# Aquaculture in the New England Region

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Document scope

This document is intended to provide an overview of aquaculture activities in the New England region and information related to their potential effects on NEFMC managed species and habitats. The document also provides an overview of the current aquaculture permitting and authorization process in the region and the review process in place designed to consider and avoid or minimize potential negative effects to NEFMC managed species and habitats. This document briefly summarizes how aquaculture operations may interact with other human activities, including fishing, but does not directly address protected species considerations associated with aquaculture activities. The discussion does not attempt to assess the full benefits and costs of aquaculture against alternate uses.

Activity overview

What is aquaculture?

Aquaculture is defined as the controlled cultivation and harvest of aquatic organisms, including finfish, shellfish, and plants (Goldburg et al. 2001). Another definition is the organized rearing, feeding, propagation, or protection of aquatic resources for commercial, recreational, or public purpose (FAO 2018), with mariculture occurring in nearshore and marine environments. NOAA considers aquaculture to be “the breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all types of water environments” (NOAA 2019). Operations of interest to the Council from the perspective of habitat, fish, and fisheries effects would be considered mariculture, but for simplicity the term aquaculture is used throughout. Enhancement of wild stocks is a close cousin to aquaculture but is outside the scope of this document. To the extent that enhancement requires aquaculture activities to occur, such issues would be covered by the permitting requirements described below.

Species cultured

Currently cultivated species in New England include the Eastern Oyster, Quahog or Hard Clam, Soft Shell Clam, Surf Clam, Razor Clam, Bay Scallop, Blue Mussel, Sugar Kelp, Horsetail Kelp, Steelhead Trout, Atlantic Salmon, Green Sea Urchin, Atlantic Cod, Atlantic Sea Scallop and European Oyster (Table 1). Other species of interest for potential future culture include Black Sea Bass (Centropristis striata), Bluefin Tuna (Thunnus thynnus), Lumpfish (Cyclopterus lumpus), Wolffish (Anarhichas lupus), Striped Bass (Morone saxatilis), and Tautog (Tautoga onitis).

Areas where aquaculture occurs

Aquaculture activities in New England can occur onshore, and in nearshore and offshore waters. For the purposes of this document we only discuss onshore aquaculture activities that utilize flow-through systems with discharge into coastal or marine waters. We refer to nearshore marine aquaculture activities as those that occur in rivers, sounds, estuaries, and other protected or semi-protected environments.
nearshore areas within the Coastal Zone. We refer to offshore aquaculture activities as those that occur in exposed open ocean environments in both the Coastal Zone\(^1\) and Exclusive Economic Zone (EEZ)\(^2\).

**Onshore Aquaculture Activities** in New England primarily consist of hatchery facilities that produce seed and juvenile molluscan shellfish, and to a lesser extent juvenile finfish, for planting on nearshore aquaculture operations for further growout and harvest. Interest in the use of onshore aquaculture systems for all stages of marine fish culture is growing in the U.S. In 2019, two separate companies proposed the construction of multi-million dollar onshore aquaculture facilities for the commercial scale production of Atlantic Salmon in coastal Maine. At the time of this report these permit applications were still under review.

**Nearshore Aquaculture Activities** in New England primarily consist of molluscan shellfish aquaculture sites utilizing bottom planting, off-bottom, and suspended and floating culture methods. There are also a growing number of operations focused on macroalgae cultivation utilizing suspended culture methods in nearshore waters. Many of these activities are co-located on shellfish aquaculture sites. Currently, the only commercial scale nearshore fish culture activities in the region are Atlantic Salmon net pen operations in coastal Maine. Recently, pilot scale net pen systems for the cultivation of Steelhead Trout have been permitted in New Hampshire and Massachusetts nearshore waters. Nearshore molluscan shellfish and macroalgae aquaculture is expected to continue to increase in the region. The potential for significant increases in nearshore commercial scale fish aquaculture production in the region are uncertain. This is primarily due to high summer water temperatures in nearshore waters that can exceed the tolerance for many cultured fish species.

**Offshore Aquaculture Activities** in New England primarily consist of pilot scale research operations culturing molluscan shellfish and macroalgae using suspended culture methods in water depths between 30’ and 200’. Except for a single pilot scale mussel farm located in the EEZ approximately 7 miles off Rockport, Massachusetts, there are currently no offshore aquaculture activities occurring in Federal waters off the New England coast. For a number of years, the University of New Hampshire (UNH) operated an open ocean aquaculture demonstration project that raised halibut, haddock, summer flounder, and Atlantic cod in a submerged pen located in New Hampshire state waters off the Isles of Shoals in approximately 120-180’ of water. That project has since been terminated. UNH recently proposed the deployment of an integrated multi-trophic aquaculture (IMTA) raft system for the cultivation of steelhead trout, sugar kelp and blue mussels near the same location but is still undergoing permitting for the project. Nearby in New Hampshire state waters is Isle of Shoals Mariculture, a commercial shellfish and kelp operation. In Massachusetts and Rhode Island state waters, there have been a small number of offshore mussel and sugar kelp aquaculture operations permitted. Interest in offshore aquaculture activities in both the coastal zone and EEZ has grown in recent years, with interest primarily focused on blue mussel and fish culture. A recent publication from the NOAA Fisheries

\(^1\) The Coastal Zone are the waters that extend seaward to the outer limit of State title and ownership under the Submerged Lands Act (43 U.S.C. 1301 et seq.)

\(^2\) The Exclusive Economic Zone are the waters under federal jurisdiction, which typically extend from 3-200 nautical miles from the shoreline.
Northeast Fisheries Science Center highlighted the environmental suitability for expansion of mussel aquaculture in offshore areas within New England (Mizuta 2019). Currently a request for a permit to expand the existing mussel farm located in the EEZ off Massachusetts from 3 to 20 lines is under review by the U.S. Army Corps of Engineers (USACE).

Table 1. Summary of cultured species, locations, and gear types in New England.

<table>
<thead>
<tr>
<th>Species</th>
<th>New England states where cultured</th>
<th>Typical culture methods</th>
<th>Relative economic importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Oyster <em>Crassostrea virginica</em></td>
<td>ME, NH, MA, RI, and CT</td>
<td>Bottom planting, also floating and off-bottom gear for nursery, intermediate grow out, and growout; nearshore intertidal and subtidal</td>
<td>Major species in most New England states</td>
</tr>
<tr>
<td>Quahog or Hard Clams <em>Mercenaria mercenaria</em></td>
<td>MA, RI</td>
<td>Nursery rearing floating, with in sediment planting under nets; nearshore intertidal and shallow subtidal</td>
<td>Secondary species in MA, RI, ME, CT</td>
</tr>
<tr>
<td>Soft Shell Clams <em>Mya arenaria</em></td>
<td>MA, RI, ME</td>
<td>Planting under nets, nearshore intertidal</td>
<td>Lesser species in MA, ME, and RI</td>
</tr>
<tr>
<td>Surfclam <em>Spisula solidissima</em></td>
<td>MA</td>
<td>In sediment, while preventing escape, nearshore intertidal</td>
<td>Pilot scale in MA</td>
</tr>
<tr>
<td>Razor Clam <em>Ensis directus</em></td>
<td>MA, RI</td>
<td>In sediment, while preventing escape, nearshore intertidal</td>
<td>Pilot scale in MA, lesser species in RI</td>
</tr>
<tr>
<td>Bay Scallop <em>Argopecten irradians</em></td>
<td>MA, RI</td>
<td>Off-bottom or suspended in lantern nets or cages, nearshore intertidal and offshore subtidal</td>
<td>Lesser species in MA and RI</td>
</tr>
<tr>
<td>Blue Mussels <em>Mytilus edulis</em></td>
<td>MA, RI, NH, ME</td>
<td>On-bottom or lines suspended from submerged arrays or dropped from moored rafts; offshore subtidal</td>
<td>Pilot scale in MA, lesser species in RI with one large farm</td>
</tr>
<tr>
<td>Sugar Kelp <em>Saccharina latissima</em></td>
<td>RI, NH, ME, CT, MA</td>
<td>Lines suspended from submerged arrays or dropped from moored rafts; nearshore subtidal and offshore subtidal</td>
<td>Secondary species in RI and MA</td>
</tr>
</tbody>
</table>
## Species

<table>
<thead>
<tr>
<th>Species</th>
<th>New England states where cultured</th>
<th>Typical culture methods</th>
<th>Relative economic importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horsetail Kelp <em>Laminaria digitata</em></td>
<td>RI</td>
<td>Lines suspended from submerged arrays or dropped from moored rafts; nearshore subtidal and offshore subtidal</td>
<td>Lesser species in RI</td>
</tr>
<tr>
<td>Steelhead Trout <em>Oncorhynchus m. irideus</em></td>
<td>NH, MA</td>
<td>Inland hatchery and then transferred to suspended ocean pens; onshore, nearshore subtidal, and offshore subtidal</td>
<td>Pilot scale in MA</td>
</tr>
<tr>
<td>Atlantic Salmon <em>Salmo salar</em></td>
<td>ME</td>
<td>Inland hatchery and then transferred to ocean net pens; onshore and nearshore subtidal</td>
<td>Primary species in ME</td>
</tr>
<tr>
<td>Pacific White Shrimp <em>Litopenaeus vannamei</em></td>
<td>NH, MA</td>
<td>Land-based recirculating aquaculture system</td>
<td>Pilot scale in NH, commercial operations in MA</td>
</tr>
<tr>
<td>Green Sea Urchin <em>Strongylocentrotus droebachiensis</em></td>
<td>ME</td>
<td>Hatchery-reared seed; grow out via sea cages, sea ranching, or land-based tank systems</td>
<td>Experimental work in ME</td>
</tr>
<tr>
<td>European Oyster <em>Ostrea edulis</em></td>
<td>RI</td>
<td>Similar methods to Eastern Oyster</td>
<td>Limited number of growers</td>
</tr>
<tr>
<td>Atlantic Cod <em>Gadus morhua</em></td>
<td>ME</td>
<td>Nearshore Netpen</td>
<td>Previous experimental work in ME 2004-2010</td>
</tr>
<tr>
<td>Atlantic Sea Scallop</td>
<td>ME</td>
<td>Wild spat collection, nursery culture, and then grow out in bottom cages, pearl nets, lantern nets, suspension cages, or by hanging from lines<a href="#">^3</a></td>
<td>Interest in other NE states as well</td>
</tr>
</tbody>
</table>

### Aquaculture permitting and authorization process in New England

This section provides an overview of the federal and state aquaculture permitting and authorization process in the New England region, highlighting places in the permitting process where opportunities exist for input on concerns related to adverse effects to NEFMC managed species and habitats from proposed aquaculture activities.

[^3]: Morse et al. (2006)
The marine aquaculture permitting process is complex. The specific federal and state agency permits and authorizations an aquaculture project proponent may be required to obtain can vary significantly based on factors such as the species intended to be cultured, the location where the project is proposed, and the scale of the project. Generally, the review and permitting of projects proposed within the EEZ are initiated at the federal level and the review of projects proposed in the coastal zone are initiated at the state level. There are many similarities between the factors state and federal agencies consider when reviewing proposed aquaculture activities and often a high level of coordination between agencies. One important distinction between federal and state authorizations is that, unlike state licenses/or leases which generally grant exclusive use to the cultured organisms within a defined area, federal agencies cannot issue licenses for aquaculture and only provide permits for the construction and operation of aquaculture facilities.

**Federal agency aquaculture permitting and authorization**

The specific federal agency permits and authorizations an aquaculture project proponent may be required to obtain generally vary based on the type of operation. The majority of aquaculture projects in New England will be required to obtain a permit from the USACE under Section 10 of the Rivers and Harbors Act of 1899 for the placement of culture gear or “structures” in the water. A small number of aquaculture activities that involve the placement of fill (shells or other material) may also be required to obtain a permit from USACE under Section 404 of the Clean Water Act. Some aquaculture activities proposing the discharge of pollutants may also require a National Pollutant Discharge Elimination System (NPDES) permit from the U.S. Environmental Protection Agency (or delegated state agency) under Section 402 of the Clean Water Act. A NPDES permit is required for aquaculture activities that fall under the EPA criteria for Concentrated Aquatic Animal Production Facilities (CAAP). CAAPs generally include aquaculture operations used to rear fish or other aquatic animals which occur in both onshore facilities (hatcheries and land-based fish production systems) and open water facilities (net pens and submerged cages used for fish culture) and meet specific feeding and production thresholds.

USACE and EPA permits each have specific requirements that must be incorporated into the construction and deployment phases of an aquaculture project, as well as day-to-day operation and maintenance activities. Some requirements will apply to all aquaculture operations, while others may be specifically tailored to individual operations. Other federal agencies, such as the US Food and Drug Administration (FDA) and the US Department of Agriculture (USDA), also have oversight of aspects of aquaculture activities such as the use of drugs, pesticides, and biologics and animal health considerations. These agencies have established regulations related to the approval of drugs, pesticides, and biologics used on aquatic animals as well as regulations associated with the source and health of cultured aquatic animals.

**Project review**

While the review of projects proposed in the coastal zone are generally initiated at the state level, projects proposed within the coastal zone are required to obtain both state and federal agency authorization prior to operation. Projects proposed in the EEZ are only required to obtain federal agency
permits; however, abutting coastal states that can demonstrate a potential coastal effect from a project proposed in the EEZ can request to review federal permit applications under their federal consistency authority granted through the Coastal Zone Management Act (CZMA). Thus, both state and federal agencies are involved with project review at some level, regardless of where they occur.

Beyond the CZMA, federal permitting agencies also coordinate compliance with other related federal laws as part of the review and authorization process. If a federal permitting agency determines a proposed project may have an adverse effect on certain public interests as outlined by federal law, they are required to consult with the federal agencies responsible for the implementation of those laws prior to issuing permits (Table 2). This includes consultation with NOAA Fisheries Greater Atlantic Regional Office (GARFO) about projects that may have an adverse effect on areas designated as Essential Fish Habitat (EFH) under the Magnuson-Stevens Fisheries and Conservation Act (MSA). A summary of the federal laws that federal permitting agencies are required to consider and the associated consultation requirements with each are summarized in Table 2. The EFH consultation process is described in greater detail below.

In addition to coordination with federal and state agencies, federal permitting agencies also are responsible for coordinating opportunities for public comment on permitting actions. USACE and EPA each have general requirements related to the timing and extent of public comment opportunities and the level of public review an individual aquaculture project will be required to undergo to obtain permits. While there are similar requirements built into the state agency review process, due to the need for federal permits and authorizations for aquaculture projects proposed in the Coastal Zone and the EEZ, and the nexus between federal permitting actions and consultation with NMFS under the MSA, it is during the federal permitting and authorization process where formal opportunities for input from the NEFMC and fishing communities/stakeholders on potential impacts to NEFMC species and habitats primarily occur. Some projects deemed to have significant impacts must receive expanded review under the requirements of the National Environmental Policy Act (NEPA) prior to the issuance of federal agency permits. We describe the NEPA process in greater detail below.
Table 2. Federal agency review of aquaculture projects and relevant applicable laws.

<table>
<thead>
<tr>
<th>Consultation or Review</th>
<th>Description of the Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endangered Species Act</td>
<td>Section 7(a)(2) of the ESA requires federal agencies to consult with the NOAA Fisheries, the U.S. Fish and Wildlife Service, or both, before taking any action that may affect an endangered or threatened species or their critical habitat to insure their actions are not likely to jeopardize any listed species or result in the destruction or adverse modification of designated critical habitat.</td>
</tr>
<tr>
<td>Magnuson-Stevens Fishery Conservation and Management Act</td>
<td>The EFH provisions (305(b)(2)) of the MSA require federal action agencies to consult with NOAA Fisheries on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH. As part of the EFH Consultation process, federal action agencies must prepare a written EFH Assessment describing the effects of that action on EFH (50 CFR 600.920(e)(1)). NOAA Fisheries issues conservation recommendations to the action agency based on this assessment.</td>
</tr>
<tr>
<td>National Historic Preservation Act</td>
<td>Section 106 of the National Historic Preservation Act (36 CFR Part 800) requires any federal agency issuing a permit to account for potential effects of the proposed aquaculture activity on historic properties, e.g., shipwrecks, prehistoric sites, cultural resources. If a proposed aquaculture activity has the potential to affect historic properties, these details must be provided by the applicant as part of the application package.</td>
</tr>
<tr>
<td>Fish and Wildlife Coordination Act</td>
<td>The Fish and Wildlife Coordination Act requires any federal agency issuing permits to consult with the U.S. Fish and Wildlife Service and NOAA Fisheries if the proposed aquaculture activities could potentially harm fish and/or wildlife resources. These consultations may result in project modification and/or the incorporation of measures to reduce these effects.</td>
</tr>
<tr>
<td>National Marine Sanctuaries Act</td>
<td>Section 304(d) of the National Marine Sanctuaries Act (NMSA) requires any federal agency issuing permits to consult with NOAA’s National Marine Sanctuary Program (NMSP) if the proposed aquaculture activity is likely to destroy or injure sanctuary resources. As part of the consultation process, the NMSP can recommend reasonable and prudent alternatives. While such recommendations may be voluntary, if they are not followed and sanctuary resources are destroyed or injured in the course of the action, the NMSA requires the federal action agency(ies) issuing the permit(s) to restore or replace the damaged resources.</td>
</tr>
<tr>
<td>Consultation or Review</td>
<td>Description of the Requirement</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Marine Mammal Protection Act</td>
<td>The Marine Mammal Protection Act (MMPA) prohibits take, including the harassment, hunting, capturing, or killing of marine mammals, except under certain circumstances. Section 118 establishes the Marine Mammal Authorization Program (MMAP), which provides an annual exemption for the incidental take of a non-endangered and non-threatened marine mammals in a commercial fishing operations having frequent or occasional interactions with marine mammals (listed as Category I and Category II fisheries under the List of Fisheries, LOF, which is published annually and is available on the NOAA Fisheries website and in the Federal Register. To be eligible for the exemption, any commercial vessel or non-vessel gear (e.g., aquaculture facilities) engaging in a Category I or II fishery must obtain a MMAP certificate from NOAA Fisheries. The MMAP does not allow for directed take or harassment of marine mammals. This Certificate must be present on the fishing vessel or on the person during fishing operations at all times. The MMAP also requires that permit holders carry an observer during fishing operations if requested, and that they adhere to all other applicable Take Reduction Plan regulations. Regardless of Categorization (I, II, or III), commercial fisheries must report every incidental death or injury of marine mammals that results from commercial fishing operations (including aquaculture) within 48 hours of returning to port.</td>
</tr>
<tr>
<td>National Environmental Policy Act</td>
<td>NEPA requires federal agencies to prepare either an Environmental Impact Statement (EIS) or Environmental Assessment (EA) for any federal action affecting the quality of the human environment, unless it is determined the activity is categorically excluded from NEPA.</td>
</tr>
<tr>
<td>Coastal Zone Management Act</td>
<td>CZMA encourages coastal states to develop and implement coastal zone management plans as a basis for protecting, restoring, and establishing a responsibility in preserving and developing the nation’s coastal communities and resources. Coastal states with an approved coastal zone management program are authorized to review certain federal actions affecting the land or water uses or natural resources of its coastal zone for consistency with its program. Under the CZMA, a state may review: activities conducted by, or on behalf of, a federal government agency within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone; an application for a federal license or permit; and any plan for the exploration or development or, or production from, any area that has been leased under the Outer Continental Shelf Lands Act for offshore minerals exploration or development. The CZMA requires federal agency activities to be consistent to the maximum extent practicable with the enforceable policies of a state’s approved coastal zone management program.</td>
</tr>
</tbody>
</table>
**EFH consultation**

If EPA or USACE determines during the permitting and authorization process that a proposed aquaculture project may result in adverse effects to EFH, they must prepare a written EFH Assessment describing the effects of the activities on EFH (50 CFR 600.920(e)(1)). The level of detail required in an EFH Assessment is commensurate with the complexity and magnitude of the potential adverse effects of the action, 50 CFR 600.920 (e)(2). For example, assessments for relatively simple actions that may adversely affect EFH are generally brief. Actions that may pose a more serious threat to EFH, or that involve a more complex range of potential adverse effects, justify a correspondingly more detailed EFH Assessment that includes information, such as an analysis of alternatives, the results of on-site inspections, literature reviews and the views of recognized experts.

NOAA Fisheries biologists (GARFO in this region) review the EFH assessment and provide conservation recommendations to federal agencies on means to avoid, reduce, or offset these adverse effects. These conservation recommendations are intended to be included on federal agency permits as special conditions or integrated into the project plans, as appropriate. Conservation recommendations may include provisions for the use of turbidity and erosion controls, time of year (TOY) restrictions, or other specific criteria to minimize adverse impacts on EFH.

**National Environmental Policy Act (NEPA) review**

While all permitting actions that the EPA or USACE determine may result in adverse effects must undergo some level of agency consultation and public review, the National Environmental Policy Act lays out specific requirements for permitting agencies when they anticipate that an action could significantly affect the quality of the human environment. If a determination of significance is made, the agency must document its consideration of those impacts in an environmental impact statement (EIS). If the impacts are uncertain, an agency may prepare an environmental assessment (EA) to determine whether a finding of no significant impact could be made or whether an EIS is necessary. In some cases, federal agencies can determine the level of analysis they will be required to undertake based on how the activities compare to past agency actions or during pre-permitting discussions with partner federal agencies. In other cases, the determination is made after an application is submitted based on considerations raised during the project review process by the permitting agency, the public, and/or consulting agencies.

If more than one federal agency authorization is required, such as in the case of fish aquaculture activities requiring both a Section 10 permit from USACE and a NPDES permit from EPA, a lead agency may be designated to undertake the NEPA review process.

**New England state agency permitting and authorization**

The specific state agency review and permits required for aquaculture projects within the coastal zone varies between the New England states. In some cases, states have developed joint federal/state permit applications for aquaculture activities and the state and federal review process is conducted concurrently under a single application.
Maine
The Maine Department of Marine Resources (MEDMR) issues experimental and standard leases. Applications are available online (MEDMR 2016). Experimental leases are up to 4 acres in size and may be issued for a 3-year term. Standard leases may be up to 100 acres in size and may be issued for a 20-year term. Applications for leases with no discharge (most species other than finfish) require the submission of an environmental characterization that describes the bottom characteristics, resident flora and fauna, tide levels, and current speed and direction. Applications for leases with a discharge into state waters (i.e. feeds, therapeutants, etc.) must also conduct a Department-approved environmental baseline to serve as a benchmark for monitoring the physical and ecological effects of farms on sediments, marine organisms and water quality of the site as a result of the operation. Those applicants must also consult with the Maine Department of Environmental Protection (MEDEP), who administers the NPDES permit program in Maine.

Experimental lease applications have a 30-day public comment period where members of the public and other stakeholders can provide written feedback on the proposal or request a public hearing. All standard leases have a public hearing. Public notices of lease proposals are posted to MEDMR’s website (https://www.maine.gov/dmr/aquaculture/leases/index.html) and include instructions on how to participate in the leasing process. After the public comment period and/or public hearing, MEDMR renders a final decision on the proposal based on lease criteria specified in statute. These criteria include impacts to navigation, commercial and recreational fishing, marine flora and fauna, and other applicable considerations.

New Hampshire
Aquaculture licensing and enforcement in New Hampshire are conducted by the New Hampshire Department of Fish and Game (NHF&G). The NHF&G will conduct a site assessment to characterize the benthic substrate, fish utilizing the area, aquatic plants, and other activities occurring (recreational or commercial); they will also measure tidal information and flow rate. A shellfish certificate through the Department of Health and Human Service is also required for aquaculturists (NHF&G 2020).

Massachusetts
Coastal municipalities manage aquaculture in Massachusetts in partnership with the Division of Marine Fisheries (MA DMF). There is variation by municipality with regards to acceptance of aquaculture and the process for the issuance of licenses (MA DMF 2019). The primary aquaculture activity is shellfish aquaculture, and there are no commercial scale finfish operations in Massachusetts state waters to date. Local regulations for shellfish aquaculture differ by municipality and include restrictions on size of site and residency requirements. Site licenses are issued by municipalities and certified by MA DMF. As part of the license certification process, MA DMF conducts a site assessment to characterize the benthic substrate, fish habitats, submerged aquatic vegetation (SAV), and other activities occurring in the area (recreational or commercial). In addition to the site license certification, applicants are required to have an aquaculture permit through the MA DMF to possess or propagate shellfish, as well as a commercial harvest permit to sell shellfish. Other local, state, and federal environmental permits must also be
applied for. MA DMF requires that aquaculture areas be at least 25 feet from eelgrass and not contain significant numbers of shellfish (MA DMF 2019). Permits are available online (MA DMF 2020), with a full description of shellfish aquaculture permitting in Massachusetts available online at https://www.massaquaculturepermitting.org.

Rhode Island

The Rhode Island Coastal Resources Management Council (CRMC) orchestrates the permitting process for aquaculture leases in Rhode Island. CRMC conducts an independent site assessment to determine if eelgrass or SAV are present, and to establish what density of shellfish are present in the lease area (CRMC 2020). Similar to Massachusetts, aquaculturists are also required to have an aquaculture permit (allowing them to possess shellfish) and a dealer permit (if they intend to sell shellfish to consumers directly) from the Rhode Island Department of Environmental Management (RIDEM 2020). The final permitting decision is made by the CRMC since they have jurisdiction over all state waters. Currently, finfish and land-based aquaculture are not legal in Rhode Island. Towns, harbor commissions, the Rhode Island Fisheries Management Council, the Department of Environmental Management, and the public provide input early in the scoping process and the Council weighs that information in their decision. RIDEM provides a free mapping tool to assist applicants in siting aquaculture and avoiding habitat impacts where possible: https://ridemgis.maps.arcgis.com/apps/webappviewer/index.html?id=8beb98d758f14265a84d69758d9674f.

Connecticut

In Connecticut, there is a statewide review of lease applications in municipal waters; leasing of aquaculture sites is done by both municipalities and the state. The state, through the Department of Agriculture, Bureau of Aquaculture (DA/BA), has issued large state shellfish leases, while municipalities have issued many smaller leases in town-managed waters. A State Jurisdiction line separates shellfish harvest areas that are under the exclusive jurisdiction of the state (DA/BA) from areas under town jurisdiction; there is no jurisdiction line for seaweed harvest areas. Generally, the Bureau of Aquaculture consults with the Connecticut Department of Energy and Environmental Protection, USACE, and local shellfish commissions when projects are in town waters. Town officials can authorize a space for aquaculture in town waters, but the state still bears statutory responsibility to ensure consistency with shellfish and harbor management plans, as well as to conduct an environmental impact statement. Aquaculture sites are prohibited within 25 feet of submerged aquatic vegetation and salt marsh (Getchis et al. 2019). The State of Connecticut provides an advanced Aquaculture Mapping Atlas for planning purposes: https://cteco.uconn.edu/viewer/index.html?viewer=aquaculture.

Potential impacts of aquaculture activities on NEFMC-managed species and their habitats

The following summary provides information that has been documented on the potential impacts, both negative and positive, posed by aquaculture activities to NEFMC managed species and EFH, and includes
references to various best management practices (BMPs) and the aforementioned regulatory framework used to safeguard coastal resources. It is important to note that the science of marine aquaculture is advancing rapidly and new information and techniques are emerging that can help to improve the understanding of the effects of aquaculture on the environment, including the best means to mitigate negative effects and bolster positive effects. This summary is not an exhaustive literature review of scientific information on this complex topic. Rather, it is a synthesis of relevant information intended to provide the NEFMC and partners with a general understanding of the environmental effects of marine aquaculture of importance to the interests of the NEFMC.

Summary of impacts

The impacts of aquaculture activities on NEFMC-managed species and their habitats can be positive, neutral, or negative, primarily depending on the system used, the species being cultured, the ecological setting, and the experience level of the operators. For example, excess nutrients, organic matter, and suspended solids from finfish aquaculture effluents can exacerbate eutrophication in nearshore receiving water bodies when nutrient inputs exceed the capacity of natural dispersal and assimilative processes. On the other end of the spectrum, some forms of aquaculture have been used to mitigate eutrophication by sequestering nutrients in nearshore waters (e.g., shellfish and algae culture). In some cases, evaluating whether the impacts from aquaculture activities on EFH will be positive or negative is more complicated. Further, many of the effects are interrelated and can lead to indirect effects on managed species and other ecosystem components. Therefore, the positive and negative effects of aquaculture activities to fisheries and EFH need to be considered concurrently when attempting to provide informed input on proposed aquaculture projects.

Positive impacts

Positive impacts of aquaculture operations include carbon and nutrient sequestration, acidification regulation, improved water clarity, coastal protection, and habitat provisioning (Gentry 2019). The majority of these are associated with shellfish and algae aquaculture, however habitat provisioning associated with equipment used for marine fish culture is widely documented (Gentry 2019). In general, shellfish and algae aquaculture has positive impacts on EFH, providing ecosystem services and habitat related benefits in the estuary including mitigation of land-based nutrients and increased habitat for fish, shellfish, and crustaceans (Shumway 2011).

- Bivalves sequester nutrients from the water column for shell and tissue formation. Both bivalve and algal culture can help reduce eutrophication through the uptake of nutrients, and bivalve aquaculture can help improve water quality through filtration and grazing (Cerco and Noel 2007, Rose et al. 2015). Thus, bivalve and algal culture can control phytoplankton bloom intensity in shallow waters (Gallardi 2014) and may present a viable strategy to mitigate eutrophication caused by agricultural and residential runoff (Petersen et al. 2016).
Aquaculture gear has been documented to attract structure-oriented species and increase biomass and biodiversity on an otherwise minimally structured bottom. This “reef effect” may result in a localized increase in biomass and local biodiversity at varying trophic levels. For example, juvenile fish are commonly observed utilizing aquaculture gear as nursery habitat. They in turn serve as a food source to higher trophic levels, including other fish. Suspended mussel culture has been documented to temporarily enhance populations of large macroinvertebrates and benthic fishes, including ecologically and commercially important species (Costa-Pierce and Bridger 2002, D’Amours et al. 2008, Forrest et al. 2009, McKindsey et al. 2011). For example, lobsters have been found to be attracted to the presence of anchor blocks and mussel farm gear. This increase in lobster abundance may be attributed to increased refuge availability and food supply created by bivalves themselves, as well as other species drawn to the aquaculture gear (D’Amours et al. 2008). Certain species of kelp have also been found to grow heavily on blue mussel longlines (McKindsey et al. 2006). DeAlteris et al. (2004) found that species diversity around aquaculture gear is equal to that of SAV, and greater than non-vegetated seabed.

In some cases, the effects from aquaculture activities on EFH can be viewed as both positive and negative. For example:

- Cages or cultch associated with aquaculture operations placed on soft sediments may be viewed as habitat conversion, however, conversion may have positive impacts if increased structural complexity is desired at the proposed site due to historic loss of structure from other anthropogenic activities. This issue would have to be considered on a project-specific basis.

- As described above, shellfish and algae culture can help regulate the abundance of phytoplankton in shallow areas which can lead to reduced turbidity and improved light penetration; however, improved light conditions may encourage the growth of nuisance algae (Cranford et al. 2003, Cranford et al. 2006, Gallardi 2014, Kaspar, et al. 1985, McKindsey et al. 2006, Newell 2004).

Balancing the potential positive and negative effects of aquaculture activities on fisheries and EFH and incorporating acknowledgement of ecosystem services into the review of proposed projects has the potential to improve environmental performance and sustainable management of aquaculture. However, when possible, conditions designed to protect sensitive habitats and bolster positive impacts should be included in permits issued under state and federal laws and regulations to ensure benefits are not negated by poor management.

Adverse effects

The MSA defines an adverse effect to EFH as any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects
to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810(a)). Researchers have identified several potential impacts to fisheries and EFH from marine aquaculture, which are described below for finfish and shellfish operations. The individual and cumulative risk of these specific adverse effects occurring as a result of aquaculture activities, and the magnitude of the impacts when they do occur, will vary by location (i.e., onshore, near-shore, and offshore) and by production format and species (i.e. fish, shellfish, algae). In some cases, the likely impacts from aquaculture activities are well understood and proper siting protocols, standardized operating procedures, and BMPs can be put in place to reduce or eliminate risk. In other cases, the impacts are not well understood and managers are required to err on the side of caution and use their best professional judgment when considering how activities may impact the environment and the most appropriate means to avoid or minimize those impacts.

**Marine fish aquaculture activities**

Marine fish culture can lead to the range of adverse effects. These include degradation of water quality resulting from the discharge of effluents containing uneaten feed and waste products (including drugs, chemicals, and other inputs); habitat degradation (including alteration of sediment composition and chemistry from settling wastes; alteration to benthic habitats, and changes to infaunal species composition); introduction of invasive species; impacts from the escape of cultured organisms (i.e. trophic and gene pool alterations); and the spread of pathogens and parasites from cultured to wild marine organisms. A significant consideration associated with finfish aquaculture is the potential for impacts on water quality and the seafloor environment adjacent to culture facilities from the discharge of effluents containing unused feed, metabolic fish wastes, and other inputs.

- Net pen and land-based flow through fish aquaculture often requires nutrient rich feeds. Depending on the efficiency of feeding and/or level of effluent treatment, this can introduce excess nutrients into coastal systems, in some cases exacerbating eutrophication. According to studies, aquaculture’s contribution to nitrogen in areas adjacent to net pens ranged broadly from none to significant levels (Price et al 2013). When nutrient inputs associated with excess feed and waste do occur, they tend to be episodic and limited to the area adjacent to pens (Nash 2003). Beyond ensuring operations are sited in well-flushed locations, other methods for reducing the impact of feed and other wastes on water quality include improved diet formulations and selection of raw materials, treating effluent water, and recovering dead or uneaten fish (Talbot and Hole 1994). Offshore areas may be less susceptible to these impacts because waters are normally nutrient deficient and fish wastes and other pollutants can dissipate more rapidly in deeper and better-flushed offshore areas than they can in nearshore areas (Gentry et al 2016, Rust et al 2014).

- Reviews have identified changes to sediment chemistry associated with solid feed and fish waste accumulation on the bottom below and around marine fish aquaculture facilities, if net pens are placed at high densities in semi-enclosed waterbodies with inadequate flushing. An assessment of a coastal Maine site with sandy mud sediments and low current...
velocity suggested that changes in sediment chemistry were localized to the area under the net pens (Findlay et al. 1995). These impacts can be avoided through proper siting (Buschmann et al. 2008, Findlay and Watling 1997, Hixson et al. 2014, Klinger and Naylor 2012). Many modern facilities utilize underwater cameras to monitor operations so they can avoid overfeeding and quickly identify and respond to issues (Rust et al. 2014, Herbeck et al. 2013, Talbot and Hole 1994).

- Pharmaceutical drugs, biologics\(^4\) and other chemicals used for the treatment of disease and pests in cultured fish have also been associated with impacts to water quality. The use of pharmaceutical drugs, biologics and other chemicals for use in marine aquaculture in the U.S. is rare and declining (Rust 2014). This decline is largely attributed to improved husbandry and use of vaccines (Asche and Bjorndal 2011; Forster 2010; Rico et al. 2012). Vaccines have been successfully used to prevent a variety of bacterial diseases in finfish and are considered the safest prophylactic approach to management of aquatic animal health as they pose minimal risk to the environment, especially with regards to impacts to fisheries and EFH. All drugs and therapeutic chemicals for use on fish destined for human consumption must be approved by the USDA APHIS and FDA (FDA 2012).

The occurrence and extent of these impacts depends on a variety of factors that should be considered during the review process, including, feed quality, digestion and metabolism, feeding rate, biomass of fish, and species. In addition, site characteristics such as cage design, depth, currents, existing water quality or nutrient levels, and benthic features also influence nutrient dispersion and impacts (Nash 2003, Rust 2014). Over the last several decades, advances in technology, improved facility siting, better feed management, and stricter regulatory requirements have greatly reduced the risk of impacts to water quality and the seafloor environment from fish aquaculture activities (Price et al. 2015, Rust et al. 2014). Effluent discharges are highly regulated by EPA and aquaculture operators are required to adopt best management practices, including integrating advanced feed management strategies, optimally formulated diets, environmental monitoring, and reporting (EPA 2017).

A regionally relevant example of how best management practices, combined with advances in production methodology, have limited the risk of environmental impacts from marine fish aquaculture can be found in Maine, where Atlantic salmon have been grown in open-net pens since the 1970s. Salmon farmers in Maine worked in cooperation with state and federal regulators and the environmental community to develop a series of BMPs that establish operational and monitoring requirements designed to minimize their environmental footprint. As a result, water quality impairments have been significantly reduced via the use of vaccines and integrated pest management, and the minimal to non-existent use of antibiotics and growth enhancers (Maine Seafood Guide – Salmon 2019\(^5\)). Improvements in feed efficiency have reduced effects on dissolved oxygen, turbidity, and nutrient loading (Price et al. 2015). Thermal baths have largely replaced the use of chemical

\(^4\) Biologics include vaccines, bacterins (suspension of killed or attenuated bacteria for use as a vaccine), and probiotics

\(^5\) [https://seagrant.umaine.edu/maine-seafood-guide/salmon/](https://seagrant.umaine.edu/maine-seafood-guide/salmon/)
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treatments for sea lice infections, and biological delousing with cleaner fish is also being explored as a preventive treatment for parasites (UNH). In 2016, Maine-raised salmon were upgraded from “avoid” to “good alternative” by the Monterey Bay Aquarium Seafood Watch Program\(^6\), which rates seafood according to whether it supports a healthy ocean (Seafood Watch 2019).

The use of IMTA by adding other organisms such as invertebrates and seaweeds to the aquaculture system is also being evaluated to lessen environmental impacts from marine fish aquaculture facilities in New England. These systems are intended to mimic natural trophic relationships, where wastes and excess nutrients from cultured fish are consumed by shellfish or assimilated by seaweed (Buck et al 2017, Rust et al 2014).

Marine shellfish aquaculture activities

Impacts to water quality, sediments and benthic habitats from marine shellfish aquaculture have also been documented. The impacts of specific concern to the NEFMC include changes to benthic habitat as a result of pseudofeces deposition, the effects of mechanical harvesting, conversion of soft sediment habitat to hard bottom shellfish reef, displacement of cultured organisms, sedimentation and loading of organic waste to the water column and benthic sediments, and disruption of the benthic community and impacts to SAV located near shellfish aquaculture operations.

- Shellfish release pseudofeces, a byproduct of filtering food from the water column. If allowed to accumulate, the increased deposition of organic matter to the benthos can degrade sediment quality (Forrest et al. 2009, Gosling 2015), increase turbidity, and deplete dissolved oxygen. This is particularly true in areas with poor tidal flushing where organic material can build up under aquaculture sites (Dumbauld et al. 2009). These impacts are likely to be negligible in areas with high tidal flushing where sediment buildup is not localized (Dumbauld et al. 2009).

- The placement and retrieval of off-bottom gear and mechanical and hydraulic harvest methods can result in a release of suspended sediment and organic matter into the water column through increased erosion, transport, and sediment shear and direct physical disturbance. The increased turbidity and physical disturbance associated with these activities may have impacts on benthic communities and demersal fish species (Dumbauld et al. 2009, Forrest et al. 2009, Smith et al. 2006). These impacts are greater for operations located in areas with fine grain sediments that area easily re-suspended into the water column (Chamberlain et al. 2001, Crawford et al. 2003, da Costa and Nalesso 2006, Shumway, 2013). Areas with low tidal flushing (~5 cm/s) are more likely to experience benthic habitat changes due to the accumulation of organic waste and its accompanying effects described above (Crawford et al 2003).

- Studies have also shown that bivalve aquaculture (via biodeposition, using both suspension and bottom-culture methods) has the ability to alter diverse benthic communities dominated by suspension feeders into one dominated by opportunistic deposit feeders, such as polychaetes, scavengers, carnivores and hydrogen sulphide-tolerant species. Hydrologic regime, culture

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\(^6\) https://www.seafoodwatch.org/
density, and culture method influence the magnitude of effects (Callier et al. 2009, Dumbauld et al. 2009, Fabi et al. 2009, Forrest et al. 2009, Frechette 2012, Gallardi 2014, Hartstein and Rowden 2004, Kaspar et al. 1985). A recent study in Rhode Island assessed the long-term disturbance from oyster cage aquaculture and found significant differences in the benthic community structures and the presence or absence of opportunistic species between aquaculture sites and sites with no aquaculture present (Duball et al. 2017). However, studies on the effects of hydraulic dredging in nearshore leased shellfish beds in fine to very fine sand in Long Island Sound, Connecticut, showed no significant differences between dredged and non-dredged treatments over a several month period for the benthic community as a whole, nor were there any major effects on sediment biogeochemistry (Goldberg et al. 2012, 2014, Meseck et al. 2014).

- Habitat conversion can be a concern with some types of shellfish aquaculture, specifically the shift from soft to hard bottom due to the addition of gear or culch or other fill material. As noted previously, this may benefit certain structure-oriented species (e.g. black sea bass), but harm species that prefer soft bottom (e.g. winter flounder). However, if increased structural complexity is desired at the proposed site due to historic loss of structure from other anthropogenic activities the conversion may be viewed as beneficial (Gallardi et al. 2014).

- SAV is susceptible to damage caused by aquaculture; impacts vary based on gear used for both grow out and harvest. Dumbauld and McCoy (2015) found no change in eelgrass due to the presence of on-bottom oyster beds. Mechanical harvesting commonly associated with bottom culture resulted in significantly less eelgrass coverage along harvested sites compared to unharvested sites. As aquaculture operations have the potential for adverse effects to eelgrass through displacement of SAV habitat and physical disturbance, on-bottom shellfish aquaculture activities should not be conducted on or in immediate proximity to existing eelgrass beds (Ford and Carr 2016); this is an existing best practice in many areas as detailed in the state permitting overview. A buffer between eelgrass meadows and bottom-planted aquaculture sites can limit physical displacement and turbidity effects. Hand-harvest methods were found to be the least disruptive (Dumbauld et al. 2009, Stephan et al. 2000). SAV may also be affected by floating or suspended culture equipment that results in light limitation. Ferriss et al. (2019) found a negative effect of off-bottom aquaculture on eelgrass density, percent cover and reproduction, along with a neutral effect on biomass and growth. Adequate spacing between off-bottom cages, bags, or longlines may mitigate this effect.

While adverse effects to EFH are possible from shellfish aquaculture, the overall risk of impacts to fisheries and EFH can be minimized or eliminated through proper management and siting (Crawford et al 2003, Dumbauld et al. 2009, Forrest et al. 2009, Gallardi 2014, Gosling 2015, Kaiser et al. 1998, Shumway 2011). Best management practices are now in place for shellfish aquaculture along the U.S. East Coast (Flimlin 2010) and there is a robust federal and state regulatory process in place designed to limit the specific concerns. This is especially true for New England, where many states have established mandatory siting criteria, such as the exclusion of siting new aquaculture sites on sensitive habitats such as eelgrass.
Interactions between NEFMC species and aquaculture activities

If not properly managed, some marine aquaculture activities have the potential to result in direct adverse effects to species managed by the NEFMC, beyond the indirect effects associated with habitat impacts. These include impacts associated with the escape of cultured organisms, the introduction of invasive or non-native species; and the spread of pathogens and parasites from cultured to wild marine organisms (Naylor et al. 2005).

The escape of cultured fish from aquaculture facilities, especially nonnative species, is a significant concern related to aquaculture. The likelihood of escapes from aquaculture operations, and the severity of the impacts associated with escapement, will vary depending on the species being cultured, siting guidelines, structural engineering and operational design, management practices (including probability for human error), adequacy of biosecurity and contingency plans, frequency of extreme weather events, and direct interactions with predators such as sharks and marine mammals that may compromise the integrity of fish enclosures.

- There are substantial concerns that nonnative fish used in aquaculture can escape and become established in the wild, competing with wild fish for food, habitat, mates, and other resources. Most introduced species do not become invasive; however, naturalization of introduced non-native species that results in invasion and competition with native fauna and flora has emerged as one of the major threats to natural biodiversity (Bax et al. 2003, D’Antonio et al. 2001, Olenin et al. 2007, Wilcove et al. 1998). Some non-native species have been documented to alter the physical characteristics of coastal habitats and may thus affect population, community, and ecosystem processes (Grosholz 2002). New England States, EPA, and USACE highly restrict the use of non-native species in aquaculture, which largely mitigates this concern. One notable exception is the culture of “naturalized” species such as European Oysters and Steelhead Trout that have been present in New England waters for over a century. NOAA Fisheries’ Aquaculture policy supports the use of only native or naturalized species in federal waters unless best available science demonstrates that the use of non-native or other species in federal waters would not cause undue harm to wild species, habitats, or ecosystems in the event of an escape.

- Even when native species are utilized, genetic diversity could be affected if hatchery-raised fish spawn with wild conspecifics. Interbreeding could result in the loss of fitness in the population due in part to the loss of genetic diversity. Genetic risks would depend on the number of escapes relative to the number of wild fish, the genetic differences between wild and escaped fish, and the ability of escaped fish to successfully spawn in the wild (Price et al. 2015). Naylor et al. (2005) suggest that the risks of escaped cultured salmon impacting wild salmon are greater where the populations of farmed salmon are higher than native populations. Changes in the genetic profiles of wild populations have been found in several rivers in Norway and Ireland, where interbreeding of wild and farmed fish is common. Large-scale experiments in Norway and Ireland show highly reduced survival and lifetime success rates of farmed and hybrid Atlantic salmon compared to wild salmon (Thorstad 2008). Means of decreasing the genetic risks associated with escapes includes the required use of wild broodstock with a genetic makeup...
that is similar to local wild populations and the use of sterile fish created through techniques such as hybridization, chemical sterilization, polyploidy (Price et al. 2015). These strategies come with trade-off such as increased production costs and the inability to benefit from selective breeding.

Another concern to NEFMC managed species is impacts from the spread of endemic and introduced pathogens and parasites from cultured populations to wild populations. Risks posed by pathogens and parasites are harder to quantify than those posed by competition or predation, as a single individual transferred to a recipient population can have dramatic consequences. Further, these agents can be spread by water, independent of any escape of cultured individuals. The risk and prevalence of disease in aquaculture operations is influenced by many factors, including immune status, stress level, pathogen load, environmental conditions, water quality, nutritional health, life history stage, and feeding management. The type and level of husbandry practices and disease surveillance will also influence the potential spread of pathogens to wild stocks.

- Cultured organisms are often more susceptible to diseases because they are kept at higher densities, which both increases their rate of contact and may induce stress. Research suggests that fish pathogens may be transferred from farmed to wild fish and that nonnative pathogens may be introduced when fish are moved from different areas (Rust et al 2014). Effluent treatment and the use of static tanks to hold potentially infected broodstock are effective measures to control the risk of transmission from on shore systems. Nearshore and offshore operations have the greatest potential for exchange of pathogens between cultured and wild organisms as they bring cultured organisms into close contact with their wild cohorts, and a diverse community of potential intermediate hosts to parasites or pathogens. These conditions provide an opportunity for parasites or pathogens with direct and indirect life cycles to proliferate in and near the pen where they may become major causes of disease in both wild and cultured hosts.

- Some studies suggest that high host densities in net pens promote transmission and growth of the parasite sea lice (*Lepeophtheirus salmonis* - a parasitic copepod). The rapid decline of wild populations of pink salmon on the Canadian Pacific Coast in 2002 was hypothesized to be the result of sea lice infections associated with salmon farms in the area (Krkošek et al. 2007). However, Marty et al. (2010) conducted an extensive review of data on farmed and wild populations and found the productivity of wild salmon was not negatively associated with either farm lice numbers or farm fish production, and all published field and laboratory data support the conclusion that something other than sea lice caused the population decline in 2002. In contrast a 2011 study found sea lice abundance on farms to be negatively associated with productivity of both pink and coho salmon in the Broughton Archipelago of British Columbia (Krkošek et al. 2011). Improved facility design engineering and buffer zones between aquaculture facilities and natural stocks, falling periods, and other measures have been employed to reduce the risk of disease transfer between cultured fish and wild populations (Krkošek 2005).
Shellfish can also carry veterinary diseases that may have adverse impacts on or decimate natural shellfish populations and cultured stocks (Carnegie, 2016). Common shellfish culture practices in New England often involve the movement of shellfish between water bodies (hatchery sites, nursery sites, and final planting/harvest site). When moved, shellfish can potentially spread disease to natural populations and cultured stocks in the receiving waters or exacerbate disease levels where the pathogens may already exist. All New England states have specific protocols that must be followed when introducing and transplanting cultured species into wild environments to minimize the incidence of disease transfer. These often include pathogen screening guidelines and certification programs for movement of germplasm, embryos, larvae, juveniles, and broodstock. Some New England states outright restrict the importation of seed stocks from other states, where others impose geographic restrictions on the source of seed and brood stock. In the case of aquaculture operations in federal waters, the Gulf of Mexico Fishery Management Council specified in their Fishery Management Plan for Regulating Offshore Marine Aquaculture that prior to stocking animals in an aquaculture system in federal waters of the Gulf, the permittee must provide NOAA Fisheries a copy of a health certificate signed by an aquatic animal health expert certifying cultured animals were inspected and determined to be free of World Organization of Animal Health reportable pathogens (OIE 2003) or additional pathogens that are identified as reportable pathogens in the National Aquatic Animal Health Plan (GMFMC 2012).

While regulatory restrictions and screening can limit the risk of pathogenic transmission, some of the most notable impacts from diseases and parasites are associated with unintentional or deliberate introductions in violation of existing requirements. Burreson et al. (2000) used molecular methods to show that the parasite *Haplosporidium nelsoni* (popularly known as MSX), which has decimated populations of the eastern oyster (*Crassostrea virginica*) along the Atlantic coast of the United States, may have originated from translocations of Pacific oyster, *Crassostrea gigas*, from Japan. However, the means of MSX introduction, whether from illegal introduction of Pacific oysters, fouling of oysters on ship bottoms, or from ballast water, is unknown (NRC 2004).

**Potential interactions with other coastal and marine activities**

Commercial and recreational fishing and boating activities may be affected by aquaculture activities if they are not sited to avoid productive fishing or vessel transit areas. Generally, an aquaculture lease provides the lessee exclusive rights to permitted organisms within the lease area, but does not restrict other activities. This therefore directly prevents the commercial and recreational harvest of cultured species within the lease area. While this does not directly restrict the harvest of other species within the lease area, many forms of commercial fishing may not be compatible with some aquaculture activities. For example, the Maine lobster industry requested a temporary ban on new aquaculture leases in 2019 because of concerns that new leases may interfere with their ability to harvest lobster with fixed bottom fishing gear/pots (Bangor Daily News 2019). Rod and reel fishing is generally still possible (e.g. on a kelp
or shellfish lease). To avoid conflicts between fishing and aquaculture, baseline environmental surveys of proposed sites are needed to avoid overlap with productive resource areas.

Recreational and commercial boating (i.e. sailing, rowing, water skiing, jet skiing, kayaking, stand up paddleboarding) may be affected by aquaculture operations if the activities are not properly sited. Bottom gear and bottom planting methods are generally not viewed as a conflict with navigation. Power boating, sailboating, jet skiing, and rowing are unlikely to be compatible with floating gear, but kayaking and paddleboarding would generally not be restricted. Depending on the depth of the aquaculture gear, boating may not be affected by suspended culture activities as most configurations are a minimum of 8’ below the surface. Through the federal review and authorization process, as well as state review processes, a navigational assessment is conducted and projects with potential conflicts undergo additional review by USCG and USACE. USACE requires aquaculture activities to be sited outside of federal navigation channels and has established thresholds related to the square footable of floating gear that can be authorized under statewide general permits.

Renewable energy and aquaculture could potentially be co-located. For example, the possibility of siting aquaculture farms within wind farms has been proposed in Germany (Gimpel et al. 2015, Buck et al. 2004). However, the installation of aquaculture facilities may prevent boating and fishing within wind energy areas, depending on the configuration.

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Selected best management practices

Some of these were referenced to identify best practices in the Council’s aquaculture policy.


- This document has useful descriptions of shellfish culture practices, including photos.


- This document applies to the farming of finfish, crustaceans, and other aquatic invertebrates, using all production methods, but does not cover bivalve mollusk or net pen salmonid production, or egg/juvenile production for transfer to other aquaculture facilities.


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