Northeast Regional Marine Fish Habitat Assessment

The Northeast Regional Marine Fish Habitat Assessment (NRHA) is a collaborative effort to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. The project aims to align habitat science goals and priorities with human and financial resources to develop habitat science products that support an assessment. Work associated with the NRHA is expected to occur over a three-year time period from July 2019 through July 2022.

The project is being led by a Steering Committee composed of leadership from the major habitat conservation, restoration, and science organizations in the region.

Core Actions

Four core actions have been identified to support the habitat assessment:

1. **Abundance and trends in habitat types in the inshore area.** This action will map the location and extent of habitat types utilized by the focus species and quantify the areal coverage, status and trends of these habitats. It will also compile metrics that may inform an assessment of habitat quality.
2. **Habitat vulnerability.** This action will involve Council and Commission staff coordination with, and participation in, the NOAA Habitat Climate Vulnerability Assessment (HCVA). That assessment will use habitat experts to examine fish habitat vulnerability to climate and non-climate stressors.
3. **Spatial descriptions of species habitat use in the offshore area.** This action will use model-based and empirical approaches to identify, predict, and map habitat use for each of the focus species and track and quantify changes in habitat use over time (e.g. seasonal, annual, and future predicted use).
4. **Habitat data visualization and decision support tool.** Habitat information will be incorporated into a publicly accessible decision support tool, making this information available to partners to visualize habitat location, extent, and use throughout the region, and provide access to relevant data and habitat metrics developed by the assessment. Please see the workplan linked in the "Documents" section for additional information about key outcomes and timelines for each of these actions.

Documents

- Northeast Regional Marine Fish Habitat Assessment Work Plan as of 6/24/19

Recent Meetings

[Northeast Regional Habitat Assessment Joint Action Teams Webinar]
Apr 30, 2020
[Northeast Regional Marine Fish Habitat Assessment – Steering Committee Meeting (Webinar)]
Jan 16, 2020

Steering Committee Member Organizations

- Mid-Atlantic Fishery Management Council (Chair)
- Atlantic States Marine Fisheries Commission
- Atlantic Coast Fish Habitat Partnership
- Duke University
- Monmouth University
- National Fish Habitat Partnership
- New England Fishery Management Council
- NOAA Fisheries Offices of Habitat Conservation (Headquarters and Region)
- NOAA Fisheries Offices of Science and Technology (Ecosystems and Monitoring)
- NOAA Northeast Fisheries Science Center
- NOAA NCCOS Marine Spatial Ecology Division
- The Nature Conservancy

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NOAA Fisheries Northeast Habitat Climate Vulnerability Assessment

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Objective of the Northeast Habitat Climate Vulnerability Assessment (HCVA) Project

The goal of this project is to provide regional fisheries, habitat, and protected species managers and scientists with a practical tool to efficiently assess the relative vulnerability of habitats to climate change. The results of the assessment may be used to improve essential fish habitat (EFH) designations and aid in EFH consultations, set habitat conservation priorities, understand cumulative impacts of fishery management actions, and provide long-term context for the management of protected and fishery species.

Project Scope

The Northeast HCVA is focused in the Northeast U.S. coastal region (Cape Hatteras, NC to the Maine/Canada border) with the aim of building a framework that can be applied to other U.S. regions. The assessment includes fifty-two habitat subclasses in the riverine, estuarine, and marine systems, based on a modified Cowardin classification. These sub-classes correspond to the range of habitats used by fishery and protected species managed by NOAA Fisheries.

Assessment Framework

The HCVA uses a similar framework as the Northeast Fish and Shellfish Climate Vulnerability Assessment (Hare et al. 2016). The HCVA considers the overall vulnerability of a habitat to climate change to be a function of two main components: exposure and sensitivity. Exposure is a measure of the predicted environmental change that a habitat may experience within the study area. It is the overlap between the current distribution of habitat and the magnitude and spatial distribution of the expected environmental change. The sensitivity component is composed of habitat attributes that are believed to be indicative of the response of a habitat to potential changes in climate. The assessment relies heavily on expert opinion to score the sensitivity and exposure of each habitat, in addition to published literature, spatial habitat distribution data, and climate projections.

The HCVA is assessing climate exposure under end-of-century projections based on the Intergovernmental Panel on Climate Change RCP 8.5 emissions scenario using two climate models—the Regional Ocean Modeling System: Northwest Atlantic Dynamical Downscaling (ROMS-NWA) and the Coupled Model Intercomparison Project 5 (CMIP5). The **exposure factors** used in this assessment are: sea surface temperature, bottom temperature, surface salinity, bottom salinity, pH, sea level rise, precipitation, stream temperature, and streamflow. The **sensitivity attributes** used in this assessment are: habitat condition, habitat fragmentation, distribution/range, mobility/ability to spread or disperse, resistance, resilience, sensitivity to changes in abiotic factors, sensitivity/intensity of non-climate factors, and dependency on ecological linkages.

Assessment Outputs

The assessment will develop a ranked list of the relative vulnerability of the fifty-two assessed habitat subclasses. Detailed results for each habitat will be discussed in a short narrative to describe the key drivers of vulnerability. The results will be written up in an article to be published in a scientific journal, in addition to more tailored products for end users as needed.

Project Timeline

The project kicked off in Fall 2017, and is anticipated to be completed by Summer 2020.

Overview of the Northeast Habitat Climate Vulnerability Assessment Methods

The goal of this project is to provide regional fisheries, habitat, and protected species managers and scientists with a practical tool to efficiently assess the relative vulnerability of habitats to climate change. The results of the assessment may be used to improve essential fish habitat (EFH) designations and aid in EFH consultations, set habitat conservation priorities, understand cumulative impacts of fishery management actions, and provide long-term context for the management of protected and fishery species. The assessment complements the Northeast Fish and Shellfish Climate Vulnerability Assessment[1] completed in 2016, and uses a similar framework.

Project Geographic Scope: The northern and southern boundaries of the study area are the U.S./Canadian border and Cape Hatteras, NC, respectively. The assessment focuses on marine, estuarine, and riverine habitats out to the U.S. EEZ and up-river to capture the full habitat range of diadromous species.

Key Elements of the Assessment

- This assessment considers the overall vulnerability of habitat to climate change to be a function of two main components: exposure and sensitivity.
- The exposure component considers the magnitude and overlap of the projected changes in climate with the distribution of each habitat.
- The sensitivity component includes habitat characteristics, or traits, that are believed to be indicative of the response of a habitat to potential changes in climate.
- Exposure and sensitivity scoring relies on expert elicitation which is based on defined criteria, but allows experts to use their expert opinion to account for the complexities of these habitats.

Vulnerability Assessment Methodology Selection

- We reviewed eleven existing climate vulnerability assessment methodologies, and selected four for further consideration at an in-person workshop in summer 2018. The steering committee decided to develop a hybrid assessment based on the NOAA Fisheries Climate Vulnerability Assessment methodology[2] and the Northeastern

[1] Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, Griffis RB, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLoS ONE 11(2): e0146756. doi:10.1371/journal.pone.0146756

[2] Morrison et al. (2015). Methodology for Assessing the Vulnerability of Marine Fish and Shellfish Species to a Changing Climate. NOAA Technical Memorandum NMFS-OSF-3. https://www.st.nmfs.noaa.gov/Assets/ecosystems/climate/documents/TM%20OSF3.pdf

Association of Fish and Wildlife Agencies' Vulnerabilities of Northeastern Fish and Wildlife Habitats to Climate Change[3].

- We surveyed potential users of the assessment results (e.g., NOAA Fisheries' regional programs including Habitat Conservation Division, fishery management council staff, etc.) to inform the assessment design and scope.

Development of Assessment Framework

- We selected fifty-two habitat sub-classes to be assessed. Habitats are organized based on a modified Cowardin classification, and include the riverine, estuarine, and marine systems to capture the range of habitats used by NOAA trust species (Appendix 1).
- We developed descriptions for nine sensitivity attributes that are indicative of a habitat's response to changes in climate. These are:
    - Habitat condition
    - Habitat fragmentation
    - Ability to spread or disperse
    - Resilience, resistance
    - Changes in abiotic factors
    - Sensitivity and intensity of non-climate stressors
    - Dependence on critical ecological linkages
- The sensitivity attributes descriptions contain information about the relationship of that attribute to climate change, guidance on how to use expert opinion, and definitions for scoring bins indicative of low, moderate, high, and very high sensitivity (Appendix 2).
- Please note: This assessment does not utilize a separate adaptive capacity component; rather, we include these traits within our sensitivity attributes. Sensitivity and adaptive capacity are difficult concepts to characterize, as they are often the inverse of each other. Traits that confer low sensitivity can also be thought to confer high adaptive capacity (e.g., ability to spread or disperse). By defining all traits as sensitivity, we have eliminated the need to create an arbitrary distinction. Furthermore, work done on the Fish Climate Vulnerability Assessment has shown that arbitrary changes in how traits are classified, sensitivity or adaptive capacity, can have unintended consequences of the outcome of the assessments.
- We developed habitat profiles that contain information about each habitat relevant for each sensitivity attribute primarily from published literature, as well as professional judgement.

[3] Galbraith, Hector. 2013. The Vulnerabilities of Fish and Wildlife Habitats in the Northeast to Climate Change. A report to the Northeastern Association of Fish and Wildlife Agencies and the North Atlantic Landscape Conservation Cooperative. Manomet, MA. https://lccnetwork.org/resource/vulnerabilities-fish-and-wildlife-habitats-northeast-climate-change

- We selected ten exposure factors, which are climate variables that could impact the habitat. These are:
    - Sea surface temperature
    - Bottom temperature
    - Air temperature
    - Stream temperature
    - Sea surface salinity
    - Bottom salinity
    - pH
    - Sea level rise
    - Precipitation
    - Streamflow
- Not all exposure factors are relevant to all habitats -- the exposure of each habitat is assessed for between two and six exposure factors.
- The HCVA is assessing climate exposure under end-of-century projections based on the Intergovernmental Panel on Climate Change RCP 8.5 emissions scenario using two climate models:
    - The Regional Ocean Modeling System: Northwest Atlantic Dynamical Downscaling (ROMS-NWA) was used for exposure factors, when available. The end-of-century time frame is 2070-2099. The historic reference period is 1976-2005.
    - The Coupled Model Intercomparison Project 5 (CMIP5) was used for exposure factors where ROMS-NWA does not have projections. The end-of-century time frame for this model is 2050-2099. The historic reference period is 1956-2005.
- For exposure factors not represented directly in the ROMS-NWA or CMIP5 climate models, we developed a scoring system based on published literature of projections driven by climate models (stream temperature[4], streamflow[5], sea level rise[6]).
- We compiled existing spatial data of the distribution of each habitat in the assessment across the study region for use in the exposure scoring, when available. Text descriptions of habitat distribution were developed for habitats with limited spatial data.

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[4] Letcher, Benjamin H., Daniel J. Hocking, Kyle O'Neil, Andrew R. Whiteley, Keith H. Nislow, and Matthew J. O'Donnell. 2016. "A Hierarchical Model of Daily Stream Temperature Using Air-Water Temperature Synchronization, Autocorrelation, and Time Lags." *PeerJ* 4: e1727. doi:10.7717/peerj.1727.

[5] Demaria, EMC, Palmer, RN, and Round, JK 2015. Regional climate change projections of streamflow characteristics in the Northeast and Midwest U.S. Journal of Hydrology: Regional Studies 5: 309-323.

[6] Sweet, WV, Kopp, RE, Weaver, CP, Obeysekera, J, Horton, RM, Thieler, ER, Zervas C. 2017. Global and regional sea level rise scenarios for the United States. National Oceanic and Atmospheric Administration, National Ocean Service. NOAA Technical Report NOS CO-OPS 083. p. 1-56.

Pilot Assessment

- The project team conducted a pilot assessment to evaluate the assessment methodology and make necessary modifications. Participants scored the sensitivity of three trial habitats.
- Feedback from the pilot test scorers was used to improve the sensitivity attribute descriptions, tighten up the scoring bins, and identify additional information that needed to be added to the habitat profiles.

Sensitivity Scoring

- Fifteen habitat experts were selected to conduct the sensitivity scoring--five each for the marine, estuarine, and riverine systems. The experts were from several federal agencies and academic institutions.
- Training: Each expert attended a web-based training in which they were introduced to all materials, scoring protocols, and the online scoring database.
- Preliminary scoring: Each expert independently scored each attribute for every habitat in their system by using a 5 tally scoring system. This system allows each scorer to indicate the uncertainty or geographic variability in their score by distributing the five tallies between the four scoring bins (low, moderate, high, very high). Scorers also provided a data quality score (between one and three) to reflect the availability and caliber of information for each attribute.
- Final scoring: Scorers gathered at an in-person workshop to compare and discuss the preliminary scores. This process helps identify errors and allows for sharing of information among the experts with the purpose of leveraging the collective knowledge of the group. The experts were encouraged to make adjustments to the distribution of their tallies (score) based on these discussions; however, we were not searching for consensus and no expert was compelled to change their scores.

Exposure Scoring

- Five experts relied on climate projections and spatial habitat data (distribution) to score the exposure of each habitat to each of the exposure factors.
- As with sensitivity scoring, scorers distributed five tallies between the four scoring bins (low, moderate, high, very high), and provided a data quality score to reflect the availability or confidence in the information for each exposure factor and habitat distribution. Scoring bins were based on the standardized historic anomaly (z-score, difference between the projected end-of-century mean for each exposure factor and the variability of the historic mean).

Vulnerability Analysis

- For every habitat we calculate a weighted mean for each sensitivity attribute and exposure factor. This is done by summing all the tallies in each scoring bin across experts (5 experts per habitat) and calculating a weighted mean (1=low; 2=Moderate, 3=High; 4=Very High).
- Sensitivity attribute means were used to determine the overall sensitivity component score using a logic rule described in Table 1 below. The same was done for the exposure factors.
- Overall vulnerability rank is determined in the same way as described in Morrison et al. (2015). Low, moderate, high and very high component scores are assigned 1, 2, 3, and 4, respectively. The product of the exposure and sensitivity component scores is then classified where 1-3 results in a low vulnerability rank, 4-6 a moderate vulnerability rank, 8-9 a high vulnerability rank, and 12-16 a very high vulnerability rank. Results can be displayed visually using a vulnerability matrix, to show final ranks as well as component scores (Figure 1).

Bootstrap Analysis

- A bootstrap analysis was conducted to determine the habitat vulnerability rank probability considering the distribution of the tallies in each attribute. This is useful in determining threshold effects, when the distribution of tallies is very close to a threshold used in scoring. The bootstrap consists of: for each attribute or factor, resample the tallies summed across scorers (with replacement) then recalculate the attribute or factor mean using the resampled tallies. Use the same scoring rubric to find the sensitivity and exposure component scores, and vulnerability rank. Repeat the process 1,000 times and record the occurrence of each outcome.

Overall Sensitivity or Exposure Score	Numeric Score	Logic Rule
Very High	4	3 of more attributes or factors mean ≥ 3.5
High	3	2 of more attributes or factors mean ≥ 3.0
Moderate	2	2 of more attributes or factors mean ≥ 2.5
Low	1	All other scores

Table 1. Logic rule for calculating overall habitat's climate exposure and sensitivity. The scoring rubric is based on a logic model where a certain number of individual scores above a certain threshold are used to determine the overall climate exposure and sensitivity. Adapted from Hare et al. 2016[7].

[7] Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, Griffis RB, et al. (2016) A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLoS ONE 11(2): e0146756. doi:10.1371/journal.pone.0146756

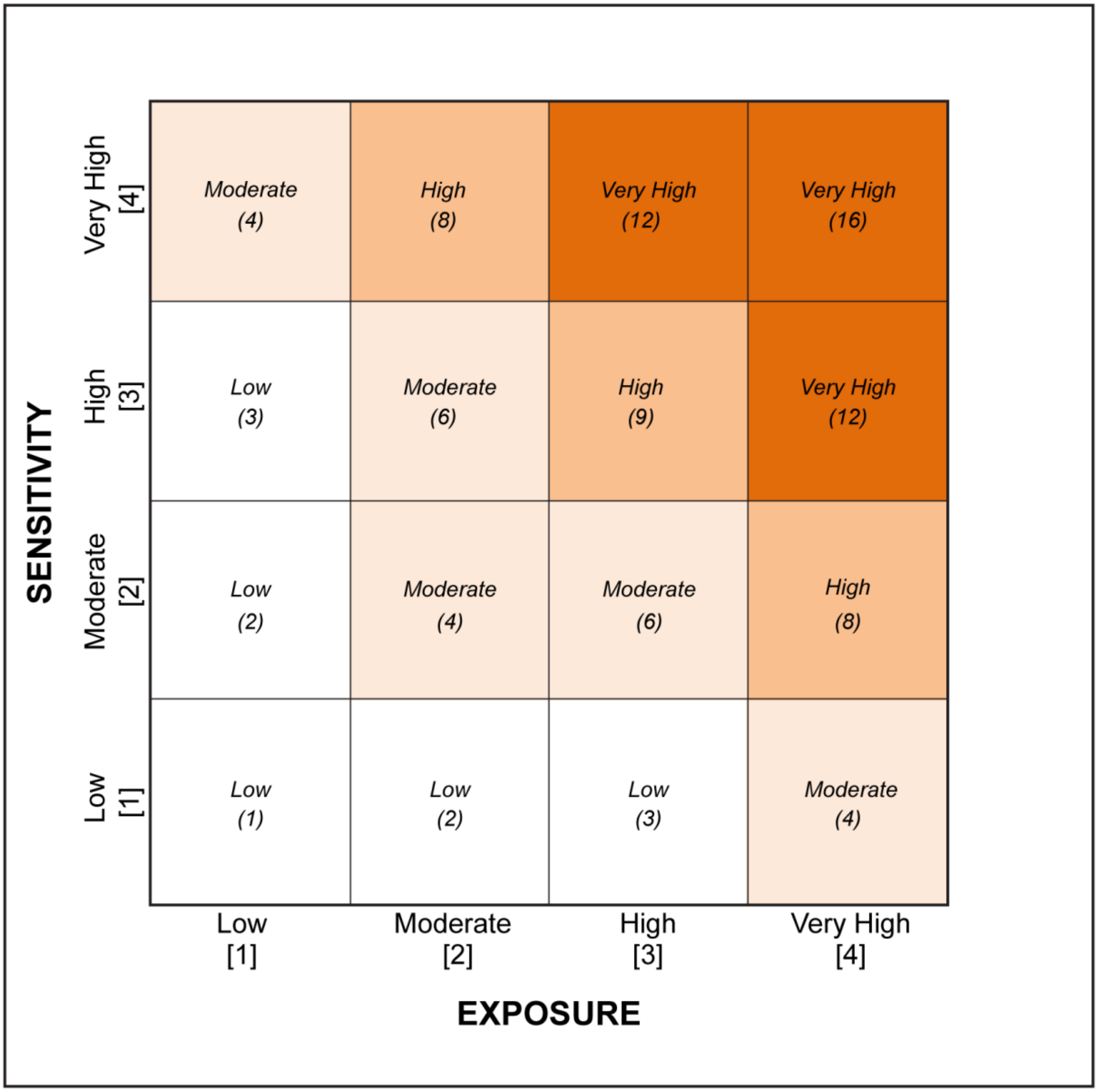

Figure 1. Matrix for determining habitat vulnerability rank based on component scores for exposure and sensitivity. Component scores are given a value of 1-4 (in brackets). Vulnerability rank is determined by multiplying the two component scores (in parentheses). Adapted from Morrison et al. 2015.

Appendix 1: Habitat Classification and Definitions

Habitat Class	Sub-Class Habitats Included in Class	Definition
Marine System: Open ocean overlying continental shelf and its associated high energy coastline with salinities > 30 ppt. The nearshore marine subtidal subsystem includes areas from the shoreline to locations where the depth reaches 200 meters, while the offshore marine subtidal system includes locations where the water is deeper than 200 meters. Intertidal sub-classes encompasses mean high to mean low water line, and include both the benthic habitat and the water from diurnal tidal inundation.		
Marine Rocky Bottom	• Marine subtidal rocky bottom bedrock, rubble, cobble/gravel (offshore; >200m) • Marine subtidal rocky bottom bedrock, rubble, cobble/gravel (nearshore; <200m) • Marine intertidal rocky bottom bedrock, rubble, cobble/gravel • Artificial fishing reefs and wrecks; groins/jetties	Rocky bottom habitat established on surfaces and crevices of relatively immobile rocky surfaces, including loose rocks of various sizes (rubble, cobble/gravel) and exposed bedrock. In addition, this habitat profile includes the epibenthic flora and fauna associated with hard bottoms, including calcareous algae (but not non-calcareous algae, which are included in marine aquatic bed habitat profile). Includes shallow corals growing on rocky bottom in <150m water depths. Artificial sub-class includes artificial fishing reefs and wrecks, groins/jetties.
Marine Unconsolidated Sand Bottom	• Marine subtidal unconsolidated sand bottom (offshore; >200m) • Marine subtidal unconsolidated sand bottom (nearshore; <200m) • Marine intertidal unconsolidated sand bottom	Subtidal offshore, inshore, and intertidal zone sand habitats. The nearshore marine subtidal sub-class includes areas from the mean low water to locations where the depth reaches 200 meters, while the offshore marine subtidal sub-class includes locations where the water is deeper than 200 meters. Intertidal sub-subclass includes the mean high to mean low water lines. This habitat subclass includes the epifauna and infauna associated with unconsolidated sand bottom, such as non-reef-forming mollusks (e.g., soft-shell clams, hard clams, sea scallops, surf clams, ocean quahogs), marine worms, small crustaceans, gastropods, and polychaetes. This subclass excludes specific habitats identified elsewhere (i.e., non-calcareous algal bed, rooted vascular beds, and reef-forming mollusks, i.e., blue mussels, eastern oysters).

Marine Unconsolidated Mud Bottom	• Marine subtidal unconsolidated mud bottom (offshore; >200m) • Marine subtidal unconsolidated mud bottom (nearshore; <200m) • Marine intertidal unconsolidated mud bottom	Subtidal offshore and nearshore zone mud habitats. The nearshore marine subtidal sub-class includes areas from the mean low water to locations where the depth reaches 200 meters, while the offshore marine subtidal sub-class includes locations where the water is deeper than 200 meters. This habitat subclass includes the epifauna and infauna associated with unconsolidated mud bottom, such as non-reef-forming mollusks (e.g., soft-shell clams, hard clams, sea scallops, surf clams, ocean quahogs), marine worms, small crustaceans, gastropods, and polychaetes. This subclass excludes specific habitats identified elsewhere (i.e., non-calcareous algal bed, rooted vascular beds, and reef-forming mollusks, i.e., blue mussels, eastern oysters).
Marine Reef (Offshore)	• Marine subtidal reef, coral-dominated hardbottom, Gulf of Maine (offshore) • Marine subtidal reef, coral-dominated hardbottom, canyons and seamounts (offshore)	Hard-bottom coral and sponge habitats in offshore zone (>150 m), including coral gardens, sponge gardens, coral thickets, etc. dominated by hard corals, soft corals, black corals, glass sponges, and demosponges. Shallow water corals (<200 m) are included in marine rocky bottom profile. *Note that the canyons and seamounts sub-class is characterized as "Mid-Atlantic" in the scoring database.*
Marine Reef (Mollusk)	• Marine subtidal reef, mollusk (oyster/mussel) (nearshore; <200m) • Marine intertidal reef, mollusk (oyster/mussel) • Cultured mollusks (aquaculture) in subtidal and intertidal zone	Bivalve reefs in the subtidal and intertidal zones in the marine system. May be on hard or soft substrates. Specifically focused on reef-building shellfish (e.g. mussels, oyster) that create a biotic hard substrate at the sediments. Note: non-reef-building shellfish (e.g., scallop, soft-shell clam, surf clam) are included in unconsolidated sand and mud bottom subclasses. The intertidal subclass includes both the reef and the water from diurnal tidal inundation. Differences between natural reefs and cultured shellfish are considered.
Marine Aquatic Bed	• Marine nearshore subtidal and intertidal kelp algal habitats	Algal and rooted vascular (seagrass) species occurring throughout the study area. Both

	• Marine nearshore subtidal and intertidal non-kelp algal habitats • Marine nearshore subtidal and intertidal rooted vascular bed	groups photosynthesize, so are limited to the photo zone of the water column. This class also includes aquaculture for macroalgae (e.g., kelp farms in New England). Seagrasses occurring in the Marine system of the study area include species occurring only in full salinity waters (> 30 ppt). Algal species include, non-rooted, benthic macrophytes separated by kelp species and non-kelp species occurring in the Marine system. Both groups generally occur in both the subtidal and intertidal zones, although are mostly limited to the lower and middle elevations of the intertidal zone due to sensitivity to dessication.
Marine Water Column	• Marine subtidal water column, shallow / well-mixed • Marine subtidal water column, shelf / stratified-surface • Marine subtidal water column, shelf / stratified-bottom • Marine subtidal water column, epipelagic • Marine subtidal water column, mesopelagic/bathypelagic	The water column is a concept used in oceanography to describe the physical (temperature, salinity, light penetration) and chemical (pH, dissolved oxygen, nutrient salts) characteristics of seawater at different depths. Water column habitats create the foundation for marine food webs, home to primary producers such as phytoplankton and microbes. These habitats are highly dynamic and exhibit swift responses to environmental variables. The marine water column encompasses open ocean overlying continental shelf and its associated high energy coastline with salinities > 30 ppt. The shallow/well-mixed sub-class refers to the shallow inner shelf (<20m water depth), and is vertically mixed year round. The shelf/stratified surface are surface waters above the seasonal thermocline for areas <200m in depth, while the shelf/stratified bottom are bottom waters below the seasonal thermocline for areas <200m in depth. The epipelagic sub-class is the surface (0 to 200m) of slope waters (areas>200m in depth), while the mesopelagic and bathypelagic are the intermediate and bottom waters (200-1000m) of those slope waters.

Estuarine System: Semi-enclosed bodies with salinities ≤ 30.0 to > 0.5 ppt, brackish water. Includes subtidal and intertidal zones, where the intertidal sub-classes include both the benthic habitat and the water from diurnal tidal inundation.		
Estuarine Rocky Bottom	• Natural estuarine subtidal rocky bottom bedrock, rubble, cobble/gravel • Natural estuarine intertidal rocky bottom bedrock, rubble, cobble/gravel • Non-natural estuarine subtidal rocky bottom bedrock, rubble, cobble/gravel • Non-natural estuarine intertidal rocky bottom bedrock, rubble, cobble/gravel	Bedrock, Rubble, Cobble/Gravel. Profile includes artificial reefs and wrecks in the subtidal, estuarine zone. Includes separate sub-classes for natural and non-natural bedrock rubble, cobble/gravel for both subtidal and intertidal zones in the estuarine system. This habitat subclass includes the epibenthic flora and fauna associated with these hard bottoms, but exclude the specific habitats identified elsewhere (i.e., non-calcareous algal and rooted vascular beds, coral-dominated hard bottom, mollusk reef). Calcareous algae is included in this class. Non-natural subclass includes riprap, artificial reefs and wrecks, and groin/jetties in the subtidal and intertidal, estuarine zones.
Estuarine Unconsolidated Bottom	• Estuarine subtidal unconsolidated sand bottom • Estuarine intertidal unconsolidated sand bottom/shore • Estuarine subtidal unconsolidated mud bottom • Estuarine intertidal unconsolidated mud bottom/shore	Includes intertidal and subtidal sub-classes for both mud and sand habitats, as well as the overtopping water column for intertidal sub-classes. This habitat type includes the epifauna and infauna associated with unconsolidated bottom, such as non-reef-forming mollusks (e.g., soft-shell clams, hard clams, sea scallops, surf clams, ocean quahogs), marine worms, small crustaceans, gastropods, and polychaetes. This subclass excludes specific habitats identified elsewhere (i.e., non-calcareous algal bed, rooted vascular beds, and reef-forming mollusks, i.e., blue mussels, eastern oysters).
Estuarine Aquatic Bed	• Estuarine subtidal and intertidal kelp algal habitats • Estuarine subtidal and intertidal non-kelp algal habitats • Estuarine subtidal and intertidal rooted vascular bed	Algal and rooted vascular (seagrass) species occurring throughout the study area. Both groups photosynthesize, so are limited to the photo zone of the water column. This class also includes aquaculture for macroalgae (e.g., kelp farms in New England). Seagrasses occurring in the Estuarine system of the study area include species occurring in brackish (≤ 30 ppt to > 0.5 ppt). Algal species include non-rooted, benthic macrophytes separated by

		kelp and non-kelp species occurring in the salinity range of the Estuarine system. Both groups generally occur in both the subtidal and intertidal zones, although are mostly limited to the lower and middle elevations of the intertidal zone due to sensitivity to dessication.
Estuarine Reef	● Estuarine subtidal mollusk reef (oyster/mussel) ● Estuarine intertidal mollusk reef (oyster/mussel) ● Cultured mollusk reefs (aquaculture) in subtidal and intertidal zone	Bivalve reefs in the subtidal and intertidal zones in the estuarine system. May be on hard or soft substrates. Specifically focused on reef-building shellfish (e.g. mussels, oyster) that create a biotic hard substrate at the sediments. Note: non-reef-building shellfish (e.g., scallop, soft-shell clam, surf clam) are included in unconsolidated sand and mud bottom subclasses. The intertidal subclass includes both the reef and the water from diurnal tidal inundation. Differences between natural reefs and cultured shellfish are considered.
Estuarine Emergent Wetland	● Mid-Atlantic Estuarine intertidal emergent wetland, native persistent & non-persistent ● Mid-Atlantic Estuarine intertidal emergent wetland, invasive spp. ● New England Estuarine intertidal emergent wetland, native persistent & non-persistent ● New England Estuarine intertidal emergent wetland, invasive spp.	Wetlands dominated by perennial plants (characterized by erect, rooted, herbaceous hydrophytes), in a estuarine system where salinity is greater than 0.5 ppt. Includes brackish to full salinity emergent wetlands, persistent and non-persistent.
Estuarine Water Column	● Estuarine subtidal water column (well-mixed)	The estuarine water column encompasses the stratum from the surface (mean low water) to a maximum depth of 200 m (although few if any estuaries approach this depth). This includes all estuaries types based on circulation (salt-wedge, well-mixed, partially-mixed, and fjord).

Riverine System: Terminates at the downstream end where the concentration of ocean-derived salts in the water ≥ 0.5 ppt. during the period of annual average low flow, or where the channel enters a lake.		
Riverine Rocky Streambed and Bank	• Riverine rocky streambed bedrock, rubble, cobble/gravel, tidal and non-tidal	Bedrock, rubble, cobble/gravel streambed and banks for tidal and non-tidal rivers. This includes the epibenthic flora and fauna associated with these hard bottoms but exclude specific habitats (algal beds, rooted vascular, emergent wetlands) that are included in other subclasses. Riverine rocky shores support sparse plant and animal communities, including lichens and blue-green algae. Also includes large woody debris, boulders, tree roots, and other structural elements that characterize rocky streambed/bank.
Riverine Unconsolidated Streambed and Bank	• Riverine sand streambed and bank, tidal and non-tidal • Riverine mud streambed and bank, tidal and non-tidal	Sand and mud streambeds and banks of tidal and non-tidal rivers, including large woody debris, tree roots, and other structural elements that occur in unconsolidated streambed/bank. Characterized by substrates lacking vegetation except for pioneering plants during brief favorable periods. This includes the epifauna/infauna and epiflora associated with these hard bottoms (e.g., freshwater mussels) but exclude specific habitats (algal beds, rooted vascular, emergent wetlands) that are included in other subclasses.
Riverine Aquatic Bed	• Riverine algal bed, tidal and non-tidal • Riverine rooted vascular bed, tidal and non-tidal	Riverine aquatic beds where the salinity is <0.5 ppt. during the period of annual average low flow. Terminates where the river or stream channel enters a lake. Algal beds occur in both tidal and non-tidal portions of a river. Algal bed species include filamentous green algae occurring in tidal portions of rivers (e.g., *Spirogyra* sp. and *Cladophora* sp.). Non-tidal, freshwater green algae species include muskgrass (*Chara* sp.) and brittle grass (*Nitella* sp.). Rooted vascular beds occur in the lower river within the influence of tidal action and include widgeon grass (*Ruppia maritima*)- a freshwater plant that is tolerant of both fresh

		and saltwater and wild celery (*Vallisneria americana*). In addition, the pondweed community, including sago pondweed (*Stuckenia pectinata*) and redhead grass (*Potamogeton perfoliatus*) are freshwater submerged plants that have some tolerance to salinities up to about 10 ppt. Hydrilla (*Hydrilla verticillata*) is an invasive freshwater plant that tolerates some salinity (up to 7 ppt). In freshwater, non-tidal portions of rivers, rooted vascular beds in the study area include water stargrass (*Heteranthera dubia*), widgeon grass, wild celery, Eurasian watermilfoil (*Myriophyllum spicatum*), and hydrilla.
Riverine Emergent Wetland	• Riverine tidal emergent wetland, native persistent and non-persistent • Riverine non-tidal emergent wetland, native persistent and non-persistent • Riverine tidal emergent wetland, invasive spp. • Riverine non-tidal emergent wetland, invasive spp.	Wetlands dominated by perennial plants (characterized by erect, rooted, herbaceous hydrophytes), in a riverine system where salinity is less than or equal to 0.5 ppt. Includes both tidal and non-tidal wetlands, and both native (persistent and non-persistent) and invasive species. Native tidal species include Spartina spp. and native non-tidal species include *Typha* spp. Invasive tidal species include common reed (*Phragmites australis*) and invasive non-tidal species include common reed and purple loosestrife (*Lythrum salicaria*)
Riverine Water Column	• Riverine water column, tidal and non-tidal	The 3-dimensional space of water for both tidal and non-tidal zones in the river. The class includes the physical, chemical, and biological components of the water, but not the river bottom/banks, submerged vegetation, or emergent and riparian vegetation. Terminates at the downstream end where the concentration of ocean-derived salts in the water ≥ 0.5 ppt. during the period of annual average low flow, or where the channel enters a lake.

RESPONSIBLE OFFSHORE SCIENCE ALLIANCE

Who We Are

The Responsible Offshore Science Alliance (ROSA), is a new, 501 (c) 3 nonprofit organization dedicated to provide for and advance regional research and monitoring of fisheries and offshore wind interactions in US state and federal waters through collaboration and cooperation.

ROSA seeks to involve states, federal agencies, fishermen, wind energy developers, and fishery scientists from Maine to South Carolina in regional science questions around offshore wind development and fisheries. ROSA is led by a board of directors comprised equally of wind energy developers, fishermen, and fishing industry leaders.

What We Do

ROSA's primary focus is on research, communication, and regional collaboration. As such, ROSA will,

- Identify regional research and monitoring needs
- Provide a forum for coordinating existing research and monitoring
- Advance regional understanding through collaboration, partnerships, and cooperative research
- Help align research and monitoring
- protocols Support access to data
- Administer research by pooling funds from multiple sources
- And, communicate and share learnings.

"To date there has been limited research conducted on the areas slated for offshore wind development in federal waters,,, ROSA presents a clear solution to this problem that comes with strong fishing industry support and their direct involvement."

- Janet Coit, Director,

Rhode Island Department of Environmental Management

"Sustainable fisheries AND renewable energy is our goal and the Regional Offshore Science Alliance will help the Northeast region get there."

- Jon Hare, Science and Research Director,
- Northeast Fisheries Science Center, NOAA Fisheries Service

For more information visit rosascience.org

The Responsible Offshore Science Alliance is a 501 (c) 3 tax exempt nonprofit organization.

How We Started

ROSA was initiated by the Responsible Offshore Development Alliance (RODA), a broad membership-based coalition of fishing industry associations and fishing companies with an interest in improving the compatibility of new offshore development and their businesses along with several offshore wind developers in January of 2019. RODA and the developers then engaged numerous states, federal agencies, additional fishermen, and others in on-going consultations and meetings through the fall of 2019.

How we are supported

ROSA's operations are jointly funded by the contributions of offshore wind developers with federal leases. Current funding companies include:

- Atlantic Shores Offshore Wind
- Equinor
- Mayflower Wind Energy
- Ørsted
- Vineyard Wind

Fishing industry leaders provide in-kind support through individual participation and extensive RODA stafftime. Events and specific research projects will be funded from a variety of federal, state and private sources.

"One of the many concerns facing offshore wind development is its potential effect on fisheries, from safety to costs to fishing patterns and gear; their concerns frequently are best studied and considered on a regional, not state-specific level. In New York's view, ROSA will provide an important opportunity for states, fisheries, developers, federal agencies, and other stakeholders to address these concerns."

- Alicia Barton, President and CEO,
New York State Research and Development Authority

ROSA Participation

ROSA has specific roles for states, commercial and recreational fishermen, offshore wind developers with federal leases, fishery management councils, and federal agencies.

ROSA will work and coordinate closely with the many states and federal agencies already undertaking research in pertinent areas along with on-going cooperative research efforts, existing regional data and monitoring networks, and interested research and academic institutions across the region.

Appointed committees of scientists from academia, research organizations, and technical firms will allow for even broader-based participation.