Preface

The Atlantic States Marine Fisheries Commission (Commission) was formed in 1942 as a means to conserve and enhance interjurisdictional fisheries of the Atlantic coast. The Commission and its 15 member states recognize that marine fisheries cannot be adequately managed without due consideration for marine fish habitat; however, the Commission does not have the capability to regulate marine fish habitat or activities other than fishing that may cause adverse impacts. Under these circumstances, the Commission recognizes that it is imperative to collaborate with the state and federal agencies that hold such authority, and equip them with the recommendations and guidance necessary to help provide for the conservation of healthy marine fish habitat.

Submerged aquatic vegetation (SAV) comprise some of the most productive ecosystems in the world. SAV is significantly important to many Commission managed fish species, and afforded different degrees of protection up and down the coast. In 1997, the Habitat Committee developed a policy to communicate the need for conservation of coastal SAV resources, and highlight state and Commission-based activities for implementation of a coastal SAV conservation and enhancement program. This policy was modeled after a similar policy prepared by the Chesapeake Bay Program, and background information relied heavily on the Commission's publication *Atlantic Coastal Submerged Aquatic Vegetation: a Review of its Ecological Role, Anthropogenic Impacts, State Regulation, and Value to Atlantic Coastal Fisheries*. The intent of the original policy was not to hold marine fisheries agencies accountable for the suggested state activities, but rather to efficiently communicate the goals of the policy to the agencies or organizations that can best carry out the prescribed activities, and encourage the participation of these agencies in achieving policy goals.

In 2017, 20 years after the original policy was released, the Habitat Committee re-evaluated its recommendations and importance. Upon review, it was determined that the policy is still relevant, and arguably more important now than ever due to emerging and intensifying threats that could reduce water quality or damage beds, such as aquaculture and coastal development. Our objective is to provide updates to the scientific research and management issues, including emerging issues over the past 20 years. The goals of the original policy are still valid, but have been revised to meet the needs of the 21st century.

Atlantic States Marine Fisheries Commission

Updated Submerged Aquatic Vegetation Policy

Introduction

Background

Submerged aquatic vegetation or SAV systems, which include both true seagrasses in saline regions and freshwater angiosperms that have colonized lower salinity regions of estuaries, are among the most productive ecosystems in the world. They perform a number of irreplaceable ecological functions, which range from chemical cycling and physical modification of the water column and sediments, to providing food and shelter for commercial, recreational, as well as ecologically important organisms, and are especially critical for juvenile development of many fish and invertebrate species (Thayer et al., 1997). All ASMFC managed species are directly dependent upon SAV for refuge, attachment, spawning, food, or prey location for at least part of their life cycle, with the possible exception of Jonah crab and Northern shrimp (data from Kritzer et al., 2016). Since all species managed by the Commission are dependent upon coastal habitats for which SAV often serves vital functions; in essence, all Commission-managed species are influenced by SAV to some degree.

The Commission established a policy on SAV in 1997 because of the important role SAV plays in the habitat of Commission-managed species. Both marine and freshwater SAV is covered by the policy because some managed species utilize both during their ontogenetic development. Dissimilar (e.g. X, Y, Z) regional management strategies (Ernst and Stephan, 1997) and human activities (Goldsborough, 1997) can threaten local and regional SAV health and abundance, and result in impacts to fisheries. SAV loss has been reported in most Atlantic coastal states (Ernst and Stephan, 1997). Some reasons for this loss, including water quality degradation, are pervasive threats along the coast. Some regions have experienced severe declines, such as Chesapeake Bay, where SAV communities underwent an unprecedented decline in the early 1970s that affected all species in all areas of the bay (Orth and Moore, 1983). In 1993, researchers identified the main influencers on SAV abundance and distribution: water clarity, suspended sediments, nitrogen, phosphorus, and chlorophyll *a* (Dennison et al. 1993). Since then, managers have been using these indicators for specific water quality targets. They also have a goal of restoring a total of 75,000 acres of SAV in the Chesapeake Bay by 2025 – 36,500 by 2017 (Orth et al. 2017).

Commented [KHF1]: Update this…has trend continued? Gotten worse?

The Commission encouraged implementation of the original policy by state, federal, local, and cooperative programs which influence and regulate fish habitat and areas impacting fish habitat; specifically SAV. The development of the original policy was overseen by the Commission's Habitat Committee, with scientific guidance from experts in the field of SAV ecology. This version of the SAV policy was updated by distributing the 1997 policy to SAV and habitat experts and incorporating their changes. The final draft was approved by the Habitat Committee (date) and by the Policy Board (date).

SAV Efforts by Atlantic Coast States and Federal Partners since the Policy was Released

Over the years, states and federal agencies have taken various approaches to SAV management (Figures X).
[Insert information on responses from state and federal agencies on implementation of the policy]

Definition of Submerged Aquatic Vegetation

SAV refers to rooted, vascular, flowering plants that, except for some flowering structures, live and grow below the water surface. Because of their requirements for sufficient sunlight, seagrasses are found in shallow coastal areas of all Atlantic coastal states, with the exception of Georgia and South Carolina, where freshwater inflow, high turbidity and tidal amplitude combine to inhibit their growth.

There are at least 13 species of seagrasses common in US waters to which this definition of SAV and these policies may apply. In the New England and northern Mid-Atlantic regions, eelgrass (*Zostera marina*) dominates, with two other species also occurring – widgeon grass (*Ruppia maritima*) and, from North Carolina southward, Cuban shoalgrass (*Halodule wrightii*). South towards Florida, turtlegrass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*) become dominant along with Cuban shoalgrass and several species of *Halophila*. One species of *Halophila*, Johnson's seagrass (*H. johnsonii*), was listed as threatened in 1998. Its critical habitat was designated in 2000, and in 2002 the National Oceanic and Atmospheric Administration (NOAA) published a recovery plan for the species[1]. Widgeon grass (*Ruppia maritima*) which can tolerate both fresh and saltwater, has the broadest range of all species (Orth, 1997).

[1] http://www.fisheries.noaa.gov/pr/species/plants/johnsons-seagrass.html

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Approximately 20-30 species of freshwater macrophytes may be found in the tidal freshwater and low salinity areas of the estuaries of the eastern United States. These lower salinity communities can be quite diverse, with as many as 10 species co-occurring at a single location. Wild celery (*Vallisneria americana*), redhead grass (*Potamogeton perfoliatus*), sago pondweed (*Potamogeton pectinatus*), horned pondweed (*Zannichellia palustris*), common elodea (*Elodea canidensis*), coontail (*Ceratophyllum demersum*), and southern naiad (*Najas quadalupensis*) are a few of the native species that will dominate these areas while two non-native (invasive) species, milfoil (*Myriophyllum spicatum*) and hydrilla (*Hydrilla verticillata*), will also be found in many areas.

This update and the original policy acknowledge that there will be cases, as with invasive species, where it may be appropriate to undertake management control measures. Additionally, where native species have been eliminated, invasive species are of functional value; however, restoration of native species should be undertaken as appropriate.

Commented [KO2]: Examples?

Policy Statement

Goal

The goal of the policy has not changed since 1997. The goal is to preserve, conserve, and restore where possible, in order to achieve a net gain in SAV distribution and abundance along the Atlantic coast and tidal tributaries, and to prevent any further losses of SAV in individual states by encouraging them to:

1. Protect existing SAV beds from further losses due to degradation of water quality, physical destruction to the plants, or disruption to the local benthic environment;

2. Establish state or regional water and habitat quality objectives that will result in restoration of SAV through natural re-vegetation;

3. Develop and attain state SAV restoration goals in terms of acreage, abundance, and species diversity, considering historical distribution records and estimates of potential habitat.

In order to protect and enhance its trust resources, the Commission supports the prioritization of SAV protection, whereas mitigation should only be applied when unavoidable impacts to SAV resulting from permitted coastal alterations or other unintended, irreversible impacts occur.

There are six key components to achieving the goal of this policy: 1) Assessment of historical, current and potential distribution and abundance of SAV; 2) Protection of existing SAV; 3) SAV Restoration; 4) Public Education and Involvement; 5) Research; and 6) Implementation. The Commission's Habitat Committee found that the goals are still relevant today, and have left them unchanged from the 1997 version, with minor updates.

I. Assessing the Resource

Determining current status and identifying trends in health and abundance are key factors in management of SAV resources. In an effort to develop consistent monitoring techniques among regions, SAV mapping protocols have been identified by NOAA's Coastal Change Analysis Program (C- CAP; Dobson et.al., 1995), and updated in 2001 (NOAA, 2001).

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Policy:
At a minimum, each member state should ensure the implementation of a SAV resource assessment and monitoring program which will provide a continuing quantitative evaluation of SAV distribution and abundance and the quality of supporting environmental parameters. The optimum coast wide situation would be a monitoring system which would establish consistent monitoring techniques among regions so that the data are comparable. In addition to evaluating distribution and abundance, monitoring should also evaluate trends in the overall health of existing SAV beds. SeagrassNet is used at several locations along the Atlantic coast and other areas worldwide to assess trends in health of discrete SAV beds using comparable techniques.

Action:
ASMFC: Support and promote adoption of a protocol for mapping of SAV which all member states can use to provide for data consistency and development of a centralized database. Assessment and data collection should have relevant metrics and scales to inform specific management questions and goals (Bernstein et al., 2011; Neckles et al., 2012; Roca et al., 2016).

Commented [KHF3]: Why not the C-CAP protocol mentioned above?

Commented [A4R3]: For those working in seagrass restoration, do you support adopting this protocol?

State: ASMFC members should encourage their appropriate state agencies or departments to implement regular statewide or regional SAV monitoring programs which will identify changes in SAV health and abundance cumulatively on a coast wide basis if they are not already doing so (see 'SAV Efforts by Atlantic Coast States and Federal Partners since the Policy was Released' above for more information). Surveys should optimally be on a five year basis at a minimum, and preferably annually, for areas considered to be especially at risk of severe declines from anthropogenic activities, disease, or other factors. Aerial images captured from a plane allow for standard comparability across regions, if resources allow. A good map provides spatial extent and rough approximations of density.

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II. Protection of Existing Submerged Aquatic Vegetation

A concerted effort should be made to protect those areas where SAV currently exists since the SAV standing stock is in decline and it is difficult to successfully restore SAV. Impacts which result in losses of SAV such as direct alterations to a vegetated area or indirect actions within a watershed should be curtailed.

Commented [A5]: More details on fishing-harvest practices/gear impacts, as well as aquaculture.

Commented [MD(6]: no

Commented [A7R6]: minimized?

While there have been numerous documented restoration successes, protection and conservation are a much more assured and cost effective approach to preservation of SAV. Because SAV habitat requirements are more stringent than those of many coastal marine living resources, controlling the type, extent, intensity and duration of impacts to SAV will further other efforts to restore and protect coastal fish habitat. Since the original policy was released, new boat mooring areas have been added to shallow water, and there has been a growing interest in aquaculture in shallow water environments that SAV can and has the potential to occupy. This is especially true for shellfish aquaculture. Aquaculture has the potential for conflicts that requires careful ocean planning, and siting not occur in current or adjacent to seagrass beds.

Commented [A8]: An interesting question is raised by the issue of SAV colonizing after shellfish culture was established; now what? I have been told of a case where this has happened at a clam farm in the Chesapeake. I have observed seeded eelgrass shoots caught in floating oyster cages, the seeds will likely drop there and eelgrass seedlings could take hold; but this would probably not happen otherwise at that location.

Commented [MD(9]: Not asmfcs job to sort out

Policy:
Member states should use existing regulatory, proprietary, and resource management programs, and in addition, develop new programs, to limit permanent and irreversible, direct, and indirect impacts to SAV and their habitats.

Action:
ASMFC and member States: Review and evaluate the effectiveness of existing administrative procedures, regulatory, proprietary and resource management programs to protect existing SAV and their habitats

(primarily fishing impacts followed by mitigation, dredging, water quality standards, dock placement, marina expansion and vessel impacts such as elevated wakes, suspended sediments, placement and maintenance of moorings, and direct impacts from hulls, propellers, and personal watercraft).

Paragraph on fishing impacts to SAV.

ASMFC: 1) Support and promote the development of water quality standards by the Environmental Protection Agency that member states can implement to protect SAV habitat (i.e. light attenuation, total suspended solids, chlorophyll a, dissolved inorganic nitrogen, dissolved inorganic phosphorus, critical life period).
2) In partnership with National Marine Fisheries Service and Fish and Wildlife Service, develop technical guidelines and standards to objectively determine gear impacts, and develop standard mitigation strategies.
3) How about something with the Army Corps? Make sure General Permit adequately protects SAV?
4) Should ASMFC provide guidance to member states about what fishing gears negatively impact SAV and what sorts of regulations (spatial, temporal, etc) work to protect SAV?

Commented [MD(10): I believe NWP have conditions about sav

Commented [MD(11): Guidance on impact and maybe recommend BMPs or model laws?

State: 1) ASMFC members should propose improvements necessary in state regulation and management including conditions pertaining to harvesting shellfish or finfish in SAV beds by use of mechanical means and the placement/operations of aquaculture activities to protect existing SAV beds.
2) encourage state agencies or departments with jurisdiction over construction activities to propose improvements necessary in state regulation and management of SAV habitats based on the standards developed in the above actions.

III. Restoration of Submerged Aquatic Vegetation

In addition to protecting existing SAV habitat, restoration of former habitat should improve the likelihood of achieving an overall net gain. In cases where SAV is in decline due to poor environmental quality, environmental quality must be attained before restoration can occur. Planning will induce maximum restoration program effectiveness. Even with adequate environmental quality, SAV restoration is challenging due to predators, human impacts, and the risk of newly planted shoots to uproot easily. Good planning and use of scientifically-based restoration protocols will help ensure success where environmental conditions warrant. Examples of tools and protocols include habitat suitability models (Vaudrey et al. 2013), site-specific planning and testing (Leschen et al. 2010), and restoration (Van Katwijk et al. 2016).

A section on potential vs historical is needed up here, before the policy paragraph.

Policy:
Protection is preferred over restoration. Restoration programs should include establishment of habitat quality necessary for SAV prior to restoration. Restoration methods should incorporate scientifically based protocols. Restoration goals should consider potential and historical SAV spatial footprint.

Action:
ASMFC and member states: ASMFC should partner with/promote/support other state agencies, departments, NGOs, universities, and other entities to support SAV restoration activities. ASMFC members should contribute or take the lead on setting state restoration goals for SAV acreage, and providing literature and best management practices to state agencies.

State: ASMFC members should encourage their appropriate state agency or department to set regional or state restoration goals for SAV acreage, abundance and species diversity considering historical records of

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abundance and distributions and estimates of potential habitat. Identify reasons for losses, and address any need for habitat improvement prior to restoration. Based on scientific protocols, identify areas currently suitable for SAV restoration, and consider them for protection and future use, or immediate use in restoration projects. Implement scientifically-based transplanting and planting protocols, and support their use by other organizations.

IV. Public Education and Involvement

An informed and involved public will provide a firm foundation of support for SAV protection and restoration efforts. Education and involvement is an important facet of increasing public awareness and stewardship (e.g., Figure X).

Commented [KHF12]: Is there any support for this statement? Like the work at SUNY Stony Brook

Commented [MD(13]: ?? look at TNC Chantall Colliers papers on garnering local support

Commented [A14R13]: Found interviews but couldn't find a paper – do you have one in mind?

Figure X. Seagrass habitat conservation signage in Jamestown, Rhode Island. Photo and sign courtesy of the Atlantic Coastal Fish Habitat Partnership.

Policy:

ASMFC and member states should promote and support public education and stewardship programs that will increase the public's knowledge of SAV, its importance as fish habitat, and commitment to SAV conservation.

Action:

ASMFC and member States: ASMFC in coordination with member States, Federal agencies, and non-profits will promote and support the improvement of public understanding of the value, habitat requirements, status, significant threats, cumulative human impacts, and trends in abundance of SAV. States should include this information in their aquatic education programs.

State: ASMFC members should encourage their appropriate state agency or department to promote the involvement of citizen's groups in activities such as groundtruthing of remotely sensed and mapped SAV locations; water quality monitoring programs; reporting of impacts, especially cumulative impacts such as dock and pier expansions; losses; or perturbations; and SAV restoration and protection activities. One way to aid in increasing awareness would be to share area maps online (preferably not requiring ArcGIS user capabilities).

V. Scientific Research

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Through scientific research, we will improve our knowledge and understanding of SAV to ensure that efforts to protect and restore the resource will be effective. Further information on growth, physiology, reproduction, genetics, life cycles, disease, transplanting, environmental requirements, and anthropogenic impacts is needed to protect and restore SAV.

Policy:
ASMFC and member states should promote and support those research projects which will improve our knowledge of SAV and its benefits as fish habitat.

Action:
ASMFC and member States: On a coast wide basis, support research financially, politically, and through data and results sharing in the following areas:

1) The relationship between SAV and the environmental quality of fish habitat and the relative importance of SAV to other, high quality habitat types. This should include the development of specific habitat functions of SAV (e.g. spawning, feeding, growth, refuge), taking into consideration the benefits to managed fish species across their ranges.

2) Improving methodologies for SAV transplanting and restoration techniques, and determine the ecological functioning of transplanted vs. naturally vegetated areas.

3) Improving our understanding of the relationships between SAV and managed fish species, including fishery production patterns associated with different landscape or bed forms and sizes within the context of location within the system, as well as the influence of human disturbance and consequences of altering seagrass landscapes vis-à-vis fragmentation and isolation.

4) The specific physical requirements for SAV survival, on a regional basis, as well as the effects of eutrophication, sediment loading, indirect (pesticides) and direct (herbicides) impacts to epiphyte grazers, disease, physical disturbance, climate change (e.g., respiratory stress from increased temperatures), and natural perturbations on growth and survival of SAV. Efforts should be made to identify the primary threat(s) to SAV health in each locale.

5) The effects of reduced genetic diversity and difference in physiology (e.g. annual vs perennial, below-ground biomass) on the ability of seagrass populations to survive habitat alterations. Research should also identify regional differences in SAV requirements.

Policy Implementation

Habitat Program
This policy was distributed to all Commissioners and other interested persons for use in promoting local and regional protection of SAV. The Commission's federal partners, including the US Fish and Wildlife Service and NOAA Fisheries, were encouraged to adopt and implement this policy. Other federal agencies, such as the US Army Corps of Engineers and the Environmental Protection Agency, were briefed on the policy, and encouraged to adopt it as well.

The Commission will continue to progress in its commitment to facilitate communication among State and Federal fishery and habitat managers, as well as assist marine fisheries agencies in transmitting this updated

Commented [KHF15]: Should they then be listed in the sections above in Policy and Action sections?

Commented [KHF16]: Should this circle include specific mention of environmental protection units, coastal zone management units, and ocean planning units?

policy to habitat protection agencies (Appendix I).

Fishery Management Planning

Under the Atlantic Coastal Fisheries Cooperative Management Act, the Commission may require that states implement certain facets of fishery management plans, termed "compliance criteria." The following is a list of compliance criteria which the Commission will continue to consider for adoption in fishery management plans (FMP) for species with demonstrated reliance on SAV habitat (Laney, 1997):

1) Preparation of an annual status report by each state and federal partner on implementation of each aspect of the policy.

2) Transmission of the policy by each state and federal partner to all agencies with habitat regulatory and management authority or organizations which can have a significant positive or negative impact on SAV.

3) Preparation of state plans to identify fishing gear and practices employed by any state regulated fishery which may negatively impact SAV; and development and implementation of strategies to eliminate negative impacts identifies pursuant to Section II where appropriate to achieve SAV objectives.

In addition, the policy should continue to be incorporated by reference into FMPs for species with demonstrated reliance on SAV habitat. These FMPs should include background information on the importance of SAVs, and recommendations which parallel the prescribed activities of the policy.

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Interstate Water Pollution Control Commission and the Long Island Sound Study. 171 p. + appendices.

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Atlantic States Marine Fisheries Commission
Habitat Committee

Habitat Management Series: Impacts of Nearshore and Estuarine Aquaculture on Fish Habitats Along the United States' Atlantic Coast

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Introduction

Aquaculture – according to the Food and Agricultural Organization (FAO) "Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resources, with or without appropriate licenses, are the harvest of fisheries."

Estuarine and marine aquaculture is considered one of the fastest growing sectors of agriculture production globally. The United States aquaculture industry produced 608 million pounds ($1.33 billion) of finfish and shellfish in 2014; marine finfish production was greatest for Atlantic salmon (41.3 million pounds), and the highest marine shellfish production by volume were oysters (33.3 million pounds) (National Marine Fisheries Service, 2016). For fishery landings and aquaculture combined, the United States is the fifth largest producer; however, the United States is fifteenth in production of aquaculture products for consumption (National Marine Fisheries Service, 2016). Globally, approximately one half of seafood consumed is from aquaculture production (National Marine Fisheries Service, 2016).

Commented [MT1]: Consider citing original source. FAO report.

Along the United States Atlantic coast, numerous aquatic animals, seaweed, algae, and plants are cultured for stock enhancement, food production, ornamental use, research, and restoration efforts. Along the east coast there are a wide variety of species under production, but dominant species in terms of overall production are clams, oysters, mussels and salmon. Estuarine and marine aquaculture primarily occurs in state waters due in part to existing policies and regulatory frameworks. Federal policies, such as NOAA's Marine Aquaculture Strategic Plan, and a federal regulatory framework have been created to guide emerging development of marine aquaculture activities in federal waters. NOAA's plan is designed to support the development of sustainable marine aquaculture from 2016-2020.

A variety of genera are being cultured across the latitudinal gradients of the eastern United States. Several different methods are utilized depending on species, water depth, and distance from shore. Aquaculture has the capacity to alter habitats through physical interaction, nutrient cycling, and species composition. Recognizing this, the Atlantic States Marine Fisheries Commission (Commission) produced this installment of the *Habitat Management Series* (*HMS*) with an objective view of estuarine and marine aquaculture practices and their effects on fish habitats. This *HMS* issue does not explore policy, human health, disease, genetics, or other such themes; however, does provide additional resources to further explore aquaculture.

Aquaculture Methods and Their Interactions with Fisheries Habitat

There are many types of aquaculture systems and techniques utilized; the selection of which is dependent upon the species, scale of production, and purpose (e.g., for food or stock enhancement). Marine and estuarine aquaculture operations may have beneficial to detrimental effects on fishery habitats based on the species being cultured, scale, location, culture systems used, and cultivation techniques.

All cultured organisms except plants require food. There are essentially two types of aquaculture based on food requirements: extractive and additive. Extractive aquaculture occurs when no feed is added to the system (e.g., bivalves, algae). Additive aquaculture requires the addition of food to the system (e.g., fish, shrimp). There are three major types of containment devices: those that are focused on the surface or midwater (e.g., floating cages, floating long lines), those that are focused on the bottom (e.g., direct bottom planting, rack and bag culture, mesh stretched on the bottom), and shore based systems (e.g., hatcheries and nurseries). The two types of culture and the three types of containment systems have different potential effects on the system.

Effects of aquaculture can be common across species and methodologies. Anchoring systems that require the use of cables or ropes have the potential to scour the bottom. Rafts, floating cages, long lines, and rack and bag systems can shade the bottom and should not be sited over submerged aquatic vegetation (SAV) beds or other similar habitat. Gear mounted to the bottom such as cages and bags can alter the benthic community. Any concentration of organisms (natural or artificial) may increase deposition rates in the area unless currents or wave action (intertidal) will disperse the accumulation. Because of the greater concentration of organisms per unit of bottom, this accumulation will generally be greater in suspended culture and in food additive systems. Shellfish can locally reduce suspended sediments and phytoplankton standing stock due to their high rate of water filtration. Deposition of feces and pseudofeces may increase levels of nutrients and organic matter in benthic communities. In general, these molluscan cultures remove nutrients from the water and either deposit them on the bottom or release them to the water column. In either case, bacterial mediated recycling occurs. Nutrients stored in the shell or tissue are removed from the system when the organisms are harvested. Similarly, fish or crustacean cultures have the potential to increase sediment nutrient load from the accumulation of excess feed and excrement. These systems differ from the extractive cultures of molluscan shellfish and algae; even with harvest removal, the added food contributes excess nutrients to the system. In all cases, effects are scale dependent and site characteristics are critical for optimal siting.

There are three other critical factors when considering aquaculture: 1) in many cases, the stocks are being cultured on private property, thus many traditional fisheries regulations concerning sizes and harvest may not apply or fit, 2) public health regulationsrequire that molluscan shellfish be grown in the highest quality of water, and 3) the scale of the aquaculture operation relative to the area under consideration needs to be carefully evaluated. Because the type of gear is closely related to the type of culture, the ecological effects below focus foremost on the type of gear and secondly on the food and deposition impacts.

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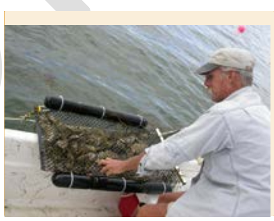
Floating Culture Systems

Net pens, raft systems, floating cages, longlines, and in-water upweller systems are open systems used to cultivate fish, shellfish, and macro algae in the natural environment. Net pens are large mesh enclosures used to confine fish and are anchored in lakes, bays, estuaries, and other bodies of relatively deep water. Raft systems are used in protected waters as a platform for cultivation of molluscan shellfish, chiefly mussels. Floating cages, used for molluscan shellfish, are considerably smaller than net pens and can be deployed at a variety of water depths and intertidal areas. The cages may be individual, but are typically floating systems attached together, end to end, and anchored at the ends of the system. Long lines consist of a main horizontal float line, anchored at each end, which supports various types of gear used to culture a specific species of molluscan shellfish or seaweed (Figure X). The main horizontal float line may be at the water surface or submerged depending on the species or location. Upwellers are a specialized floating container that is used as a nursery system for molluscan shellfish. In an upweller, sometimes called a FLUPSY (floating upweller system), the ambient water is pumped or forced into the system through a mesh bottomed container, across the bivalves, and out the side.


Net Pen (fish)


Floating cage (oyster)


Taylor Floats (oyster)

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US Army Corps of Engineers – Norfolk District

<u>Net Pens</u>

There are two categories of net pens: those floating on the surface with an open top, and those that are completely submerged and entirely enclosed in mesh with the exception of the umbilical which exits the surface. Pen construction typically consists of rigid steel or high-density polyethylene (HDPE) frames which support a net composed of galvanized, plastic, or artificial fiber mesh. Unique to net pen systems is the use of antifouling materials. Net pens are suspended at or below the surface with floats and are anchored to the bottom or attached to associated structures, such as platforms.

Effects: Net pens with their associated anchor systems, and other structures serve as artificial reefs. Addition of these structures provide substrate for settlement and growth of epibiota, and shelter and shade to which fish and invertebrates aggregate. Predators such as seals have been drawn to net pens and have become entangled in the lines and netting. If sited in shallow water, growth and diversity of aquatic vegetation could be negatively affected; shade created by floating structures and anchoring systems can scour the substrate. Because of the added food, the largest impact of net pens is the accumulation of uneaten food, feces and debris fouling below the structure (Rust et. al 2014).

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Cultivation: Net pens are currently used to grow Atlantic salmon. Net pen culture of cobia has been refined in the Caribbean and may be developed to production operations in southern Atlantic states.

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Occurrence: Net pens are currently deployed in Maine and New Hampshire state waters. Florida is developing a regulatory framework for net pen systems. New York has permitted limited striped bass culture. Prohibited in Rhode Island.

<u>*Raft Systems*</u>

Raft based systems are used for water column culture of molluscan shellfish. The raft consists of a series of floats held together by a framing system made of wood, plastic, or metal. There are often a series of stringers across this framing from which lines holding the shellfish (chiefly mussels) are dropped. The raft is held in place by an anchoring system.

Effects: As with other systems, rafts and the associated shellfish act as artificial reefs, providing substrate for settlement and growth of epibiota, and shelter and shade to which fish and invertebrates can aggregate. If sited in shallow water, growth and diversity of aquatic vegetation could be negatively affected; shade created by the floating structure and the anchoring systems can scour the substrate. Because of the added biomass, the largest impact of raft culture is the accumulation of feces, pseudofeces, and debris from the shellfish and fouling organisms below the structure. Nutrients incorporated into the bivalves are removed from the system. The filtration may clear the water and assist in nutrient recycling.

Cultivation: Rafts are currently used to cultivate mussels. There is interest in utilizing either rafts or longline systems (see below) for ear hanging of scallops.

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Occurrence: Currently used in Maine - confirm.

Floating Cages

Floating cages are used to maintain molluscan shellfish near the surface in relatively protected areas; taking advantage of ease of maintenance and warmer water temperatures. The cage system may be a single metal or polyethylene cage, either attached to floats, a dock, or additional cages in a linear fashion. These cage systems are often arrayed so one side is in the air and the other submerged. This configuration allows them to be flipped periodically to control fouling of the cage surface.

Effects: Because floating cage systems are in a linear array, they typically do not add large biomass to the system. Fouling is controlled through flipping and deposition effects are minimal. Anchoring systems can scour the bottom.

Cultivation: Floating cages are most commonly utilized for oyster culture where they can be deployed for nursery or grow-out systems. They have been utilized as nurseries for other species including scallops and clams, but they have been less than ideal for this purpose.

Occurrence: Maine, New Hampshire? Currently occurring in Massachussetts, Rhode Island and Florida.

Longline Suspension Culture

Longline suspension systems are used for culture of molluscan shellfish and seaweed (macro algae). These systems consist of a main horizontal float line anchored at each end. The float line supports various types of gear used to culture a specific species of shellfish or seaweed (Figure X). The main horizontal float line may be at the water surface or submerged depending on the species or location. Common gear types attached to the main float line are dropper lines, lantern nets, sleeves, and bags. Longline systems can be deployed in a wide range of water depth and exposure. Drop lines are a length of rope often used to grow mussels. Lantern nets are cylindrical containers made of nylon netting that are divided into sections and are used to culture scallops and oysters. Sleeves are a mesh cylinder and used to culture mussels. Seaweed is attached to the long line systems after the desired species has been set on a small diameter cord in a land based system. This small cord is then wrapped around a larger rope that is part of the longline system. Because of light requirements, seaweed is cultured near the surface and as the culture grows, additional floats are added. A unique feature of seaweed systems is that they are typically seeded in the fall and removed by spring so they are out of phase with most other culture operations.

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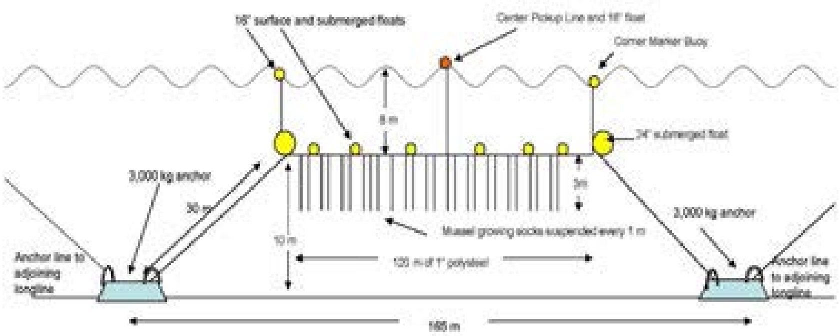

Effects: Longline anchor lines and mooring systems can scour the bottom, and the anchoring systems can displace habitat. As with any system of lines, entanglement of large biota can occur. Depending on system design and depth, shading of submerged aquatic vegetation is possible, and biodeposits can accumulate if longline systems are concentrated into one area. This same concentration of molluscan shellfish and the fouling biota can locally reduce nutrients and phytoplankton. As opposed to the accumulation of wastes, shellfish in suspended culture enhance fish and crab populations on the bottom (Iglesias 1981; Mattson and Linden 1983), and the fouling organisms on the mussel longlines act as a reef and can enhance populations of grazing and predatory fish (Tenore and Gonzalez 1976, Rice 2008). Longline macro algal culture (Flavin et al. 2013) is similar to bivalve shellfish culture, but there have been few studies as to its effects. The seasonal nature of algal culture suggests that other than scour from the gear and potential for entanglement, use of nutrients and habitat formation would be the largest effects, and bio-deposition should be minimal.

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Cultivation: Longline systems are used to cultivate seaweed and shellfish such as mussels, scallops, and oysters.

Occurrence: Longlines are used in Maine, Rhode Island, and Massachusetts. Maine, New Hampshire, Rhode Island, Florida.

Upweller Systems

Upwellers are a floating container that is used as a nursery system for molluscan shellfish. Upwellers have also been designed to work within a floating dock structures. These systems are commonly known as a FLUPSY (floating upweller system), the ambient water is pumped or forced into the system, through a mesh bottomed container, across the bivalves, and out the side. The pump can also be used to evacuate the water, thus allowing water to enter from below. Upwellers can be as small as a single 55 gallon drum or fill an entire boat slip. Most upwellers require relatively calm water and a power source, often associated with docks or marinas. Some have been designed to be anchored in open water take advantage of tidal flow to force the water through the system (Baldwin et al. 1995).

Effects: Upweller systems have not been studied extensively, but because of relatively little biomass, limited fouling, typical marina or near shore location, and seasonal use they are unlikely to have a significant impact. Tidally driven upwellers, if anchored in open water, would have the typical scour impact of any anchored system.

Cultivation: Upwellers are typically used for nursery culture of clams and oysters, thus are mostly seasonal in their use.

Occurrence: Upweller systems are utilized in Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, Virginia, North Carolina, South Carolina and Florida (? Georgia, Delaware? No additional upweller information was obtained from interviews.

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Integrated Multitrophic Aquaculture

Integrated multitrophic systems are based on ecosystem principles by taking advantage of different species' nutritional needs. Species are cultured in the same system where waste products from one species (fish) are recycled as feed or fertilizer for another species (bivalves and/or macro algae). The primary objective is to reduce operational costs by minimizing feed waste, increasing water filtration efficiency, and reducing system size while maximizing the amount and type of species cultured for harvest.

> *Effects:* Although waste products may be reduced, they are still present. Effects of these systems, both positive and negative, resemble those of net pen aquaculture.
>
> *Cultivation:* Mixture of heterotrophs (fish and shellfish) and autotrophs (seaweed) in a combination allows some of waste products to be recycled.
>
> *Occurrence:* Maine, New Hampshire. Virginia (water column lease and bottom lease), Florida (water and bottom lease).

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Benthic On-Bottom Culture

Benthic systems are those that are directly on the bottom and may be in intertidal or subtidal waters. In shallow water the typical installations are rack and bag, intertidal longline, and screen mesh stretched over the bottom. In some cases, cages are also used in shallow waters. A number of other systems are used to catch spat or act as nurseries such as "Chinese hats," stakes and nursery boxes. In deeper water cages, soft bags, and traditional bottom planting are typical. Most of these systems are used for molluscan culture and their use depends on site considerations such as tidal amplitude, protection from severe waves, bottom type, and access.

Rack and Bag Systems

Rack and bag systems are typically intertidal and are constructed of a metal or a HDPE plastic frame with legs that are embedded into bottom sediments. Bags containing the bivalves are placed in mesh bags and attached to the frame. The cultured organisms are washed free of debris, and periodically thinned by separating the growing bivalves into separate bags. These larger individuals are usually placed in larger mesh bags to reduce maintenance. Rack and bag systems often consist of steel rebar rod racks that support and elevate mesh bags off of the bay bottom. These rack systems are typically laid out in rows separated by alleyways (or "lanes") at least as wide as the racks themselves to allow access for tending the structures and the oysters (See Figure XY). For example, in New Jersey, the majority of individual racks currently deployed in the Delaware Bay are approximately 10 feet (3 m) long by 2.5 to 3 feet (76 to 91 cm) wide, though some growers use a 5-foot-long (1.5-m-long) rack. All racks hold plastic mesh bags that are generally wider than the rack (typically three feet [1 m] wide by 20 inches [21 cm] long) with varied size mesh. Over the course of growing a batch of oysters to market size, several sizes of mesh are used

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in this culture system, with progressively larger mesh openings on the bags as the oysters increase in size.

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Effects: A limited number studies of these systems prevents a complete understanding of cage and rack effects on intertidal habitat. Racks can act as refuge for a variety of marine organisms, including the early life history stages of various commercially valuable finfish species (DeAlteris et al. 2004; Tallman and Forrester 2007). Racks can also increase deposition of fine sediment, preventing the growth of submerged aquatic vegetation due to shading. Gear is typically permitted only in areas devoid of seagrass and benthic hard bottom communities. Placement of equipment on tidal flats and shallows may affect substrate stability, sedimentation rates, and erosion. The magnitudes of these effects are related to the system size and design, location, tidal regime, and substrate composition. Biofouling is one of the most prominent issues facing the structural aquaculture industry, particularly growers using rack and bag systems. Growers maintain their product and/or gear almost daily during the peak months, or run the risk of high mortalities due to sedimentation and biofouling (Gaine 2012). Labor costs

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associated with biofouling management on a small to mid-sized Delaware Bay farm (250,000 market oysters) have been estimated at up to 700 man-hours, with equipment and supplies costing up to $2,000 annually (Haskin 2014). The majority of biofouling in Delaware Bay is caused by two marine polychaetes. *Polydora cornuta* (formerly *P. lingi*) are commonly referred to as "mud worms." Mud worms create thick colonies of mud tubes on the exterior of oyster bags, causing suffocation and mortality of oysters (Haskin 2014; Brown 2012). Delaware Bay provides ideal conditions for the settlement of *P. cornuta* due to its high turbidity, high sediment loads, wide intertidal flats, and temperate climate, and the gear used in shellfish aquaculture provides prime settling locations for the worms and their larvae (Haskin 2014). *Polydora websteri,* referred to as "mud blister worms," cause internal shell blisters that create physiological impacts on the oyster, increasing its susceptibility to predators and environmental conditions (Brown 2012). In addition, the market value of oysters affected by mud blister worms is decreased due to the occurrence of unsightly blisters, along with weak shells that make shucking difficult (Brown 2012). Growers use power washer pumps to remove this biofouling, which if low energy areas, can lead to deposition issues on the bottom.

In some important migratory stopover areas, rack and bay culture may potentially impact red knots both directly and indirectly. In a literature review, Forrest *et al.* (2009) found that effects on birds from elevated oyster culture conceivably arise due to the alteration of food sources, displacement from foraging habitat, and as a result of disturbance related to farm activities. Best available science permits a high degree of certainty regarding direct effects of structural aquaculture on red knots. Placement of gear on intertidal flats precludes red knots from foraging in those areas due to the physical presence of the gear because red knots will not or cannot forage under racks, cages, or floats. In addition, structural aquaculture methods require frequent tending by oyster growers, which is likely to disturb red knots attempting to forage or roost in the area during their stopover, thereby impacting the birds' already tight time and energy budgets.

Cultivation: Rack and bag systems are primarily used for culture of oysters.

Occurrence: Widely used along the coast in open and semi-protected areas where there is enough tidal amplitude. Intertidal areas are often selected for ease of access at low tide for maintenance activities. The installations can be susceptible to ice damage and freezing of product during winter months.

Intertidal Longline Systems

A modification of longline systems is used in the intertidal zone. The system is anchored by stakes embedded in the bottom and cages are clipped to the tensioned longline. A modification of this system hangs bags with floats attached on one side off the longline, causing the bags to touch bottom during low tide, but float during higher tide periods. Intertidal

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suspended oyster culture typically involves hanging oyster trays, baskets, or nets of young oysters linked together within intertidal areas. This method may be used in intertidal or even subtidal zones and includes a wide range of practices. Some of the variants of this method include supporting the line by floats or poles, as well as a vast array of containment systems for the oysters. The bags used in this system are similar to those described above, consisting of a durable plastic mesh bags. The bags, lines, and potential arrays that can be created with this generic system are only limited by the local conditions and needs of the grower, with a variety of systems in use throughout other parts of the U.S. east coast (Walton *et al.* 2012). Some systems will use a line supported by poles with each bag having a float attached. As the tide floods, the float lifts and ultimately flips the bag and allows for wave action while suspended at high tide, thereby reducing the fouling levels and maintenance requirements.

Effects: The effects of these systems are similar to that of rack and bag. The longline bags are more narrow, therefore the effects are expected to be less. No comparison studies have been conducted.

Cultivation: Intertidal longline systems are typically used for oyster culture.

Occurrence: Embedding the end stakes sufficiently to take the strain of the tensioned lines can be difficult, particularly in high energy areas. Therefore, this method is used only in a few locations.

Anti-Predator Screen Mesh

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Plastic mesh screening (typically with 6 to 12 mm opening) is spread across the bottom to protect and contain the cultured organisms. These systems are usually the width of the mesh material (10-15 feet) and may be 20 or more feet long. Clams are spread across the bottom and the mesh is embedded directly in the bottom. Depending on the substrate, the mesh may be fringed with leadline that is embedded, held down with rebar or pvc covered rebar, or sand bags. In all cases, the edges are embedded into the substrate to keep out predators. In a modification of the technique used in the Pacific NW, PVC pipe pieces are placed on tidal flats, seeded with clams, and either individually or as a group covered with mesh.

Effects: Because of their extensive use, these systems have received considerable study. While there may be an accumulation of fine sediments under the mesh, the wave action of the intertidal location tends to limit this accumulation. Most studies (Luckenbach, 2016; Vanblaricomb *et al.*, 2015) have shown that the mesh may accumulate algal cover and act as a reef, but few ecosystem level effects have been observed. Harvesting may be by hand rake, suction dredge or other means. Harvesting disrupts the bottom, but because it is a small area relative to its surroundings, it typically recovers relatively quickly (Luckenbach, 2016; Spencer, 1997).

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Cultivation: Protective screening is very common and primarily utilized for clam culture where the cultured organism must be embedded in the sediments and protected from predators such as cownose rays.

Occurrence: This is a widespread method of culture in protected intertidal areas from Maine to Florida.

Nursery Boxes

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In some areas, a screen system modification is used in which lumber planks forming a planting box are embedded to the bottom and covered by a screen mesh.

Effects: Because of the limited number of these systems, there has not been a careful study of their effects. It is likely that the effects would be similar to that of screen mesh systems.

Cultivation: Used in colder regions where clams do not reach a size that would allow planting for grow-out. These nursery systems provide protection for a second season of growth.

Occurrence: Massachusetts.

Spat Attraction Devices

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Spat are a juvenile (or larval) life stage of bivalves, ranging from first settlement up to one year of age. Spat attraction devices are used to obtain wild oyster spat, thus reducing the cost of purchasing seed from a hatchery. Shell bags and “Chinese hats” are two types of spat recruitment methods proposed for use within the action area. Shell bags consist of placing cured shell or cultch (*e.g.*, broken shells, typically oyster shell) into plastic mesh bags and deploying the bags during the oyster spawning season (usually mid-June to early August). Oyster spat set (*i.e.*, attach themselves) on the shell within the bags, and are then transferred to bags and deployed on rack systems or in cages for grow-out. “Chinese hats” are an alternate method for collecting spat. The structure is constructed of 10 to 12 disks or “hats,” spacing rings, a central support, and a locking collar. Once assembled, the stack is dipped in a lime-based cement solution. Oyster larvae are attracted to the lime in the cement coating, while the shape of the hats provides the favorable flow velocities for settlement. Following spat setting, the hats are disassembled and each hat is torqued or twisted to break off the cement. Oyster spat are then transferred to bags and deployed on rack systems or in cages for grow-out. Following seed retrieval in mid- to late summer, spat attraction devices are typically removed from the lease or grant and placed into storage to avoid possible losses from ice and storm damage. These systems are typically in place for only a few months before the spat are transferred to other systems.

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Effects: Because of the limited area and short time span of use there have been no studies on the effects of these systems. Expected effects would be limited, but would probably be an increase in habitat (reef effect) and the potential for some bottom scour.

Cultivation: Oyster spat collection for culture grow out or for resource restoration and enhancement activities.

Occurrence: New Jersey, South Carolina. No additional information on stakes/Chinese hats was obtained during interviews.

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Continuously Submerged Benthic Culture Systems

Subtidal Cages

Cage systems consisting of a metal or HDPVC frames are constructed withseries of slots acting as shelves. Bags, usually of a rigid plastic mesh, containing the cultured species are inserted into the slots. The systems are typically 3 to 4 bags high and 1 to 3 tiers wide. The cages are usually set on the bottom. Bottom cages are typically a 3-foot by 4-foot (91-cm by 122-cm) rectangular shape, ranging in height up to 3 feet (1 m). Cages sit off of the seafloor via small legs spanning the cage's width, providing a clearance of several inches. Cages usually consist of a number of tiers, each tier providing enough space to contain one of the bags described in the rack and bag system, above. These structures are typically made with heavy-gauge vinyl-coated metal and contain multiple full plastic mesh bags. These culture systems are typically placed into subtidal areas and tended by boat. Some growers may choose to place cages in intertidal or shallow subtidal areas to access via land, or may modify this system to limit the number of bags and the weight of the loaded cage. Growers in the Delaware Bay are turning to subtidal cage culture to 1) avoid heavier biofouling rates within the intertidal high salinity areas and 2) lessen the potential for conflict and disturbance of protected species such as the federally listed (threatened) red knot (*Calidris canutus rufa*).

Effects: Cage culture disrupts the bottom in areas where the cage is deposited. This is a temporary effect because the cage must be moved periodically to tend the stock. Cages, either themselves or in combination, create a reef effect and thus cause aggregations of fish and motile invertebrates. As with other bottom gear, the cages should not be used in SAV beds or on live bottom habitat. In some cases - depending on the size and weight of each cage – each subtidal cage may have its own tending line and surface buoy. In large deployed fields of cages, the potential for interactions with protected species grows. Growers must work through the permitting system to obtain federal and state permits that outline scope and scale conditions to minimize this effect. Growers must abide by a number of regulations aimed at addressing and minimizing interactions with protected species.

Cultivation: Cages are usually used for oyster culture.

Occurrence: Massachusetts, New Jersey, Rhode Island and Florida.

Mesh or Soft Bags

Soft bags are a culture system used in shallow subtidal areas for culture or shellfish restoration and enhancement purposes. Mesh bags of a variety of sizes (usually 4'x4') are filled with clams and placed on the bottom as a single bag or in belts of 5 or more. The bag or belt is attached to the bottom with a pvc, rebar or metal staple-like stake in each of the corners. The sediment from the site gradually fills the bag. Nursery bags for small clams may have 3 to 4 mm mesh. Grow-out bags are 9-12 mm mesh.

Effects: Limited studies have examined the effects of soft bags on benthic communities. Similar to other bottom gear bags, soft bags should not be used in areas of SAV or live bottom habitat. There is most likely a reef effect due to the bag structure and fouling which offsets the changed habitat under the bag. Harvesting removes the bag and clams. Given the relatively small area occupied by a single bag, the benthos should recover quickly from lateral movement of local biota.

Cultivation: Soft bag culture is used for clams on the west coast of Florida. It has been attempted at other sites, but often has not been successful.

Occurrence: Florida. Maine, New Hampshire, Massachusetts, Rhode Island.

Bottom Planting

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In many areas of the United States, shellfish aquaculture was first developed when the wild oyster harvesters noticed a decline in natural oyster abundance on wild oyster seed beds or reefs. Oystermen, concerned with this scarcity of market-sized oysters on the natural reefs, began to transplant smaller sized oysters from the natural seed beds onto privately leased areas. Oystermen also planted shell (e.g., crushed or processed sea clam or shucked oyster shell) on both lease and natural areas. This practice is done to elicit settlement of newly recruited oysters onto planted shell. Planting clean shell at the appropriate time to increase recruitment is a cornerstone and consistent aquaculture practice by growers (NJMFA, 2017). This is one of the simplest forms of "traditional" aquaculture by simply planting shell or planting clam seed, and rearing of marine biota on or in any natural underwater lands. This may be in water depths from the intertidal to deeper subtidal. In some instances, the bottom may be "prepared" by planting shell to harden the bottom, removing large objects or flattening the system before the molluscan shellfish are "seeded" onto the bottom.

Effects: Disruption may be caused by bottom preparation, increasing the numbers of cultivated organisms, and increasing filtration. However, there are many positive benefits associated with planting of shellfish by increasing habitat complexity and enhancing filtration and clearance potential of culture areas. Some negative effects of

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this system are those associated with the type of harvest activity. Harvest in shallow areas may be by hand (rakes and tongs) and these effects are temporary. Because of the lower density of cultivated organisms in deeper water, mechanical, hydraulic or suction dredges are used for harvesting. Mechanical harvest can oxygenate sediments and remove fine, organic sediments, thereby improving subsequent bivalve recruitment (Meseck et al., in prep.). Harvest by suction dredge may reduce infaunal abundance by 80%, and recovery of the sediment structure and the invertebrate infaunal communities can take 12 months. In general, the effects of harvest by all gear is usually relatively short in duration. The rate at which sediment restructures and invertebrate recolonization occurs is affected by scale of disruption, frequency of disruption, hydrography, sediment composition, and larval availability (Goldberg et al. 2012, 2014, Constantino et al. 2009).

*Cultivation***:** On bottom techniques are used for hard clams, soft shell clams, mussels and oysters**.**

Occurrence: Maine, New Hampshire, Massachusetts, Rhode Island, Virginia, New Jersey, Connecticut, New York, Virginia, and South Carolina

Land Based Aquaculture

Coastal Ponds

Coastal ponds are natural or constructed in-ground systems that can be used for the culture of fish, shellfish, or algae. Coastal pond design is influenced by site geography, typography, soil, human population density, land use, and water supply.

Effects: Coastal pond systems, as with coastal rivers and creeks, can affect nearby natural fish habitat through discharge. Ponds that are natural systems can be greatly affected by upland development, runoff, and groundwater. Ponds may have excess nutrients that can spur phytoplankton and macro algal blooms. These same conditions limit their use for aquaculture, but some larger systems have been used for shellfish nurseries. Man-made ponds have been designed to cultivate shrimp and fish. These fed systems, due to the added feed, can develop high levels of nutrients; the aperiodic discharges can temporarily increase nutrient levels in the receiving water body. In parts of the world, construction of the man-made systems have destroyed mangroves and salt marshes. Such construction is prohibited in the US.

Cultivation: Estuarine or marine fish, molluscs (oysters), crustaceans (shrimp), algae, and echinoderms (need confirmation for echinoderms).

Occurrence: New England States, North Carolina, South Carolina.

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Raceways are rectangular canals with a unidirectional flow of water. They may be simple in ground channels of plastic liners, sophisticated concrete designs, trays made of fiberglass, or wood coated with fiberglass that are installed on above ground frames. The constant flow of water from end to end may prevent the accumulation of some waste, in addition to facilitating the waste discharge. Raceways may be used in recycling systems, but most are flow through systems, drawing water from a nearby source and discharging the wastewater into the same water body.

Effects: Benefits of raceway systems include higher stock densities and better water quality from the high flow rate; additionally, recirculation systems benefit from filtration technology. In 2004, the Environmental Protection Agency (EPA) implemented regulations[1] for concentrated aquatic animal production (CAAP) with the intent to reduce the potential for eutrophication and pollution in surrounding waters due to discharge of nutrients, pharmaceuticals, chemicals, and toxins. Regulations apply to new and existing facilities that produce more than 100,000 pounds of fish in a year; facilities that directly discharge at least 30 days in a year[2]; and operations that use flow-through, recirculating, and net pen systems. Because shellfish have little biomass, extract nutrients, and use no antibiotics and few chemicals, they have been exempt from most of these regulations. Current CAAP regulations do not include seaweed aquaculture, but seaweed culture on land (raceways, tanks, etc.) has little biomass, extracts nutrients, and rarely uses chemicals, pharmaceuticals or toxins. In all cases, review of facility siting and operational scale is critical.

Commented [MT17]: Does this include shellfish?

Commented [MT18]: This statement is not entirely correct.

The 100,000 pound threshold is for warm water species and triggers effluent limitation guidelines (ELGs). There is a 20,000 pound limit for cold water species that triggers ELGs.

EPA's website states:"Fish farms and hatcheries producing less than 100,000 pounds/year, and other aquaculture systems such as ponds, are not subject to the CAAP Effluent Guidelines, but still require NPDES permits for discharging wastewater. " https://www.epa.gov/eg/concentrated-aquatic-animal-production-effluent-guidelines

I suggest running this paragraph by Kip Tyler at the EPA Region 4 language in Atlanta to ensure it is accurate. Tyler.Kip@epa.gov

Cultivation: Raceways are commonly used in facilities that specialize in captive propagation and rearing of fish and shellfish to larval, juvenile, or adult stages. Atlantic sturgeon, American shad, Atlantic salmon, oysters, clams, bay scallops, and shrimp.

Occurrence: All US states on the east coast (except maybe Georgia - confim). No additional information obtained during interviews.

Commented [MT19]: Recirculating systems for shellfish

Tanks

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Tanks may be of any size and are typically constructed of some form of plastic material, but may be of coated metal, wood covered with fiberglass, or other materials. The shape of a tank may vary from square, rectangular, oblong, or most typically, circular, and the bottom may be flat or conical. Water is usually pumped into the top of the tank and exits through the bottom.

[1] https://www.federalregister.gov/documents/2004/08/23/04-15530/effluent-limitations-guidelines-and-new-source-performance-standards-for-the-concentrated-aquatic

[2] Exemptions - Cold water facilities which 1) produce less than 9.090 harvest weight kilograms (20,000 pounds) of aquatic animals per year or 2) feed less than 2,272 kilograms (5,000 pounds) of food during the calendar month of maximum feeding. Warm water facilities which 1) have closed ponds which discharge only during periods of excess runoff or 2) produce less than 45,454 harvest weight kilograms (100,000 pounds) of aquatic animals per year.

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Effects: The effects of tanks are similar to those of raceways. The systems configuration (static, flow through, recirculation), species cultured (fish, shellfish), stage of culture (larvae, juvenile, adult), scale relative to source, and receiving water conditions are all important factors.

Cultivation: Tanks are commonly used in facilities that specialize in captive propagation and rearing of fish and shellfish to larval, juvenile, or adult stages. Atlantic sturgeon, American shad, Atlantic salmon, striped bass, oysters, clams, bay scallops, and shrimp.

Occurrence: All US states on the east coast.

Table X: Effect of Marine and Estuarine Aquaculture on Natural Fishery Habitats

Aquaculture Method	Effect
Subtidal or water column	
Net pen	• Encourage settlement of epibiota • Attracts and aggregates fish • Impingement • Nutrient enrichment of benthos • Bottom scour • Shading
Cage	• Encourage settlement of epibiota • Attracts and aggregates fish • Shading • Bottom disturbance • Nutrient removal
FLUPSY	• Bottom scour • Nutrient removal
Longline	• Encourage settlement of epibiota • Attracts and aggregates fish • Impingement • Nutrient enrichment of benthos • Bottom scour • Shading • Nutrient removal
Rafts	• Encourage settlement of epibiota • Attracts and aggregates fish • Impingement • Nutrient enrichment of benthos • Bottom scour • Shading • Nutrient removal
Integrated multitrophic system	• Encourage settlement of epibiota • Attracts and aggregates fish

Commented [MT20]: Most of the impacts are neither inherently positive or negative. Which column one lists them depends on perspective, assessment criteria, and scale. I'd suggest listing the effect (not impact) then describe how that impact may be positive and how it may be negative.

Commented [MT21]: For both positive and negative consequences, please identify which are documented and which are conjectural.

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	• Impingement • Nutrient enrichment of benthos • Bottom scour • Shading
Intertidal and shallow water	
Rack and bag	• Encourage settlement of epibiota • Attracts and aggregates fish • Nutrient enrichment of benthos • Shading • Nutrient removal
Longline	• Encourage settlement of epibiota • Attracts and aggregates fish • Impingement • Nutrient enrichment of benthos • Bottom scour • Shading • Nutrient removal
Screen	• Encourage settlement of epibiota • Attracts and aggregates fish • Nutrient enrichment of benthos • Bottom stabilization Nutrient removal
Soft bag	• Encourage settlement of epibiota • Attracts and aggregates fish • Nutrient enrichment of benthos • Bottom stabilization Nutrient removal
Chinese hats and stakes	• Encourage settlement of epibiota • Attracts and aggregates fish Nutrient removal
On-Bottom Planting	• Encourage settlement of epibiota • Attracts and aggregates fish • Nutrient enrichment of benthos • Bottom disturbance (harvest) • Nutrient removal
Cage	• Encourage settlement of epibiota • Attracts and aggregates fish • Nutrient enrichment of benthos • Bottom stabilization • Nutrient removal
Land-based Systems	
Coastal pond	• Point source nutrient discharge
Raceway	• Point source nutrient discharge • Nutrient removal (molluscan shellfish)
Tank	• Point source nutrient discharge

Commented [MT22]: Is this a habitat impact?

Commented [BR23R22]: It's a habitat effect…maybe ?

Commented [BR24]: Not sure I consider this land based. Different than open water, but not land based.

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Potential Side Bar Features

A good side-bar may be the Horn Point Lab in Cambridge, Maryland which produces oyster spat/spat on shell. It has been operated for several decades by the University of Maryland. The oyster spat are used for restoration, stock enhancement for the fishery, and seed stock for the aquaculture industry and academic research.

Common Nearshore Aquaculture Species - Maine to Florida

Currently, a number of marine and estuarine species are cultured in Atlantic coast states. Techniques for culturing the most common species are presented below. A list of aquaculture species among Atlantic coast states is provided in Table Y.

Commented [MT25]: What species are cultured in SC, Georgia, & Florida? From SAFMC doc, "In the South Atlantic region, offshore aquaculture may include the cultivation of macrophytic algae, molluscan shellfish, shrimp, or finfish. … a few live rock aquaculture operations".

Commented [MT26]: ECSGA lists the following reported being produced by east coast shellfish hatcheries: Oysters: eastern, flat Clams: hard, soft shell, surf, sunray, blood ark Mussels: blue, Scallops: bay, sea

Commented [J27]: **I would restrict this to those that are really common. 3 bivalves and 1 fish as listed. The remainder may be locally important, but are not widely cultured. There are a host of species that have limited culture and/or are at the experimental or development stage.**

Northern quahog (*Mercenaria mercenaria*)

Hard clams inhabit the Gulf of St. Lawrence, continuing south to the Atlantic coast of Florida. They inhabit mud, sand, or sand/shell sediments as well as eel grass beds in estuaries and bays (Kraeuter and Castagna, 2001; Peterson and Beal 1989). Hard clams are found in groups ranging from small patches to extensive beds.

Aquaculture techniques: Hard clams are one of the most widely cultured mollusk species along the U.S. Atlantic coast. After hard clams are spawned, larval to post-settlement stages are cultured in a hatchery (Hadley et al.). When clams grow beyond their most vulnerable stages, they are either seeded directly onto sediment or transferred to a growout culture facility. Netting is sometimes placed over young clams in intertidal areas to reduce predation. Wild grown clams are harvested mechanically by hand rake, hydraulic dredge, and suction dredge.

Commented [MT28]: Citation.

Commented [HAJ29]: Complete citation.

Commented [MT30]: Is there a size range?

Commented [MT31]: Is this actually done?

Commented [BR32R31]: Yes – see anti predator screening

Eastern oyster (*Crassostrea virginica*)

Eastern oysters are found along the Atlantic coast from the Gulf of St. Lawrence, south to Florida, and throughout the Gulf of Mexico. They inhabit intertidal and subtidal zones of estuaries, lagoons, tidal creeks, and bays. Eastern oyster seed ("spat") settle on and attach to hard substrates forming large three dimensional structures. Clean oyster shell is the preferred substrate, but other hard substrates such as concrete and clam shell are suitable. Oysters are a keystone species and ecosystem engineers because they form complex, three-dimensional reef structures, filter algae and sediment from the water, and provide nursery, refuge, and spawning habitat for numerous organisms including Commission-managed species (Dame 1996). Wild eastern oyster populations in the Mid-Atlantic region have declined drastically since the early 1900s due to reef removal for navigation, overharvest, disease, and watershed development.

Commented [MT33]: Is (Jenkins et al. 1997) a reference that can be used for this?

Commented [PS34]: Could not find reference to confirm

Aquaculture techniques: Oyster cultivation begins with the use of whole shell (cultch) for spat on shell setting or larvae are set as cultchless oysters (spat). Oysters grown as spat-on-shell are then cultured using on-bottom techniques. Once market size, the oysters are mechanically harvested using a power dredge or tongs. Cultchless spat, referred to as seed, are placed into upwellers until they are large enough or "hardened" to be placed into bags and cages. Cages, floats or rack and bag are the typical culture techniques.

Blue mussel (*Mytilus edulis*)

Blue mussels are found from the Labrador region of Canada to Charleston, South Carolina. Blue mussels inhabit intertidal to sublittoral zones (<100 m) of mesohaline to marine waters; however, blue mussels have been found in deeper, cold water (100 - 500 m) (Theroux and Wigley 1983). Blue mussels use byssal threads to attach to substrate, often in dense clusters within estuaries, sheltered harbors, and exposed rocky shores.

Aquaculture techniques: Production techniques include longline suspension systems and cage orrack and bag systems. Commercial fishermen in New England are developing submerged rope culture in the ocean (NOAA 2007). Offshore demonstration projects are ongoing in New Hampshire and Massachusetts.

Atlantic salmon (*Salmo salar*)

The historical range of North American Atlantic salmon extended from northern Quebec to Newfoundland and to Long Island Sound. Atlantic salmon are anadromous fish that spend 2-3 years in freshwater, migrate to the ocean for 2-3 years, then return to their natal freshwater streams and rivers to spawn. Pressure from fishing in addition to industrial and agricultural development have extirpated most native New England populations. The only remaining native Atlantic salmon populations are in Maine. Restoration efforts throughout New England include stocking, dam removal, and fish passage construction (Oystein et al. 2010).

Aquaculture techniques: Atlantic salmon aquaculture has existed in northern New England since the 19__s. Floating net pen systems are the primary method used in Maine.

Marine Species Cultured

Table Y. Marine species produced by aquaculture, by state. Species with aquaculture potential are italicized.

State	Currently Produced	Primary Types of Facilities
Maine	• American oyster • Atlantic salmon • Blue mussel • European oyster • Hard clam (Quahog) • Softshell clam • Seaweed	• Bottom culture • Closed recirculation systems • Floating cages • FLUPSY • Hatcheries • Integrated multitrophic systems • Longline • Net Pens • Raceways • Rafts • Screen mesh

Commented [MT35]: Maine? If so then just say it.

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Commented [MT36]: What decade?

Commented [MT37]: How are the fish actually grown?

Commented [MT38]: Isn't this the purpose of Table Y?

Commented [MT39]: This table needs a lot of work. The states listed all have aquaculture extension agents through Sea Grant who I'm sure would be happy to provide the information needed to fill out this table completely and accurately. Probably should distribute to state reps to complete (if possible).

Commented [J40]: Someone needs to check each of these species by state and the systems being utilized in the state. Should private (commercial) operations be kept separate from university, state and federal operations?

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Commented [PS41]: Mainly checked for species, not for facility type. Also, the fish species were not mentioned in interview – therefore I removed them from the list.

Commented [MT42]: Seaweed are cultivated on longlines in Maine; mussels are cultivated on longlines attached to rafts

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New Hampshire	• American oyster • Black sea bass • Blue mussel • European oyster • Hard clam (Quahog) • Softshell clam •	• Bottom culture • Floating cages • FLUPSY • Longline • Raceways • Rafts • Screen mesh
Massachusetts	• American oyster • Bay scallop • Blue mussel • Hard clam (Quahog) • Softshell clam • Sugar kelp •	• Bottom culture • Floating cages • Hatcheries • Longline • Nursery boxes • Raceways • Rack and Bag • Rafts • Screen mesh • Submerged cages
Rhode Island	• American Oyster • Bay Scallop • Blue mussel • Hard clam (Quahog) •	• Bottom culture • Floating cages • FLUPSY • Longline • Raceways • Rack and Bag • Screen mesh • Submerged cages
Connecticut	• American Oyster • Bay Scallop • Gracilaria • Hard clam (Quahog) • Sugar kelp	• Bottom culture • Bottom cages • Floating cages • FLUPSY • Hatcheries • Longline • Raceways • Rafts • Screen mesh
New York	• American Oyster • Bay Scallops • Hard clam (Quahog) • Macroalgae • Salmon? • Striped bass (incl. hybrids)	• Bottom culture • Bottom cages • Floating cages • FLUPSY • Hatcheries • Raceways • Rack and Bag • Rafts • Screen mesh • Submerged cages
New Jersey	• American Oyster • Bay scallops • Black sea bass • Hard clam (Quahog) • Horseshoe crabs • Mummichog	• Bottom culture • Bottom Cages • Chinese hats • FLUPSY • Hatcheries • Raceways

Commented [MT43]: Seaweed are cultivated on longlines in Maine; mussels are cultivated on longlines attached to rafts

Commented [MT44]: Seaweed are cultivated on longlines in Maine; mussels are cultivated on longlines attached to rafts

Commented [MT46]: Seaweed are cultivated on longlines in Maine; mussels are cultivated on longlines attached to rafts

Commented [MT45]: Laminaria is sugar kelp
Oysters are grown on bottom and in cages
Clams are grown subtidally on bottom
Seaweed are grown on longlines
I'm not aware of a bay scallop industry in CT

Commented [MT47]: Seaweed are cultivated on longlines in Maine; mussels are cultivated on longlines attached to rafts

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	• Ribbed mussels • Spot • Striped bass (and hybrids) • Surf clams	• Screen mesh
Pennsylvania	• American shad	• Hatchery
Delaware	• American Oyster • Hard clam (Quahog)	• Bottom culture • Floating cages • Screen mesh
Maryland	• American Oyster • American shad • Atlantic sturgeon • Blue crab • Hard clam (Quahog) • Striped bass (and hybrids)	• Bottom culture • Hatchery • Raceway • Screen mesh
Virginia	• American Oyster • Hard clam (Quahog) • Bay scallops	• Bottom culture • Bottom cages • Floating Cages • FLUPSY • Hatchery • Raceways • Screen mesh
North Carolina	• American Oyster • Black sea bass • Hard clam (Quahog) • Mummichogs • Red drum • Red Porgy • Striped bass and hybrids • Summer flounder • Yellow tail	• Bottom culture • Bottom cages • Floating cages • FLUPSY • Hatchery • Ponds
South Carolina	• American Oyster • Hard clam (Quahog) •	• Bottom culture • Floating cages • FLUPSY • Hatchery • Ponds • Screen mesh?
Georgia	• American Oyster • Hard clam (Quahog)	• Bottom culture • Bottom cages • Screen mesh
Florida	• American Oyster • Hard clam (Quahog) • Live rock • Sunray Venus clam ***List is not exhaustive***	• Bottom culture • Floating cages • Raceways • Soft bags • Screen mesh

Commented [PS48]: Not currently expansive, aquaculture relatively new in coastal bays.

Commented [MT49]: This list is intended to be exhaustive.

Commented [BR50R49]: It just means we don't have all we need at the moment.

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- http://www.mdsg.umd.edu/sites/default/files/files/103-Marine%20species.pdf
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Maine

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- Shellfish: http://www.seagrant.umaine.edu/resources-for-shellfish-growers/species/mussel

New Hampshire

- http://www.wildlife.state.nh.us/marine/index.htm

Massachusetts

- http://www.mass.gov/eea/agencies/agr/about/divisions/aquaculture-industry-generic.html

Rhode Island

- http://www.rismp.org/topics/aquaculture/

Connecticut

- Permits: http://www.ct.gov/doag/cwp/view.asp?a=3768&q=259186

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- Brochure: http://www.ct.gov/deep/cwp/view.asp?a=2705&q=431902&deepNav_GID=1622
- Sea Grant: http://seagrant.uconn.edu/whatwedo/aquaculture/gettingstarted.php

New York

- NY mariculture regulations (6NYCRR, Part 48: Marine Hatcheries, On-Bottom and Off-Bottom Culture Of Marine Plant and Animal Life): http://www.dec.ny.gov/regs/4007.html
- Permits: http://www.dec.ny.gov/permits/6084.html

New Jersey

- NJ Aquaculture Innovation Center (Rutgers University): http://aic.rutgers.edu/
- Haskin Shellfish Research Laboratory (Rutgers University): http://hsrl.rutgers.edu/
- NJ Division of Fish and Wildlife: http://www.state.nj.us/dep/fgw/shelhome.htm
- NJ Dept. of Agriculture: http://www.nj.gov/agriculture/divisions/anr/sea/

Delaware

- Aquaculture Resource Center: http://darc.cms.udel.edu/

Maryland

- Coordinating Council: http://www.dnr.state.md.us/fisheries/management/?com=acc
- Oyster: http://www.mdsg.umd.edu/topics/oysters/oyster-aquaculture-and-restoration
- Finfish: http://www.mdsg.umd.edu/topics/finfish-aquaculture/finfish-aquaculture
- Hatcheries: http://dnr.maryland.gov/fisheries/hatchery/?page=aquaculture
- University of Maryland Aquaculture Resource Guide: https://extension.umd.edu/sites/default/files/_docs/programs/aquaculture/ARG_110413.pdf

Virginia

- http://www.vims.edu/research/units/centerspartners/map/aquaculture/index.php
- Shellfish: http://www.mrc.virginia.gov/Shellfish_Aquaculture.shtm
- Regulations for shellfish: http://www.mrc.virginia.gov/regulations/onbottom.shtm

North Carolina

- Marine Aquaculture Research Center: http://www.ncseagrant.org/component/content/article/175-coastwatch-winter-2013/769-a-center-for-growing-seafood-testing-ideas

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South Carolina

- https://www.dnr.sc.gov/marine/mrri/aquaculture.html
- http://agriculture.sc.gov/content.aspx?contentID=558
- Shellfish: http://www.dnr.sc.gov/marine/shellfish/index.html

Georgia

Florida

- http://www.freshfromflorida.com/Divisions-Offices/Aquaculture
- Certificate and Regulations: http://myfwc.com/license/aquaculture-certificate/

Resources: Federal Aquaculture Actions

New England Fishery Management Council

- Amendment 5 to the Atlantic Sea Scallop Fishery Management Plan (FMP) (approved but not implemented)

South Atlantic Fishery Management Council

- Amendment 3 to the Corals and Coral Reefs FMP

Gulf of Mexico Fishery Management Council

- Fishery Management Plan for Regulating Offshore Marine Aquaculture in the Gulf of Mexico

Resources: Federal Aquaculture Policies

Department of Commerce

- 2011 Department of Commerce Aquaculture Policy

NOAA

- 2011 NOAA Marine Aquaculture Policy

South Atlantic Fishery Management Council

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- Policies for the Protection and Restoration of Essential Fish Habitats from Marine Aquaculture

US Fish and Wildlife Service

- Programmatic Biological Opinion of Effects of Existing and Expanded Structural Aquaculture of Native Bivalves in Delaware Bay https://www.fws.gov/northeast/njfieldoffice/pdf/AquaculturePBO_20160401.pdf

Additional Resources: Effects of Marine Aquaculture Practices to Fish Habitats

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Price, C.S. and J.A. Morris Jr. 2013. Marine cage culture and the environment: twenty-first century science informing a sustainable industry. Center for Coastal Fisheries and Habitat Research, National Oceanic and Atmospheric Administration. NOAA Technical Memorandum NOS NCCOS 164. Source: http://www.noaanews.noaa.gov/stories2013/pdfs/2013_PriceandMorris_MarineCageCultureandTheEnvironment(5).pdf

Northeast Ocean Data Portal. Access: http://www.northeastoceandata.org/?page_id=1122

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Background

The Atlantic States Marine Fisheries Commission's (Commission) Habitat Committee (Committee), a branch of the Interstate Fisheries Management Program, was developed to identify, enhance, and cooperatively manage vital fish habitat for conservation, restoration, and protection, as well as support the cooperative management of the Commission and jointly managed species.

In 2016 the Committee identified each state's ongoing practices that address climate change impacts, with a focus on state coastal regulatory planning (Appendix A).

This document builds upon the information gathered in 2016, adding new information since the report was produced, as well as identifying gaps in climate change initiatives among states and providing recommendations for the future. It addresses Strategy 4.6, Task 4.6.2 of the 2017 Action Plan:

4.6 Engage in state and federal agency efforts to ensure climate change response strategies are included in habitat conservation efforts.

4.6.2 Identify gaps in state coastal regulatory planning regarding climate change impacts and make recommendations to increase resiliency.

Summary of State Initiatives that Address Climate Change

From the information gathered in 2016, state initiatives were grouped into eight different categories:

1. Established a working group or legislation to reduce carbon output
2. Established a working group or legislation to respond to climate change threats
3. Produced reports on climate change
4. Assesses and monitors the effects of climate change
5. Has mechanisms in place for collaboration among agencies and other organizations
6. Addresses climate change in planning documents
7. Has responded to climate change on the ground
8. Includes climate change in outreach efforts.

Each state[*] has implemented 1 – 8 of the initiative categories listed above. New Hampshire, New York, New Jersey, and Virginia have practices in place that meet all eight categories. A table of each state's practices can be found in Appendix II (also Figure 1). All states address climate change in their planning documents (Initiative 6), at a minimum in their 2015 State Wildlife Action Plans. All but one are also assessing and monitoring the effects of climate change (Initiative 4). This includes habitat distribution and condition, sea level rise, changes in species distribution and abundance, and more. Twelve out of 14 states have produced reports on climate change (Initiative 3), some of which are regularly updated.

[*] Except Delaware – data not available.

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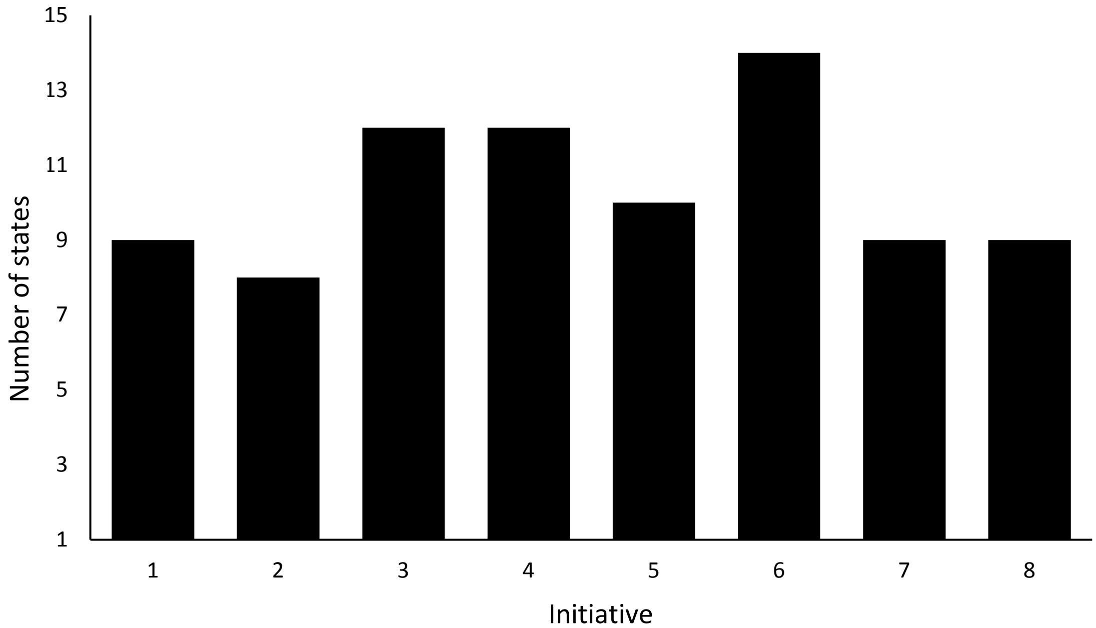

Figure 1. Number of Atlantic coast states carrying out each initiative category. List of categories can be found on page 1.

There is a lot of opportunity regarding initiatives 1, 2, 5, 7, and 8. Only nine of the states have responded to climate change on the ground. Examples of on-the-ground responses that have taken place include installing or working towards offshore wind facilities, encouraging living shorelines during the permitting process, minimizing road crossing impacts on aquatic habitats, and restoring connectivity among habitats. Restoration efforts that promote resiliency, adaptive strategies, and habitat enhancement are also underway. Working groups or legislation to reduce carbon outputs have been created in nine states, and working groups or legislation to respond to climate change threats have been created in eight states. Initiatives range from no action to Maryland's commitment to 100% clean energy by 2050. There is also room for more collaboration and outreach – only ten states work with other agencies or organizations, and nine include climate change in their outreach efforts. Example of outreach that states are conducting include messaging in K-12 and teacher education programs, community preparedness programs, providing guidance on best management practices, and more.

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Recommendations

1. Increase renewable energy production.
2. Increase communication, coordination, and collaboration among federal, state, local, tribal, and nongovernmental organizations.
3. Continue monitoring key climate change parameters and sentinels to assess ongoing effects.
4. Promote the development or modification of regulatory mechanisms so that sea level rise and storm surge flooding are factored into development assessments.

5. Analyze long-term datasets to understand the effects of climate change variables on fishery species.
6. Conduct new research to understand the effects of climate change on fish habitats and species.

Additional Literature and Initiatives

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Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS). 2015. Report to the Secretary of Interior. Washington, DC. https://www.eenews.net/assets/2017/08/17/document_cw_01.pdf

Please see Appendix III for NOAA and US Fish and Wildlife Service climate change initiatives.

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Appendix I 2016 Report on State Climate Change Initiatives

Background

The Atlantic States Marine Fisheries Commission's (Commission) Habitat Committee (Committee), a branch of the Interstate Fisheries Management Program, was developed to identify, enhance, and cooperatively manage vital fish habitat for conservation, restoration, and protection, as well as support the cooperative management of the Commission and jointly managed species. In 2016 the Committee has been focused on Goal 4 of the current Commission Action Plan: to 'Protect and enhance fish habitat and ecosystem health through partnerships and education.'

This document addresses Strategy 4.6, Task 4.6.2 of the Action Plan:

4.6 Engage in state and federal agency efforts to ensure climate change response strategies are included in habitat conservation efforts.

4.6.2 Identify ongoing practices in the state coastal regulatory planning that address climate change impacts.

It contains information on climate change initiatives, as well as links to documents and websites, as reported by each within the Commission's boundaries. This information is the first step towards identifying gaps and making recommendations for improving coastal preparedness and resiliency to climate change.

Maine

In 2013, the State of Maine established the Environmental and Energy Resources Working Group to identify administrative and strategic opportunities to improve Maine's ability to respond and adapt to changing physical conditions in the environment due to climatic influence. The Working Group was led by the Commissioner of the Department of Environmental Protection, and included the Director of the Governor's Energy Office, and the Commissioners of the Departments of Transportation; Marine Resources; Agriculture Conservation and Forestry; and Inland Fisheries and Wildlife. The report, Monitoring, Mapping, Modeling, Mitigation and Messaging: Maine Prepares for Climate Change, presents current programs and activities and contains 32 recommendations. In general, the recommendations are to continue the interdepartmental cooperation; as well as current monitoring, mapping, modeling, and mitigation activities.

The Department of Environmental Protection's Sustainability Division is developing mechanisms for cross agency partnerships, information sharing, efficiencies, and streamlining. These efforts will provide specific and identifiable tools to assist decision-makers. The Adaptation Toolkit, in development, will aid climate adaptation efforts by providing a centralized source to go to for the information one might need for designing and implementing resiliency practices, as well as information on important regulations and standards to integrate into their project or planning

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process, and opportunities to connect with state and other engaged practitioners for technical expertise.

In 2015, The Maine Department of Inland Fisheries and Wildlife collaborated with over 150 public and non-profit Conservation Partner groups (including private landowners, conservation organizations, sporting groups, scientists, and governmental agencies) to draft Maine's 2015 Wildlife Action Plan. The Action Plan addresses the full array of Maine's wildlife across all taxa groups and habitats and identifies 378 Species of Greatest Conservation Need and provides species-specific and habitat-based actions to help prevent further species declines over the next ten years. In an effort to understand which of Maine's species and habitats are most vulnerable to climate change impacts, the Department of Inland Fisheries and Wildlife collaborated with the Manomet Center for Conservation Science and other partners on a climate change vulnerability assessment. The report, Climate Change and Biodiversity in Maine: Vulnerability of Habitats and Priority Species, classifies the vulnerability of the species and habitats to climate change.

The Maine Stream Connectivity Work Group and Maine's Aquatic Resources Management Strategy are working to minimize the impacts of road crossings on Maine's aquatic systems, which are becoming stressed by more frequent and severe storms.

The Department of Marine Resources continues to implement a wide range of fisheries research monitoring activities for stock assessments; however, the time series will also be useful for understanding changing environmental conditions.

The Department of Marine Resources has maintained an Environmental Monitoring Program in Boothbay Harbor for over a century. The observations began in March of 1905 and constitutes one of the longest running, continuous series of sea temperature observations for any point on the North American Atlantic Coast. Currently, observations of air temperature, barometric pressure, sea surface temperature, relative humidity, wind speed, and wind direction are recorded at daily intervals.

New Hampshire

The New Hampshire Fish and Game Department (NHFG) is addressing climate change through four different avenues: planning, science, outreach, and communication.

The NHFG's 2015 Wildlife Action Plan (WAP) Update specifically recognized climate change as a risk factor for both habitats and species. Because of this, species and habitat profiles include their sensitivity to climate change-related parameters, and the weighted risk of those species and habitats in regards to impacts such as sea level rise (SLR), changes in precipitation, increased storm activity, changes to air and sea temperature, etc.

The Great Bay National Estuarine Research Reserve (NERR, part of NHFG) continuously monitors salt marsh distribution and condition along with information about the salinity of pore water and marsh elevation. Over time, this information will help inform if and how SLR is impacting salt marsh health at three sites around Great Bay. NHFG also has detailed habitat maps for Great Bay (and will have them for the whole coastal region by next fall). These are considered baseline maps from which to compare future changes. The NERR is also installing a tide gauge in the southern reach of Great Bay to monitor water level over time. The Sea Level Affecting Marsh Migration Model (SLAMM) was run for all of coastal New Hampshire as a part of the WAP, predicting how salt marsh distribution is likely to change under different SLR scenarios and where there is potential for migration. This information was combined with current condition information to determine where the highest quality marsh is likely to migrate, and where restoration opportunities are likely to be valuable in light of potential SLR.

The Great Bay NERR and NH Department of Environmental Services co-chair the Coastal Adaptation Workgroup – a group of outreach professionals that coordinate to bring the best climate-related science to local communities. Much of this revolves around wise planning to protect both natural and built assets. The Great Bay NERR hosts a Climate Summit each spring (topics this year include: living shorelines, presentations about the WAP, fisheries impacts in the Gulf of Maine, impacts on groundwater along the coast, culvert assessment work, dune restoration, city planning case studies, etc.). NHFG is also incorporating climate-related messages into their K-12 and teacher education programs. This summer they will host a teacher training workshop focused on how protected places can be observed to determine climate-related impacts over time; and the NHFG will be hosting an intern who will be developing a volunteer phenology program for the center.

NHFG has two representatives on the Coastal Risks and Hazards Commission, a state wide legislatively-directed commission that was charged with providing guidance and consistent information to state agencies and municipalities on how to assess and prepare for coastal storms, SLR, and increased precipitation. A draft report and recommendations on "Preparing New Hampshire for Projected Storm Surge, Sea-level Rise, and Extreme Precipitation" has been prepared. Because of the recommendations from the report, each state agency is going to be asked to review its rules and regulations in light of the science and recommendations provided by the commission. The legislation is pending now (2016), and if passed would likely go into effect next year (2017).

Additional Links:
The NH Fish and Game Department's Wildlife Action Plan:
http://www.wildlife.state.nh.us/wildlife/wap.html
The State of New Hampshire website: http://www.nh.gov/climate/
The NH Department of Environmental Services:http://des.nh.gov/organization/divisions/air/tsb/tps/climate/

Massachusetts

In 2008 Massachusetts passed a global warming solutions act to reduce emissions, increase green infrastructure, and to analyze strategies for adapting to predicted changes in climate. The Massachusetts Climate Change Adaptation Report released in September 2011 by the Executive Office of Energy and Environmental Affairs includes an overview of anticipated impacts and key adaptation strategies to increase resilience and preparedness.

Regarding fisheries, Massachusetts sits on the boundary of two biogeographic provinces, the Gulf of Maine and the Mid-Atlantic Bight. The state is already seeing shifts in species range distributions (black sea bass, American lobster, northern shrimp). The Division of Marine Fisheries collects bottom temperature data, every two hours at 60-70 sites across the state. Bottom temperature data is stored in an in-house database containing over 2 million readings dating back as far as 1986 for some sites. The Division of Marine Fisheries also has trawl data back to the 1970's.

In 2007 the mayor of Boston passed an Executive Order Relative to Climate Action, which called for a plan every three years. The first update was produced in 2014 (summary here: http://www.cityofboston.gov/images_documents/Greenovate%20Boston%202014%20CAP%20Update_Summary_tcm3-49733.pdf), and includes a variety of proposals, addressing open space, education, renewable energy, etc.

Rhode Island

In July 2014, the Rhode Island General Assembly approved the Resilient RI Act (RIGL §42-6.2), which formally established the Executive Climate Change Coordinating Council, as well as set specific greenhouse gas reduction targets, and incorporated consideration of climate change impacts into the powers and duties of all state agencies. The Coordinating Council is comprised of Directors and Commissioners from nine state agencies/offices and is supported by an Advisory Board and Science and Technical Advisory Board. It is charged with leading and coordinating state agencies in responding to the challenges posed by climate change in a timely and effective manner, focusing in particular on:

- assessing, integrating and coordinating efforts throughout state agencies to reduce greenhouse gas emissions, strengthen the resilience of communities, and prepare for the impacts of climate change;
- improving our understanding of the effects climate change will have in RI;
- working in partnerships to identify, develop and implement strategies to be better prepared, and reduce risk and losses.

There are several projects underway that will provide information to support future Coordinating Council recommendations. A few coastal related projects include the following. As first step in helping to reduce Rhode Island's greenhouse gas emissions is the completion of the 30 Megawatt Block Island Offshore Wind Project. This will be the first offshore wind project in the country. Located approximately three miles southeast of Block Island, the project which started construction in 2015, is now complete and currently undergoing operational tests. The system is expected to be commercially operational by the end of 2016. The spatial planning and fisheries-related research and monitoring used to guide this work may provide a blueprint for other states and coastal communities.

To assess the effects climate change in Rhode Island the Executive Council's Science and Technical Advisory Board prepared a brief synopsis of the state of knowledge of the following manifestations of climate change: SLR, warming air temperatures, warming water (marine and fresh) temperatures, storm frequency and intensity, biodiversity (changes in species and habitats), and precipitation and inland flooding. The information summarized in this report will assist state agencies, decision-makers, and the public understand the real impacts RI is already experiencing due to a changing climate.

The Coastal Resources Management Council continues work on the Shoreline Change Special Area Management Plan, developing scientifically-based data and tools to aid in coastal hazard adaptation planning. The Management Council has completed revised Shoreline Change Maps for the shout shore communities showing how Rhode Island's shoreline has changed over time due to erosion, and how we might expect it to change in the future. Additional tools and other key resources are available from the website to aid the state and municipalities in supporting sound policy decisions which address coastal erosion, SLR and storm surge inundation problems.

The Department of Environmental Management has also addressed considerations related to climate change throughout the recently updated State Wildlife Action Plan. In short, Wildlife Action Plan reviewed vulnerability assessments for several species of great concern, identified threats to species and their habitats, and proposed actions to reduce these threats. In addition, the Division of Fish and Wildlife's Marine Fisheries Section continues to conduct long-term monitoring programs and collaborate on several local and regional research projects investigating the effects of climate change on managed species and the state's marine resources. State Wildlife Action Plans also have to specifically take into account climate change adaptation. Climate change is primarily in Chapters 1 (species), 2 (habitats), 3 (threats), and 4 (actions to abate threats to species and habitats).

In October 2015, the State Planning Council voted to adopt Rhode Island's new State Energy Plan "Energy 2035" as an element of the State Guide Plan, codifying the Plan as the state's formal long-term, comprehensive energy strategy. The Plan, produced by the Office of Energy Resources in collaboration with the Division of Planning, represents Rhode Island's first data-driven energy planning and policy document. Its vision is to provide energy services across all sectors—electricity, thermal, and transportation—using a secure, cost-effective, and sustainable energy system

In January 2016, the Management Council adopted amendments to Section 145 - Climate Change and Sea Level Rise of the Coastal Resources Management Program to update SLR projections for short-, mid- and long-term timelines of 2035, 2050, and 2100 respectively, as calculated using the current NOAA methodology, and based on the Newport, RI NOAA tide gauge.

In early 2016, OER launched the state's first ever electric vehicle rebate program to support adoption of electric vehicles by Ocean State drivers: Driving RI to Vehicle Electrification (DRIVE). The program made $200,000 available for qualified RI residents interested in purchasing or leasing an electric vehicle to apply for a financial rebate of up to $2,500, based upon vehicle battery capacity. Modeled closely on existing rebate programs offered in other states, DRIVE offers the potential to increase the total number of EVs on RI roadways by 20-35%.

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Connecticut

The Connecticut Climate Change Action Plan was initiated in 2005 with the goal of reducing greenhouse gas emissions to achieve regional goals set by the New England Governors/Eastern Canadian Premiers. The Action Plan addresses quantification of benefits and costs of greenhouse gas reductions using existing analytical measures and a newly developed desktop modeling tool developed under the direction of the Environmental Protection Agency (EPA). As the first state to utilize this new tool, Connecticut was able to identify benefits previously not quantified. To successfully meet the requirements of the Action Plan, a Governor's Steering Committee established working committees at both the agency head and staff level to develop, implement, and track progress on recommended actions.

Additional legislation passed in following years, and complementary to the Action Plan, Connecticut adopted California emissions standards; promoted hybrid fuel cars through tax incentives; set efficiency standards for products and appliances; and promoted the purchase of "Connecticut Grown" foods. A Governor's Executive Order requires the state to purchase renewable energy in increasing amounts, leading to 100% clean energy by 2050. Legislation also simplified the permitting process in ways that encourage implementation of 'living shorelines' in place of shoreline armoring.

Additional monitoring programs include:

Long Island Sound Study Sentinel Monitoring for Climate Change: A multidisciplinary scientific approach to provide early warning of climate change impacts to Long Island Sound ecosystems. This program is conducted jointly by EPA Regions 1 & 2, Connecticut Department of Energy and Environmental Protection, New York Department of Environmental Conservation, and several academic institutions.

Connecticut Institute for Resilience and Climate Adaptation: Established in 2013 under the direction of the Department of Energy and Environmental Protection and the University of Connecticut to conduct research, outreach, and education projects as well as guide the development of technologies and regulatory provisions that increase the protection of ecosystems, coastal properties, other lands, and attributes of the state that are subject to the effects of rising sea level.

New York

New York has an Office of Climate Change within the New York Department of Environmental Conservation that coordinates efforts relating to climate change. The New York State Energy Research and Development Authority developed the Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State report that includes the impacts of climate change and recommendations.

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New York developed a Sea Level Rise Task Force Report in 2009, which includes impacts and recommendations as well. The report led to the 2014 Community Risk and Resiliency Act. This Act:

1) Incorporates state-adopted SLR projections as regulation by Jan. 1, 2016 (Department of Environmental Conservation) and establishes a new 6 New York Community Risk and Resiliency Part 490, Projected Sea-level Rise (Part 490). Part 490 will establish projections of SLR in three specified geographic regions over various time intervals, but will not impose any requirements on any entity.

2) Adds mitigation of SLR, storm surge, and flooding to Smart Growth Public Infrastructure Policy Act criteria and guidance by Jan. 1, 2017 (Department of Environmental Conservation, Department of State).

3) Models local laws to enhance resiliency by Jan. 1, 2017 (Department of Environmental Conservation, Department of State).

4) Considers SLR, storm surge, and flooding in 19 programs (facility-siting regulations, permits and funding) by Jan. 1, 2017 (Department of Environmental Conservation, Department of State), including a checklist on how to consider SLR, storm surge and flooding in permitting decisions.

5) Requires guidance on implementation of the Community Risk and Resiliency Act and the use of natural resiliency measures to reduce risk by Jan. 1, 2017 (Department of Environmental Conservation, Department of State), considering the ability of natural resiliency measures to provide for storm-related and other benefits.

New York also has guidance on flood risk management standards, culvert sizing, living shorelines, nature-based shorelines, and wetland migration. The Office of Climate Change also has a greenhouse gas emissions initiative, which develops caps, performance standards for CO_2 emissions, Climate Smart Communities programs – certifying communities for climate-friendly actions, greenhouse gas emissions targets, and grants to assist in implementation.

The New York State Energy Research and Development Authority conducts environmental research and analysis and provides technical expertise and support to New Yorkers in order to increase renewable energy usage and efficiency. They are currently studying atmospheric deposition and impacts on natural resources. New York also has a Climate Change Science Clearinghouse, which provides New York State-related climate change data and information to inform decision making.

New York is involved in National Estuary Programs and National Estuarine Research Reserve sites, which conduct research monitoring, the results of which are integrated in all climate change management plans and state wildlife action plans, ultimately affecting how we manage resources. Vulnerability assessments are being conducted – these assess at-risk natural

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resources and infrastructure, develop adaptation strategies, support low impact development and green infrastructure, and include wetland migration pathway modeling to advise management decisions.

Finally, New York also has monitoring networks (climate sentinel monitoring projects, sediment elevation tables, water quality, is developing wetland rapid assessments, and conducting marsh loss trend assessments). Restoration efforts support habitat connectivity, large scale wetland restoration, and focus on managing threats to trust species.

New Jersey

There are many efforts underway in New Jersey to mitigate and respond to the impacts of climate change including: substantial investment in clean energy initiatives such as renewable energy production from solar, wind, and geothermal sources; improving energy efficiency; and reducing overall energy use and intensity. In addition, the State of New Jersey has taken significant steps in creating climate change-related community preparedness programs with a focus on resiliency and adaptation efforts at the local and state level. These programs involve strong interaction with local governments at the land use planning level as well as efforts to protect critical infrastructure and ecosystems, and new suites of regulations related to the design of buildings, roads, and bridges (www.globalchange.gov).

Following Superstorm Sandy, New Jersey State Departments and Agencies have incorporated resiliency strategy and planning into every aspect of the recovery process in an effort to rebuild better and more resilient than before. Many of these initiatives will serve to make New Jersey more resilient to the adverse effects of future climate change. Among the initiatives are: beach and dune projects, acquisition of properties in repetitive flood loss areas, energy resilience at critical facilities throughout the State, and actions to address emergency fuel – highlighted during Superstorm Sandy by building resilience in fuel supply and distribution. As part of their long-term recovery strategy, New Jersey has committed to rebuilding by focusing on implementing *resilient* infrastructure projects and mitigation opportunities to prevent future damage, and utilizing construction techniques and materials that will better withstand future weather events. The State will continue to leverage existing federal and state resources to pursue these long-term strategic priorities and empower local governments to revitalize their communities. New Jersey has also focused its efforts on future emergency response programs. For more detailed information, please visit the Governor's Office of Recovery and Rebuilding website at http://nj.gov/gorr/.

The continued development of a long-term comprehensive statewide adaptation plan needs to involve the input and action of many parties, including federal, state and local governments; non-governmental organizations; academia; private industry; and the citizens of New Jersey. Safeguarding New Jersey's residents, its built and natural environment, and ensuring that the State continues to grow in a manner that is both sustainable and resilient to the adverse effects of climate change will require adaptation planning. More information on New Jersey's Adapting to a Changing Environment Program is available at http://www.nj.gov/dep/aqes/adapting.html.

Additionally, Rutgers University formed the New Jersey Climate Adaptation Alliance in 2011 (http://njadapt.rutgers.edu). The Climate Adaptation Alliance is described as *"a network of policymakers, public and private sector practitioners, academics, and NGO and business leaders designed to build climate change preparedness capacity in New Jersey…The Alliance is focused on climate change preparedness in key impacted sectors (public health; watersheds; rivers and coastal communities; built infrastructure; agriculture; and natural resources)."* The ultimate goal of this initiative is to assess climate vulnerability and preparedness needs for critical sectors in New Jersey and to develop capacity for response implementation in New Jersey. One of the important products of the Climate Adaptation Alliance was the development of the New Jersey Climate Adaptation Directory. According to the Climate Adaptation Alliance, *"the directory was created to provide resources that assist in guiding practitioners in New Jersey through the adaptation planning process. This directory brings together geographic data, tools, reports, model policies and ordinances, case studies, and current projects focused on evaluating vulnerabilities and developing and implementing climate change adaptation plans and strategies. The resources included are aimed at professionals in a range of fields, including but not limited to infrastructure, public health, emergency management, hazard mitigation, natural resources, economic development, agriculture, and land use planning."* This resource can be found here: http://njadapt.rutgers.edu/resources/climate-adaptation-directory#.

Pennsylvania

Pennsylvania has two separate fish and wildlife agencies: Pennsylvania Fish and Boat Commission and Pennsylvania Game Commission. The state also has the Pennsylvania Department of Environmental Protection, which is primarily regulatory, and the Department of Conservation and Natural Resources that manages the State Parks and Forests.

The Pennsylvania Climate Change Act of 2008 required the Department of Environmental Protection to produce a report on the anticipated climate change impacts in Pennsylvania and also a Climate Change Adaptation Strategy. Both are to be updated every three years. The original reports were produced in 2009 and have both been updated in 2013 and 2015 (http://www.dep.pa.gov/Business/Air/BAQ/AdvisoryGroups/CCAC/Pages/default.aspx#.VyJQWYLD-po). The report addresses freshwater tidal waterfront on page 197. From the report: Pennsylvania has approximately 56 miles of coastline on the Delaware Estuary that is largely freshwater and home to diverse flora and fauna. This includes approximately 1200 acres of freshwater tidal wetlands. Impacts to these habitats include decreased dissolved oxygen concentrations, SLR, and salinity intrusion. The potential for loss of these wetlands is high if accretion rates do not keep up with SLR. There is a low potential for migration due to development. Further discussion on typical climate change impacts and strategies is extensive in these documents.

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The Department of Conservation and Natural Resources has developed the DCNR and Climate Change: Planning for the Future document describing climate change's current and projected impacts on the state parks and forests, and their approach to adapt to these impacts. The 2015-2025 Pennsylvania Wildlife Action Plan offers a review of threats posed by climate change. This plan includes species with declining or imperiled populations, or with secure populations, but substantial environmental threats, and their habitats. Among the primary climate change information sources in this plan include the Northeast Climate Science Center (Staudinger et al. 2015), and state documents produced by the Department of Environmental Protection. Climate change is identified as a threat to 29.5% (196 species of a total 664) of the Species of Greatest Conservation Need in the plan, which also discusses vulnerability and associated risk of those species and habitats to climate change (2015-2025 Pennsylvania Wildlife Action Plan, Chapter 3, pp. 29-70 and 95-107). The Plan (Chapter 4, pp 85-101) also includes conservation actions to address climate change, including regional (Staudinger et al. 2015) and national adaptation strategies (National Fish Wildlife Plants Climate Adaptation Partnership 2012).

Maryland

Maryland has developed the Climate Change Maryland website to educate citizens about climate change and the actions that the state is taking to reduce its carbon footprint. This program includes participation from over 12 states agencies. It contains information on the Greenhouse Gas Reduction Plan, which was written in 2012 (and updated in 2015) to address the 2009 Greenhouse Gas Emissions Reduction Act. The Greenhouse Gas Reduction Plan's goals are to reduce greenhouse gas emissions by 25% by 2020 by reducing all sectors' (energy, transportation, agriculture, etc.) carbon footprint. It has more than 150 programs and initiatives to address carbon emissions related to energy, construction, fisheries, forestry, etc.

The state also has a two phase plan to reducing Maryland's vulnerability to climate change. Phase I was published in 2008 and addresses SLR and coastal storms. Phase II was completed in 2011 and focuses on building societal, economic, and ecological resilience.

In 2012 the Climate Change and CoastSmart Construction Executive Order was signed to ensure all new and reconstructed state structures have minimal to no flood risk based on improved planning and construction.

Virginia

The Governor's Commission on Climate Change published A Climate Change Action Plan in 2008, which includes the effects of climate change (on the built environment, insurance, natural systems, etc.), recommendations, and commission deliberations. In December of 2014, the state published Virginia Accomplishments Since the 2008 Climate Action Plan Release. According to the executive summary, Virginia has taken many mitigation and adaptation actions in regards to climate change, but these changes were not necessarily in response to particular recommendations or carried out in a coordinated manner. One year later, in December 2015, the Governor Terence R. McAuliffe's Climate Change and Resiliency Update Commission published the Report and Final Recommendations to the Governor, which includes the top five recommendations to address climate change in the state. These include: i.) establishing a climate change and resilience resource center, ii.) creating a new Virginia bank for energy and resiliency, iii.) establishing a renewable energy procurement target for Commonwealth agencies, iv.) adopting a zero emission vehicle program, and v.) leveraging federal funding to make coastal communities more resilient. During the 2016 legislative session Virginia created the Commonwealth Center for Recurrent Flooding Resiliency, a joint venture of Old Dominion University, the College of William & Mary and the Virginia Institute of Marine Science. With an initial budget allocation of $2 million in state support these institutions will work together to provide critical research, policy, and outreach resources to protect natural resources and create resilient communities across the Commonwealth.

North Carolina

In 2015, the North Carolina Coastal Resource Commission Science Panel completed their five-year update of their 2010 Report and the 2012 Addendum as mandated by the General Assembly in Session Law 2012-202. This update incorporated the most recent science and uses a 30-year projection for SLR. The report emphasized the different rates of SLR across the coast of North Carolina. These differences were attributed to subsidence and the effects of water movements within the ocean itself. The panel recommended that the report continue to be updated every five years.

The 2016 update of North Carolina's Coastal Habitat Protection Plan addresses SLR and climatic changes in several locations with recommendations specifically to the protection of wetlands and buffers to help offset the expected rise. The Source Document for the Coastal Habitat Protection Plan, and the Plan itself, can be accessed at: http://portal.ncdenr.org/web/mf/habitat/chpp/downloads.

The Albemarle-Pamlico National Estuary Partnership, through its 2012-2022 Comprehensive Conservation and Management Plan incorporates climatic impacts throughout, but has three actions focused on climate change and SLR. Two actions address the impacts of SLR and climate change on the regional ecosystem as well as supporting research on adapting to those impacts. The third action supports engaging state, regional, and local governments and assisting them with incorporating SLR and climate change into their planning processes.

Both the North Carolina National Estuarine Research Reserve and the U.S. Fish and Wildlife Service have incorporated significant aspects of SLR and climate change research into their strategic plans. With several extensive National Wildlife Refuge systems on North Carolina's coast and four National Estuarine Research Reserve sites in eastern North Carolina, significant research is being done in those locations. Much of the research deals with hydrologic restoration and the study of wetlands and their mitigating impacts on SLR.

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South Carolina

In 2013, the South Carolina Department of Natural Resources compiled a report titled "Climate Change Impacts to Natural Resources in South Carolina." The following two sentences from the report highlight the goal the agency had in writing it: "The Department of Natural Resources is taking a lead role among South Carolina state agencies to advance the scientific understanding of the vulnerability of South Carolina's vital natural resources during an era of changing climate. This will enable the agency, its partners, constituents, and all Palmetto State citizens to avoid or minimize the anticipated impacts while protecting South Carolina's natural resources." The report identifies a number of concerns for the state's natural resources including SLR, ocean acidification, and temperature rise effects. The state has a high proportion of the coastline that is comprised of marshes, barrier islands, and hammock islands. Many of these lands are owned by state and federal entities. The document has various strategies for research and for developing and protecting land to provide for migration.

Other scientists, such as Dr. James Morris from the University of South Carolina, are conducting research evaluating the fate of marshes due to potential SLR. The recent thousand-year rain event in the state and King Tides are raising public awareness of what SLR will probably entail.

Georgia

In Georgia, most of the authority for responding to climate change rests with the local governments. There is not a statewide plan or regulatory measures in place. Their State Wildlife Action Plan, however, does address climate change. With that in mind, there aren't any vulnerability assessments regarding fisheries. NOAA Fisheries Science Centers are working on assessing climate vulnerabilities for many species at the federal level.

Georgia is home to Gray's Reef National Marine Sanctuary, and NOAA is taking a three-pronged approach to address climate change: they are using Gray's Reef as a sentinel site, responding to change through adaptive management, and increasing climate change communication.
Climate change links for Gray's Reef and other National Marine Sanctuaries include:
http://sanctuaries.noaa.gov/science/sentinel-site-program/climate-change-ocean-acidification.html
http://marineprotectedareas.noaa.gov/sciencestewardship/climatechangeimpacts/
http://sanctuaries.noaa.gov/science/sentinel-site-program/grays-reef/climate-change-ocean-acidification.html

Florida

The Florida Fish and Wildlife Commission led a stakeholder summit on Climate Change in 2008. A report was generated in 2009 from this summit entitled "Florida's Wildlife: On the front line of climate change." As a result of this summit and due to the resulting recommendations, the Fish and Wildlife Commission established a Climate Change Oversight Team and developed

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adaptive strategies to address identified climate change threats to fish and wildlife and their habitats. Climate change considerations have been integrated into Florida's State Wildlife Action Plan, and funding has been provided to aquatic habitat projects supporting climate change adaptive strategies, such as living shoreline projects and regional climate change effects mitigation planning efforts. Funding opportunities for aquatic habitat restoration and enhancement projects supported by the Fish and Wildlife Commission ensure evaluation of climate change adaptation in all project proposals submitted. The state follows guidance in Adapting to Climate Change: A Planning Guide for State Coastal Managers, a 2010 report from NOAA.

The Florida Oceans and Coastal Council published The Effects of Climate Change on Florida's Ocean and Coastal Resources in 2009, and updated the report in December 2010. These reports were written for the Florida Energy and Climate Commission and the residents of Florida. The original report included information on the 2007 Intergovernmental Panel on Climate Change Report, the impacts of climate change on Florida's infrastructure, human health, and economy, the effects of the 'drivers' of climate change, and research priorities, while the update focused on SLR effects and research priorities.

Florida has also worked with partner organizations, such as The Nature Conservancy, to implement projects addressing resiliency and plan for coastal climate change. This has been a key focus of south Florida, which is generally recognized as being one of the most vulnerable regions in the Commission management region to SLR. Partners have developed shoreline resiliency and coral reef teams including the Shoreline Resiliency Working Group and Southeast Florida Coral Reef Initiative, which are focused on assessing and addressing the effects of climate change on coastal habitats. The Governor's South Atlantic Alliance recently sponsored (April 2016) a southeast U.S. Living Shorelines Summit in Jacksonville, Florida, which specifically addressed coastal habitat resiliency in the face of accelerated SLR. This effort has resulted in the development of a number of different regional resources, including a living shoreline training academy, which provides managers and the public with a certification in living shoreline design and implementation.

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Appendix II Summary of Climate Change Initiatives by State

(see Excel spreadsheet – will be incorporated into the document in final form)

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Appendix III NOAA and US Fish and Wildlife Service Climate Change Initiatives

NOAA

NOAA Program	Climate Change Initiative Description
Annual NOAA/NCDC State of the Climate Reports	These began in 1991 and can be downloaded from http://www.ncdc.noaa.gov/bams-state-of-the-climate/
NOAA-wide effort	The Third National Climate Assessment (2014). It includes regional chapters, as well chapters for coastal and oceans, ecosystems, and ancillary reports with additional details for some regions and subject areas. http://nca2014.globalchange.gov/report
NOAA Restoration Center, Community-based Restoration Program and Damage Assessment, Remediation and Restoration Program	Restoration project designs consider climate change impacts to both the immediate restoration and long-term stewardship of project sites. E.g., sea level rise impacts
NOAA Restoration Center, Northeast Region	Guidance on flood frequency estimates for resilient infrastructure and stream restoration. The Restoration Center has been studying historical climatic trends in river floods in the Northeast to support the design of fish passage and river restoration projects, and findings have documented increasing flood magnitudes and frequencies in recent decades. They have also developed Planning for Sea Level Rise in the Northeast: Considerations for the Implementation of Tidal Wetland Habitat Restoration Projects (2011)
NMFS Habitat Conservation Division (HCD), Essential Fish Habitat and Hydropower License – Fish Passage Prescriptions	Consider climate change effects on habitats from the action. Includes climate effects on the proposed action that result in adverse effects to habitat
NMFS HCD (GARFO)	Developing a regional climate change guidance document to assist in integrating climate change information in consultation processes
NMFS Office of Habitat Conservation	Climate Smart Habitat Conservation webpage on climate change information with links for Coastal Blue Carbon, addressing sea level rise in salt marsh restoration projects, and other climate-related topics. http://www.habitat.noaa.gov/ourwork/climate.html
NOAA Climate Program Office	U.S. Climate Resilience Toolkit, hosted by NOAA's National Centers for Environmental Information. https://toolkit.climate.gov/. The U.S. Climate Resilience Toolkit includes training materials and guidance documents to assist coastal resource managers in incorporating climate change

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	information into new or existing conservation plans. https://coast.noaa.gov/digitalcoast/training/considering-climate-change
NOAA Coral Reef Conservation Program	Competitive grant program providing funding and coordination for external and internal NOAA activities on shallow-water coral reef conservation, including research on ocean acidification and bleaching
NOAA Chesapeake Bay Office	Program contributes to climate change research, monitoring, resiliency, and adaptation, e.g., research on climate change effects on oysters
NOAA Sentinel Site Cooperative in North Carolina and Chesapeake Bay	NOAA works with regional partners and leverages resources on issues related to climate change, including sea level rise and inundation through coordinated data sharing, monitoring, research, local community capacity building, and adaptation support, which includes habitat conservation
National Fish, Wildlife, and Plants Climate Adaptation Strategy	Office of Habitat Conservation contributed to the development of this broad strategy that includes coastal habitat adaptation needs
NMFS Office of Habitat Conservation, Coastal Blue Carbon	General information on coastal blue carbon, with a number of links for further reading on the subject including research and development and protocol standards. http://www.habitat.noaa.gov/coastalbluecarbon.html
NOAA Living Shorelines Guidance	NOAA's living shorelines webpage contains background and technical information on, as well as examples of, living shorelines: https://www.habitatblueprint.noaa.gov/living-shorelines/; NOAA Fisheries Office of Habitat Conservation's Restoration Center website contains information related to living shorelines: http://www.habitat.noaa.gov/restoration/techniques/livingshorelines.html; NOAA guidance on living shorelines can be downloaded here: http://www.habitat.noaa.gov/pdf/noaa_guidance_for_considering_the_use_of_living_shorelines_2015.pdf
NOAA Regional Coastal Resilience Grant Program	Grants program to support regional approaches that build resilience of coastal regions, communities, and economic sectors to the negative impacts from extreme weather events, climate hazards, and changing ocean conditions. https://www.coast.noaa.gov/resilience-grant/
NMFS Saltonstall-Kennedy Grant Program	$10 million competitive grant program to build resilient coastal communities and sustainable marine resources.
NMFS Northeast Region Fishery Science Center, Ecosystems Dynamics and Assessment Program	Program website includes a comprehensive review of climate change effects on the Northeast Continental Shelf ecosystem. https://www.nefsc.noaa.gov/ecosys/
NMFS Climate Science Strategy and Regional Climate Science Action Plans	Informs NMFS science activities (monitoring, research, modeling, and assessments), including tracking current conditions, providing early warnings and forecasts, understanding the mechanisms of climate impacts, and projecting future conditions, evaluating possible options for fisheries management and protected resources conservation in a changing world
NOAA's Earth Science Research Laboratory,	Climate Change Portal, a web interface that users can access and display climate and earth system model output. https://www.esrl.noaa.gov/psd/ipcc/ocn/

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Physical Sciences Division (PSD)	
NOAA National Oceanographic Data Center, National Centers for Environmental Information, Ocean Climate Laboratory Team	Provides support for the Northwest Atlantic Regional Climatology webpage, providing high-resolution ocean climatology as part of the NOAA-wide Sustained Marine Ecosystem in Changing Climate Project. https://www.nodc.noaa.gov/OC5/regional_climate/nwa-climate/
NOAA's Office for Coastal Management	In collaboration with The Nature Conservancy and ESRI, NOAA developed the Climate Wizard, a web-based interactive mapping platform which provides access to U.S. and global climate change information including historical and projected temperature and precipitation data using different greenhouse gas emission scenarios for two future time periods. http://climatewizard.org/. Digital Shoreline Analysis System is an ArcGIS-based software package jointly developed by NOAA and the U.S. Geological Survey. The software computes the rate of shoreline change using historical shoreline positions represented in a GIS. https://coast.noaa.gov/digitalcoast/tools/dsas.html. The Digital Coast is a sea level rise projection mapping tool. https://coast.noaa.gov/digitalcoast/tools/slr
The National Ocean Service (NOS) National Center for Coastal and Ocean Science	Ecosystem Effects of Sea Level Rise research program provides a suite of science products to inform coastal managers of local coastal vulnerability and solutions to mitigate flood risk.
NOAA's National Centers for Environmental Information (NCEI)	Arctic Regional Climatology Data. https://www.nodc.noaa.gov/OC5/regional_climate/arctic/

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Department of Interior

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DOI Program	Climate Change Initiative Description
US Geological Survey (USGS)	Responsible for climate change science leadership within the Department of Interior
USGS Climate Science Centers and National Climate Change and Wildlife Science Center	Work with natural and cultural resource managers to gather the scientific information and build the tools needed to help fish, wildlife, and ecosystems adapt to the impacts of climate change. https://nccwsc.usgs.gov/
US Fish and Wildlife Service (FWS) The Climate of Conservation in America: 50 Stories in 50 States	State-by-state look at how accelerating climate change is impacting or may impact fish and wildlife across America. https://www.fws.gov/home/climatechange/stories505050.html
National Fish, Wildlife and Plants Climate Adaptation Strategy	National, government-wide strategy to safeguard fish, wildlife, plants, and the natural systems upon which they depend. Led by FWS, NOAA, and New York Division of Fish, Wildlife, and Marine Resources. https://www.wildlifeadaptationstrategy.gov/index.php
FWS Climate Change Strategic Plan	Rising to the Urgent Challenge, Strategic Plan for Responding to Accelerating Climate Change. https://www.fws.gov/home/climatechange/pdf/CCStrategicPlan.pdf

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