other criteria, and if enough input data are available, a habitat suitability model could be developed for sessile-mollusk-dominated communities that generates products with full-coverage of the Sound. The benefit of using a habitat suitability model is that an existing and limited set of observations could be used to predict habitat suitability across the entire Long Island Sound, rather than rely on a piece-meal sampling approach that may never sample every Long Island Sound habitat.

viii. **Criterion 13: Managed shellfish beds**

Definition: Locations of commercial and recreational shellfishing harvest areas, including shellfish restoration activities and areas closed to shellfishing.

Significance of Managed shellfish beds

In Connecticut, shellfish are defined as oysters, clams, mussels and scallops; either shucked or in the shell, fresh or frozen, whole or in part. Scallops are excluded from this definition when the final product is the shucked adductor muscle only. Lobsters, crabs, snails and finfish are not included in this definition. Managed shellfish beds is the only ESA criteria with a clear dependence on a human use or activity. Therefore, managed shellfish beds are also described in the Significant Human Use Areas analysis (see section 3.4b). However, as ecological features, managed shellfish beds provide many if not all of the same ecosystem services as unmanaged shellfish beds (see Sessile-mollusk-dominated communities), such as providing substrate and habitat for a variety of other species, water column filtration, and nutrient cycling.

Data sources for Managed shellfish beds

Several datasets from the Connecticut Bureau of Aquaculture were used to map Ecologically Significant Areas for managed shellfish beds. Since the state of New York does not map and maintain data on shellfish resources in the same way as the state of Connecticut, only Connecticut maps were used. All of the Connecticut datasets are available via the Connecticut Aquaculture Mapping Atlas (CT Aquaculture Mapping Atlas, 2018). Any area mapped as a managed shellfish bed was considered ecologically significant.

Oyster seed beds (Connecticut Natural Shellfish Beds Dataset)

Natural beds get their name from the fact that shellfish, especially oysters, naturally inhabited the area (Figure 2a-70). Natural beds have specific regulations concerning their use including licensing and harvesting methods. They are predominately oyster seed beds that cannot be mechanically harvested. A complete description and listing of regulations are available from the Bureau of Aquaculture.

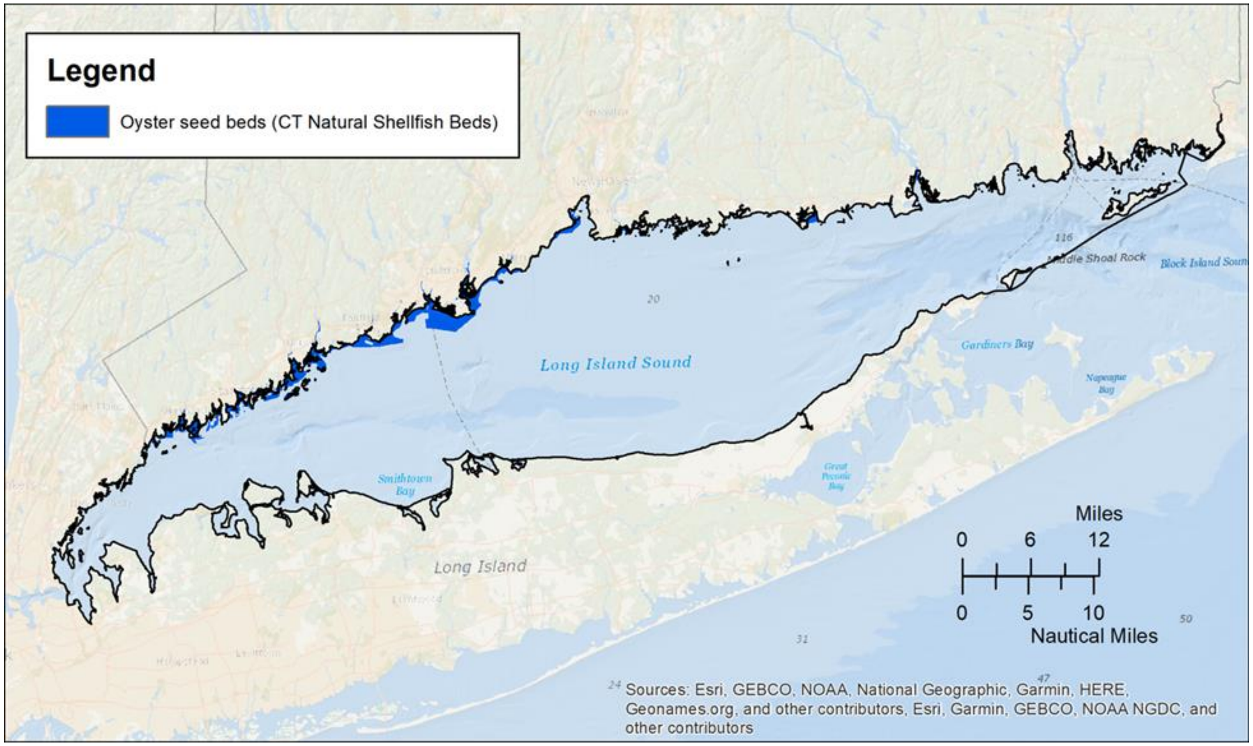


Figure 2a-69 Connecticut oyster seed beds.

Connecticut Recreational Shellfish Beds Dataset

Recreational beds are areas that are used for recreational shellfish harvest, and further delineated by shellfish growing area classifications of “Approved” and “Conditionally Approved”. (Figure 2a-71) In certain areas there may be overlap between town natural beds, undesignated town beds and recreational beds. The sources for the recreational beds layer came from maps and information provided by local shellfish commissions.

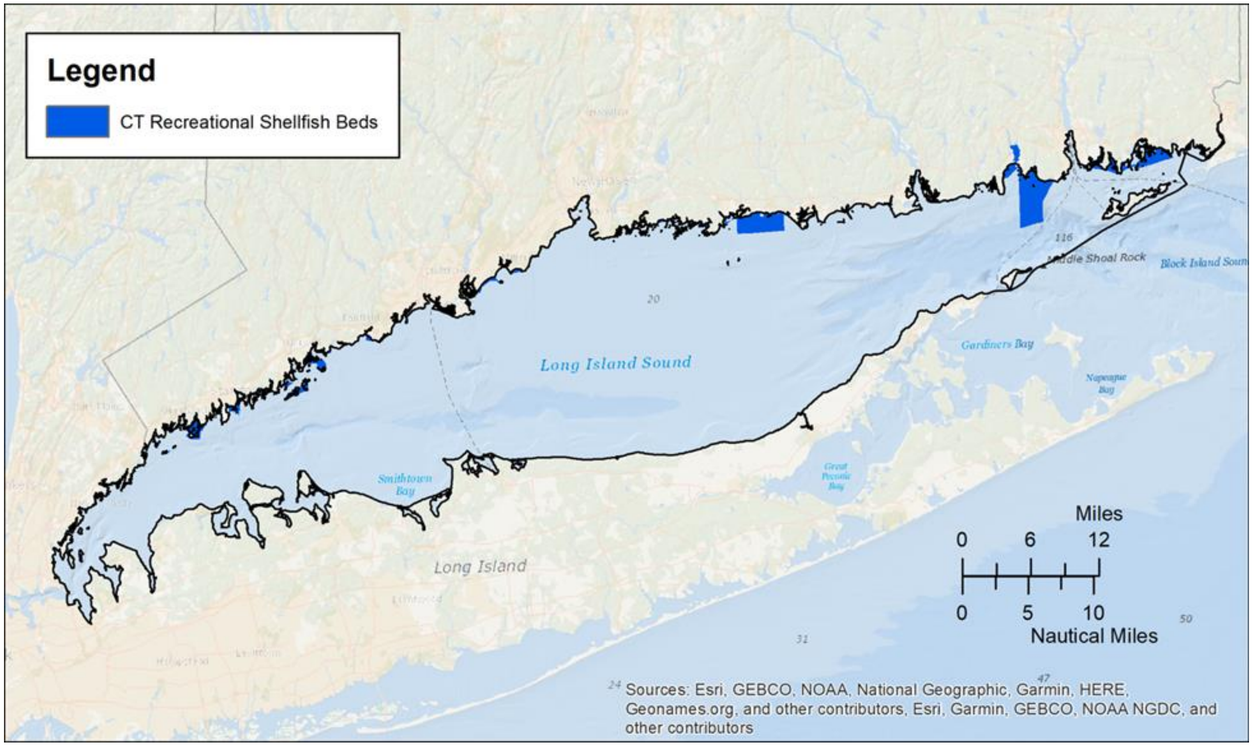


Figure 2a-70 Connecticut recreational shellfish beds.

Connecticut State-managed Shellfish Beds Dataset

In 1881 a line was established, referred to as the Commissioners line that divides the waters of the state into a northern and southern section. All beds south of this line are State beds and most beds north of this line are town beds. All the Beds under state jurisdiction were mapped using longitude/latitude data from Bureau of Aquaculture access database. These coordinates were taken from converted sextant angles. This data is subject to change and the Bureau of Aquaculture may have more recent information for some areas. State-managed shellfish beds are shown in Figure 2a-72.

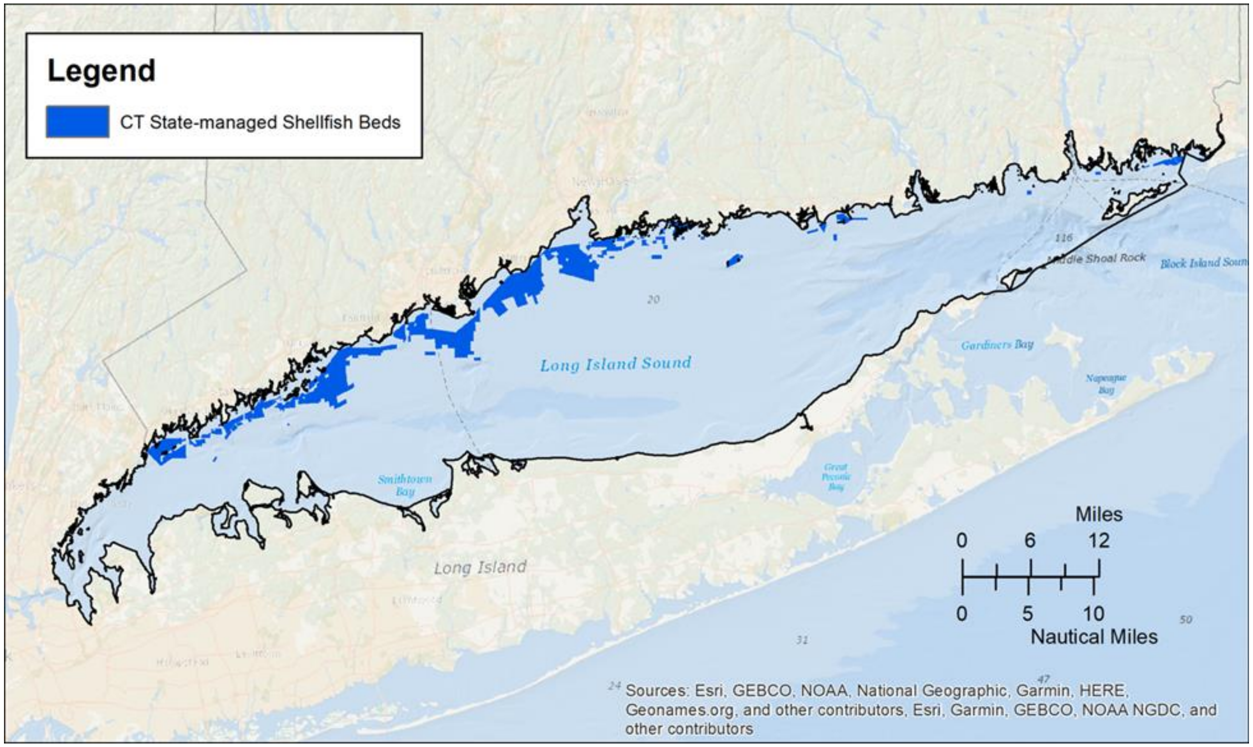


Figure 2a-71 Connecticut state-managed shellfish beds.

Connecticut Town-managed Shellfish Beds Dataset

Town beds are under town jurisdiction and may be leased, licensed or otherwise managed through the local shellfish commission. Towns may require additional local permits to work in waters under local jurisdiction. The beds north of the line in Milford, West Haven, and New Haven are exceptions to this as they are under state jurisdiction. The sources of data for the town managed beds layer were quite varied. The sources included longitude/latitude data and maps from Bureau of Aquaculture, maps and longitude/latitude provided by local shellfish commissions and longitude/latitude data and maps obtained from Tallmadge Brothers. Additionally, a few towns provided maps of their beds in an electronic format such as CAD or shapefile. This data is subject to change and the Bureau of Aquaculture may have more recent information for some areas. Town-managed beds are shown in Figure 2a-73.

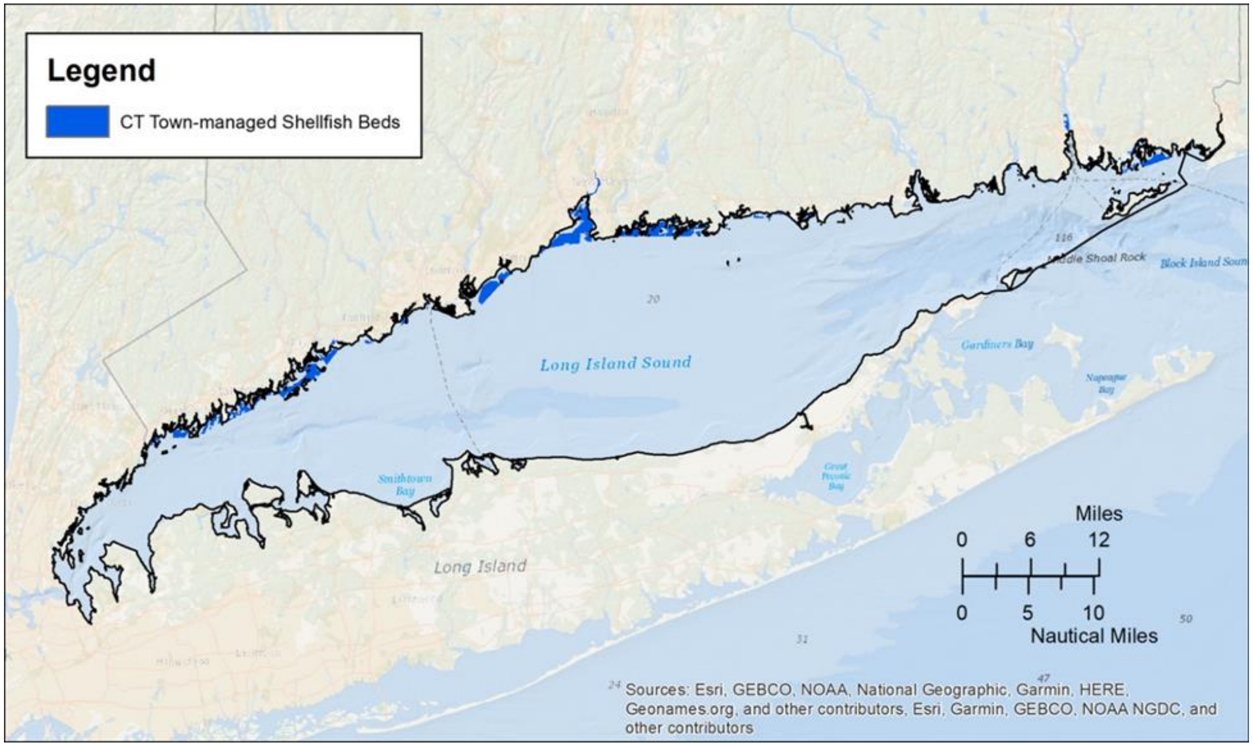


Figure 2a-72 Connecticut town-managed shellfish beds.

Integration of data sources

The datasets described above were mapped together to represent the extent of Ecologically Significant Areas for managed shellfish beds. Figure 2a-74 shows all datasets dissolved together to show a single presence/absence layer of ESA for managed shellfish beds.

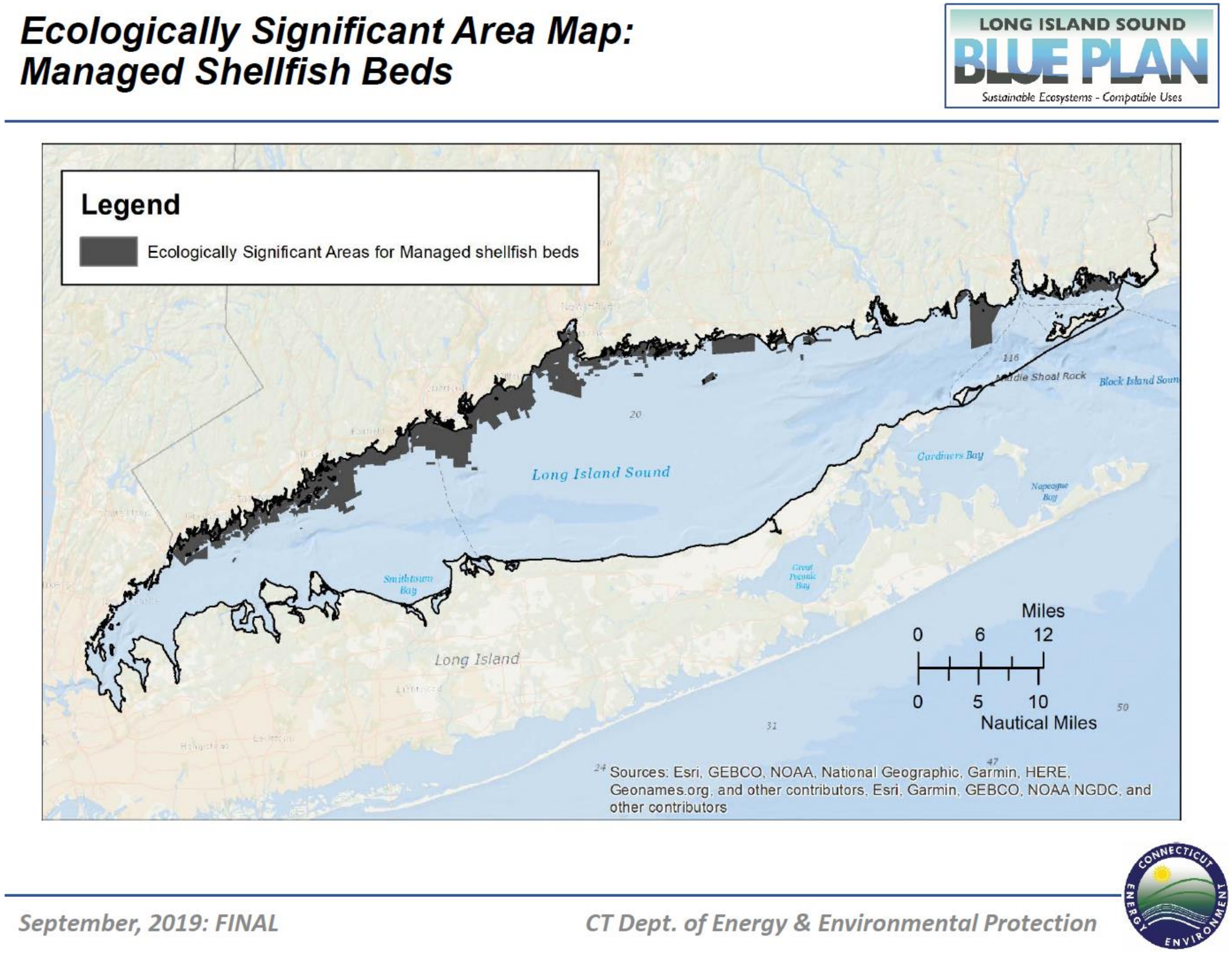


Figure 2a-73 Final ESA map of Managed shellfish beds.

Updates and potential future work

This criterion should be updated when the Connecticut Bureau of Aquaculture publishes updated maps.

ix. **Criterion 14: Soft-bottom benthic communities**

Definition: Areas of soft-bottom seafloor communities where natural productivity, biological persistence, diversity, and/or abundance of marine flora and fauna are high, as well as areas of soft-bottom seafloor communities known to support important life history or important ecological functions of mobile species (e.g., migratory stopovers and corridors, feeding areas, and nursery grounds).

Significance of Soft-bottom benthic communities

Soft-bottom benthic communities are the biological assemblages that are associated with sandy and muddy seafloor types. Because soft-bottom habitats comprise so much (perhaps the majority) of the seafloor habitats of Long Island Sound, understanding the composition of the benthic communities and the types of ecosystem services they provide, is critical.

Data sources and conceptual challenges

Several data sources relevant to soft-bottom benthic communities were identified in the Blue Plan Inventory. However, none of them were comprehensive in their spatial coverage, nor were they compatible temporally or thematically such that a comprehensive map could be developed. Furthermore, the EEG discussed what would constitute an ecologically significant area for soft-bottom benthic communities, considering their ubiquity in the environment (e.g., are vulnerable soft-bottom benthic communities ecologically significant, and/or are resilient soft-bottom benthic communities ecologically significant?).

These data and conceptual limitations could not be resolved by the EEG in the time available for draft ESA maps to be completed. The EEG continues to explore ways to leverage the available data and represent ESA for soft-bottom benthic communities spatially.

Updates and potential future work

The EEG identified several recent or ongoing efforts that could contribute data, methods, or other information in the future to support the development of ESA for soft-bottom benthic communities. These included the data being collected by the Long Island Sound Seafloor Mapping Project; specifically, the “integrated habitat map” of the

Stratford Shoals area in the Phase I report (LIS Steering Committee, 2015). The EEG recognized that a significant increase in habitat mapping effort would need to occur to generate and integrated habitat map for the entire sound. Another resource discussed by the EEG was a paper describing a method to identify areas within regions of Long Island Sound where at least 20% of each sediment texture type (used as a proxy for habitats) was represented (Neely & Zajac, 2008). It is unclear how exactly this method would be used to identify ESA, but the EEG recognized it as an objective and quantitative way to partition habitat/seafloor data toward establishing places that may be ecologically significant. Future work could include adjusting the criteria used by the method, updating the input datasets, or other modifications.

c. Synthesis

The complete set of ESA results presented above describes 14 individual ESA criteria and corresponding ESA layers or maps (with the exception of criterion 14). While each individual layer is useful on its own, it can also be informative to visualize the multiple criteria together, to better understand the distribution of ESA and where they might overlap, if at all. Again, it is important to remember that the current suite of maps represents the best available knowledge about the location of ESA, and just because a map doesn't show ESA for a particular criterion, it does not mean that ESA does not exist there. Therefore, composite maps for ESA should be viewed as "The minimum number of ESA".

The EEG did not apply a ranking or prioritization scheme to the individual layers. Therefore, the map legends are simple to interpret: a value of 5 corresponds to a minimum of 5 ESA present in a location and a minimum of 5 siting and performance standard to consider.

Three synthesis maps were developed: one for each Criteria Pillar and a third for all ESA criteria together (Figures 2a-75 to 2a-77)

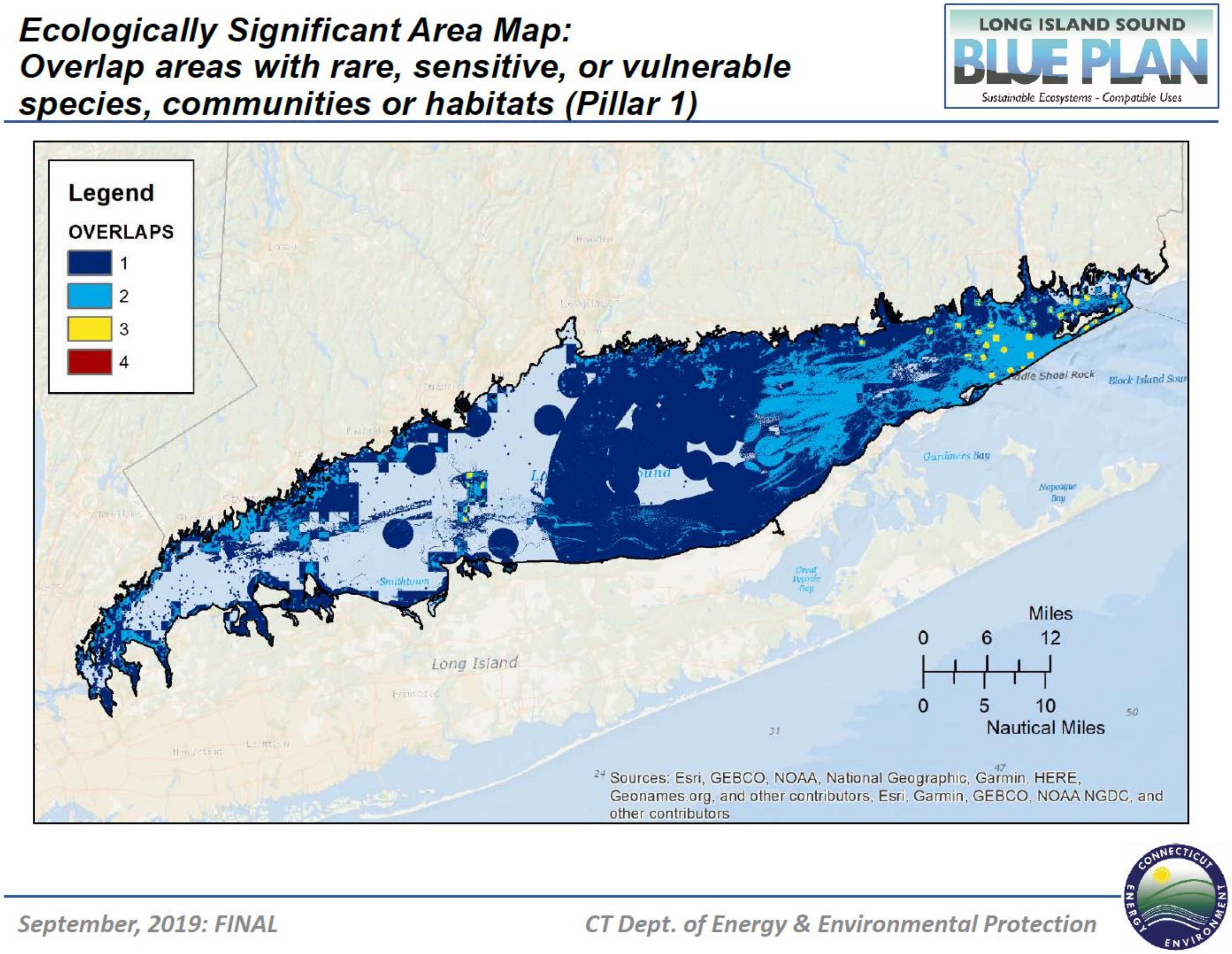


Figure 2a-74 Overlaps among the five criteria that contribute to ESAs with rare, sensitive, or vulnerable species, communities or habitats.

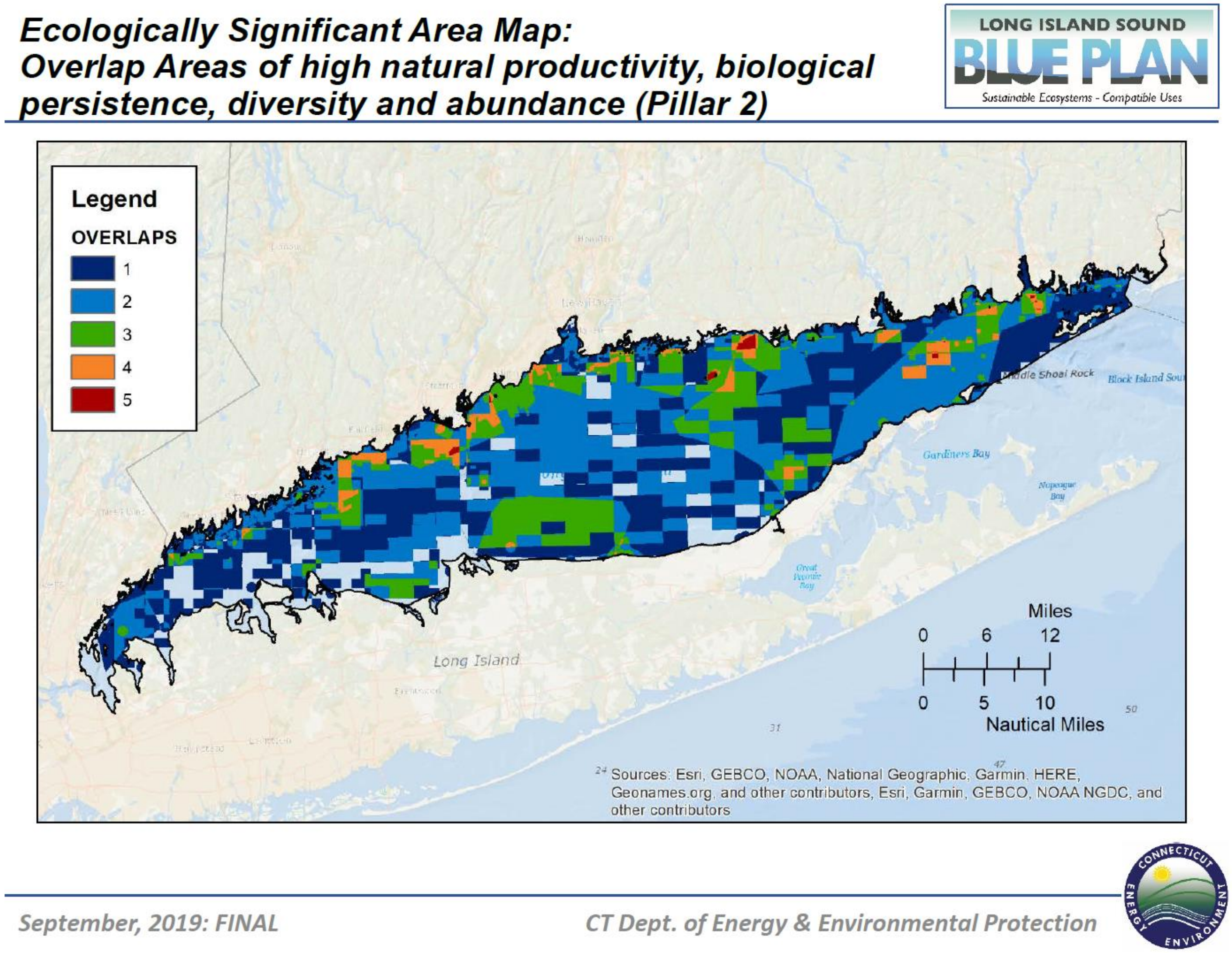


Figure 2a-75 Overlaps among the 9 criteria that contribute to the ESAs of high natural productivity, biological persistence, diversity, and abundance.

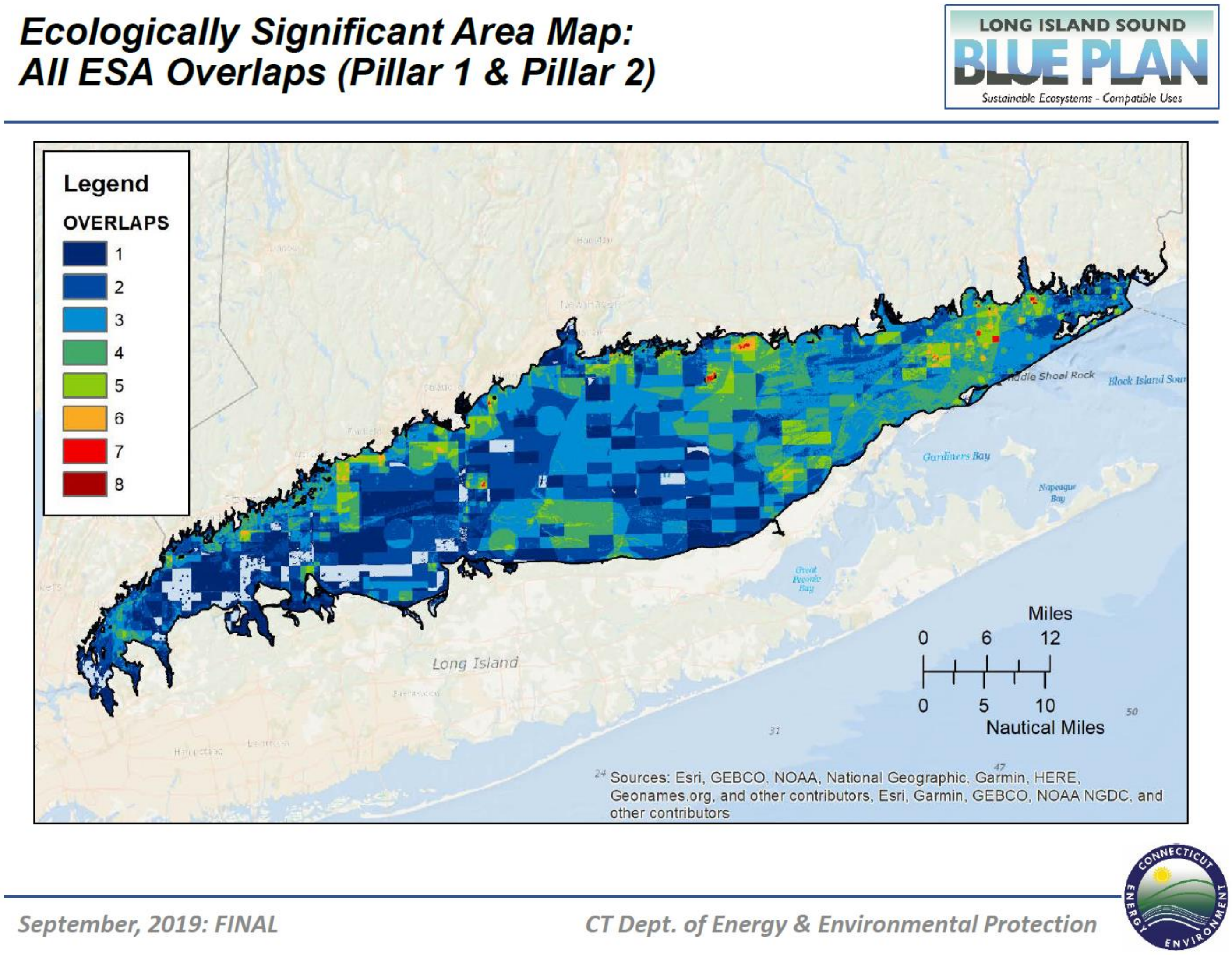


Figure 2a-76 Overlaps among all 14 criteria that represent the full set of ESAs in LIS

3. ESA Layer Construction Tables:

Criteria Pillar 1: Areas with Rare, Sensitive, or Vulnerable Species, Communities, or Habitats
Criterion 1: Hard bottom and complex seafloor

Table 2a-9 Data construction table for Hard Bottom and Complex Seafloor.

	Areas of Hard Bottom and Complex Seafloor
ESA Criterion Description	Areas of hard bottom are characterized by exposed bedrock or concentrations of boulder, cobble, pebble, gravel, or other similar hard substrate distinguished from surrounding sediments and provide a substrate for sensitive sessile suspension-feeding communities and associated biodiversity. Complex seafloor is a morphologically rugged seafloor characterized by high variability in neighboring bathymetry around a central point. Biogenic reefs and man-made structures, such as artificial reefs, wrecks, or other functionally equivalent structures, may provide additional suitable substrate for the development of hard bottom biological communities. Areas of hard bottom and complex seafloor are areas characterized singly or by any combination of hard seafloor, complex seafloor, artificial reefs, biogenic reefs, or wrecks and obstructions.
Data Source	Hard bottom: The Nature Conservancy's Long Island Sound Ecological Assessment (LISEA; 2015) known occurrences of hard bottom from usSEABED, USGS East Coast Sediment Texture Database, and NOAA Nautical Chart ENC data. Points are described as "bedrock", "boulders", "rock" or "rocky"; the USGS Long Island Sound Surficial Sediment map; Long Island Sound Mapping and Research Collaborative Phase II SEABOSS hard bottom observations described as gravel and coarser (unpublished data courtesy of C. Conroy christian.conroy@uconn.edu) Complex seafloor: TopoBathy – LIS 8m composite Terrain Ruggedness Index (TRI). Wrecks and obstructions: NOAA's Automated Wreck and Obstruction Information System (AWOIS). AWOIS is a catalog of reported wrecks and obstructions that are considered navigational hazards in coastal U.S. waters. These data are not a comprehensive inventory of wrecks. Data were downloaded from the Northeast Ocean Data Portal.
Data Extent	Long Island Sound
Data Adjustment and Pre-processing	Hard bottom: Data were clipped to Long Island Sound. Complex seafloor: Data were clipped to Long Island Sound. Wrecks and obstructions: Data were clipped to Long Island Sound

Data Analysis	Hard bottom: LISEA hard bottom points were buffered with a 160-meter radius. The buffer distance was chosen so that individuals points were visible at the ~1:800,000 scale. Areas classified as "gravel, bedrock" were extracted from the USGS sediment map. The gravel/bedrock zones and buffered hardbottom points were merged and gridded to an 8-meter grid (same resolution as the TRI dataset). Complex seafloor: Complex seafloor was calculated using bathymetry data by applying the TRI algorithm developed by Riley (1999) to measure the variability in seafloor relief. The resulting unitless output ranges from 0 to 100 and has a resolution of 8-meters. Wrecks and obstructions: Wrecks and obstructions points were buffered with a 160-meter radius. The buffer distance was chosen so that individuals points were visible at the ~1:800,000 scale. The buffered wrecks/obstructions points were then gridded to an 8-meter grid (same resolution as the TRI dataset).
Data Classification	Hard bottom: LISEA hard bottom data were classified using the Wentworth (1922) grain-size scale that defines hard bottom ("bedrock or concentrations of boulder, cobble, or other similar hard bottom") as sediment with a grain size of 64 mm or larger. LISMaRC hard bottom data included any points classified as "gravel", or "cobble", or "rock". Areas classified as "gravel, bedrock" were extracted from the USGS sediment map. Complex seafloor: Complex seafloor was classified from descriptive statistics calculated on the TRI dataset. Seafloor complexity values were divided into fifths (quintiles), and areas in the top quintile were classified as complex. This threshold was chosen based on a comparison between the USGS classification of gravel and bedrock areas and the complex dataset, and a comparison between the observed locations of cold water corals and the complex dataset. Complexity values in the top quintile were coincident with some gravel and bedrock areas (although much of the complex seafloor in LIS is not gravel and bedrock). In addition, every positive cold water coral observation overlapped with complexity values in the top quintile. Wrecks and obstructions: N/A
Selection of ESA	All 8x8-meter grid cells classified as 1) hard bottom, or 2) complex seafloor, or 3) wrecks and obstructions were selected for inclusion as Ecologically Significant Areas.

Criterion 2: Areas of submerged aquatic vegetation

Table 2a-10 Data construction table for areas of submerged aquatic vegetation.

	Areas of submerged aquatic vegetation
ESA Criterion Description	Areas where submerged aquatic vegetation, e.g., eelgrass (Zostera marina), etc., are present or have been found to be present.
Data Source	Tier 1 2017 mapping of *Zostera marina* in Long Island Sound and change analysis, Bradley and Paton 2018. http://longislandsoundstudy.net/wp-content/uploads/2018/08/LIS_2017_report2_wAppendix.pdf Tiner et al. 2013, 2012 Eelgrass Survey for Eastern Long Island Sound, Connecticut and New York. USFWS National Wetlands Inventory Program Tiner et al. 2010, 2009 Eelgrass Survey for Eastern Long Island Sound, Connecticut and New York. USFWS National Wetlands Inventory Program Tiner 2006, Delineations of 2006 eelgrass beds, eastern Connecticut to Rhode Island border, USFWS National Wetlands Inventory Program Tiner 2002, Interpretation and identification of Eelgrass beds located in the Long Island Sound Eastern Connecticut shoreline, Fishers Island NYS and the Northshore of Long Island NYS, USFWS National Wetlands Inventory Program
Data Extent	Coastal eastern Long Island Sound, approximately from Westerly RI to Guilford CT on the north shore of LIS to the North Fork of Long Island.
Data Adjustment and Pre-processing	None.
Data Analysis	Features from all 5 datasets containing eelgrass were converted to an 8-meter grid.
Data Classification	None.
Selection of ESA	All 8x8-meter grid cells containing eelgrass from any of the 5 surveys were selected as Ecologically Significant Areas.

Criterion 3: E, T, SC species

Table 2a-11 Data construction table for E, T, and SC species.

	Endangered, threatened, species of concern, and candidate species listed under state or federal Endangered Species Act, and their habitats
ESA Criterion Description	The species listed by federal or state statutes (e.g., the US Endangered Species Act, the CT Endangered Species Act, the NY Endangered Species Act) as endangered, threatened, species of concern, and candidates for listing, and their associated habitats, recognizing that detailed spatial data depicting the distribution and abundance for these marine species in Long Island Sound are potentially unavailable.
Data Source	<u>Federal:</u> Federal Endangered Species Act designated Critical Habitat (NOAA GARFO) <u>Connecticut:</u> Connecticut Natural Diversity Database (CT DEEP); Connecticut Estuarine Critical Habitats (CT DEEP); Roseate tern predicted occurrence (May – September), Steen and Elphick 2018; Atlantic Sturgeon high use areas, migratory corridors, gear restriction areas (CT DEEP) <u>New York:</u> New York Rare Animals and Rare Plants (NY DEC); New York Significant Natural Communities (NY DEC); New York Significant Coastal Fish and Wildlife Habitats (NY DEC/DOS)
Data Extent	• Critical Habitat for New York Bight Distinct Population Segment of Atlantic Sturgeon: Connecticut River, Housatonic River, Hudson River, and Delaware River • Connecticut Natural Diversity Database (CT DEEP) – state of CT • Connecticut Estuarine Critical Habitats (CT DEEP) – state of CT • Roseate tern predicted occurrence (May – September), Steen and Elphick 2018 – Long Island Sound • Atlantic sturgeon and shortnose sturgeon high and medium use areas, migratory corridors, gear restriction areas (CT DEEP) – Long Island Sound • New York Rare Animals and Rare Plants (NY DEC) – state of NY • New York Significant Natural Communities (NY DEC) – state of NY • New York Significant Coastal Fish and Wildlife Habitats (NY DEC/DOS) – state of NY

Data Adjustment and Pre-processing	Critical Habitat for New York Bight Distinct Population Segment of Atlantic Sturgeon River lengths (polylines) were buffered with an 800 m buffer All layers All layers were clipped to Long Island Sound.
Data Analysis	All features were converted to an 8-meter grid.
Data Classification	None.
Selection of ESA	All 8x8-meter grid cells containing features were selected as Ecologically Significant Areas.

Criterion 4: Cold water corals

Table 2a-12 Data construction table for cold water corals.

	Areas of cold water corals
ESA Criterion Description	Areas where cold-water corals have been observed or where habitat suitability or other scientific models predict they occur.
Data Source	Long Island Sound Mapping and Research Collaborative Phase I and Phase II seafloor mapping; geospatial data provided by Conroy and Auster, University of Connecticut. Formal citation for Phase I data: Long Island Sound Cable Fund Steering Committee, eds. (2015). "Seafloor Mapping of Long Island Sound – Final Report: Phase 1 Pilot Project." (Unpublished project report). U. S. Environmental Protection Agency Long Island Sound Study, Stamford, CT
Data Extent	Multiple discrete sampling locations (polygons) near Stratford Shoal and eastern Long Island Sound
Data Adjustment and Pre-processing	Sampling locations (polygons) where *Astrangia poculata* (a species of cold water coral) was found to be present were extracted from the full dataset.
Data Analysis	All features were converted to an 8-meter grid.

Data Classification	None.
Selection of ESA	All 8x8-meter grid cells containing features where *Astrangia poculata* were found to be present were selected as Ecologically Significant Areas.

Criterion 5: Coastal wetlands

Table 2a-13 Data construction table for coastal wetlands.

	Coastal wetlands
ESA Criterion Description	According to Connecticut General Statute (CGS) 22a-29: "Those areas which border on or lie beneath tidal waters, such as, but not limited to banks, bogs, salt marshes, swamps, meadows, flats, or other low lands subject to tidal action, including those areas now or formerly connected to tidal waters, and whose surface is at or below an elevation of one foot above local extreme high water; and upon which may grow or be capable of growing some, but not necessarily all, of [a list of specific plant species found in CGS section 22a-29(2)].
Data Source	Tidal and nontidal wetlands of Connecticut and New York from the National Wetlands Inventory (NWI) 2010, provided by the Long Island Sound Study.
Data Extent	Coastal Connecticut and Long Island.
Data Adjustment and Pre-processing	None.
Data Analysis	All features were converted to an 8-meter grid.
Data Classification	None.
Selection of ESA	All 8x8-meter grid cells containing tidal and nontidal wetlands were selected as Ecologically Significant Areas.

Criteria Pillar 2: Areas of High Natural Productivity, etc.
Criterion 6: Cetaceans

Table 2a-14 Data construction table for cetaceans.

	Cetaceans
ESA Criterion Description	Areas where cetaceans occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support cetaceans (e.g. particular feeding areas, nursery grounds).
Data Source	Predicted cetacean density Modeled average density of cetacean species (predicted animals per 100 square kilometers) by the Duke University Marine Geospatial Ecology Lab and Marine-life Data and Analysis Team. Roberts J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, L.P. Garrison, K.D. Mullin, T.V.N. Cole, C.B. Khan, W.M. McLellan, D.A. Pabst, and G.G. Lockhart. 2016. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6: 22615. doi: 10.1038/srep22615. Roberts J.J., L. Mannocci, and P.N. Halpin. 2017. Final Project Report: Marine Species Density Data Gap Assessments and Update for the AFTT Study Area, 2016-2017 (Opt. Year 1). Document version 1.4. Report prepared for Naval Facilities Engineering Command, Atlantic by the Duke University Marine Geospatial Ecology Lab, Durham, NC. Curtice C., J. Cleary, E. Shumchenia, and P.N. Halpin. 2018. Marine-life Data and Analysis Team (MDAT) Technical Report on the Methods and Development of Marine-life Data to Support Regional Ocean Planning and Management. Prepared on behalf of the Marine-life Data and Analysis Team (MDAT). Accessed at: http://seamap.env.duke.edu/models/MDAT/MDAT-Technical-Report.pdf. Marine-life Data Analysis Team (MDAT; Patrick Halpin, Earvin Balderama, Jesse Cleary, Corrie Curtice, Michael Fogarty, Brian Kinlan, Charles Perretti, Jason Roberts, Emily Shumchenia, Arliss Winship). Marine life summary data products for Northeast ocean planning. Version 2.0. Northeast Ocean Data. http://northeastoceandata.org. Accessed 09/04/2018. Expert participatory mapping January 3, 2019 - Patrick Comins, Executive Director, Connecticut Audubon Society.
Data Extent	US Atlantic Coast.

Data Adjustment and Pre-processing	<u>Predicted cetacean density</u> Data products for species or guilds with model results in Long Island Sound were extracted from the MDAT data download package. The following 11 models predicted cetacean abundance in Long Island Sound: Cuvier’s beaked whale, Fin whale, Humpback whale, Harbor porpoise, Mesoplodont beaked whales, Minke whale, North Atlantic right whale, Pilot whale, Sei whale, and Sperm whale, Unidentified beaked whales. For the seven species with monthly predictions (Fin whale, Humpback whale, Harbor porpoise, Minke whale, North Atlantic right whale, Sei whale, Sperm whale) the 12 monthly layers were averaged to develop an annual mean predicted abundance layer. The remaining four species products already represented annual predictions. Each of the 11 annual layers were clipped to Long Island Sound.. <u>Expert participatory mapping</u> None.
Data Analysis	<u>Predicted cetacean density</u> All 11 annual mean layers were summed to create a layer that represented the average annual total predicted abundance of 11 cetacean species in Long Island Sound, with 10km grid size. Contours for the 10km gridded total predicted abundance layer were generated using the contour tool in the Spatial Analyst toolbox in ArcGIS 10.5. Contours were generated at an abundance increment of 1.0. <u>Expert participatory mapping</u> None.
Data Classification	<u>Predicted cetacean density</u> The contours representing 5 or more predicted animals were merged and converted to a polygon feature. The polygon feature representing the average annual predicted abundance of 5 or more animals was converted to an 8-meter grid. <u>Expert participatory mapping</u> None.
Selection of ESA	<u>Predicted cetacean density</u> All 8x8-meter grid cells representing the average annual predicted abundance of 5 or more animals were selected as Ecologically Significant Areas. <u>Expert participatory mapping</u> All 8x8-meter grid cells representing an area off New Rochelle, NY where humpback whales have been recently observed, as identified by Patrick Comins, were selected as Ecologically Significant Areas.

Criterion 7: Pinnipeds

Table 2a-15 Data construction table for pinnipeds.

	Pinnipeds
ESA Criterion Description	Areas where pinnipeds occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support pinnipeds (e.g. particular haul-out locations, feeding areas).
Data Source	Seal concentration areas (Environmental Sensitivity Index data plus expert input) representing 2015-2017 conditions
Data Extent	Long Island Sound planning area
Data Adjustment and Pre-processing	None.
Data Analysis	Polygon features representing seal concentration areas were converted to an 8-meter grid.
Data Classification	None.
Selection of ESA	All 8x8-meter grid cells representing seal concentration areas were selected as Ecologically Significant Areas.

Criterion 8: Sea turtles and other reptiles

Table 2a-16 Data construction table for Sea turtles and other reptiles.

	Sea turtles and other reptiles
ESA Criterion Description	Areas where sea turtles and other reptiles occur in higher concentrations and/or particular significant areas as noted in the general description (above) that support sea turtles and other reptiles (e.g. particular feeding areas, nesting grounds, hibernation areas).

Data Source	Strandings and in-water observations of sea turtles, Riverhead Foundation Strandings and in-water observations of sea turtles, Mystic Aquarium Point locations of 2018 coastal Connecticut sea turtle mortality events at Silver Sands State Park, Long Beach, and Sheffield Island. Diamondback terrapin probability of occurrence, Conservation Wildlife Foundation of New Jersey (Egger, Davenport, Leu, Maslo).
Data Extent	Long Island Sound and NY bight
Data Adjustment and Pre-processing	Strandings data from both Riverhead Foundation and Mystic Aquarium were filtered to retain only live strandings or in-water observations of live animals. All point locations of live strandings, in-water observations, and 2018 coastal Connecticut mortality events were buffered with an 800-meter radius. The buffers were clipped to Long Island Sound.. The diamondback terrapin probability of occurrence model outputs were clipped to Long Island Sound..
Data Analysis	800-meter buffers representing sea turtle live strandings, in-water observations, 2018 coastal Connecticut mortality events, and diamondback terrapin occurrence were converted to an 8-meter grid.
Data Classification	Sea turtle live strandings, in-water observations, and 2018 coastal Connecticut mortality events - none. Diamondback terrapin probability of occurrence - A threshold of 0.3188 was generated by the modeling program (Maxent) and is considered a relatively conservative threshold that has been used as an indicator for suitable habitat in other studies.
Selection of ESA	All 8x8-meter grid cells representing sea turtle live strandings, in-water observations, and 2018 coastal Connecticut mortality events were selected as Ecologically Significant Areas. All 8x8-meter grid cells representing diamondback terrapin probability of occurrence greater than 0.3188 were selected as Ecologically Significant Areas.

Criterion 9: Birds

Table 2a-17 Data construction table for birds.

	Birds
ESA Criterion Description	Areas where birds are abundant or diverse including feeding areas; areas of high bird productivity including nesting areas.
Data Source	eBird models in Long Island Sound (eBird data since 2010), Steen and Elphick 2018 Summer bird species: Common tern, Double-crested cormorant, Great black-backed gull, Herring gull, Laughing gull, Ring-billed gull, Roseate tern Winter bird species: American black duck, Black scoter, Bonaparte's gull, Brant, Bufflehead, Common eider, Common goldeneye, Common loon, Double-crested cormorant, Great black-backed gull, Great cormorant, Greater scaup, Herring gull, Horned grebe, Laughing gull, Lesser scaup, Long-tailed duck, Northern gannet, Red breasted merganser, Red throated loon, Ring-billed gull, Surf scoter, White-winged scoter <u>Expert participatory mapping</u> January 3, 2019 - Patrick Comins, Executive Director, Connecticut Audubon Society.
Data Extent	Long Island Sound
Data Adjustment and Pre-processing	None.
Data Analysis	Presence/absence layers for all 7 summer species were overlaid and summed to create a single summer species richness layer. Presence/absence layers for all 23 winter species were overlaid and summed to create a single winter species richness layer. Summer and winter richness layers were converted to an 8-meter grid. <u>Expert participatory mapping</u> Areas delineated were converted to an 8-meter grid.
Data Classification	The summer and winter richness layers were each classified by quintiles.
Selection of ESA	All 8x8-meter grid cells in the top quintiles of summer and winter richness were selected as Ecologically Significant Areas.

	The top quintiles of summer and winter richness were overlaid to create a single layer that represented Ecologically Significant Areas for birds. Expert participatory mapping All 8x8-meter grid cells that were delineated were selected as Ecologically Significant Areas.

Criterion 10: Fish

Table 2a-18 Data construction table for fish.

	Fish
ESA Criterion Description	Areas of high weighted fish persistence and high fish abundance and concentration.
Data Source	CT DEEP LISTS data: Mean spring and fall individual species abundance, by site and season, 1995-2004 and 2005-2014, CT DEEP Long Island Sound Trawl Survey (LISTS), for species caught in more than 5 tows (full species list in this appendix). LISEA data: Demersal, diadromous, and pelagic weighted persistence layers from the Long Island Sound Ecological Assessment (LISEA) Demersal species (59 spp.) includes the following subgroups: Elasmobranchs (7 spp.), Gadids (7 spp.), Pleuronectids (7 spp.), Structure-oriented (6 spp.), Other (32 spp.) Diadromous species (13 spp.) Pelagic species (23 spp.) (see Anderson and Frohling 2005 for a full listing of species.)
Data Extent	Long Island Sound
Data Adjustment and Pre-processing	CT DEEP LISTS data: CT DEEP LISTS data were grouped by demersal or pelagic (or "water column") functional groups (full species list in this appendix). There were some species in LISEA that were not caught in >5 tows in the LISTS data. LISEA data: None.

Data Analysis	<u>CT DEEP LISTS data:</u> All CT DEEP LISTS individual species abundance layers were converted to an 8-meter grid. For each season (spring; fall) and time period (1995-2004; 2005-2014) demersal and water column species were overlaid and summed to create total mean abundance layers for each functional group. This resulted in 8 individual layers. <u>LISEA data:</u> All LISEA weighted persistence layers were converted to an 8-meter grid.
Data Classification	<u>CT DEEP LISTS data:</u> Each of the 8 individual layers (demersal and water column; spring and fall; 1995-2014 and 2005-2014) were each classified into quintiles. <u>LISEA data:</u> The LISEA weighted persistence layers were already classified so that "high" weighted persistence corresponded to species that had been detected at levels 1 or 2 standard deviations above the mean for the time series in all 3 of the examined time periods within a 26-year span (1984-2009).
Selection of ESA	The following layers were overlaid to create a single layer representing Ecologically Significant Areas for fish. <u>CT DEEP LISTS data:</u> 1. All 8x8-meter grid cells in the top quintile of fall demersal species abundance 1995-2004 were selected as Ecologically Significant Areas. 2. All 8x8-meter grid cells in the top quintile of spring demersal species abundance 1995-2004 were selected as Ecologically Significant Areas. 3. All 8x8-meter grid cells in the top quintile of fall demersal species abundance 2005-2014 were selected as Ecologically Significant Areas. 4. All 8x8-meter grid cells in the top quintile of spring demersal species abundance 2005-2014 were selected as Ecologically Significant Areas. 5. All 8x8-meter grid cells in the top quintile of fall water column species abundance 1995-2004 were selected as Ecologically Significant Areas. 6. All 8x8-meter grid cells in the top quintile of spring water column species abundance 1995-2004 were selected as Ecologically Significant Areas. 7. All 8x8-meter grid cells in the top quintile of fall water column species abundance 2005-2014 were selected as Ecologically Significant Areas. 8. All 8x8-meter grid cells in the top quintile of spring water column species abundance 2005-2014 were selected as Ecologically Significant Areas. <u>LISEA data:</u>

	9. All 8x8-meter grid cells in the highest LISEA weighted persistence category for each Pelagic and Diadromous species were selected as Ecologically Significant Areas. 10. All 8x8-meter grid cells where both Pelagic and Diadromous species in the second highest LISEA weighted persistence category overlap were selected as Ecologically Significant Areas. 11. All 8x8-meter grid cells in the highest LISEA weighted persistence category for each Demersal species functional group (Elasmobranchs, Gadids, Pleuronectids, Structure-oriented, Other) were selected as Ecologically Significant Areas. 12. All 8x8-meter grid cells where 3 or more of the 5 Demersal species functional groups in the second highest LISEA weighted persistence category overlap were selected as Ecologically Significant Areas.

Criterion 11: Mobile invertebrates

Table 2a-19 Data construction table for mobile invertebrates.

	Mobile invertebrates
ESA Criterion Description	Areas of high mobile invertebrate (e.g., lobster, other crustaceans, squid) abundance and concentration
Data Source	<u>CT DEEP LISTS data:</u> Mean spring and fall individual species decapod (blue crab, flat claw hermit crab, lady crab, rock crab, spider crab) biomass and counts for horseshoe crab, American lobster, and long-finned squid, by site and season for 1995-2004 and 2005-2014, CT DEEP Long Island Sound Trawl Survey (LISTS). <u>CT DEEP Horseshoe crab data:</u> CT spawning beaches Development of the predictive model and classification scheme was completed by Alicia Landi through University of Connecticut Masters thesis (2011) under a State Wildlife Grant for CT DEEP. <u>American lobster thermal refuge:</u> American lobster habitat based on IPCC intermediate projection of bottom water temperatures (12-20°C) under a doubling of CO_2 over 20 years by the Stevens Institute of Technology
Data Extent	Long Island Sound

Data Adjustment and Pre-processing	<u>CT DEEP LISTS data:</u> None. <u>CT DEEP Horseshoe crab data:</u> None. <u>American lobster thermal refuge:</u> Data from the Stevens Institute were presented as the predicted number of days per month (2002-2012, and future) at various water temperature thresholds. The predicted number of future days with bottom temperatures between 12-20°C during July and September for the period representing conditions under a doubling of CO_2 with respect to 2012 levels was extracted for further analysis. Bottom water temperatures between 12-20°C are considered optimal for American lobster reproduction and survival.
Data Analysis	<u>CT DEEP LISTS data:</u> The CT DEEP LISTS individual species biomass layers were converted to an 8-meter grid. Individual species biomass layers were overlaid and summed to create total mean biomass layers for mobile invertebrates in each season (spring and fall) and time period (1995-2004 and 2005-2014), resulting in 4 total layers. <u>CT DEEP Horseshoe crab data:</u> The CT DEEP Horseshoe crab data layers were each converted to an 8-meter grid. <u>American lobster thermal refuge:</u> The average proportion of days with bottom temperatures between 12-20°C from July to September from 2002-2012 for all Long Island Sound Trawl Survey grid cells was calculated to be 31%. The predicted proportion (%) of future days with bottom temperatures between 12-20°C from July-September was calculated for each Long Island Sound Trawl Survey grid cell. This layer was converted to an 8-meter grid.
Data Classification	<u>CT DEEP LISTS data:</u> Each of the 16 total mean biomass or abundance (counts) layers were classified into quintiles. <u>CT DEEP Horseshoe crab data:</u> Offshore hotspots – no classification Presence in open water – already classified into "High" (above median) and "Medium" (below median) CT spawning beaches – already classified into "High use" and "Medium use" <u>American lobster thermal refuge:</u> None.

Selection of ESA	The following layers were each selected to represent a component of Ecologically Significant Areas for mobile invertebrates. Layers representing # below were overlaid to create a single layer representing Ecologically Significant Areas for mobile invertebrates. <u>CT DEEP LISTS data:</u> 1. All 8x8-meter grid cells representing the top quintile of decapod biomass in fall 1995-2004 were selected as Ecologically Significant Areas. 2. All 8x8-meter grid cells representing the top quintile of decapod biomass in spring 1995-2004 were selected as Ecologically Significant Areas. 3. All 8x8-meter grid cells representing the top quintile of decapod biomass in fall 2005-2014 were selected as Ecologically Significant Areas. 4. All 8x8-meter grid cells representing the top quintile of decapod biomass in spring 2005-2014 were selected as Ecologically Significant Areas. 5. All 8x8-meter grid cells representing the top quintile of horseshoe crab abundance in fall 1995-2004 were selected as Ecologically Significant Areas. 6. All 8x8-meter grid cells representing the top quintile of horseshoe crab abundance in spring 1995-2004 were selected as Ecologically Significant Areas. 7. All 8x8-meter grid cells representing the top quintile of horseshoe crab abundance in fall 2005-2014 were selected as Ecologically Significant Areas. 8. All 8x8-meter grid cells representing the top quintile of horseshoe crab abundance in spring 2005-2014 were selected as Ecologically Significant Areas. 9. All 8x8-meter grid cells representing the top quintile of American lobster abundance in fall 1995-2004 were selected as Ecologically Significant Areas. 10. All 8x8-meter grid cells representing the top quintile of American lobster abundance in spring 1995-2004 were selected as Ecologically Significant Areas. 11. All 8x8-meter grid cells representing the top quintile of American lobster abundance in fall 2005-2014 were selected as Ecologically Significant Areas. 12. All 8x8-meter grid cells representing the top quintile of American lobster abundance in spring 2005-2014 were selected as Ecologically Significant Areas. 13. All 8x8-meter grid cells representing the top quintile of long-finned squid abundance in fall 1995-2004 were selected as Ecologically Significant Areas. 14. All 8x8-meter grid cells representing the top quintile of long-finned squid abundance in spring 1995-2004 were selected as Ecologically Significant Areas. 15. All 8x8-meter grid cells representing the top quintile of long-finned squid abundance in fall 2005-2014 were selected as Ecologically Significant Areas. 16. All 8x8-meter grid cells representing the top quintile of long-finned squid abundance in spring 2005-2014 were selected as Ecologically Significant Areas.

	<u>CT DEEP Horseshoe crab data:</u> 17. All 8x8-meter grid cells representing horseshoe crab "High use" and "Medium use" CT spawning beaches were selected as Ecologically Significant Areas. <u>American lobster thermal refuge:</u> 18. All 8x8-meter grid cells higher than the 2002-2012 average proportion (i.e., > 31%) of days with bottom temperatures between 12-20°C during July-September were selected as Ecologically Significant Areas.

Criterion 12: Sessile-mollusk-dominated communities

Table 2a-20 Data construction table for sessile-mollusk-dominated communities.

	Sessile-mollusk-dominated communities
ESA Criterion Description	Areas where wild, natural sessile-mollusk-dominated communities occur.
Data Source	2012 and 2013 sessile mollusk percent cover from: Long Island Sound Mapping and Research Collaborative Phase I seafloor mapping; geospatial data provided by Conroy and Auster, University of Connecticut. Formal citation for Phase I data: Long Island Sound Cable Fund Steering Committee, eds. (2015). "Seafloor Mapping of Long Island Sound – Final Report: Phase 1 Pilot Project." (Unpublished project report). U. S. Environmental Protection Agency Long Island Sound Study, Stamford, CT 2017 sessile mollusk presence, from: Long Island Sound Mapping and Research Collaborative Phase II seafloor mapping; unpublished geospatial data provided by Conroy and Auster, University of Connecticut.
Data Extent	Multiple discrete sampling locations (points) near Stratford Shoals (Phase I sampling) and multiple discrete sampling locations (polygons) in eastern LIS (Phase II sampling)
Data Adjustment and Pre-processing	<u>2012 and 2013 sessile mollusk percent cover near Stratford Shoals</u> Sampling locations (points) where *Crepidula fornicata* (a species of gastropod mollusk) or Mytilus edulis (a species of bivalve mollusk) were found to have >= 50% cover in 2012 or 2013 were extracted from the full dataset. The extracted points were buffered with a 375-meter radius to match the footprint and scale of the Phase II sampling data. <u>2017 sessile mollusk presence in eastern LIS</u> Sampling locations (polygons) where *Crepidula* or *Mytilus* were found to be present.

Data Analysis	2012 and 2013 sessile mollusk percent cover near Stratford Shoals 375-meter buffers were converted to an 8-meter grid. 2017 sessile mollusk presence in eastern LIS Polygons were converted to an 8-meter grid.
Data Classification	2012 and 2013 sessile mollusk percent cover near Stratford Shoals The grid cells were classified by whether values were less than, equal to, or greater than 50 (percent cover). 2017 sessile mollusk presence in eastern LIS All grid cells where *Crepidula* or *Mytilus* were found to be present were retained.
Selection of ESA	2012 and 2013 sessile mollusk percent cover near Stratford Shoals All 8x8-meter grid cells representing values >= 50% cover of *Crepidula fornicata* or *Mytilus edulis* were selected as Ecologically Significant Areas. 2017 sessile mollusk presence in eastern LIS All 8x8-meter grid cells where *Crepidula fornicata* or *Mytilus edulis* were found to be present were selected as Ecologically Significant Areas.

Criterion 13: Managed shellfish beds

Table 2a-21 Data construction table for managed shellfish beds.

	Managed shellfish beds
ESA Sub-criterion Description	Locations of commercial and recreational shellfishing harvest areas, including shellfish restoration activities and areas closed to shellfishing.
Data Source	Oyster seed beds (Connecticut Natural Shellfish Beds Dataset), Connecticut Recreational Shellfish Beds Dataset, Connecticut State-managed Shellfish Beds Dataset, Connecticut Town-managed Shellfish Beds Dataset, from the Connecticut Department of Agriculture Bureau of Aquaculture and Connecticut Department of Energy and Environmental Protection
Data Extent	Connecticut state waters of Long Island Sound

Data Adjustment and Pre-processing	None.
Data Analysis	All features were converted to an 8-meter grid.
Data Classification	None.
Selection of ESA	All 8x8-meter grid cells characterized as natural shellfish beds, recreational shellfish beds, state-managed shellfish beds, and town-managed shellfish beds were selected as Ecologically Significant Areas. All layers were overlaid to develop a single layer that represents commercial and recreational shellfish harvest Ecologically Significant Areas.

Criterion 14: Soft-bottom benthic communities

Table 2a-22 Data construction for soft-bottom benthic communities.

	Soft-bottom benthic communities
ESA Criterion Description	Areas of soft-bottom seafloor communities where natural productivity, biological persistence, diversity, and/or abundance of marine flora and fauna are high, as well as areas of soft-bottom seafloor communities known to support important life history or important ecological functions of mobile species (e.g., migratory stopovers and corridors, feeding areas, and nursery grounds).
Data Source	
Data Extent	
Data Adjustment and Pre-processing	
Data Analysis	

Data Classification	
Selection of ESA	

4. ESA Metadata Index

This document describes the location of the geospatial metadata files for the layers that contribute to the 14 ESA Criteria. Many of these files are also available via the ESA Data Layer List associated with the Blue Plan Map Viewer (http://cteco.uconn.edu/projects/blueplan/layersESA.htm).

Table 2a-23 ESA Metadata Index

ESA Criteria	Metadata Source (URL if available)
Hard Bottom and Complex Sea Floor	Criterion 1 Hard bottom and complex seafloor
• Long Island Sound Ecological Assessment (LISEA) hard bottom	The Nature Conservancy
• USGS Surficial sediment map, gravel areas	USGS Distribution of surficial sediments in Long Island Sound
• Long Island Sound Mapping and Research Collaborative (LISMaRC) Phase II SEABOSS hard bottom observations	Long Island Sound Mapping and Research Collaborative (LISMaRC) Phase II SEABOSS hard bottom observations in seafloor imagery. DEEP Blue Plan Team has metadata write-up by Chris Conroy
• Terrain Ruggedness Index	Long Island Sound 8m composite Terrain Ruggedness Index. DEEP Blue Plan Team has metadata write-up by Emily Shumchenia
• Wrecks and obstructions	Northeast Ocean Data Portal
Submerged Aquatic Vegetation	Criterion 2 Areas of Submerged Aquatic Vegetation
• Seagrass surveys from 2002, 2006, 2009, 2012, 2017	Connecticut Department of Energy & Environmental Protection
Endangered, Threatened, Species of Concern	Criterion 3 Endangered, Threatened, and Species of Concern
• Atlantic sturgeon gear restriction areas	CT DEEP Marine Fisheries

• Atlantic sturgeon and shortnose sturgeon high and medium use areas	CT DEEP Marine Fisheries
• Atlantic sturgeon migratory corridor	CT DEEP Marine Fisheries
• Predicted summer occurrence of roseate tern	University of Connecticut, Steen & Elphick. DEEP Blue Plan Team has metadata write-up by Steen & Elphick
• Connecticut Natural Diversity Database approximate locations of endangered, threatened, species of concern	Connecticut Department of Energy & Environmental Protection
• Connecticut Critical Habitats	Connecticut Department of Energy & Environmental Protection
• New York rare plants and rare animals	New York Department of Environmental Conservation
• New York Significant Natural Communities	New York Department of Environmental Conservation
• New York Significant Coastal Fish and Wildlife Habitats	New York Department of State
• US Endangered Species Act Critical Habitat for Atlantic sturgeon	NOAA GARFO
Cold Water Corals	Criterion 4 Cold Water Corals
• LISMaRC Phase I and Phase II cold water coral observations near Stratford Shoals and eastern LIS	University of Connecticut DEEP Blue Plan Team has metadata write-up by Chris Conroy
Coastal Wetlands	Criterion 5 Coastal Wetlands
• National Wetlands Inventory, clipped to Long Island Sound Study boundary	USFWS NWI
Cetaceans	Criterion 6 Cetaceans
• Cetacean density models	Marine life Data & Analysis Team (MDAT)
• Expert participatory mapping	Cetaceans – participatory mapping
Pinnipeds	Criterion 7 Pinnipeds

• Seal concentration areas	NOAA Environmental Sensitivity Index
• Expert participatory mapping	Pinnipeds – participatory mapping DEEP Blue Plan Team has metadata write-up by Emily Shumchenia
Sea Turtles and Other Reptiles	Criterion 8 Sea Turtles and Other Reptiles
• Live sea turtle strandings, rescues, and in-water observations	Riverhead Foundation
• Live sea turtle strandings and rescues	Mystic Aquarium
• Point locations of 2018 coastal CT mortality events at Silver Sands State Park, Long Beach, and Sheffield Island	2018 coastal CT sea turtle mortality events DEEP Blue Plan Team has metadata write-up by Emily Shumchenia
• Diamondback terrapin probability of occurrence	Conservation Wildlife Foundation of New Jersey
Birds	Criterion 9 Birds
• Seabird occurrence models	University of Connecticut, Steen & Elphick DEEP Blue Plan Team has metadata write-up by Steen & Elphick
• Expert participatory mapping	Birds – participatory mapping DEEP Blue Plan Team has metadata write-up by Emily Shumchenia
Fish	Criterion 10 Fish
• Persistently productive places for fish, Long Island Sound Ecological Assessment high weighted persistence)	The Nature Conservancy
• Areas of high fish abundance and concentration	CT DEEP Marine Fisheries Long Island Sound Trawl Survey
Mobile Invertebrates	Criterion 11 Mobile Invertebrates
• Areas of high mobile invertebrate biomass and concentration	CT DEEP Marine Fisheries Long Island Sound Trawl Survey
• Horseshoe crab predicted spawning beaches	CT DEEP Marine Fisheries
• American lobster projected thermal refuge	DEEP Blue Plan Team has metadata write-up by Emily Shumchenia

Sessile-mollusk-dominated Communities	Criterion 12 Sessile-mollusk-dominated Communities
• LISMaRC Phase I and Phase II observations of Slipper shell (*Crepidula fornicata*) aggregations and blue mussel (*Mytilus edulis*) aggregations near Stratford Shoals and eastern LIS	University of Connecticut DEEP Blue Plan Team has metadata write-up by Chris Conroy
• Expert participatory mapping	Sessile-mollusk-dominated communities – participatory mapping DEEP Blue Plan Team has metadata write-up by Emily Shumchenia
Managed Shellfish Beds	Criterion 13 Managed Shellfish Beds
• Oyster seed beds (CT Natural Shellfish Beds)	Connecticut Department of Agriculture/ Bureau of Agriculture and Connecticut Department of Environmental Protection
• CT Recreational Shellfish Beds	Connecticut Department of Agriculture/ Bureau of Agriculture and Connecticut Department of Environmental Protection
• CT State-managed Shellfish Beds	Connecticut Department of Agriculture/ Bureau of Agriculture and Connecticut Department of Environmental Protection
• CT Town-managed Shellfish Beds	Connecticut Department of Agriculture/ Bureau of Agriculture and Connecticut Department of Environmental Protection