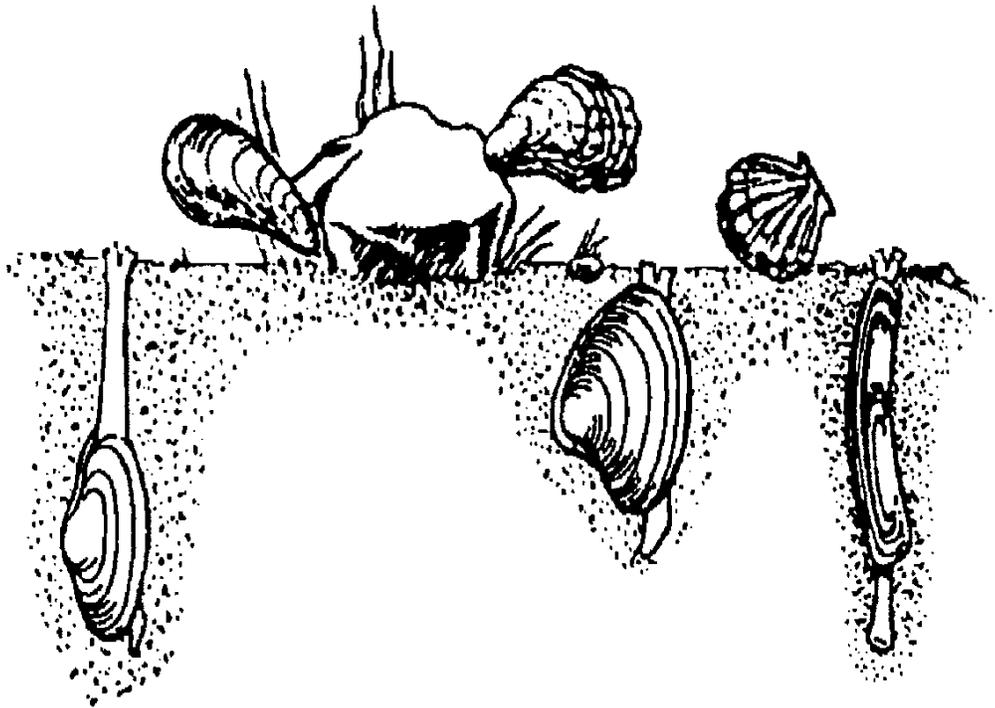


Best Management Practices for the Shellfish Culture Industry in Southeastern Massachusetts

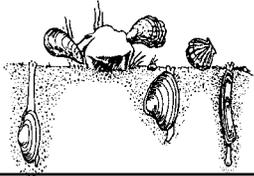
(Version 09-04a)



Developed by:
Massachusetts shellfish growers
in collaboration with
the SouthEastern Massachusetts Aquaculture Center
with support provided by the Massachusetts
Department of Agricultural Resources and the
USDA Risk Management Agency



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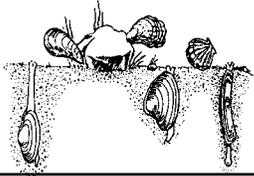


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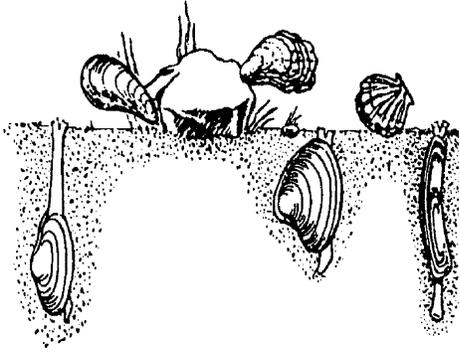
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Forward

The shellfish farming industry

Shellfish farming in southeastern Massachusetts entails the husbandry of all or part of the life cycle of various bivalve mollusc species for the purpose of generating a harvestable and marketable product. The principal species reared in the area includes quahogs (*Mercenaria mercenaria*) and oysters (*Crassostrea virginica*). Other species are also cultured at a smaller scale in the region, including, but not limited to, soft shell clams (*Mya arenaria*), bay scallops (*Argopecten irradians*), surf clams (*Spisula solidissima*) and European oysters (*Ostrea edulis*). Shellfish farming is practiced by the coastal municipalities of southeastern Massachusetts for restoration and restocking as well as by private individuals for economic gain. It has a local history of activity dating back to colonial days where King's Grants were awarded to private individuals for propagating oysters.

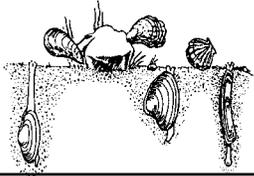
Aquaculture crops, particularly shellfish that are farmed in intertidal and shallow subtidal locations, utilize relatively small areas of the tidal flats but are highly valuable and require

“Shellfish aquaculture is a privilege
and not a right.”

*Robert Wallace – Shellfish Farmer
Co-President; Massachusetts Aquaculture
Association*

intensive skilled management. The total area under cultivation for clams and oysters in the southeastern Massachusetts area is approximately 1,000 acres (in 2000). This represents about 9.2% of the total tidal flat area on Cape Cod (*Massachusetts Department of Environmental Protection – 1995 Wetland Mapping*) but cannot overlap, by statute (M.G.L. Chapter 130), with the 10,500 acres of productive shellfish beds on Cape Cod.

In 1996, the landed value of the shellfish farmed in southeastern Massachusetts was in excess of \$4.5 million in reported income. However, shellfish aquaculture has a much broader economic impact, in excess of \$15.5 million, based on an economic study of the soft shell clam industry in Casco Bay, Maine (*Heinig et al. 1995*)



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Regulation of shellfish farming

Shellfish farming is licensed by the local municipality, the Massachusetts Division of Marine Fisheries (Mass. General Law – Chapter 130, Sections 57 through 67; included as Appendix 2) and the U.S. Army Corps of Engineers (Section 10 of the Rivers and Harbors Act of 1899; and Section 404 of the Clean Water Act through the Massachusetts General Programmatic Permit; included as Appendix 3). Licenses and area leases are awarded to individuals either to propagate shellfish, i.e. possess and cultivate sub-legal size shellfish while marketing only legal size shellfish (referred to as a Propagation Permit), or to aquaculture shellfish, i.e. possess, grow and market sub-legal and legal size shellfish (referred to as an Aquaculture Permit). Table 1 outlines a generalized version of the steps required to acquire a license for shellfish farming. Due to Massachusetts "home rule", where towns set their own regulations for aquaculture licensing, each municipality may vary somewhat from this generalized scenario.

Most of the shellfish produced by farmers in southeastern Massachusetts are used or consumed directly by the end user with little to no processing. The MA Department of Public Health and the MA Division of Marine Fisheries, in collaboration with the Interstate Shellfish Sanitation

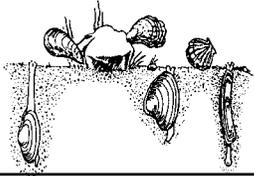
Without clean water and a healthy environment, the shellfish farmer is out of business!

Conference (ISSC), oversee shellfish transport and sales. Today's regulatory environment, along with the consumer's expectations, is very demanding. They want the high product quality that is associated with farmed crops, including consistent flavor and reduced risk of contamination. At the same time, regulators, consumers and the general public are concerned about the environmental and social impacts of aquaculture.

Shellfish farming and the environment

Sustainability and competitiveness are key words to all individuals involved in aquaculture. Growers must be efficient in production to stay competitive. They must conserve and protect water quality and sustain the environment to remain viable. ***Without clean water and a healthy environment, the shellfish farmer is out of business!***

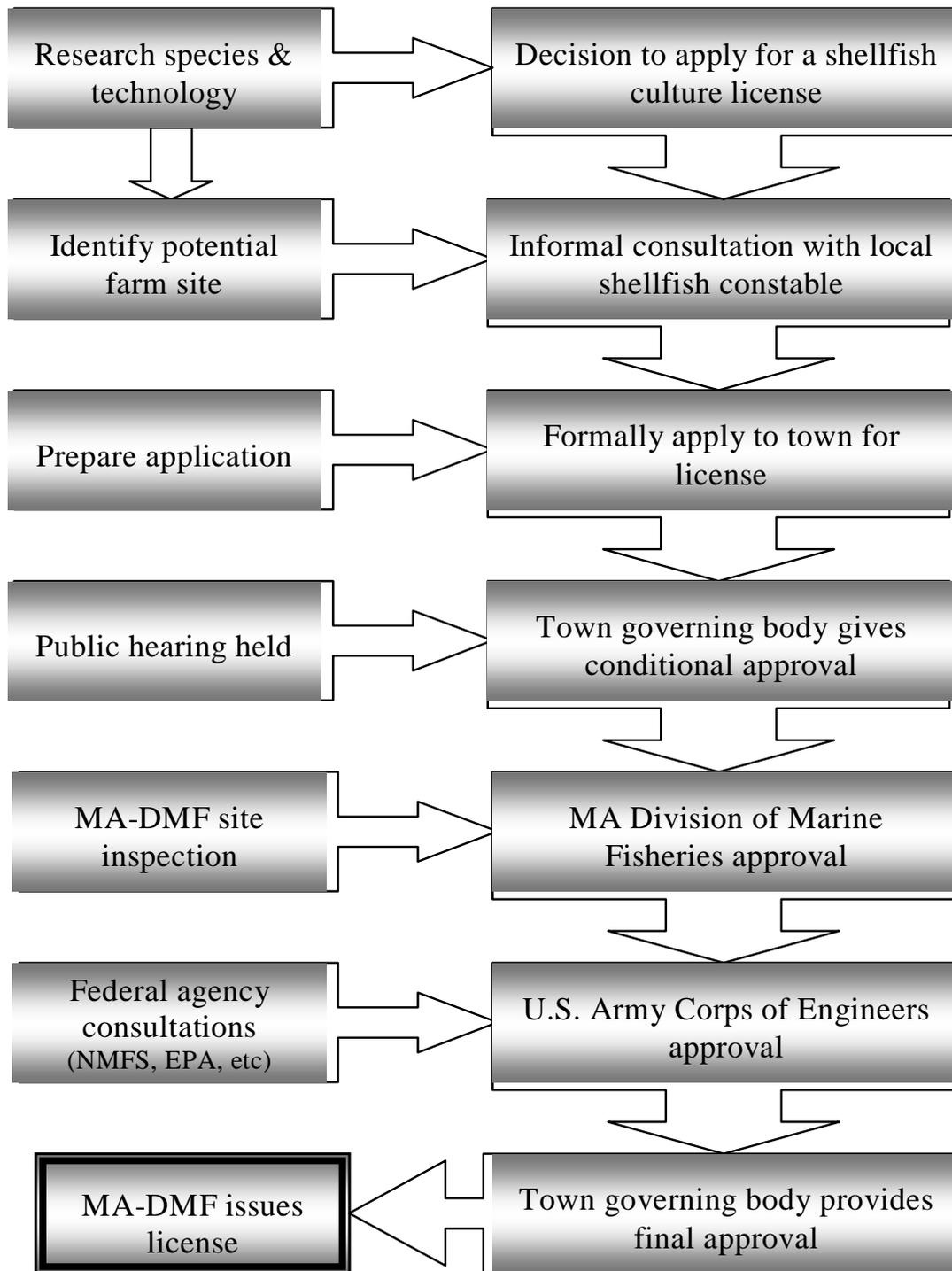
Shellfish farming also contributes to improving water quality. This aspect of shellfish farming is thoroughly discussed in an editorial included as Appendix 1.

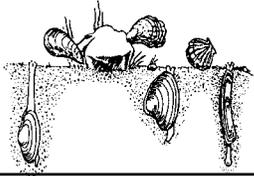


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Table 1: an overview of the general procedure for acquiring a shellfish aquaculture license in Massachusetts.





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Shellfish farmers are neighbors to many other users of the intertidal and shallow subtidal environment and, as such, they must be sensitive to the needs and expectations of their neighbors to minimize potential conflicts or detrimental interactions. At times, these realities appear to conflict but in truth they are complementary. Good neighbor policies coupled with high water quality within a healthy environment will make local aquaculture crops more competitive in today's markets. If these considerations are coupled with practices that increase crop productivity, then everyone wins, including the public, other coastal users, and the shellfish growers.

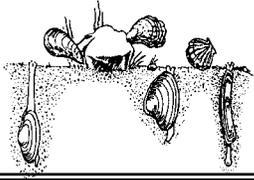
Shellfish farming BMPs

Shellfish Aquaculture Best Management Practices (BMPs) are a set of voluntary procedures that have been developed by the Massachusetts shellfish aquaculture industry in collaboration with the SouthEastern Massachusetts Aquaculture Center (SEMAC) to address areas where attention should be focused to improve production while preserving the environment. The intent of a BMP is to provide information on "normal industry practices" to help growers to farm profitably and in harmony with their neighbors and the surrounding environment. To be considered a best management practice, an action must maintain or increase crop production

There is no single best management practice for all shellfish crops at all sites. Therefore, the best practice for any individual grower will depend on site-specific circumstances, economic opportunities and environmental considerations.

while minimizing impact on the environment, i.e. promote sustainability. In the case of farmed shellfish, this means using good management so that the crop is properly managed and healthy. There is no single best management practice for all shellfish crops at all sites. Therefore, the best practice for any individual grower will depend on site-specific circumstances, economic opportunities and environmental considerations.

The Best Management Practices Manual for Shellfish Growers in Southeastern Massachusetts has been designed with a number of target audiences in mind. The primary audience is the members of the shellfish aquaculture industry, both experienced and novice. Many of the accepted farming techniques developed by the shellfish growers have originated from individual trial and error experimentation. As such, there is no common clearinghouse for best technologies, as most of the industry knowledge has been passed by word of

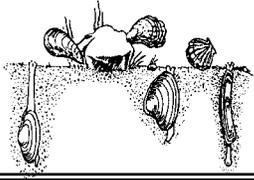


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mouth. This manual strives to identify and describe the best available technologies for specific management considerations in shellfish farming with an emphasis on sustaining acceptable production levels in concert with positive or benign impacts on the environment. A second audience that will find this manual useful is policy makers. Massachusetts “Home Rule” dictates that the management of shellfish aquaculture is the responsibility of the Town Council or Board of Selectmen. In many cases, there is a lack of understanding as to what technologies exist for shellfish farmers and how those technologies should be overseen at a local level. Therefore, this manual will provide factual information to Selectmen or other local management agencies, as well as state and federal regulators, as to the best available technology for managing a shellfish farm. Lastly, there is a desire of many individuals in the public sector to understand the nuances of shellfish aquaculture. We hope the public too will learn about shellfish aquaculture through this manual and their new knowledge will allow them to be conversant with the industry in terms of the industry’s needs and limitations.

In conclusion, it is important to note that this current Best Management Practices Manual for the southeastern Massachusetts shellfish aquaculture industry should be considered a “living document”. Publication of the Manual has been arranged in a loose-leaf format with the intention that sections of the Manual will be replaced as better technology and/or practices become available.



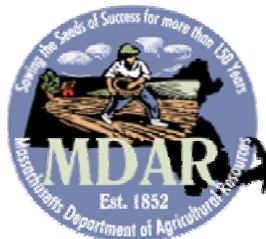
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Acknowledgments

This document has been developed through the efforts of a large group of individuals who are interested in the sustainable growth of the shellfish aquaculture industry in southeastern Massachusetts.

Support for the publication and distribution of this document was provided by the New England Small Farm Institute, the Massachusetts Department of Agricultural Resources and the University of Massachusetts through a cooperative agreement with the USDA Risk Management Agency for crop insurance education.



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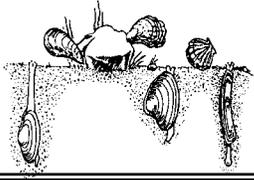
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Introduction to the BMP Manual

The overall strategy for identifying and addressing activities important as Best Management Practices (BMPs) is to consider both the impact the BMP will have on farm production as well as its impact on systems and issues ancillary to the culture business. Setting industry standards can identify better shellfish production methods, such as optimal construction and operation of nursery raceways, improved planting and harvesting, reduced losses due to predation, minimized biofouling, and etc. BMPs can also recommend practices that minimize the overall environmental impact that the culture effort may have, including minimizing the risk for marine animal entanglement, reducing disturbance to migratory shorebirds, or generating better neighbor-to-neighbor relations with other coastal resource users. The overall effect is intended to be an improved atmosphere within which the grower can operate their business profitably, insurance of optimal environmental conditions to maximize production of the farm with minimal environmental impacts, and ultimately increased profits to the farmer.

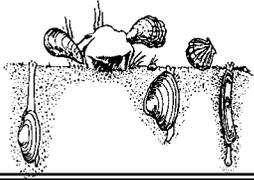
This document has identified five separate categories of standard practices. They are

1. Site selection and access,
2. Materials, operations and maintenance,
3. Improvement of shellfish survival and productivity,
4. Disease prevention and management, and
5. Maintenance of environmental quality.

All five categories have been subdivided into management considerations that are related to specific operating practices.

The overall format employed in this manual for each management practice is:

- identify the management consideration,
- provide background information explaining the rationale behind the selection of the consideration,
- identify the regulatory authority having oversight at the federal and state level, including only those regulations that address the environment under which the grower must conduct their business. For a more in-depth overview of Massachusetts laws and regulations addressing aquaculture, please refer to the MA-CZM's Massachusetts



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Aquaculture White Paper - Legal and Regulatory Issues (<http://www.mass.gov/czm/WPMLGLRG.HTM>)

Municipal regulations and ordinances have not been included in this section as they vary among municipalities and are beyond the scope of this document to summarize. Local laws have been summarized in: Raddatz, A.K. 1998. Commercial shellfish aquaculture in Mass.: a local regulatory perspective. M.A. Thesis, Dept. Urban and Env. Policy, Tufts University, Medford, MA.)

- provide a list of recommended best management practices that exemplify current industry standards or practices and that demonstrate the best available approach to management.

Additional information has been included at the end of the Manual. Any terms unique to shellfish aquaculture appear in **bold type** the first time they appear in the text and are included in the glossary at the end of the manual. In addition, numerous Appendices are included to provide information to existing and prospective shellfish farmers.

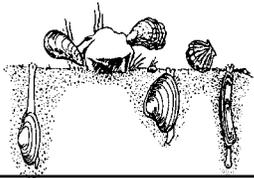
The Appendices include:

- A published manuscript detailing the economic and environmental

benefits of shellfish farming (Appendix 1),

- The complete text of MGL Chapter 130, Section 57 defining the current state laws addressing shellfish aquaculture (Appendix 2),
- The complete text of the Programmatic General Permit specific for shellfish aquaculture awarded to Massachusetts by the U.S. Army Corp of Engineers (Appendix 3),
- Information on the hard clam crop insurance program available to Massachusetts clam farmers from the USDA Risk Management Agency (Appendix 4),
- A list of contacts for individuals in southeastern Massachusetts able to provide technical assistance to clam farmers (Appendix 5).

It must be emphasized at this juncture that not all BMP recommendations are appropriate for all sites growing all species. Shellfish aquaculture is a site- and species-specific phenomenon and therefore the best technology for maintaining or enhancing production will vary between sites and crops. To accommodate this observation, we have tried to identify, whenever possible, those differences as they occur in the document.



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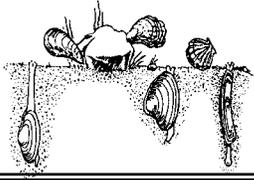
1) Site selection and access

The selection of an appropriate site for growing shellfish has ramifications throughout all aspects of farm management. From meeting the biological needs of the growing **mollusc** through maintaining **ambient** water quality at a level defined for the safe consumption of shellfish products, to assuring that your neighbors are agreeable and cooperative with your efforts, proper site selection can make or break your efforts.

It is important to mention that the overall siting of shellfish farming activities is controlled by the classification of the local waters. Shellfish can only be raised and/or harvested from waters “Approved” by the Massachusetts Division of Marine Fisheries and the Department of Public Health, based on standards recommended by the Interstate Shellfish Sanitation Conference (ISSC). With the exception of the early nursery stage, shellfish aquaculture cannot be located in waters classified as “Conditionally Approved” or “Prohibited”. In addition, proximity to areas with the potential for reduced water quality is considered when siting to minimize the risk that shellfish farming operations be impacted by declining water quality in the future.

Site selection is usually an iterative process between the prospective shellfish farmer and the town, primarily through the town shellfish constable. Although each town is different, it generally involves a formal application, site review by the town, opportunities for public comment, and review by state and federal authorities before the license is granted to the farmer, as outlined in Table 1. Because the application process varies from town to town, it is recommended that the prospective shellfish grower discuss the correct application process for their municipality with local authorities.

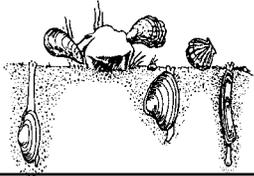
A more recent development in shellfish aquaculture licensing is the concept of “**block permitting**” by towns to form **aquaculture areas**. Originated via encouragement at the state and federal levels, towns have recently started designating larger tracts (50 to 100 acres) of intertidal and/or subtidal areas for shellfish aquaculture development. This method allows the town to expedite the permitting process through acquiring required permits for the “aquaculture area” from local, state, and federal authorities. The large tracts are then subdivided into smaller parcels



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(generally 2 to 3 acres) and licensed to individual growers. The advantages are that it simplifies the process of permitting and expedites the award of an aquaculture license to the individual grower while it allows the town to incorporate a level of long-term planning into their harbor development plan while selecting sites deemed appropriate for shellfish aquaculture.



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1-1) Site selection and access: Legal association with adjoining uplands

Management Consideration:

In Massachusetts, coastal **upland** landowners may have deeded ownership to **intertidal** areas and therefore have authority to control the availability of these areas as shellfish aquaculture sites.

Background:

Massachusetts is one of the few states in which private property extends to the **low water mark**. Based on the Colonial Ordinances of 1641-1647, upland landowners are permitted to own the nearshore intertidal area, down to the low water mark or 100 rods from the **high water mark**, whichever is less. These early laws were promulgated to encourage commercial development of the coastline by giving individuals ownership of any commercial structures they placed in the intertidal area. The exception to the privatization of the intertidal zone was to allow unlimited access of the intertidal area for “fishing, fowling or navigation” – often referred to as the “*Riparian Rights*” clause.

Until 1994, it was generally accepted that shellfish aquaculture was fishing and therefore exempt from an upland owner’s control. However, the

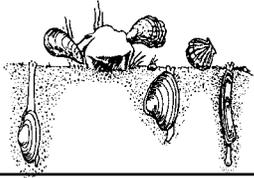
Massachusetts Supreme Judicial Court has recently ruled, in the Pazolt decision (Pazolt v. Director of the Division of Marine Fisheries, 417 Mass. 565, 567-568 (1994)), that aquaculture, as licensed by MGL Chapter 130, Section 57 (generally placing structures on the flats, such as nursery trays or boxes), is not part of the **public trust** right of fishing and, therefore, aquaculturists may need permission from the private upland property owner to practice aquaculture in the intertidal zone. Issuance of an aquaculture license does not convey any real property rights to the aquaculturist.

Pertinent State & Federal References:

- ◆ *Marine Fish and Fisheries (M.G.L. CHAPTER 130. Section 57): Shellfish aquaculture licenses; ... shall be issued ..., but not so as to impair the private rights of any person ...*

Recommended Best Management Practice(s):

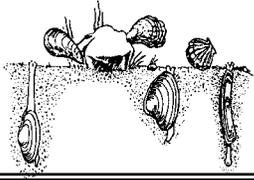
- All shellfish growing areas licensed after 1994 must address the issue of private ownership of the land before the license is issued. It is in the best interest of the prospective grower, or the town if the site is a block



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- permitted site, either to ensure that the proposed growing area is outside of an upland owner's jurisdiction, to research the upland owner status on a case by case basis, or to arrange permission with the upland owner prior to applying for the aquaculture license.
- Because of the Pazolt decision and issues of private ownership, when possible it behooves the municipality or the individual aquaculture participant to identify areas where private ownership will not become an issue of conflict.
 - In areas where the upland landowner has natural resource responsibilities (i.e. federal or state parks, refuges, sanctuaries, etc.), the shellfish grower should clear their proposed uses and activities with the respective agencies to avoid resource conflicts.
 - Cultivating shellfish includes cultivating good rapport with your neighbors.



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1-2) Site selection and access: access to site

Management Consideration:

Location and layout of shellfish aquaculture areas must consider access to the site, including motorized transport, for daily and normal maintenance of the structures and shellfish.

Background:

Maintenance of shellfish farms requires intensive activity during initiation and termination of the growing process as well as constant diligence to ensure optimal growing conditions for the shellfish. These activities may require transport of materials and equipment to and from the site. Routine maintenance may be achieved through the use of low impact equipment left on-site and access may be limited to foot or boat traffic. However during set-up, selected maintenance and harvest, transport of heavier materials to the site may necessitate **motorized transport** on occasion.

If access to the leased site is through a **wetlands buffer zone**, as defined in the Wetlands Protection Act (M.G.L. 131, Sec. 40) and is not a pre-existing **public access** point, the applicant (either individual or town) may be required to submit a Request for Determination of Applicability or a

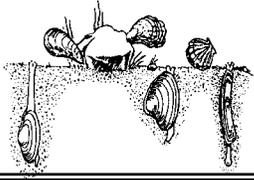
Notice of Intent with the local Conservation Commission to permit such activities.

Pertinent State & Federal References:

- ◆ *MA Wetlands Protection Act (M.G.L. CHAPTER 131 Section 40) & Wetlands Protection Regulations (310 CMR 10.00)*

Recommended Best Management Practice(s):

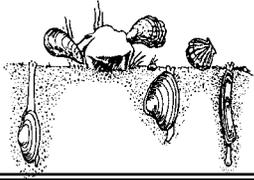
- Whenever possible or feasible, access to the farm site should be limited to foot or boat traffic.
- Research your site and plan routes for access and maintenance prior to the initial permit application and development of your site.
- A number of public access points exist throughout coastal Massachusetts. Plan to use public access routes whenever possible to minimize transport over private property.
- If access is direct from a privately owned upland site, you may need written permission from the landowner whose property you are traversing.



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1-3) Site selection and access: layout and placement of nets and other gear

Management Consideration:

Spacing within an aquaculture area should be planned to permit normal operations and maintenance on the site without impairing or interfering with activities within and around the farmed area.

Background:

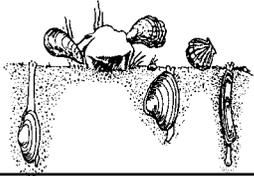
Normal operations within a shellfish farm entail the placement of containment systems throughout the footprint of the licensed area. Containment can be in the form of racks with mesh bags to hold the oysters or anti-predator netting on the sediment surface to hold and protect infaunal clams. The distribution of the equipment potentially can impact the natural function of the ecosystem as well as the normal activities of the shellfish farmers and other users on the water.

The presence of racks, cages or netted **raceways** alters habitat conditions while limiting access through the aquaculture areas. It has been suggested that the layout of racks or nets in close proximity to each other prevents access across the site by humans and access to the potential resources on-site normally used by

non-cultured species. By distributing the netted raceways with adequate spacing between them, open corridors of natural habitat are left available for other species to use or for humans to traverse.

Site preparation, normal maintenance, and harvest of individual shellfish growing areas require physical activities around and within the farm site. Given the normal activities on a shellfish farm, it is important to plan for and provide enough working room to accommodate for efficient operations, to plan layout and use (timing) of gear to allow for normal operations on site with minimal disturbance to adjoining aquaculture sites and all other legitimate users, and to plan the use of the site to avoid unnecessary disruption of non-farm species.

Lastly, if rafts or other floating equipment are in use, then total area coverage must be considered. The equipment must be maintained so as not to impede normal navigation through the area. The Army Corp of Engineers stipulates that when rafts and floating gear are in use that they can cover no more than 10% of the project area or 20,000 ft², whichever is greater.



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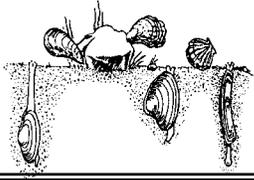
Pertinent State & Federal References:

- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2).*
- ◆ *Marine Fish and Fisheries (M.G.L. CHAPTER 130. Section 57).*

Recommended Best Management Practice(s):

- If municipalities block grant an aquaculture site and sub-divide the area to individual licenses, adequate spacing between the licensed plots should be integrated into the overall site plan.

- Individual farmers should consider normal movement and access patterns when laying out the growing areas within their farms.
- Although the specifications of design will vary with respect to the overall shape, size and conditions present at each individual site, one should consider leaving corridors between plots and between your site and adjacent sites to allow for adequate working room to and from your site without disturbing adjacent plots.



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1-4) Site selection and access: habitat

Management Consideration:

The coastal zone in southeastern Massachusetts may be important habitat to a number of important or rare and endangered species. Designation of aquaculture areas must consider potential impacts to these natural resources.

Background:

Growing shellfish in the natural environment occupies space within the ecosystem that has traditionally been used by a wide variety of other species. Given the proximity of other natural resources to shellfish farms, the grower should develop an awareness of the role that the natural system plays in maintaining a diverse community and the importance of **biodiversity** in sustaining a healthful ecosystem.

A number of aquatic species have been identified as rare or endangered in the Commonwealth of Massachusetts. Oversight of these special interest species, at the state level, is through the Natural Heritage & Endangered Species Program (NHESP) in the Massachusetts Division of Fisheries and Wildlife. At the federal level, the Endangered Species Act is administered by the U.S. Fish and Wildlife Service (USFWS - Department of the Interior) and the

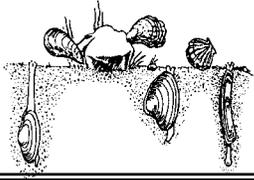
National Marine Fisheries Service (NMFS - Dep't of Commerce).

The overall goal of these programs is to protect the range of native biodiversity and the continued existence of species identified as threatened, endangered or of special concern. The U.S. Army Corps of Engineers General Programmatic Permit, the Massachusetts Endangered Species Act and the Wetland Protection Act achieve protection of critical habitat for important species through environmental impact review as mandated.

Shellfish aquaculture in southeastern Massachusetts may impact species identified as being of critical concern in the region through changing the habitat and other conditions upon which these species rely. A listing could include

- marine turtles, including the diamondback terrapin (*Malaclemys terrapin*);
- shorebirds, including the piping plover (*Charadrius melodus*); and
- marine mammals, including the northern right whale (*Eubalaena glacialis*).

Of particular importance is the designation of a large portion of Cape Cod Bay as critical habitat for the



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northern right whale, through the federal Endangered Species Act.

Any application for an aquaculture site in Massachusetts includes reviews of the site plans for impact on important species and their habitat by NHESP, USFWS, and the NMFS, factored in through comment to the Army Corp of Engineers authorization process and by MA DMF, Div, of Wildlife and NHESP through the Division of Marine Fisheries review.

In addition, the presence of marine vascular plants, or **submerged aquatic vegetation** (SAV), also represents an important aquatic habitat. Submerged aquatic vegetation includes primarily eelgrass (*Zostera marina*) and widgeon grass (*Ruppia ruppia*). Protection of submerged aquatic vegetation areas is accomplished at the state level by action of the Division of Marine Fisheries through the mandated aquaculture site review. At the federal level, site review is overseen by the Army Corp of Engineers and includes comment from NMFS, USFWS and USEPA.

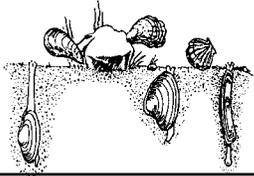
Information on the distribution of important habitat in Massachusetts can be initially investigated through two sources of habitat maps. The NHESP publishes maps of critical habitat for threatened species. Massachusetts Coastal Zone Management's Marine Ocean Resource Inventory System (MORIS) is another

resource based on Geographic Information System (GIS) mapping of specific marine conditions, such as distribution of submerged aquatic vegetation. Critical habitat and SAV distribution needs to be confirmed by on-site inspection to mark the extent and importance of these natural resources.

If in question, the perspective grower should consult with their local shellfish constable and/or representatives from MA DMF, NMFS and USEPA to determine significance.

Pertinent State & Federal References:

- ◆ *Marine Mammal Protection Act of 1972 (16 U.S.C. § 1371 et seq.): prohibits the "take" of all marine mammals in U.S. waters. The law defines "taking" as harassing, hunting, capturing or killing marine mammals.*
- ◆ *Endangered Species Act of 1973 (16 U.S.C § 1531 et seq.): declares the intention of the Congress to conserve threatened and endangered species and ecosystems on which those species depend.*
- ◆ *Migratory Bird Treaty Act of 1918 (16 U.S.C. § 702 et seq.): takes measures to protect identified ecosystems of special importance to migratory birds against pollution, detrimental alterations, and other environmental degradations.*
- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2): Aquaculture projects that*



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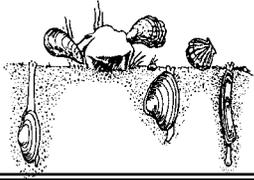
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involve more than minimal negative impacts cannot be authorized by the U.S. Army Corps of Engineers (USACE) as Category II activities under Programmatic General Permits (PGP). The Aquaculture Guidelines for the USACE PGP in Massachusetts address impacts to birds, invertebrates and wetland resources that may result directly from the aquaculture activity and associated vehicular access.

- ◆ *Mass. Endangered Species Act: (M.G.L. CHAPTER 131A) & Endangered Species Regulations (321 C.M.R. 10.00 et seq.).*
- ◆ *Wetlands Protection Act (M.G.L. CHAPTER 131. Section 40) & Wetlands Protection Regulations (131 CMR 10.00 et seq.).*
- ◆ *Marine Fish and Fisheries (M.G.L. CHAPTER 130 Section 59): Application for license; request for survey and plan.*

Recommended Best Management Practice(s):

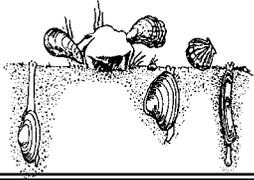
- During initial site location discussions, conduct a site visit with the local shellfish constable and MA DMF representative to ensure that the proposed site does not contain significant amounts of submerged aquatic vegetation or is not within an area of critical habitat for an aquatic or upland species identified as important, threatened or endangered.
- Be aware of local important, rare and endangered species that you may encounter, learn about their natural history and plan your operations to avoid interactions with them.



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1-5) Site selection and access: other users

Management Consideration:

The coastal zone is a highly populated and highly utilized sector of our land resources and, as such, there are a number of user groups who compete for access to public tidelands.

Background:

Greater than 50 percent of the population of the United States lives within 50 miles of an oceanic or Great Lakes coastline. This fact suggests the importance of our shorelines to American culture and indicates the level of use that our shores are subjected to annually.

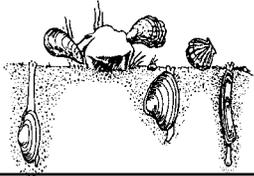
Traditionally the coast of Massachusetts has been used for many recreational and commercial applications. Activities such as sailing, motor boating, personal watercraft use, fishing, swimming, water skiing, and walking as well as aesthetic overlooks are all representative of the variety of recreational uses our waters support. In addition, there are a variety of individuals who make their living on the water, including commercial fishermen, marine engineers, marina operators and, of course, shellfish farmers.

Not only do these activities provide recreational and direct income resources to the public, they also

provide supplemental income for many people in the region through tourism activities, fishing activities and other venues.

Given the wide variety of users who inhabit and/or visit our coastlines, there are ample opportunities for conflicts to arise, particularly when a public resource is privatized for commercial activities, such as shellfish farming. To minimize potential conflicts, regulations at the local, state and federal levels are in place that mandate aquaculture areas be distinctly identified and that equipment placed on the flats are designed to minimize the risk of interference, injury, or damage to other users. Regulations define marking the aquaculture area, limiting the elevation of deployed equipment into the water column, and ensuring access for other users to enjoy our marine resources.

In addition, regulations also minimize interference with other commercial users of the marine resources through mandated limits on development of aquaculture away from areas where there are significant quantities of commercial or otherwise important natural resources.



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Pertinent State & Federal References:

- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2).*
- ◆ *Marine Fish and Fisheries (M.G.L. CHAPTER 130 Section 57): Shellfish aquaculture license; application; renewal; transfer.*
- ◆ *Marine Fish and Fisheries (M.G.L. CHAPTER 130, Section 61): Marking of territory covered by license, maintenance of markings...*

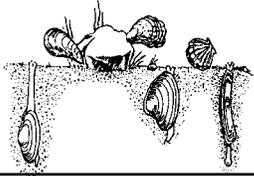
Recommended Best Management Practice(s):

- Respect the needs and wishes of other users of the public tidelands. Recognize that other users can have access to the water column above your site and plan accordingly.
- Minimize accidental intrusion onto your aquaculture site through properly marking the site and maintaining the markers during periods of high use of the coastal zone.

- Use the **U.S. Aids to Navigation System** to mark your site.
 - Hazard = diamond with two red or orange stripes (see Figure 1-5a)
 - Submerged aquaculture = 20 inch diameter yellow ball.
- Assist local residents and visitors in identifying aquaculture site markers and understanding the significance of the markers.
- Be courteous to visitors at your site and use these visits as an opportunity to educate the public about shellfish aquaculture.



Figure 1-5a: An example of a buoy used to mark a boating hazard. The buoy is conventionally white with red or orange diamond and stripes



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2) Materials, operations and maintenance

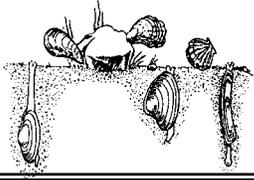
Shellfish aquaculture is a highly varied industry in southeastern Massachusetts. Variations on the central theme of farming shellfish result from differences in factors such as farm location, the species cultured, site access, preferred technology, and capital cost of the operation. Shellfish farmers are creative, independent self-initiators and therefore no two shellfish farms are exactly the same in terms of the materials used, normal operating procedures, nor scheduling or degree of maintenance.

However, there are some commonalities in the general approach to shellfish aquaculture that can be identified for which BMPs can be developed. Normal activities may include:

- manipulating sediment to enhance production,
- placing equipment in and on the intertidal flats to hold shellfish and to delineate planting areas,
- using anti-predator containment devices to hold and protect the shellfish,
- keeping equipment free from **biofouling** to optimize production,

Given the range of general activities involved in shellfish farming, there

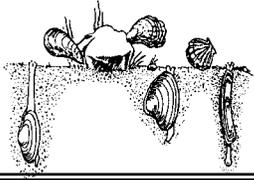
are practices that, if adopted, will assist the farmer in increasing their productivity while decreasing the overall impact of the farm on the surrounding environment. The following BMPs have been developed to address some of these practices.



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2-1) Materials, operations and maintenance: sediment management.

Management Consideration:

Management of **sediment** on-site is an important component of shellfish farming during the **nursery, grow-out,** and harvesting stages.

Background:

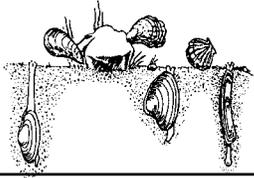
Many shellfish farmed in the intertidal flats of southeastern Massachusetts are **infaunal**, meaning that they live buried in the sediment. These include the quahog, the soft shell clam, the surf or butter clam and the razor clam. As young **juvenile** clams, these species are capable of living out of the sediment for extended periods of time but as they get older and grow larger they become more dependent on living buried in the sediment. Therefore, as the shellfish get older, it is very important that shellfish farmers provide their crop with an opportunity to dig into the sediment.

At the same time, the shellfish farmer needs to contain his/her crop to keep it in one place and to protect it from predators. This is routinely accomplished by covering the clam plots with some form of netting. However the specific containment technology may vary depending on the size and species of the clam.

During the early stages of growout, the juvenile clams are frequently held in small enclosed trays that have been filled with sand, usually from an off-site source such as washed or mason's sand from the local gravel pit. The Aquaculture Guidelines for the US Army Corp of Engineers Programmatic General Permit in Massachusetts (Appendix 2) stipulates that "mineral growth medium used in culture trays shall be clean and of comparable grain size to the native substrate."

Later grow-out culture efforts are accomplished by broadcasting (planting) **seed** clams directly to the bottom and covering with a small mesh netting (1/4 to 1/2 inch diamond or square mesh). Net coverings are a risk in that they may trap large amounts of sediment or **silt** that normally move across the intertidal flats. This could result in high levels of shellfish mortality due to burial and/or low oxygen levels resulting from the newly deposited materials covering the raceways.

The final effort of the shellfish farmer is to harvest his/her crop for market. Harvesting infaunal clams requires their mechanical or manual



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removal from the sediment.

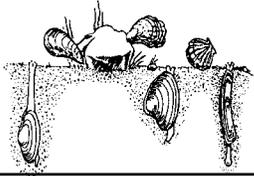
Traditionally this has been done using some type of rake to physically excavate the site and separate the shellfish from the sediment. Other technology that has been used both for bed preparation during initial planting and at harvest is the **hydraulic rake**. This apparatus pumps pressurized water from a discharge manifold into the sediment thereby liquefying the sediment and exposing the clams to facilitate removal. Hydraulic harvesting is controlled locally by the municipality. It is always best to check with the town before planning to use this harvesting technique.

Pertinent State & Federal References:

- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2): "mineral growth medium used in culture trays shall be clean and of comparable grain size to the native substrate."*
- ◆ *MA Wetlands Protection Act (M.G.L. CHAPTER 131. Section 40) & Wetland Protection Regulations (310 CMR 10.00 et seq.): The provisions of this section shall not apply to ... work performed for the normal maintenance or improvement of land in agricultural use ...*

Recommended Best Management Practice(s):

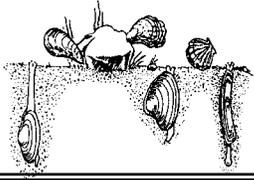
- When using sediment from an upland source, match the sediment type and grain size to the prevailing sediment type and grain size at your site.
- When adding sediment material to your site, inspect the sand and source closely to minimize the risk of introduction of contaminants into your site.
- Monitor your site regularly and be aware that sediment burial of your nets can cause mortality. The buried net may hold clams deeper than their optimal depth and they can't pump oxygenated water through their respiratory system. Always make sure you can see the net at the sediment surface in your raceways.
- Be aware of heavy natural **siltation** events at your site and remove any built up organic material from the surface of your net. Decomposing organic material consumes oxygen and may reduce ambient oxygen levels sufficiently to suffocate your crop.



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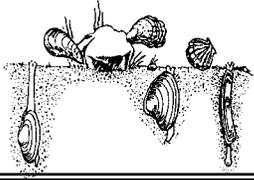
- Try modifying the overlying nets by adding modest floatation. This allows the nets to work their way up through overlying sediment during high tide thus preventing burial of the clams too deep in the sediment.
- When hydraulically working the sediment either for bed preparation or for harvest be aware of the fate of the resuspended materials generated by your activities. Ensure that your activities are not impacting sites downstream.



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2-2) Materials, operations and maintenance: onsite deployment and storage of gear.

Management Consideration:

Equipment utilized to grow shellfish may rise above the sediment surface into the water column creating a potential hazard for navigation and other users of the site.

Background:

Growing shellfish requires that structures be placed on the intertidal and subtidal flats. The presence of structures rising above the sediment surface represents a potential source of interference with other activities taking place at the water surface or in the overlying water column. Therefore use of structures in shellfish farming has been carefully regulated to minimize potential conflicts.

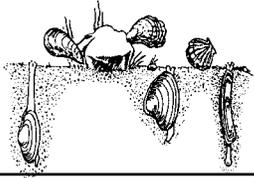
State and federal regulations require that aquaculture sites be marked in accordance with state and Coast Guard guidelines. Guidelines include marking corners of the aquaculture site “by monuments, marks or ranges and by stakes or buoys” (insert reference) Each marker must present the number of the aquaculture license in 2 inch lettering. The marking structures can be changed from buoy to winter stick when ice may be present. In addition, the licensed aquaculturist

must notify the U.S. Coast Guard, First District Aids to Navigation Branch to coordinate the proper buoy markings for the activity. Regulations require that all markers be reasonably maintained during the term of the license.

To further limit the potential of interference from structures placed on flats used for shellfish aquaculture, restrictions have been established limiting the elevation of materials above the sediment surface. The Aquaculture Guidelines for the US Army Corp of Engineers Programmatic General Permit in Massachusetts (Appendix 2) stipulates that “no structure or device (except marking buoys and as noted in Paragraph D of the Guidelines) shall protrude more than 18 inches (46 cm) above the substrate.”

Pertinent State & Federal References:

- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2).*
- ◆ *Marine Fish and Fisheries (M.G.L. CHAPTER 130 Section 61): Marking of territory covered by license, maintenance of markings...*”



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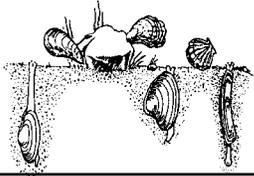
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Recommended Best Management Practice(s):

- Minimize accidental intrusion onto aquaculture sites through properly marking the site. Use the U.S. Aids to Navigation System to mark your site.
 - Hazard = diamond with two red or orange stripes (see Figure 1-5a)
 - Submerged aquaculture = 20 inch diameter yellow ball.
- Maintain your site markers, particularly during periods of high use of the coastal zone.
- Do not exceed the 18-inch (46 cm) elevation limit on structures placed on your site.
- Do not leave unused equipment lying on the culture site.



Figure 2-2a: An example of a buoy used to mark a boating hazard. The buoy is conventionally white with red or orange diamond and stripes



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2-3) Materials, operations and maintenance: on-site equipment management.

Management Consideration:

Some equipment may remain at the field growout site to minimize transport and increase efficiency.

Background:

Shellfish aquaculture requires the use of equipment onsite to accomplish daily maintenance of the farm. In many cases, it is impossible or inefficient to transport the needed equipment on and off-site daily. Often equipment is left on-site to optimize the farmer's time given the narrow window of opportunity for work, dictated by the tidal cycle.

The presence of the equipment on-site represents a risk to the farmer and other users of the coastal environment. It may be intentionally or unintentionally damaged or moved away from the site by vandals or other individuals. Also, it is susceptible to damage and transport by severe storm events during the growing season. (The winter season is discussed in BMP 2-4.)

Another consideration with regards to equipment left at the growout site relates to the potential for visitors to the area. Unsightly materials on the intertidal flats may interfere

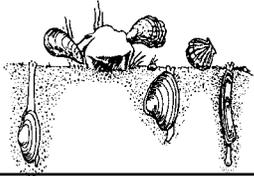
with scenic vistas within our coastal zone. This may prove an irritation to upland landowners and other visitors, generating unneeded and costly remedial actions.

Pertinent State & Federal References:

- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2): Aquaculture projects that involve more than minimal negative impacts cannot be authorized by the U.S. Army Corps of Engineers (USACE) as Category II activities under Programmatic General Permits (PGP). The Aquaculture Guidelines for the USACE PGP in Massachusetts address impacts to birds, invertebrates and wetland resources that may result directly from the aquaculture activity and associated vehicular access.*

Recommended Best Management Practice(s):

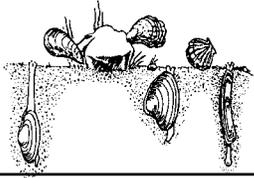
- Remove all unused or unnecessary equipment from the field site in a timely manner.
- All equipment left on the flats should be signed with distinctive marks to permit identification.



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- If equipment must be left onsite, secure it carefully to the site to minimize the risk of damage or it moving offsite.
- Keep aesthetics in mind when leaving equipment at the field site and try to make the presence of the equipment as visually unobtrusive as practicable.
- It is imperative that you police your site following a storm event to ensure equipment and materials are secure on-site.
- Monitor your neighbor's site and equipment along with your own to ensure unauthorized individuals are not using or damaging the equipment and site.



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2-4) Materials, operations and maintenance: preparing for winter conditions.

Management Consideration:

Winter conditions can move and destroy equipment and structures placed in intertidal and subtidal areas.

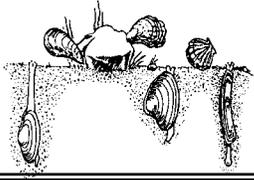
Background:

Extreme conditions that occur during winter may include severe storms, large masses of ice and very low water/air temperatures. Any and all of these conditions can lead to damage and losses within the farmer's growing area. Proper husbandry and care must be exercised to minimize damage and loss due to winter conditions.

In addition to impacting the farmer's crop, extreme conditions can damage and destroy culture equipment, including carrying damaged items off-site. Especially during winter, ice can freeze around a mesh net during low tide and lift the netting with the tide. As the tide lifts the net, it can be ripped from the sediment and transported with the flow of the ice. Damaged netting, plastic mesh bags, rebar racks and other materials may generate potential hazards for entanglement and destruction of marine resources in the immediate environment.

Pertinent State & Federal References:

- ◆ *International Convention for the Prevention of Pollution of Ship (MARPOL 73/78), Annex V Regulations for the Prevention of Pollution by Garbage from Ships) & Act to Prevent Pollution from Ships (33 USC 1901 et seq.): includes the complete ban imposed on the dumping into the sea of all forms of plastic*
- ◆ *Marine Plastic Pollution Research and Control Act (33 U.S.C. § 1901 et seq.)*
- ◆ *Solid Waste Disposal Act (42 U.S.C. § 6901 et seq.)*
- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2): activities that have more than minimal negative impacts, including cumulative impacts, cannot be authorized by the U.S. Army Corps of Engineers (USACE) under Programmatic General Permits (PGP). Aquaculture permittees holding USACE permits shall maintain the work of structures in good condition to ensure public safety. Additionally, the Massachusetts PGP requires seasonal structures that are removed from the waterway be stored in an upland location, located above mean high water and not in tidal wetlands.*
- ◆ *MA Crimes Against Public Health (M.G.L CHAPTER 270: Section 16): Disposal of rubbish, etc. on or near highways and coastal or inland waters.*

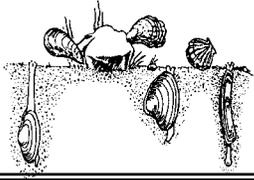


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Recommended Best Management Practice(s):

- Remove all elevated and/or unnecessary equipment, including rebar racks and damaged or discarded nets, from the area during winter.
- To prevent ice damage and transport, position all equipment and materials flush with the sediment surface.
- Carefully secure all netting and other materials to the substrate with supplemental attachment devices during winter.
- Ensure that any nets left on the flats during the winter are free from fouling to reduce the potential for attachment of ice to the netting.
- Replace marker buoys on-site with winter sticks to minimize the risk of the ice moving marker buoy.
- Survey and maintain the area whenever possible during winter.
- When reasonable, organize local shellfish farmers to police the surrounding marine resource areas for damaged and displaced aquaculture materials following winter. Hosting an annual spring clean up, for example in coordination with “Coast Sweep”, can provide both a cleaner environment and good public relations for the aquaculture industry.
- At all times of the year – if you see damaged material in the marine environment – remove it to minimize risk of impact to other marine resources or users of the coastal environment.



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2-5) Materials, operations and maintenance: use and management of netting.

Management Consideration:

The use of mesh netting is a necessary component of shellfish aquaculture; therefore, the proper selection, use and maintenance of netting material are critical to the successful practice of shellfish farming.

Background:

The overall objective of a shellfish farmer is to optimize growth while minimizing mortality to maximize profits. The primary source of mortality to a shellfish farmer is predation.

Mobile predators, such as crabs, whelks, snails, birds and fish present a wide variety of predation strategies to open and consume shellfish. The primary line of defense that shellfish farmers have to protect themselves from excessive predation losses is to physically exclude the predator from accessing their shellfish.

In general, shellfish farmers place a net barrier between the shellfish and the predator. As an added benefit, netting holds the small seed in place and minimizes washout of the seed by tidal current or wave action following planting.

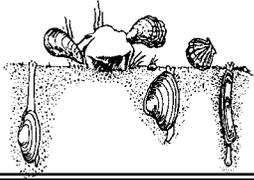
The netting used by the shellfish industry is an extruded plastic net that

ranges from semi-rigid Tenax[®] to flexible Plurima[®]. The actual mesh size varies with the preferences of the grower and the size of the shellfish seed planted. The net is usually changed as the shellfish grow, as larger mesh sizes are easier to maintain and provide a better growing environment (see BMP 2-6 on biofouling).

Traditionally, the net is placed on the sediment surface covering the planted clam seed and secured in place by wire staples (approximately 1 foot in depth) while burying the margin of the sheet of netting. The grower sometimes inserts a floatation device (a small bobber or buoy) under the net to keep it at the sediment surface to prevent burial of the net.

In the case of oysters, the netting is in the form of an enclosed mesh bag. The oyster bag is secured to a rack or frame at the sediment surface or sometimes elevated slightly above the sediment to promote accelerated growth.

Regardless of the type or application, netting constitutes a potential hazard to the marine environment in that it can be lifted, transported and acts as an entanglement



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device in place if not carefully monitored and maintained.

Lastly, in the event that the license holder decides to cease operations at their site, it is the grower's responsibility to remove all equipment, gear and shellfish from the growing area.

Pertinent State & Federal References:

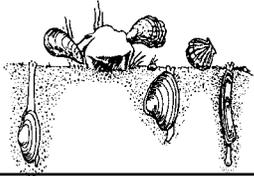
- ◆ *International Convention for the Prevention of Pollution of Ship (MARPOL 73/78), Annex V Regulations for the Prevention of Pollution by Garbage from Ships) & Act to Prevent Pollution from Ships (33 USC 1901 et seq.): includes the complete ban imposed on the dumping into the sea of all forms of plastic*
- ◆ *Marine Plastic Pollution Research and Control Act (amended to 33 U.S.C. § 1901 et seq. in 1987.)*
- ◆ *Solid Waste Disposal Act (42 U.S.C. § 6901 et seq.)*
- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2): activities that have more than minimal negative impacts, including cumulative impacts, cannot be authorized by the U.S. Army Corps of Engineers (USACE) under Programmatic General Permits (PGP). Aquaculture permittees holding USACE permits shall maintain the work of structures in good condition to ensure public safety. Additionally, the Massachusetts PGP requires seasonal structures that are removed from the waterway be stored in an upland location,*

located above mean high water and not in tidal wetlands.

- ◆ *MA Crimes Against Public Health (M.G.L. CHAPTER 270: Section 16): Disposal of rubbish, etc. on or near highways and coastal or inland waters.*

Recommended Best Management Practice(s):

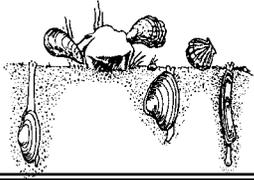
- Ensure that all netting is properly deployed to minimize the risk of damage and the potential for loss. Precautionary activities include:
 - ensure secure attachment of the net to the sediment or to the rack,
 - ensure the net is pulled taut with no folds or pockets on the surface,
 - keep the net close to the sediment surface, although not to the degree where it will be buried leading to suffocation of the shellfish.
- As soon as shellfish seed size permits, increase the net mesh size to the next larger level to provide optimal conditions for water and food flow across the shellfish.
- Inspect nets on a regular basis and repair or replace any damaged netting as soon as it is observed to minimize the risk of



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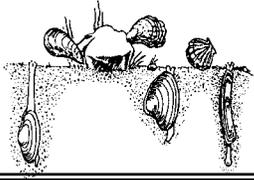
- further damage or of transport away from the site.
- Some towns require netting to be marked to identify the owner. If this is the case in your area, follow the established guidelines and make sure all nets are marked appropriately.
 - When changing nets, stake or anchor the fouled net upon removal to prevent transport off-site, remove the old netting from the site as soon as possible and dispose of it properly. Do not leave unused netting on-site for extended periods of time.
 - Do not limit your net maintenance to your site alone. If loose netting is observed anywhere in the coastal area, remove and dispose it properly.
 - If using **leadline** to hold netting in place, inspect it frequently. Do not use if lead is exposed and has the potential of breaking up and entering the marine environment. Do not use lead shot sinkers on nets. Dispose of all materials containing elemental lead in an environmentally responsible manner.
 - If using a rigid net anchoring system, make sure the rigid frame is adequately stapled and properly buried in the sediment to hold the net in place.
 - Regularly organize bay-wide clean-ups to minimize the presence of loose netting or other foreign materials in the coastal zone. Clean-up should not be limited to the high water wrack line only but needs to be marsh-wide, including salt marsh creeks at low tide and the surface of the salt marsh.
 - If using nylon ties (also known as cable ties or ny-ties) to secure netting or other equipment, dispose of used ties properly. Do not discard them into the marine ecosystem.



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2-6) Materials, operations and maintenance: controlling biofouling on submerged surfaces.

Management Consideration:

Biofouling of structures in the marine environment is a ubiquitous problem for shellfish farmers.

Background:

The primary activity that occupies the daily schedule of a shellfish farmer during the growing season (March through November) is control of biofouling. The overgrowth of **algae** and marine animals on nets and other structure in the water can significantly impede your farming effort. Marine biofouling is increasing annually as nitrogen introduction from land-based systems into the marine environment enhances coastal **eutrophication** leading to increased aquatic productivity.

Biofouling organisms can overgrow and occlude the mesh openings in clam netting or oyster bags. The resultant blocking of mesh openings restricts water flow across the growing shellfish. Captive shellfish rely on water flow across their **siphons** to bring oxygen and food to the clam or oyster. Without adequate water movement, shellfish growth will slow

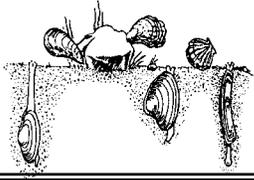
or stop and the shellfish will eventually die.

Management of biofouling normally involves removing the fouling organisms from the structure either through physically brushing or applying a high-pressure stream of water to wash the biofouling off into the marine environment. Another management strategy involves manipulating the biofouled structure so it air dries for an interval of time thereby drying out the fouling organisms.

Pesticides or other chemicals are not allowed in treating shellfish for biofouling. The exception permitted by the Food and Drug Administration is to dip your structures into a high strength salt brine (100% saturation) disrupting the fouling organisms through osmotic shock.

Pertinent State & Federal References:

- ◆ *Federal Food, Drug, And Cosmetic Act (21 USC §1-1404): FDA restrictions on treatments for cultured food organisms.*

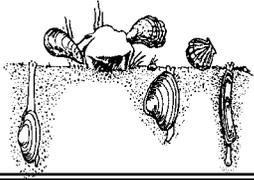


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Recommended Best Management Practice(s):

- Monitor your nets and other equipment regularly for biofouling.
- If biofouling develops to the extent that it restricts water flow to cultured shellfish, clean and remove the fouling organisms to facilitate shellfish health and growth or replace the nets with new material.
- Cleaning can be accomplished by:
 - pressure washing,
 - physical removal by scrubbing with a brush or broom,
 - air drying for an extended period of time,
 - high concentration saline dip.
- If using a cleaning method that entails an internal combustion engine, be aware of noise issues and use the motorized equipment at times when it will be the least disruptive to other users of the coastal environment.
- When cleaning nets of biofouling, practice good management techniques with respect to the removed material and do not allow it accumulate on downstream sites where it may cause local degradation of the environment.



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3) Improvement of shellfish survival and productivity

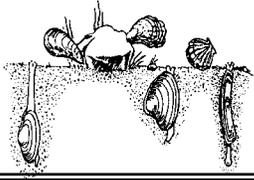
Common objectives of all agriculture production systems are to bring the greatest amount of product to the market in the least amount of time with the fewest losses for the least expense. This is as true in shellfish aquaculture as it is in cranberry farming or beef cattle production. Any modification of existing methods or introduction of new technologies must improve on one or more of the objectives listed above. In other words, criteria for implementing improvement in shellfish farming technology can be restated as new technology that must:

1. increase production,
2. reduce production time,
3. minimize losses, and/or
4. decrease production costs.

An over-riding criterion that is implied and understood but not stated explicitly is that any new technologies used in shellfish farming must preserve the sustainability and not adversely impact the environment, particularly water quality. **Clean water and a clean environment are fundamental requirements for shellfish farming.** Any activity that compromises water and environmental quality compromises the farmer's ability to

provide income for his/her family through shellfish farming. Shellfish farmers must be stewards of the marine coastal environment.

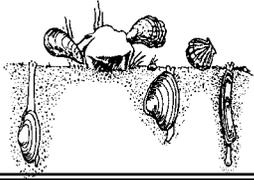
New technologies are continually evolving to improve shellfish farming. The shellfish farmer must decide on the appropriateness of the new technology as it relates to the unique characteristics of his/her farm site and crop. Selection and implementation of new technologies should follow extensive testing and research to understand the full impact of the technology. The following BMP recommendations provide a foundation for the farmer to review and to select technologies that are appropriate for his/her operation while maintaining environmental quality and the sustainability of his/her enterprise.



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3-1) Improvement of shellfish survival & productivity: performance selection to increase productivity.

Management Consideration:

Shellfish production under intensive farming conditions may require development of selected **strains** of shellfish that demonstrate superior performance.

Background:

Shellfish farming is not maintaining a natural native clam flat or oyster bed. Although the original King's Grants awarded in Massachusetts were akin to private harvest reserves, the modern shellfish farm is an area of intensive management of a crop within an area that would otherwise be nonproductive. Shellfish production is controlled and optimized by the grower through

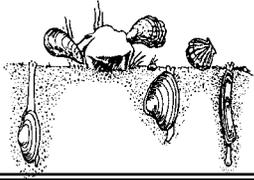
- selection of appropriate species,
- development of site specific planting strategies,
- application of customized grow-out technologies, and
- use of suitable husbandry techniques.

The shellfish farmer will increasingly have a selection of shellfish **strains** and **varieties**

available to them, similar to the selection of plant varieties available to the corn or cranberry farmer. For the most part, the strains being developed by aquaculture researchers are being generated using classical **breeding selection** technology. In other words, find the animal in your crop that survives the best or produces the best growth under the prevailing conditions at your site and use them for **broodstock** for your next generation of seed.

Strain selection involves consideration of many factors such as growth rate, tolerance of specific environmental conditions, disease resistance, performance under varied planting densities, and etc. As the technology develops, the application of selected strains better suited for growing in Massachusetts will become more prevalent in the region.

Strain development using classical breeding techniques requires an understanding of the genetic and ecological consequences of selection. Efforts must be established to maintain a semblance of the native **genetic diversity** of the species while selecting for "desired" traits. Genetic selection



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requires an understanding of genetic diversity and the consequences of applying artificial selection pressure. Conscientious adherence to these criteria will yield genetic strains developed for shellfish aquaculture that can be applied with benign impacts on native populations.

Use of selected shellfish strains also will require extensive testing by the farmer. Without adequate and strenuous tests, the use of selected strains may not provide the results anticipated based on published performance standards. Because shellfish growth is very site specific, the use of selected strains will require on-site testing and evaluation to assure that the strain is appropriate for application at a specific location.

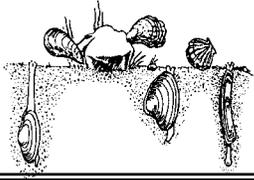
Pertinent State & Federal References:

- ◆ *In Massachusetts, there are no regulations pertaining to the use of genetically improved lines in farming. There currently is a panel of state regulators that are meeting to discuss and recommend regulatory oversight for use of genetically modified plants and animals in Massachusetts' agriculture.*
- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2): the Aquaculture Guidelines for the U.S. Army Corps of Engineers (USACE) Programmatic General*

Permits (PGP) in Massachusetts addresses impacts to existing or naturally occurring beds or populations of shellfish, marine worms or other invertebrates that could be used by humans, other mammals, birds, Reptiles, or predatory fish. When genetically improved lines will have more than a minimal negative impact upon such resources, including cumulative impacts, the associated work, structures and discharges cannot be authorized by USACE under Programmatic General Permits.

Recommended Best Management Practice(s):

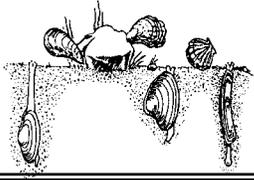
- Only purchase shellfish seed that have been produced by a commercial hatchery that is certified by the Division of Marine Fisheries for importation into the Commonwealth.
- New entrants into the shellfish aquaculture industry are encouraged to purchase the largest shellfish seed they can afford until they are secure in their ability to rear shellfish through grow-out. Shellfish survival through the first winter is directly related to the size of the seed going into winter.
- Do research on shellfish seed sources prior to investing in their seed. Query other growers who have experience with the specific seed source. Otherwise, start with a small seed purchase to test the specific hatchery product before investing at a large scale.



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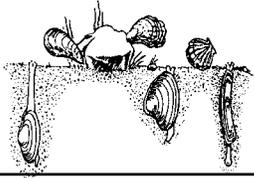
- Commercial hatcheries should be encouraged to ensure adequate genetic diversity in their shellfish breeding programs to maintain native diversity of the selected strains developed for farming.
- Encourage research and commercial shellfish hatcheries to undertake development of selected shellfish strains to improve farm performance, including the development of disease resistant strains of oysters, quahogs, and other molluscs.



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3-2) Improvement of shellfish survival & productivity: minimizing crop loss from predators.

Management Consideration:

Predators can severely impact the production of a shellfish farm. Therefore predator management and control is necessary.

Background:

Loss of shellfish to predators is a real and severe problem in shellfish farming. Predators of farmed shellfish encompass a wide variety of animals, including

- marine crabs, such as
 - mud crab
 - rock crab
 - spider crab
 - blue and lady crabs
 - green crab (an exotic species)
 - Japanese shore crab (an exotic species)
- predatory snails, such as
 - whelk or conch
 - oyster drill
 - moon snail
- avian predators, such as
 - winter ducks
 - eider
 - brant
 - shore birds
 - various gulls
 - oystercatcher

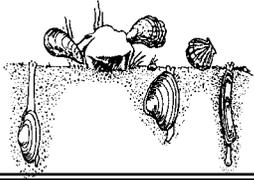
The distribution of predators is not uniform in terms of location or season. Therefore, predator control methods will depend on the suite of predators present at any given location or time.

The primary means that a shellfish farmer can avoid losses due to predators is to physically exclude the predators from access to the vulnerable shellfish. Exclusion is generally achieved through the use of protective netting or wire mesh barriers.

Chemical means of predator control cannot be legally applied in the marine environment. Removal of the aquatic predator is another suggested means to protect shellfish from excessive predation, although this technique is of questionable value unless applied carefully in a time- and location-sensitive manner.

Pertinent State & Federal References:

- ◆ *US EPA Pesticide Registry Board: there currently are no pesticides registered for use against shellfish predators.*
- ◆ *Pesticide Control Act (MGL CHAPTER 132B) & Pesticide Use Regulations (333 CMR 1.00 to 13.00)*
- ◆ *Marine Fish and Fisheries (M.G.L. CHAPTER 130 Section 103): Disposal of starfish, winkles and cockles.*

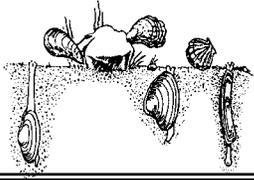


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Recommended Best Management Practice(s):

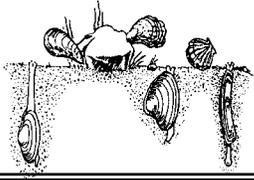
- Carefully inspect shellfish seed acquired from outside sources to prevent the introduction of small predators with the seed.
- Coordinate your shellfish seed-planting schedule to take advantage of your knowledge of predator behavior and seasonality. For example, planting seed in the fall as water temperatures are cooling will reduce predator pressure due to lower water temperatures.
- Use netting or wire mesh barriers to exclude predators from your planted shellfish. Do not remove barriers until the shellfish have grown to a size where they are not vulnerable to predation by most of the common marine predators.
- Be vigilant in monitoring your site to ensure that barriers have not been breached or small predators have not entered the culture system. Small predators will grow and become a problem by consuming shellfish.
- If using trapping or other removal techniques, limit your activities to intervals when your shellfish are most vulnerable. For example, intensively trap an area where you will be planting small shellfish seed to reduce predation pressure for a short period of time to permit the newly planted shellfish to become established within the site. Continuous trapping at a site is of questionable value in removing mobile predators given their ability to migrate into areas with reduced predator populations.
- Egg cases of large predatory snails are easily recognized and can be readily removed. Learn to identify egg cases from predatory snails, including oyster drills, whelks and moon snails, and remove them from the growing area during the reproductive season.
- Be aware that predation by ducks on farmed shellfish can be a severe problem during winter. Maintain exclusion barriers if winter ducks are present.
- One method to reduce predation pressure is to maintain a sacrificial population of prey away from the farmed site. For example, provide an elevated substrate to promote a barnacle set away from the oyster beds. Oyster drills prefer to climb and will preferentially prey on young barnacles thereby luring the drills away from your oyster seed. It is imperative that the sacrificial site



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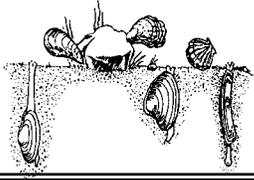
is carefully monitored and predators removed from the site on a routine basis. Otherwise the site will attract and concentrate predators.



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3-3) Improvement of shellfish survival & productivity: environmental considerations.

Management Consideration:

Bivalve molluscs are living animals that require specific environmental conditions for optimal survival and growth.

Background:

Shellfish farming requires that the crop be grown in a manner that optimizes productivity. Because bivalve molluscs are mostly immobile (**sedentary**), their living environment is limited to essential elements that move past them due to natural water movements, including oxygen and food.

Shellfish growth is dependent on a number of environmental factors, including

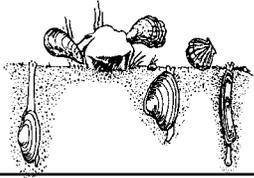
- genetic characteristics of the seed,
- temperature,
- **dissolved oxygen** concentration,
- **salinity**,
- food availability, and
- absence of disease or toxic materials.

Most of these factors are beyond the immediate control of the farmer. Environmental parameters such as temperature, dissolved oxygen concentration and salinity are ultimately controlled by site selection

during start-up of the shellfish farm. Environmental quality must be maintained thereafter by a concerted effort of the local community and others to protect that water body.

An example of a degraded environment leading to problems with shellfish farming can be cited with regards to coastal **eutrophication**. Increasing nutrient inputs from land often leads to enhanced production of **macroalgae** in our coastal ponds. Marine algae such as sea lettuce (*Ulva* sp.), oyster thief (*Codium fragile*) and mermaid's hair (*Enteromorpha* sp.) proliferate and subsequently cause increased problems for the shellfish grower. These algae can block water flow through the net or they can settle on top of the netted shellfish and cause local **hypoxic/anoxic** conditions that will harm or kill shellfish. These macroalgae firmly attach to netting and are difficult to remove and transport off-site.

Nevertheless, a farm management program implemented by the shellfish farmer can moderate and minimize many potentially adverse environmental factors. In other cases, such as exposure to undesirable materials and toxics, the shellfish



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farmer is dependent on the regulatory authority, goodwill and environmental stewardship of the community and local/state/federal natural resource managers.

It is the responsibility of all citizens to preserve our surroundings in a manner that provides a clean and healthy growing environment for all living things. For the shellfish farmer, it means that they must be diligent in maintaining environmental quality within their growing area and within the realm of their water sources. Without clean water, the shellfish farmer is out of business!

Pertinent State & Federal References:

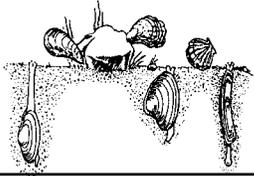
Many local, state and federal regulations that influence water quality are in effect. Some examples of these include:

- ◆ *National Pollution Discharge Elimination System (NPDES) as authorized by the Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C. § 1251-138).*
- ◆ *National Rivers and Harbors Protection Act of 1899*
- ◆ *MA Environmental Code Regulating Septic Systems (310 CMR 15.00 et seq.)*
- ◆ *MA Wetlands Protection Act (M.G.L. CHAPTER 131. Section 40) & Wetland Protection Regulations (310 CMR 10.00 et seq.)*
- ◆ *MA Waterways (M.G.L. CHAPTER 91 Sections 1-63) & MA Waterways Regulations (310 CMR 9.00 et seq.)*
- ◆ *MA Rivers Protection Act (M.G.L. CHAPTER 258, Acts of 1996) & Rivers Protection Regulations (310 CMR 13.0)*

- ◆ *MA Water Management Act (M.G.L. CHAPTER 21G) & Water Management Regulations (310 CMR 36.00; 313 CMR 2.00, 4.00 & 5.00).*
- ◆ *Pesticide Control Act (MGL CHAPTER 132B) & Pesticide Use Regulations (333 CMR 1.00 to 13.00)*

Recommended Best Management Practice(s):

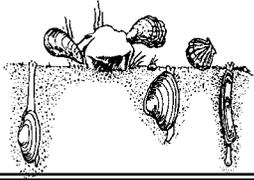
- Water quality issues bridge all stakeholders in the coastal region. The shellfish farmer should:
 - Work with all interested parties and organizations to enhance the public's awareness of water quality issues.
 - Support local water quality monitoring groups by volunteering to monitor conditions at or near your site.
 - Strive to improve water quality whenever possible.
- Manage your farm to provide the highest quality of water to your growing shellfish. Typical efforts might include:
 - During start-up, carefully research your site selection to ensure that the local environmental conditions are conducive for shellfish growth. This information can be obtained from the local shellfish constable, the Division of Marine Fisheries area shellfish biologist, your local aquaculture extension agent, or, perhaps



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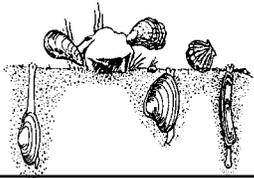
- most importantly, other shellfish farmers within your local area.
- Work the sediment before planting to enhance the shellfish's growing environment by softening the bottom, removing predators and flushing excessive organic materials out of the sediment. Mechanical or hydraulic manipulation (i.e. dredging) of the sediments is not permitted under the Massachusetts Programmatic General Permit. A Department of the Army permit is required before performing dredging.
 - Remove fouling material from nets to improve water flow to the shellfish but be aware of the fate of removed materials to ensure they do not impact another site downstream.
 - Alternative net management strategies could include:
 - Rotation of nets where fouled nets are brought to shore for cleaning and air-drying while the alternate set is in place on-site.
 - Complete removal and replacement of fouled nets with new ones. Carefully dispose of fouled nets using approved methods.
 - Continuously monitor the condition of your site to ensure that local conditions have not changed to the point where your crop is at risk to degraded water quality.



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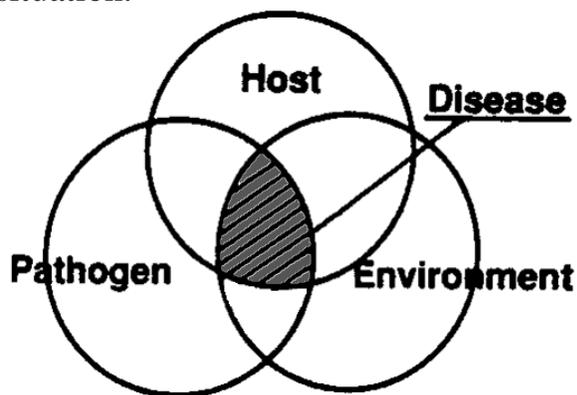
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4) Disease prevention and management.

As is true in all farming situations, where there is a high concentration of one plant or animal species, disease is a constant threat. Disease is a natural phenomenon in that an opportunistic **pathogen** (fungal, bacterial, viral or other) responds to a situation where the host organism is in a state such that it cannot counteract the pathogen invasion.

Disease results from a specific set of conditions that may occur in a group of shellfish. The figure provided below illustrates a classic interpretation of the key components associated with the development of a disease situation.



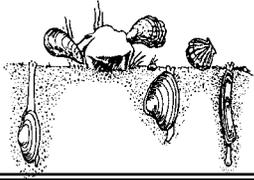
Generally, the development of a disease condition involves the convergence of the following factors:

- a compromised host organism, in our case – the shellfish, usually associated with some type of stress where the shellfish can't protect itself from the pathogen,
- an adverse environment (in our case – the intertidal flats where the shellfish are located), frequently the source of the stress to the shellfish, and
- an opportunistic pathogenic organism (in our case – one of a variety of shellfish disease organisms), that has an opportunity to flourish under the prevailing conditions.

When all three pieces of the disease puzzle are in the right state, we have a situation where the farmer can lose their entire shellfish crop.

Given the shellfish species routinely farmed in our local industry, the shellfish diseases that are particularly noxious and of regulatory concern include:

1. Oyster
 - a. Multinucleated Spheroid Unknown (MSX) caused by the protistan parasite *Haplosporidium nelsonii*.
 - b. Dermo caused by the protistan parasite *Perkinsus marinus*.
 - c. Seaside Organism (SSO) caused by an unknown protistan parasite similar to the MSX organism.
 - d. Juvenile Oyster Disease (JOD) caused by an unknown



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- disease agent but thought to be a bacterial problem.
2. Quahog
 - a. Quahog Parasite Unknown (QPX) caused by a protistan parasite of the Labrynthomorpha class and Thaumastochytriales family.
 3. Soft Shell Clam
 - a. Hematopoietic neoplasia (clam leukemia) a disseminated sarcoma thought to be caused by a virus.

These six shellfish diseases have caused the greatest economic damage to shellfish growers in southeastern Massachusetts and currently are **pandemic** to this area.

Movement and transmission of these diseases varies. Some infect by **direct transmission** where a sick mollusc dies and the pathogen is released into the environment where it transfers directly to a neighboring mollusc (of the same species). Alternatively, other pathogens infect by **indirect transmission** where an alternate host or carrier is involved in moving the disease organism from one individual to another. The management of shellfish diseases is somewhat dependent on the mode of disease transmission as well as a multitude of other factors.

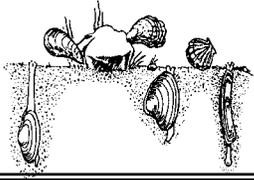
Unfortunately, much of the information needed to manage shellfish diseases adequately is currently

unknown. The research community is aggressively investigating mechanisms driving the many shellfish diseases. As more information becomes available regarding specific diseases, the better the management for those diseases will become.

One avenue of research that holds promise is the development of "disease-resistant" shellfish strains through selective breeding programs. The value of breeding program has been demonstrated in a number of situations, including the development of MSX resistant oyster lines in Delaware Bay. The development and testing of selected lines of disease resistant shellfish continues and their incorporation in shellfish farming will become more accepted as resistance to specific diseases is demonstrated.

In the meantime, there are a number of management strategies that can be undertaken to minimize the impacts of shellfish diseases on a farm. In general, the husbandry of shellfish to minimize disease follows the same protocols as other livestock farming situations. A universal means to control disease is to limit disease movement through monitoring of the disease status in shellfish being considered for transport. Always ensure that shellfish being moved to an area devoid of disease are disease-free.

The following practices can assist in maintaining your farm as disease-free.



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4-1) Disease prevention and management: impact of shellfish diseases.

Management Consideration:

Shellfish diseases can result in significant crop loss and adversely impact a farmer's productivity.

Background:

Diseases specific to the shellfish being farmed can significantly impact the production of the farm. **Mortality rates** of up to 95% have been observed in infected shellfish beds. Needless to say, a farmer cannot absorb these levels of product loss and remain in business. Therefore, it is imperative that the shellfish farmer manages his/her farm to minimize the risk of disease introduction and to minimize their losses if a disease occurs.

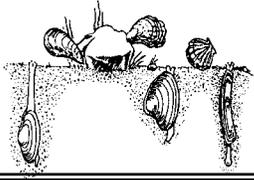
New disease introductions in Massachusetts' shellfish resulting from the activities of shellfish farmers are virtually nonexistent due to careful monitoring and control by the Commonwealth. The Division of Marine Fisheries controls all movement of shellfish between isolated water bodies. A "**health inspection certificate**", based on a pathological inspection from a veterinary professional, is required by DMF to demonstrate the absence of known shellfish pathogens prior to the

shellfish relay, i.e. moving the shellfish from one body of water to another. In the case where shellfish pathogens are observed, the relay request will be denied.

Where a specific disease is pandemic to a geographical area, the skills of the farmer are directed to managing the crop so losses due to the disease are minimal. In many cases, the disease risk can be minimized or eliminated by maintaining a healthy growing environment for shellfish. Practices described in this section reference management decisions that will minimize disease impacts for those shellfish diseases pandemic to Massachusetts.

When monitoring your crop for disease, the following symptoms may indicate the presence of disease in your farm:

- large numbers of live shellfish or empty shells appearing at the surface of the sediment,
- unexplained mortalities where the die-offs appear to be happening over specific time intervals,
- abnormal occurrences, such as large numbers of shellfish gaping or showing extensively chipped shell margins.



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Pertinent State & Federal References:

- ◆ *The Massachusetts Division of Marine Fisheries requires health Inspection Certification for all shellfish moved into Massachusetts from out of state or within from one isolated water body to another.*

Recommended Best Management Practice(s):

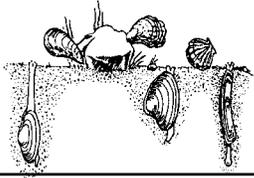
- Be aware of the prevalent shellfish diseases in your area and be knowledgeable with regards to their symptoms and seasonal cycles. Contact your local shellfish constable or aquaculture extension specialist to be updated on current disease issues.
- Keep up-to-date on current shellfish disease management practices by reading trade magazines/journals and/or talking with aquaculture professionals or other farmers. New approaches to shellfish disease management are developing regularly so make a point of keeping informed.
- Early detection is the best prevention, regularly monitor the condition and appearance of your crop.
- If you suspect that a disease situation may be developing at your farm, contact your local natural resource specialist immediately and notify them of the situation.

Individuals that you should consider contacting include:

- shellfish constable,
- Division of Marine Fisheries area shellfish biologist,
- aquaculture extension agent,
- neighboring farmers who may be at risk.

These individuals can assist you in dealing with the disease and will provide guidance to minimize losses from the disease and to minimize the disease risk to neighboring farmers.

- Planting density is a key factor in the development of shellfish diseases. Whenever possible, keep planting densities at a level to optimize growth as growth rate is an indication of the health and well being of your shellfish.
- If a shellfish disease is present at your site, carefully monitor mortality and remove any diseased shellfish from the flats whenever possible. Risk of contracting disease is dependent on the level of shellfish exposure to the disease-causing organism. Removal of diseased organisms reduces the level of exposure at any given site.
- DO NOT dispose of diseased shellfish in an area where further disease contamination could occur, i.e. don't dump them at the boat



Best Management Practices

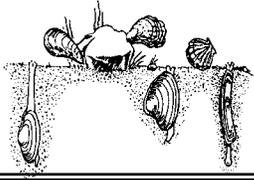
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landing. Dispose diseased animals removed from the flats in appropriate upland areas where the risk of reintroducing disease into shellfish areas is minimal, e.g. municipal disposal areas.

- It is not uncommon to observe shellfish mortality due to causes other than disease, e.g. over-winter mortality. If in doubt as to the causes for mortality situation, contact a local aquaculture specialist (Appendix 3) and solicit their assistance in determining the problem.
- If a disease situation is suspected, shellfish should be collected for submission to an animal health specialist for diagnosis. When collecting shellfish for disease diagnosis, the following guidelines will help ensure the samples are in a suitable condition for analysis.
 - specifically collect living shellfish that are weakened or showing symptoms of the disease. Do not collect dead animals as they cannot be diagnosed given the rapid rate of decomposition of dead shellfish,
 - if possible, collect 60 or more individual shellfish samples for submission to ensure an adequate number for diagnosis,
 - place the shellfish samples in a bag or other suitable holding

container, preferably one that limits shellfish fluids from leaking from the container and increasing the risk of spreading the suspected disease,

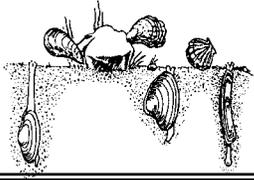
- carefully transport the shellfish samples to ensure that other areas or shellfish populations are not exposed to the potential disease.
- deliver the samples to the diagnostic facility as soon as possible. If delivery is delayed, refrigerate (**DO NOT FREEZE**) the live samples to extend their life until they can be analyzed in the veterinary diagnostic lab,



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4-2) Disease prevention and management: transporting shellfish.

Management Consideration:

Shellfish diseases can be spread through transport of infected shellfish.

Background:

As is true of all infectious diseases, the occurrence of the disease requires that the causative pathogen be present in the environment. When the environmental and host conditions are sufficiently compromised, the pathogen can proliferate and cause the disease.

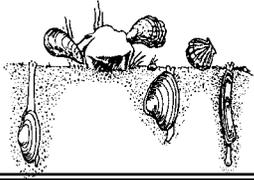
The presence of the pathogen is dependent on the nature of the infective organism. Some pathogens are **facultative** in that they are capable of living outside of their host in the environment while others are **obligate** and must reside in the host to survive. Facultative pathogens are not dependent on the presence of the host and therefore can exist in the shellfish's surroundings for extended periods of time without manifestation of a disease. Obligate pathogens require a constant supply of hosts to persist in a location.

Regardless of the pathogen's requirements, introduction of a new disease within an area is key to the spread of the disease. Obligate pathogens are moved into new areas through the transfer and introduction of

diseased shellfish into uninfected areas. The exception is a shellfish disease, such as the oyster disease MSX that appears to have an alternate or intermediate host that may serve to carry the disease from one site to another. Facultative pathogens are more easily moved from site-to-site because they are capable of living outside of the host and may be moved via sediment or water transport.

Another consideration in the spread of shellfish disease is the level of exposure that shellfish may experience. As a clam or oyster grows from egg to adult, it is held in a sequence of containment systems. Each subsequent step becomes less intensive in a more exposed environment. Therefore, as the shellfish grow their chance for exposure to diseases increases. There is a higher risk associated with moving larger shellfish (e.g. from the nursery to the grow-out system) than smaller less exposed shellfish (e.g. early juveniles coming from a hatchery.) Therefore, a grower should carefully consider the source and history of any shellfish he/she is considering moving.

Another, larger concern, for shellfish growers is the inadvertent



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movement of disease through **wet storage** of imported shellfish. Non-native shellfish are purchased from a local importer, distributor or retailer and held in local open waters, to “refresh” the shellfish. The risk of moving disease through wet storage is exceedingly high and the public must be educated concerning the risk to local shellfish stocks from this practice.

Pertinent State & Federal References:

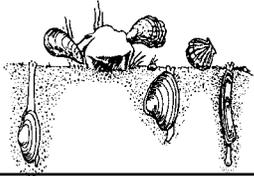
- ◆ *The Massachusetts Division of Marine Fisheries has authority to control movement of shellfish both at the level of interstate transport as well as across town boundaries within the state.*
- ◆ *All commercial shellfish hatcheries intending to sell shellfish seed in Massachusetts are required to provide proof of meeting specific health specifications, as set by DMF, prior to their importing or moving shellfish.*
- ◆ *In known disease situations, DMF will impose shellfish movement restrictions, contingent on health inspections, to manage the movement and risk of spreading the disease.*

Best Management Practice(s):

- Only purchase shellfish seed that have been produced by a commercial hatchery that is certified by the Division of Marine Fisheries for importation into the Commonwealth.
- Due to potential shellfish disease problems and the potential of spreading the disease through your

actions, do not move shellfish from one waterbody to another without consulting local and/or state authorities. All shellfish being moved require a green-tag to indicate undersized shellfish and if being moved across municipal borders, transport requires DMF permission.

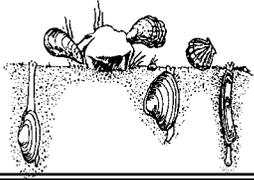
- When grading or handling under-sized shellfish and **replants** off-site, keep lots from different sites separate, be aware of the originating source and do not move the animals from one waterbody to another.
- If grading in a common-use facility, ensure your shellfish culls and replants do not co-mingle with those of other growers. Return only your shellfish to your grow-out area.
- When exposing equipment to shellfish from different locations and/or when moving equipment between farm sites, rinse the gear thoroughly with freshwater (and, preferably, biodegradable soap) between uses to minimize the risk of spreading pathogenic organisms.
- Do not dispose of empty shells with fresh uncooked meats into the marine environment. Compost the shells for an interval until the meats have decomposed and the shells are clear of tissue.



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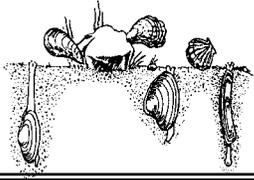
- It is not legal for unlicensed individuals to hold shellfish in seawater systems that flow into the open environment (wet storage). Be aware of others practicing wet storage of foreign shellfish in your area. When possible, educate the public about the risk of shellfish disease introduction associated with wet storage of foreign shellfish and, if necessary, report incidences of illegal wet storage to the appropriate authority.



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5) Maintenance of environmental quality.

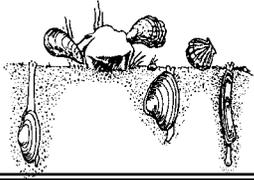
The success and long-term viability of shellfish aquaculture is dependent upon good water quality conditions. A "clean environment" can be compromised by a wide variety of influences. The primary consideration for shellfish farmers and shellfish markets are public health risks. Harvesting shellfish from areas that are contaminated significantly increases the risk of exposure to serious human pathogens for consumers who eat raw shellfish. Fortunately, the risk of consuming shellfish from contaminated waters is extremely low in Massachusetts due to the extent of existing public health controls.

To minimize human health risks to shellfish consumers, the Massachusetts Department of Public Health and the Division of Marine Fisheries closely collaborate to monitor shellfish harvest areas and control harvests from areas where health may be compromised. Utilizing recommendations from the Interstate Shellfish Sanitation Conference (ISSC) and the Model Ordinance of the National Shellfish Sanitation Program (NSSP), shellfish and waters from shellfish areas are tested on a regular basis to ensure human health safety. No shellfish are legally marketed in

Massachusetts unless harvested from tested and approved areas.

Many detrimental environmental impacts result from human activity and therefore can be mitigated by human actions. Environmental contamination results from careless disposal of chemicals and other contaminants that are detrimental to ecosystem health. In many cases, contaminants interfere with the normal metabolism of shellfish in the field. Chemicals, such as spilled diesel fuel or other petroleum products, impact shellfish metabolism and result in impaired growth, potentially leading to death. It is in the best interest of the shellfish farmer to monitor and protect the marine environment to ensure the health and quality of their shellfish as well as their customers.

Coastal **eutrophication**, resulting from excessive nutrient introduction into the environment, can cause problems in the marine environment. Excess nitrogen enhances algal growth, both **phytoplankton** in localized **blooms** and **macroalgae** in the form of prolific growth. Both forms of algal proliferation can result in environmental degradation. As the biomass of the macroalgae increases the algae can overgrow the bottom and cause pockets of hypoxia and anoxia



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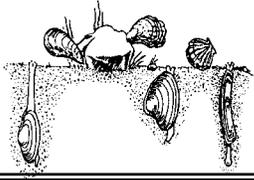
resulting in suffocation of any organisms under the macroalgae. Under bloom conditions, shellfish can be impacted when a single species dominates the phytoplankton community within the water body. If the dominant microalgal species is not an adequate food resource for the shellfish, i.e. wrong cell size/shape or producing chemical feeding deterrents, then the shellfish can starve from reduced food availability. In addition, if the phytoplankton bloom should crash, the high loading of dead organic matter settling to the sediment surface can result in hypoxia or anoxia with similar results to those described above.

On the other hand, coastal eutrophication may enhance food availability to shellfish. Shellfish consume phytoplankton and if the dominant plankton species proliferating is of an appropriate cell size and shape, it will provide a bountiful food resource for the clams or oysters.

Alterations in phytoplankton composition in our coastal waters are drastically influenced by coastal, land-based nitrogen run-off and may or may not improve the growing conditions for the shellfish. In those cases where the phytoplankton blooms are of a type and a quality that are readily consumed by shellfish then shellfish farms can assist in the removal of excess nitrogen and actually serve as a means to remediate the impact of excessive nitrogen inputs

from human activity. Shellfish can enhance nutrient remediation by two mechanisms. Shellfish can directly remove nitrogen from the environment and incorporate it into shellfish tissue that is subsequently removed by harvest. They also can boost the removal of nitrogen from the environment through enhancing the process of **denitrification** in the sediment under shellfish beds.

On the whole, shellfish farmers need clean water and any inputs that adversely alter water quality put the shellfish farm at risk. Shellfish farmers need to help educate the public regarding the fragility of the coastal marine environment and any insults to our marine environment should be remediated as soon as possible to minimize impacts to the local ecosystem and to the shellfish farm.



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5-1) Maintenance of environmental quality: water quality.

Management Consideration:

The success of shellfish farming is dependent on maintaining good water conditions throughout the region.

Background:

The role of water quality, with regards to shellfish farming, focuses on three different issues. These can be described in terms of the impact that they pose on the shellfish farm and the farm's economic potential. It should be noted that most water quality problems associated with shellfish aquaculture are the result of upland land use issues and are, for the most part, out of the direct control of the shellfish farmer.

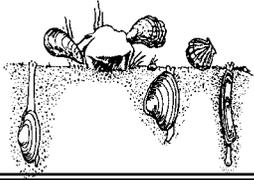
The first risk is to human health that will ultimately impact the marketability of the shellfish produced. Human health risks are associated primarily with the presence of human pathogens in the water. Shellfish are predominantly filter feeders and pathogens, such as bacteria or viruses, may be filtered from the water in the course of the shellfish's feeding behavior. The shellfish, in turn, may hold and concentrate the pathogens and/or their toxic metabolites thereby increasing the dose and subsequently the risk for humans contracting an

illness when consuming shellfish.

Therefore, it is imperative to ensure that water quality where the shellfish are farmed is of the highest quality with no pathogenic organisms present.

The second risk is to shellfish health and the concomitant survival and/or growth of farmed shellfish. Introduction of noxious chemicals in local waters may result in chronic stress on shellfish populations leading to reduced growth and potentially to the death of the shellfish. Many **anthropogenic** products can harm shellfish; ranging from direct toxics, including diesel fuel or pesticides, to more subtle contaminants like tributyltin (TBT), a compound used in antifouling paints for boats until recently banned in the U.S. TBT has been implicated in a variety of deleterious sublethal effects to bivalve molluscs.

The third issue relates to **hypertrophication** where human generated chemicals, such as lawn fertilizers that run-off into our estuaries or nitrogen derived from human sewage waste, contribute to excessive algal growth in the water resulting in the potential for low to no oxygen in the water. Although this environmental



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perturbation does not directly impact human health and therefore does not entertain the high degree of monitoring that higher risk problems demand, it does have the potential to impact shellfish health and subsequent production from a shellfish farm. On the plus side, hypereutrophication also stimulates **phytoplankton** growth thereby increasing the potential food resources for the shellfish to consume within a given water body.

Pertinent State & Federal References:

Based on mandates from the Massachusetts Department of Public Health (DPH) and the Division of Marine Fisheries (DMF), shellfish harvesting areas are monitored for the presence of human pathogens through a routine sampling program implemented by DMF. Shellfish harvesting areas are classified according to the presence or absence of human health risk and shellfish grow-out can only occur in waters holding the highest water quality classification. Nursery culture of shellfish may take place in “conditionally approved” areas but the seed must be moved to “approved” areas as the seed approaches 10% of its market size.

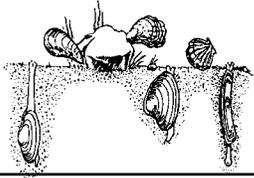
The Massachusetts Department of Environmental Protection (DEP) monitors chemical contaminants in the marine environment. In situations where high-risk chemical contaminants are identified in the marine environment, appropriate controls are placed on managing the area by DEP to protect human health.

Many local, state and federal regulations that influence water quality are in effect. Some examples of these include:

- ◆ *National Pollution Discharge Elimination System (NPDES) as authorized by the Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C. § 1251-138).*
- ◆ *MA Environmental Code Regulating Septic Systems (310 CMR 15.00 et seq.)*
- ◆ *MA Wetlands Protection Act (M.G.L. CHAPTER 131, Section 40) & Wetland Protection Regulations (310 CMR 10.00 et seq.)*
- ◆ *MA Waterways (M.G.L. CHAPTER 91 Sections 1-63) & MA Waterways Regulations (310 CMR 9.00 et seq.)*
- ◆ *MA Rivers Protection Act (M.G.L. CHAPTER 258, Acts of 1996) & Rivers Protection Regulations (310 CMR 13.0)*
- ◆ *MA Water Management Act (M.G.L. CHAPTER 21G) & Water Management Regulations (310 CMR 36.00; 313 CMR 2.00, 4.00 & 5.00).*
- ◆ *Pesticide Control Act (MGL CHAPTER 132B) & Pesticide Use Regulations (333 CMR 1.00 to 12.00)*

Recommended Best Management Practice(s):

- Support local water quality monitoring groups in your area by volunteering to monitor conditions at or near your site.
- Most contaminant problems in the coastal environment are the result of upland land activities. The management of point and non-point sources of contaminants is a

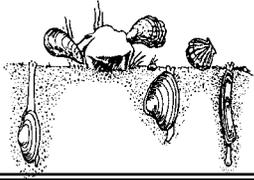


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regional problem and must be addressed by the entire coastal community. Some issues that a shellfish farmer may influence include advocating for:

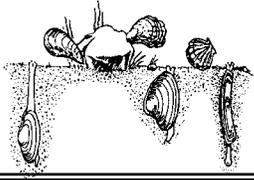
- control of road run-off through the use of catch basins and other technologies to prevent direct introduction of run-off into coastal waters. One strategy to aid in controlling road run-off is the development of a local road run-off by-law that mandates engineered solutions to run-off,
 - control of pets and water fowl in the coastal environment to prevent increased loadings of **fecal coliform bacteria** in local waters,
 - inspection and improvement of private sewage systems to minimize the introduction of both human pathogens and nutrients into the marine environment.
- Maintain the water quality of your site by carefully handling of all fuels and oils. Insure that fuel storage area are secure and provide adequate containment to prevent release to the environment in the event of an accidental spill.
 - Carry oil absorbent pillows to absorb oil and gas residues in the bilge.
 - Encourage increased presence and use of pump-out stations at local marinas and the development of "no discharge" harbors to reduce the risk of direct introduction of human waste into the local marine environment.
 - Avoid the use of pressure treated lumber whenever possible, especially on surfaces that may come into contact with water. Use fiberglass, metal or plastic wood as a substitute.
 - When cleaning fouling materials from your shellfish farm, dispose of the material such that it does not impact the water quality of adjacent sites. Remove the material to an appropriate disposal site.
 - Use non-toxic anti-fouling coatings on vessels instead of paints that contain tin, copper or other compounds typically found in off-the-shelf anti-fouling paints.



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5-2) Maintenance of environmental quality: minimizing harmful chemical exposures.

Management Consideration:

There are many pathways for harmful chemicals that may impact shellfish farms to enter the marine environment.

Background:

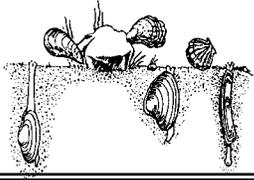
Introduction of toxic compounds into the marine environment is a constant threat to the shellfish farmer. Many compounds routinely used in land-based systems (household and industrial) can be highly toxic to aquatic organisms. Prevention of discharge of these chemicals anywhere within the marine environment must be a top priority.

There are no chemicals that are specifically permitted for use in shellfish aquaculture. Some commonly used treatments for marine applications, such as anti-fouling paints used on boats, are used within an aquaculture setting but it must be remembered that any compound that may impart some form of toxicity also threatens the shellfish. Chemical compounds applied near the shellfish farm must be thoroughly tested to ensure they don't impact the shellfish crop.

Two types of chemicals, routinely used near or within the marine environment, that must be carefully controlled are **petrochemicals**, such as gasoline or motor oil, and pesticides, such as might be used to control biting insects. Petrochemicals are routinely handled within the coastal zone as boat engines and other internal combustion engines are operated to ease the workload. Their toxicity is well established within the regulatory community and strict controls for handling these compounds have been implemented.

Pesticides are also used routinely in the coastal zone and, when applied by professional applicators, their risk to marine organisms is minimal. Untrained or careless application of pesticides may result in catastrophic losses. Applications must be monitored and controlled.

A third chemical type that may find its way into the marine environment but does not have a direct toxicity on marine organisms are fertilizers and other nutrient sources. Untrained or careless application of fertilizers greatly increases the risk of coastal eutrophication and may result in degradation of marine habitats. Any



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increase in environmental degradation will eventually have a negative impact on shellfish farming.

Pertinent State & Federal References:

No specific chemicals have been permitted for use in shellfish aquaculture. Therefore, no chemicals can be legally applied directly to shellfish in an aquaculture situation.

The United States Coast Guard enforces marine discharge regulations regarding petrochemicals. Stiff fines will be applied to individuals found guilty of introducing unapproved petrochemicals into the marine environment.

All professional applications of pesticides and fertilizers are managed according to guidelines established by the U.S. Environmental Protection Agency and/or the Massachusetts Department of Environmental Protection and are overseen by the Massachusetts Department of Food and Agriculture's Pesticide Board..

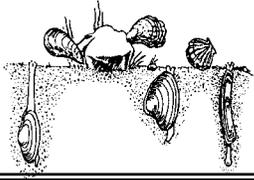
Many local, state and federal regulations that influence water quality are in effect. Some examples of these include:

- ◆ *National Pollution Discharge Elimination System (NPDES) as authorized by the Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C. § 1251-138).*
- ◆ *MA Environmental Code Regulating Septic Systems (310 CMR 15.00 et seq.)*
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- ◆ *Pesticide Control Act (MGL CHAPTER 132B) & Pesticide Use Regulations (333 CMR 1.00 to 12.00)*

Recommended Best Management Practice(s):

- *Whenever you are transporting or transferring petrochemicals (gas, fuel, lubricants and other petroleum products) near the coastal zone, always carry the materials in clearly and properly marked containers and exercise the highest degree of care to minimize the risk of spillage.*
- *Carry oil absorbent pillows to absorb oil and gas residues in the bilge.*
- *If you should observe any spills of petrochemicals or other chemicals in the marine environment, immediately report the location and time to the nearest U.S. Coast Guard office.*
- *Educate the public to enhance awareness of the impacts that pesticides and fertilizers have on the marine environment and advocate for reduced use of these compounds within the coastal zone.*



5-3) Maintenance of environmental quality: introduction of exotic aquatic species.

Management Consideration:

The introduction of non-indigenous nuisance marine species can have severe consequences on the profitability of the shellfish farm.

Background:

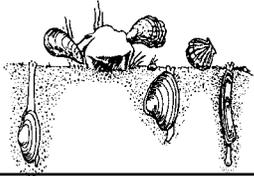
Although the most common examples of exotic nuisance species introductions have been identified in freshwater systems (e.g. zebra mussel *Dreissena polymorpha* or Eurasian milfoil *Myriophyllum spicatum*), shellfish farmers need to be aware of and protect against these aquatic invaders.

Inadvertent exotic species introductions may be inconsequential or they may be devastating to the industry. In some cases, shellfish farmers have exploited an exotic introduction, e.g. the introduction of the Japanese oyster (*Crassostrea gigas*) on the West Coast of the United States or the European flat oyster (*Ostrea edulis*) locally. Regardless, it is recommended that the risk of introducing new species be minimized for a variety of reasons.

From the Massachusetts shellfish farmer's perspective, the majority of new species introductions should be

considered to have a negative impact on their business. Locally, the introduction of species such as the green crab (*Carcinus maenas*), the oyster thief algae (*Codium fragile*), and the fouling tunicates, *Styella clava*, *Botrylloides violaceus*, *Botryllus schlosseri*, and *Molgula manhattensis* have had severe consequences on the way they conduct their farming operations. The introduction of each of these species has resulted in economic losses to the farmer either in terms of product loss or increased time required to maintain their grow-out systems.

Another group of exotic organisms that have proven to be particularly noxious are the variety of shellfish diseases referenced in Section 4. Many of the diseases common to commercially important shellfish in Massachusetts originated in other places (e.g. MSX originated in Delaware Bay and dermo in the Gulf of Mexico) and have been introduced into the local environment. Although the shellfish aquaculture industry has been implicated in the transport of these diseases, a number of possible mechanisms have been suggested, including ship ballast water discharge



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and wet storage of non-native shellfish by private citizens.

Exotic introductions can be controlled via management of the transport and release of target organisms and water from areas outside of the immediate locale. Eradication, once the introduction has occurred, is generally ineffective.

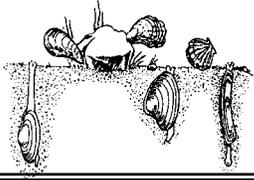
Pertinent State & Federal References:

- ◆ *Lacey Act (16 U.S.C. § 701): prohibits the importation and movement across state lines of certain fish and wildlife species without Federal authority.*
- ◆ *Non-Indigenous Aquatic Nuisance Prevention and Control Act 16 (U.S.C. § 4701 et seq.) reauthorized as the National Aquatic Invasive Species Act: created a national Aquatic Nuisance Species Task Force, which was given authority to research and develop guidelines for ships to report their ballast water treatment or treat their ballast water, among other national concerns, and provided funding for regional and state plans and panels to better coordinate aquatic invasive species management.*
- ◆ *Massachusetts Aquatic Invasive Species Management Plan: The Massachusetts Invasive Species Management Plan was approved in November 2002. The plan outlines a five-year strategy for state agencies and their partners to minimize damage from non-native species by preventing their introduction, informing the general public about their impacts, monitoring for new introductions, and meeting other objectives related to invasive species management. Details of the plan are available at:*

<http://www.mass.gov/czm/invasivemanagementplan.htm>.

Recommended Best Management Practice(s):

- Commercial shellfish hatcheries rear a variety of shellfish species.
 - Carefully inspect shellfish seed as it is received from the hatchery and remove non-target species.
 - Do not import shellfish seed from hatcheries outside of those approved by MA-DMF.
- Do not hold or store non-local shellfish or other non-native aquatic organisms in a situation where escapement or introduction into local waters is possible.
- Educate the general public about the risk of introducing exotic species and encourage them to purchase and wet store only local shellfish for private consumption.



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5-4) Maintenance of environmental quality: remediation of eutrophication.

Management Consideration:

Shellfish aquaculture can provide a level of remediation for local algal blooms associated with nutrient loading from land-based sources.

Background:

Coastal **eutrophication** results from the introduction of excess **nutrients** into the marine environment. Nutrients that impact the marine system are primarily derivatives of nitrogen compounds that originate from a variety of sources, including human sewage, lawn fertilizers, farm run-off and atmospheric deposition. The primary form of nitrogen that influences the marine environment is nitrate (NO_3^-).

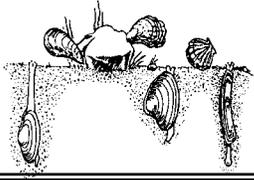
Excess nitrate in coastal waters stimulates excessive plant growth. In the marine system, the plants most influenced are various commonly occurring algae species. One group consists of single-celled species, commonly referred to as **phytoplankton** that either remains suspended in the water column or is found on the any submerged surface. A second group of algae that flourishes under eutrophic conditions are the **macroalgae** or seaweed, large marine

plants that can be seen without a microscope and easily handled.

Macroalgae are most commonly found attached to structures on the bottom, although they can be found floating free in the water column. Macroalgae can be observed free-floating after being disturbed by storms, boats or other conditions influencing the movement of water.

Environmental impacts of algae, stimulated by **hypertrophication** can be significant. High densities of macroalgae can settle out on the bottom and will eventually decompose, increasing the local oxygen demand until the waters overlying the shellfish are devoid of oxygen or **hypoxic**. A lack of oxygen will smother all living animals on the bottom that cannot move away from the impact area. Mass mortality of shellfish can result from excess macroalgae decomposing on the bottom.

Shellfish rely on phytoplankton as food. When phytoplankton levels moderately increase shellfish flourish due to increased food resources. In many instances, shellfish can be used to remediate eutrophication by incorporating the excess nutrients into clams. Recent studies have suggested



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that the demise of oyster populations in Chesapeake Bay lead to increased environmental degradation due to increased phytoplankton densities associated with excess nutrients.

High phytoplankton densities shade the water and reduce light penetration resulting in less productive submerged aquatic vegetation areas, such as eelgrass beds, an important habitat in our local waters. When phytoplankton levels become extreme they can strip all of the nutrients from the water leading to a large-scale die-off of the algal cells. The sudden population death, or phytoplankton **crash**, leads to a similar end as when the macroalgae proliferate where the dead and decomposing algae material consume oxygen and kill other aquatic organisms through hypoxia.

Growing shellfish from seed to market size provides a mechanism to remove excess nutrients that are incorporated into shellfish tissue. Harvested shellfish are removed from coastal waters improving water quality while generating a food product. In many instances, it is an advantage to have high densities of shellfish growing as a means to control eutrophication.

Pertinent State & Federal References:

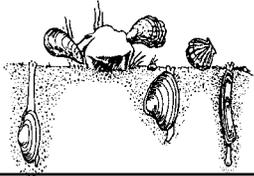
- ◆ *Department of the Army General Programmatic Permit, Section VIII. Aquaculture Guidelines: incorporating*

the substance of the Letter of Permission for Aquaculture in the Commonwealth of Massachusetts, September 1, 1991 (Appendix 2): A Department of the Army permit is required for dredging, including prop dredging in tidal waters. Dredging that affects a special aquatic site, including mudflats, is not eligible for authorization under the current USACE Programmatic General Permit for Massachusetts. An individual Department of the Army Permit from the USACE is required for such activities.

- ◆ *Although many local groups monitor nitrogen levels in coastal embayments, there are no specific regulations describing thresholds for inputs. Controls have been indirectly incorporated through the MA Environmental Code Regulating Septic Systems (310 CMR 15.00 et seq.)*
- ◆ *MA Wetlands Protection Act (M.G.L. CHAPTER 131. Section 40) & Wetland Protection Regulations (310 CMR 10.00 et seq.): Local Conservation Commissions can condition projects that threaten local water bodies (within 100 feet) through the state Wetlands Regulations if the threat of excess nutrient run-off is present.*

Recommended Best Management Practice(s):

- Educate the general public regarding the negative impacts of excess nutrients on our marine environment and the positive benefits of shellfish farming. Include information regarding the potential contributions of a single household to the problem.
- Encourage professional or volunteer groups to monitor water quality in



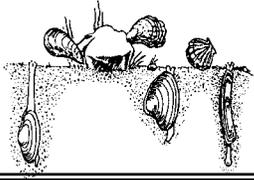
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the region and include measurement of nitrogen inputs and fates.

Consider joining a volunteer group to become involved in advocating for improved water quality.

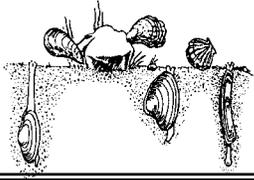
- Provide information to and monitor the activities of your local Conservation Commission. Encourage them to protect local water quality through Orders of Conditions on suspected projects.



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5-5) Maintenance of environmental quality: management of water flow.

Management Consideration:

Local patterns of water movement are important to the growth and survival of farmed shellfish.

Background:

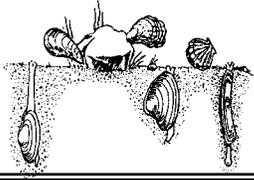
The coastal marine system is a dynamic environment that is dramatically influenced by water movement. The natural course of water movement gives coastal areas their unique characteristics and their ability to support the diversity of living organisms. Water moves for a variety of reasons, primarily tides and wind, and generally flows along specific pathways resulting in the formation of channels and waterways. As water moves, it carries with it materials ranging from natural materials such as sediment or algae to man-made items, the proverbial "flotsam and jetsam".

Water flow is extremely important to the shellfish farmer. Water movement replenishes the supply of oxygen and food to the shellfish while removing the metabolic waste products from the vicinity of the shellfish. Without these "services" provided by Mother Nature, water quality at a shellfish site, or any other coastal site, would rapidly degrade.

Alternatively, water movement can also be detrimental to the shellfish farmer. **Sedimentation** over shellfish nets and the movement of spilled fuel onto the shellfish farms are just two examples of issues that a shellfish farmer would have to manage with regards to water movement.

Another aspect of water movement that impacts the shellfish farmer is the movement of freshwater from terrestrial sources to the marine system. On Cape Cod, freshwater runoff is a transitory situation following rain events although there are areas where groundwater upwelling in the intertidal zone can be observed. Some shellfish species, such as the American oyster, can survive and may even flourish in seawater that is diluted to some degree by freshwater. On the other hand, many shellfish, e.g. the bay scallop, are very sensitive to reduced **salinity** and require full strength seawater to survive.

Control of water movement is achieved through the development and maintenance of passages and channels. Water flows through the path of least resistance. It is important to maintain the naturally occurring paths to sustain the movement of water throughout the



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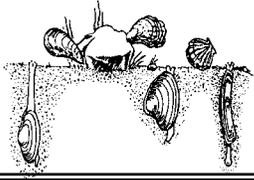
coastal system. **Dredging, armoring,** and a wide variety of coastal engineering strategies have been employed to manage the movement of water with some being more effective and/or less environmentally damaging than others. Overall, management and control of water movement within the coastal zone and near shellfish farming areas is an important consideration for the shellfish farmer. However, do not attempt to alter water movement in your area through dredging without the appropriate permits.

Pertinent State & Federal References:

- ◆ *The management of water movement in the coastal zone is primarily the responsibility of the U.S. Army Corps of Engineers (USACE). This authority is defined in the Rivers and Harbors Act of 1899. All proposed activities associated with maintaining or modifying the movement of water in the coastal zone requires review and approval by the USACE.*
 - ◆ *Any proposed project that will influence water movement in the coastal zone is subject to review and comment by a wide variety of federal, state and local agencies, including:*
 - *federal agencies, such as National Marine Fisheries*
 - *state agencies, such as the Massachusetts Department of Environmental Protection and the Division of Marine Fisheries*
 - *county planning agencies, such as the Cape Cod Commission*
 - *town authorities, such as the shellfish constable.*
- ◆ *Many agencies and individuals are provided an opportunity to comment on any proposed changes to the water flow characteristics in our marine environment through the permitting process of the USACE.*

Recommended Best Management Practice(s):

- Understand the importance of water and adequate water flow to the success of your shellfish farm, particularly as it relates to your specific geographic area.
- Be aware of any proposed activities in the region that may influence the water movement characteristics at your site. Provide comment to the appropriate authorities as to the impact proposed changes may have on your farming activities.
- Do not attempt to alter water movement in your area through prop dredging or other means without appropriate permits.



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Glossary

Algae: non-vascular plants that grow submerged in marine or freshwater environments. Large bodied algae, such as rockweed or sea lettuce, are called **macroalgae**. Single-celled algae floating in the water and providing food for shellfish are called **phytoplankton**.

Ambient: pertaining to the status of the surrounding environment. For example, ambient temperature describes the natural temperature of the water or sediment in which a clam exists.

Anoxia: a situation where the amount of dissolved oxygen in the water is reduced to zero. The end result is a localized area that is not capable of supporting biological activity.

Anthropogenic: derived from or associated with human activity, often used to describe environmental contamination resulting from human activities.

Aquaculture Zone or Aquaculture

Development Area: a management boundary established to allow aquaculture within a designated and permitted area.

Armoring: the protection of coastal banks from erosion through the application of impervious materials, such as stones or concrete.

Best Management Practices (BMP): a set of voluntary procedures developed by the industry to address areas where attention could be focused to improve production while preserving the sustainability of the environment.

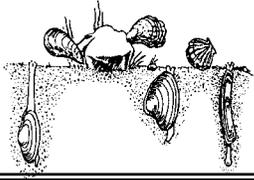
Biodiversity: a description of the variety, abundance and distribution of living organisms within a defined ecosystem or habitat.

Biofouling: the overgrowth of algae, marine invertebrates, and other organisms on nets and structures in the water. Biofouling can restrict water flow and access to oxygen and food by the growing shellfish.

Block permitting: the application of state and federal site licensing to intertidal areas, employed as a means to pre-permit large areas for shellfish aquaculture.

Breeding selection: a strategy applied to domesticated plants and animals where the genetic traits controlling specified and desirable qualities of the organism are preserved and amplified through conventional reproductive pairings of parent stock.

Broodstock: those adult organisms that are held and used as parent stock for controlled breeding within a hatchery.



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Crash: a situation where a dense population of an organism, e.g. a bloom of phytoplankton, depletes the resources from their immediate environment that are necessary to support their life processes. This results in the population, as a whole, dying within a short time interval.

Denitrification: a chemical process that is mediated by bacteria in the sediment and that converts organic nitrogen (in the form of ammonia, nitrite and nitrate) to elemental nitrogen (in the form of nitrogen gas).

Direct transmission: a disease pathogen that is capable of infecting its host organism directly from a previous host of the same species.

Dissolved oxygen: in the aquatic environment, the life supporting gas - oxygen - is present dissolved in solution with the water and must be extracted from the water by living organisms using specialized respiratory structures, such as gills. If the level of dissolved oxygen drops too low, then respiratory distress leading to death may occur.

Dredging: an engineering practice where sediment is removed from the bottom of waterways to allow increased water flow or to permit transit of boats through designated channels.

Eutrophication: an environmental condition where excess nutrients, in the form of nitrogen, are introduced into a water body leading to increase growth of micro- and macroalgae.

Facultative: a disease-causing organism that is capable of living outside of their host in the marine environment.

Fecal coliform bacteria: a class of bacteria that is unique to the intestinal tracts of warm-blooded animals and is used as an indicator of the presence of human waste in the aquatic environment.

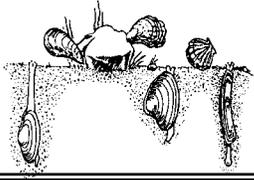
Genetic diversity: the variety of genetic materials within a single species of organism that permit the organism to adapt to changes in the environment.

Grow-out: a practice conducted by shellfish farmers where small shellfish are transferred from a nursery culture system and placed in a containment system that permits the shellfish to grow to a size that is accepted in traditional markets.

Health inspection certificate: a document provided by a shellfish pathologist that demonstrates a specific group of shellfish have been analyzed for all known pathogenic organisms and that reports on the shellfish health status resulting from the inspection.

High water mark: the average water level that demarcates the transition from exposed land to submerged land at the point of high tide.

Hydraulic rake: a mechanical device consisting of a water pump, hose and handheld nozzle or jet manifold system that is used in the coastal environment to loosen sediment and hydraulically bring large organisms, such as clams, to the surface for removal.



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Hypernutrification: a situation where excess nutrients, primarily nitrogen, are introduced into the aquatic environment resulting in eutrophication.

Hypoxia: a situation where the amount of dissolved oxygen in the water is reduced to a level significantly lower than its theoretical maximum resulting in induced stress in aquatic organisms due to lack of oxygen for normal metabolism.

Indirect transmission: a disease pathogen that is not capable of infecting its host organism directly from a previous host of the same species but rather it must pass through an alternate host before becoming infective to the target organism.

Infauna: those aquatic organisms that exist buried in the sediment as opposed to those that live at the sediment surface or in the water column.

Intertidal: that area of the coastal environment demarcated by the range of coverage provided by the tidal cycle. Those areas or flats exposed during low tide and submerged during high tide are considered intertidal.

Juvenile clam: a size class of clam defined as the interval between metamorphosis (set) and when the animal becomes sexually mature or attains a marketable size.

Leadline: a material, sometimes used in shellfish farming, consisting of rope constructed from synthetic material with a core of lead metal in it to ensure the rope will sink and stay on the bottom.

Littleneck: one of a number of marketing names for the quahog, *Mercenaria mercenaria*. The littleneck represents a sub-adult quahog in the size range of approximately 2 inches length up to 2.5 inches.

Low water mark: the average water level that demarcates the transition from exposed land to submerged land at the point of low tide.

Macroalgae: a classification of algae that are defined according to the size of the plant where the body of the plant is large enough to be observable to the eye.

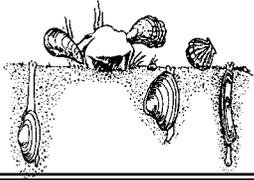
Microalgae: a classification of algae that are defined according to the size of the plant where the body of the plant is small enough that it requires magnification to observe.

Mollusc: a member of the Phylum Mollusca.

Mortality rate: the rate at which a population of organisms are dying due to adverse environmental conditions, a disease situation or some other stress impacting the population.

Motorized transport: any form of transport that utilizes an internal combustion engine to provide propulsion.

Notice of Intent: a document filed with the local Conservation Commission that notifies them of your intentions to undertake a project that may have an adverse impact on the lands under the jurisdiction of the Commission.



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Nursery: a practice conducted by shellfish farmers where very small shellfish are held under conditions that promote growth while protecting them from predators and other environmental hazards. Generally this intermediary culture step grows the shellfish from post-metamorphosis (post-set) to a size large enough to be held in the grow-out system.

Nutrients: a variety of chemical compounds that are necessary to promote growth of plants and animals. In the marine environment, the most common nutrient that is limiting for plant growth is nitrogen in the form of nitrate (NO_3^-).

Obligate: a disease-causing organism that cannot live in the marine environment on its own and must reside in the host tissue to survive.

Oyster: *Crassostrea virginica*, a commercially important bivalve mollusc native to Massachusetts. Also known as the American oyster.

Pandemic: a situation where a disease organism is commonly found in the local environment and presence of the disease in local populations of the host organism is routinely observed.

Pathogen: any type of biological entity that causes disease through infecting a host organism.

Peck: a volume measurement used with shellfish and consisting of 10 quarts.

Petrochemical: a group of chemical compounds derived from petroleum or natural gas and used predominantly for energy or as a lubricant.

Phytoplankton: small single-celled algae that are commonly found suspended in the water column and provide the first step in the food chain of an aquatic system

Public access: rights of way located along coastal areas that allow for the general public to transit across the upland to reach a beach or intertidal coastal area.

Public Trust: a legal description of the rights of all individuals to have access to and reap the benefits of our marine environment.

Quahog: *Mercenaria mercenaria*, a commercially important bivalve mollusc native to Massachusetts. Also known as the hard clam, littleneck, cherrystone or chowder clam.

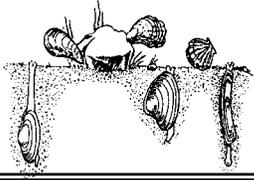
Raceway: any shellfish growing area that is laid out as an elongated rectangle and generally covered by netting or some other type of barrier to exclude predators.

Replant: a management strategy in shellfish farming where animals that have been harvested but are too small to be legally marketed are returned to the growing beds.

Request for Determination of

Applicability: an official request to the local Conservation Commission to determine if proposed activities within wetlands or coastal areas require approval or permitting by the Commission.

Riparian rights: The legal right for the general public to use privately owned intertidal areas in Massachusetts for fishing, fowling, and navigation. Derived from the Colonial Ordinances of 1641-1647.



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Salinity: a measurement of the amount of salt that is dissolved in water and is normally reported in parts per thousand (ppt). Normal seawater has a salinity of 30-35 ppt.

Scallop: a family of commercially important bivalve molluscs. Those native to Massachusetts include the bay scallop (*Argopecten irradians*) and the sea scallop (*Placopecten magellanicus*).

Sedentary: a life strategy that constitutes lying stationary in the environment and frequently anchored to the bottom either through physical attachment or burying in the sediment.

Sediment: any material having a geological origin and comprised of small particles. The size of the individual particles determines the description of the sediment and it can range from fine clay to coarse gravel.

Sedimentation: a situation where sediment is moved by wind or waves from one area to another and in the course of that movement may bury or block structures or organisms in the path of the sediment movement.

Seed clam: a stage in the growth of a shellfish that is generally demarcated by size and the culture system that it is derived from. Seed clams are generally small and are derived from a nursery culture system.

Silt: fine particles that are either sediment or organic material that lies on the bottom of quiescent waters but is easily stirred up by physical activity in the near vicinity. The source of the activity can be natural or generated by human activity.

Siltation: a situation where the fine silt particles have been resuspended by physical activity and subsequently settle down onto areas where they were not previously observed. In extreme cases, siltation can bury shellfish and result in adverse growing conditions leading to reduced growth or mortality.

Siphon: the part of the clam's anatomy that provides a channel for the seawater to enter and leave the mollusc's body cavity that houses the gills, the digestive system and the feeding apparatus. Sometimes referred to as the "neck".

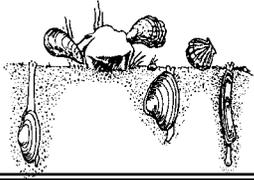
Strain: a specific line of individual organisms identified with a larger group (species) that is selectively bred to enhance desirable characteristics for farming.

Submerged aquatic vegetation (SAV): any of a group of vascular plants that can live and grow under water. Local examples of submerged aquatic vegetation include eelgrass (*Zostera marina*) and widgeon grass (*Ruppia ruppia*).

U.S. Aids to Navigation System: A system of colors, shapes, numbers and light characteristics to mark navigable channels, waterways and obstructions adjacent to these and enforced by the U.S. Coast Guard.

Upland: lands elevated above sea level and generally dry.

Variety: a type of domesticated plant or animal that displays a unique set of performance characteristics yet can freely interbreed with other varieties of the same species.

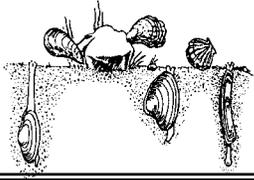


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Wet storage: a practice where harvested shellfish are held in seawater during the interval between harvest and consumption.

Wetlands buffer zone: naturally vegetated resource areas defined to provide protection of wetland areas from man-made alterations of the upland adjacent to the wetlands.



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Appendix 1:

Shellfish aquaculture: In praise of sustainable economies and environments

SANDRA E. SHUMWAY¹, CHRIS DAVIS², ROBIN DOWNEY³, RICK KARNEY⁴,
JOHN KRAEUTER⁵, JAY PARSONS¹, ROBERT RHEAULT⁶, GARY WIKFORS⁷

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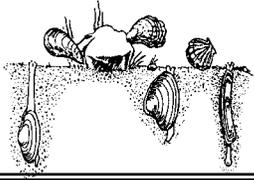
We write to extol the virtues of filter feeding bivalve shellfish – clams, mussels, oysters and scallops – to give them their due as key players in ecologically sustainable aquaculture in the marine environment and as environmentally sensitive monitors and water purifiers. Shellfish are successfully farmed throughout the world and shellfish culture represents a legitimate use of the marine environment for sustainable food production. An equally compelling case can be made for the primary grazers such as abalone and sea urchins.

In recent years it has become all too common for the press and some scientific literature to focus only on the negative aspects of man's use of the environment. Unless we as humans decide to eat substantially less seafood, which is contraindicated by the latest in health and nutrition research, aquaculture is here to stay; seafood production is a key to our present and future food supply. Worldwide, the demand for seafood continues to surpass supplies of wild caught fish and shellfish, and appetites for these products are growing steadily at a time when the world is increasingly looking to the sea to provide food. Promoting ecologically sustainable shellfish culture is promoting sound resource stewardship and a clean environment. There is a critical need worldwide to bring ecological balance to some forms of aquaculture and an

urgent challenge to foster aquaculture as an environmentally sound and socially acceptable practice in the United States. Marine/estuarine shellfish culture is an optimally environmentally sustainable form of aquaculture.

In 1999, bivalves represented nine percent of total world fishery production, and 27 percent by volume or 18 percent in value of total world aquaculture production. World bivalve production (capture + culture) has increased continuously and substantially over the past half century, rising from approximately one million tons in 1950 to about 11 million tons in 1999. This growth is primarily due to aquaculture (Anderson 2002). As the global population continues to grow, demand and production of food, especially seafood from aquaculture will continue to be an essential element in the future of our food security.

Unfortunately and quite unfairly, aquaculture has become an all inclusive term, especially when used by special interest and advocacy groups to rail against the perceived impacts of some coastal farmers on the environment. All aquaculture is not created equal and should not be treated as such. The various attributes and intricacies of different forms of aquaculture need to be understood. Aquaculture is a broad term that encompasses



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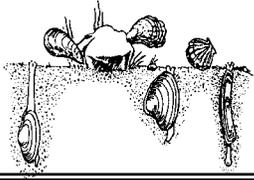
the farming of many aquatic species such as fish, shellfish and seaweeds, not only for food but also for medicinal and nutraceutical purposes. Filter-feeding bivalves have unique requirements for growth compared to other aquaculture-reared organisms such as fish and seaweeds and, consequently, they have different interactions and impacts on the coastal waters, habitats and food webs in which they are grown. Given this fact, these various attributes and potential beneficial interactions amongst the various species under culture need to be considered on their own merits in order for the continued sustainable aquaculture production of seafood. Cultured shellfish are one of the few forms of marine aquaculture to get a solid thumbs up of approval for ecological stewardship from the Audubon Society, Monterey Bay Aquarium's Seafood Watch and Eco-Fish. The broad-brush approach of lumping all aquaculture impacts together is too simplistic an approach to what is actually a complex set of issues.

Molluscan shellfish aquaculture is, by definition, a 'green' industry. Shellfish growers are committed to water quality – quality of their product and quality of the environment – from the day the molluscs spawn to the day the finished product is eaten by the consumer. Shellfish grown in approved, certified waters provide a safe, nutritious, healthy food source. In addition, the act of shellfish feeding (biofiltering) improves water quality by removing particulates and some unwanted nutrients from the water column.

Shellfish feed at the base of the food chain - as first-order consumers they are vegetarians. Filter-feeding bivalve molluscs are an essential link between the bottom-dwelling aquatic communities and phytoplankton production in the water column. Shellfish are highly efficient water filters that directly

remove particulate material thus reducing turbidity and both directly and indirectly removing nitrogen and other nutrients. Via this process, these highly efficient water purifiers remove or reduce organic matter, nutrients, silt, bacteria and viruses, and improve clarity and light transmission which, in turn, improves the condition of critical habitat, including survival of critical habitat species such as seagrasses and other submerged vegetation. Thus they provide a net gain for the environment. As with any living organism, too many shellfish in a given area can result in an unbalanced ecosystem, as has been demonstrated by intense mussel raft culture operations in Spain. The phenomenon of overstocking has not been documented in U.S. shellfish aquaculture operations to date, however. Clearly, it is in shellfish growers' best interest to guard against overstocking their farms, which would result in slower growth and reduced production of their valuable crops. Working in concert with Mother Nature is always preferable to the shellfish farmer.

It is important to emphasize that as opposed to other forms of aquaculture, or agriculture for that matter, none of the food consumed by bivalve shellfish is added to the environment. They feed entirely on naturally occurring particulates in the water column. While much of the food and nutrients captured by shellfish are returned to the environment as undigested waste or feces, some is assimilated and used for growth and reproduction. What is not assimilated falls to the bottom and becomes food for deposit feeders including many of the worms and crustaceans that, in turn, are used as food by predatory fish. Increased biodeposition of organic matter in sediments leads to increased bacterial denitrification that can help to remove nitrogen (N) from estuarine systems



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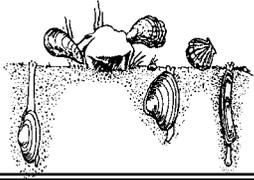
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over-enriched with nutrient pollution (see Kaspar *et al.* 1985).

Filter-feeding molluscs not only remove N from the water column, but also incorporate a high proportion of it into their tissues. When the molluscs are harvested, the N is removed from the system. Shellfish are approximately 1.4 percent nitrogen and 0.14 percent phosphate by weight. This may not seem like much, but when those shellfish are harvested, substantial amounts of nutrients are permanently removed from the water. A weekly harvest of only about 200 oysters can compensate for the nutrient inputs of a typical waterfront homeowner on a properly functioning septic system (Rice *et al.* 2001). A commercial weekly harvest of ~10,000 oysters contains about 13.6 kg of nitrogen and 1.4 kg of phosphate, and can result in the removal of about 100 kg of N per year! In simple terms, an oyster farm of about 1 ha can compensate for the nitrogenous wastes of 40-50 coastal inhabitants. As an added benefit, the associated bacteria in sediments of an oyster bed can remove 20 percent or more of the N in oyster wastes, using the same process that is used in modern wastewater treatment plants (see Newell *et al.* 2003). Shellfish feeding can also help to control or even prevent harmful algal blooms by removing the cells before the algae accumulate to environmentally detrimental levels. Data indicate the importance of bivalves as modulators of suspended materials and nutrient cycles in ecological systems. The effects are a primary reason that programs designed to rehabilitate our estuarine and nearshore water such as the Chesapeake Bay Program in the USA are encouraging hundred to thousand fold (or more) increases in the numbers of bivalves in the system.

Public health standards under which shellfish aquaculture operates demand clean

waters and commercial shellfish harvest can only take place in growing waters that have been certified under the National Shellfish Sanitation Program (NSSP), a stringent set of standards adopted by all shellfish producing states and operated under the Food and Drug Administration. These standards include monitoring for fecal coliform level, which is used as an indicator for human activity and the potential for pathogenic bacteria in the water; *Vibrio's*; harmful algal toxins; heavy metals and other contaminants. The NSSP standards fostered the first estuarine/ marine monitoring programs, and are the most stringent of all our water quality classifications, far exceeding those required for swimming. They are also one of the few environmental monitoring programs where failure to meet water quality standards causes an immediate closure of the water to harvest. These bans remain in effect until water quality monitoring indicates the area once again meets standards. As a result, the presence of molluscan aquaculture often results in increased awareness and monitoring of environmental conditions of estuaries and coastal waters. Shellfish growers cannot tolerate the discharge of untreated sewage near their farms and regularly monitor other potentially harmful inputs to the local areas. The contamination of areas for shellfish culture or harvest has often provided the political impetus for improvement in sewage treatment plants, or programs to fix local septic systems. Even the courts are upholding the environmental benefits of shellfish culture. Recently, Taylor Shellfish in the state of Washington's Puget Sound was sued by a group of waterfront homeowners who claimed that the cultured mussels were polluting the water. The court found in favor of Taylor Shellfish stating: "...feces and chemicals exuded from the live mussels have not been shown in the record significantly to alter the



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character of Puget Sound waters, and the record suggests instead that the mussel-harvesting operations generally purify the waters.”

Shellfish aquaculture is sustainable farming at its best, including the latest in hatchery and nursery technology, stocking, crop-tending/density management, and integrated pest management. Growers recognize the need to be stewards, of the environment to maintain clean growing waters and ensure their own future viability. Many aquaculture organizations have or are developing Environmental Codes of Practice, including Best Management Practices, to ensure that as the industry develops, it maintains a responsible environmental record. Examples can be found in the USA, Chile, New Zealand, Ireland and Canada.

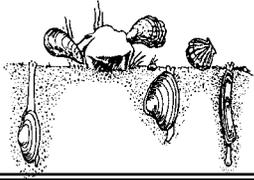
Shellfish culture is a winning proposition on several fronts, and by its very nature in most cases meets the National Organics Standards Board’s criteria required for ‘organic’ aquaculture (NOSB 1996) – which calls for “an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity.” According to the NOSB, farming practices should be based on “minimal off-farm inputs and on management practices that restore, maintain and enhance ecological harmony.” Shellfish farming embraces all these principles.

Further, due to the sedentary nature of shellfish, they are not prone to escape. They are farmed in well-defined areas, intertidally or subtidally, either directly on the substrate or suspended from rafts or stakes, often with protective netting, or on racks. Shellfish culture also promotes and enhances biodiversity by creating structure and habitat for other marine

species. Shellfish beds provide a larger variety and biomass of associated invertebrates and finfish than a similar area without shellfish.

On the West Coast, the native oyster (*Ostrea conchaphila*, “Olympia” oyster) came close to the point of extinction in the mid 1900’s, due to a combination of over-harvest and pollution from pulp mills that dumped toxic wastes directly into the marine waters. The Japanese oyster (*Crassostrea gigas*) was introduced by enterprising oyster farmers during that period, providing the farmers with a hardier oyster and allowed the industry to continue. Armed with the knowledge of how pollution can destroy growing areas, shellfish farmers become first in the line of defense in enacting laws and protecting and restoring water quality to keep their industry alive. As a result, water quality has been restored in many of the bays where the native oysters were once prolific, and restoration efforts, that have included the latest in hatchery technology to maintain and promote native broodstock used to recolonize beaches, are bringing about a resurgence in native oyster populations.

The structures used in aquaculture (racks, cages, nets, ropes, trays and lines), and in particular shellfish aquaculture, act like reefs and provide habitat and protection for a myriad of other organisms, frequently serving as nursery grounds for fish and other shellfish, such as juvenile lobsters. They provide protection from predators for juvenile fish and crustaceans, increased surface area for fouling (a benefit for many microorganisms and grazers, although not a benefit to the growers), and an increased food supply for other organisms.



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Shellfish culture additionally can reduce the negative impacts from bottom disturbance that would occur if the area had been used instead for harvest of wild stocks. The increased density on shellfish farms means less environmental impact and disturbance for equal yield compared to wild harvest. Growers will typically plant at densities that are ten to several hundred times those found in beds that are open to wild harvesting. Farmers who rely on mechanical harvesting will therefore disturb a proportionately smaller area to harvest the same biomass. Moreover, culture areas are the same year after year and typically are only disturbed when the crop reaches harvest size, whereas wild harvesters work the same grounds many times a year.

Aquaculture represents an important opportunity for economic activity and social cohesion in coastal, rural areas, providing family wage jobs in rural areas that are often otherwise economically depressed. Aquaculture is an activity that occurs in and on the water and can, in part, provide an ideal occupational alternative for displaced fishermen. Its development can preserve the character and ambience of seaside fishing communities, utilize the local acquired knowledge and skills of the coastal folk, and allow the local denizens to remain economically and culturally tied to the marine environment.

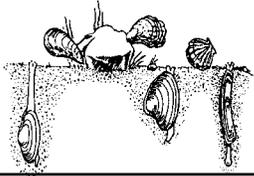
Odum (1989) stated that, “.....modern aquaculture should adopt a new strategy, a model of community-based, ecologically sustainable aquaculture.” Polyculture of shellfish on salmon leases has been demonstrated to be a viable option by many studies (see Parsons *et al.* 2002) and seaweed culture is a net consumer of dissolved nutrients from the water column. It is possible that by integrating the culture of shellfish and

seaweeds with marine finfish culture a more ecologically balanced approach can be achieved for the sustainable development of seafood. Aquaculture is where the future growth of seafood will come and we believe that shellfish are the key to an ecologically sustainable venture.

Shellfish are one of the best candidates for ecologically sustainable aquaculture. Farming of shellfish not only provides a high quality, high value, sustainable harvest from the ocean, it also provides jobs and social and economic development, all while providing tangible benefits to the marine environment. A productive shellfish farm means a healthy and equally productive surrounding environment – let’s give the lowly molluscs their due!

Notes

- ¹ Department of Marine Sciences, University of Connecticut, 1080 Shennecossett Road, Groton, Connecticut 06340 USA.
- ² Pemaquid Oyster, P.O. Box 302, Waldoboro, Maine 04572 USA.
- ³ Pacific Coast Shellfish Growers Association, 1120 State Avenue NE, PMB #142, Olympia, Washington 98501 USA.
- ⁴ Martha’s Vineyard Shellfish Group, Oak Bluffs, Massachusetts 02557 USA.
- ⁵ Rutgers University, Shellfish Research Laboratory, P.O. Box 687, Port Norris, New Jersey 08349 USA.
- ⁶ Moonstone Oysters, Wakefield, Rhode Island 02879 USA.
- ⁷ NOAA National Marine Fisheries Service, 212 Rogers Avenue, Milford, Connecticut 06460 USA.

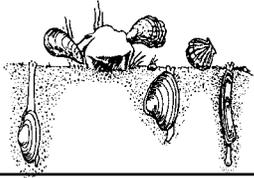


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Appendix 2:

GENERAL LAWS OF MASSACHUSETTS

PART I. ADMINISTRATION OF THE GOVERNMENT.

TITLE XIX. AGRICULTURE AND CONSERVATION.

CHAPTER 130. MARINE FISH AND FISHERIES.

{<http://www.state.ma.us/legis/laws/mgl/gl-130-toc.htm>}

Section 57. Shellfish aquaculture licenses; application; renewal; transfer.

The city council or mayor of any city, or the selectmen of any town, may upon written application, accompanied by plans sufficient to show the intended project and project area to be licensed, and after public notice and hearing pursuant to section sixty, grant to any person a shellfish aquaculture license.

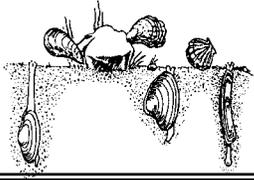
Said license shall authorize said licensee in such city or town at all times of the year, in, upon, or from a specific portion of coastal waters of the commonwealth, of tidal flats or land under coastal waters: (1) to plant and grow shellfish, bottom/off bottom culture; (2) to place shellfish in or under protective devices affixed directly to the tidal flats or land under coastal waters, such as boxes, trays, pens, bags, or nets; (3) to harvest and take legal shellfish; (4) to plant cultch for the purpose of catching shellfish seed; and (5) to grow shellfish by means of racks, rafts or floats.

After receipt of a written application by the city council or selectmen, and after the notice and public hearing requirements of this section are satisfied and the licensing authority approves the application, the director shall, after inspection of the intended project area, certify

that issuance of a shellfish aquaculture license and operation thereunder will cause no substantial adverse effect on the shellfish or other natural resources of the city or town.

Upon such certification by the director, the city council or selectmen may issue the license, provided, however, that no license shall be issued for any areas then or within two years prior thereto, closed for municipal cultivation under the provisions of section fifty-four. Failure of the director to so certify shall be deemed a denial of the shellfish aquaculture license. The director's certification or refusal to certify shall be reviewable in accordance with section fourteen of chapter thirty A.

Licenses under this section shall be granted or denied in writing within sixty days after receipt of the written application and shall be issued upon forms supplied by such cities and towns and upon such terms and conditions and subject to such terms, conditions or regulations as the city council or selectmen issuing the same shall deem proper, but not so as to impair the private rights of any person or to materially obstruct navigable waters, and said license shall describe by metes and bounds the waters, flats or creeks covered



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thereby. Shellfish aquaculture licenses pursuant to this section shall be subject to any rules and regulations promulgated by the director, including those concerning the use and scope of predator controls in the intertidal zone, and said licenses may be further conditioned by the director as he deems necessary and appropriate, including species to be propagated and the source and movement of seed shellfish.

Said license shall be for a period of not more than ten years and may be renewed for similar periods. Said license may be revoked by the city council, selectmen or the director for failure to comply with any terms, conditions or regulations set forth by these entities, or for lack of substantial use of the licensed area. Said licensee shall have the right to the exclusive use of the lands and waters for the purposes of growing shellfish thereon, and the licensee shall plainly mark the boundaries of said area. The selectmen or city council shall permit, as a condition of the license, such public uses of said waters and lands as are compatible with the aquacultural enterprise. Whoever without the consent of the licensee, unless otherwise permitted by the terms and conditions of said license: (1) takes shellfish from the licensed lands or waters or from said racks, rafts or floats; (2) disturbs the licensed area or the growth of the shellfish thereon in any way; (3) discharges any substance which may directly or indirectly injure the shellfish; (4) willfully injures, defaces, destroys, removes or trespasses upon said racks, rafts, or floats; or (5) willfully injures, defaces, destroys, removes or trespasses upon said protective devices affixed directly to the tidal flats, such as boxes, trays, pens, bags, or nets shall be liable in tort for treble damages and costs to the licensee injured by such act.

Nothing in this section shall be deemed to affect the validity, conditions, or terms of any license granted under the corresponding provisions of earlier laws and in full force upon

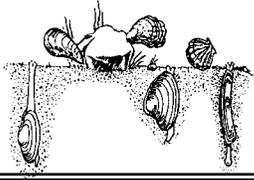
the effective date of this section. Nothing in this section shall excuse the licensee from complying with other laws of the commonwealth, including environmental laws and laws concerning interference with navigation.

Said shellfish aquaculture license may be transferred pursuant to section fifty-eight and all rights and privileges enjoyed by the licensee shall be assumed by the transferee. Any license issued under the provisions of this section shall, upon the death of the licensee, continue in full force and effect, subject to the same terms, conditions, and regulations imposed upon the original license, for the balance of the unexpired term, or one year whichever is longer, for the use of the members of the immediate family of the deceased licensee. For the purposes of this section, immediate family shall mean the spouse, son, daughter, mother, father, brother and sister of said deceased licensee.

Nothing in this section shall be deemed to affect the validity, conditions, or term of any license granted under corresponding provisions of earlier laws and in full force upon the effective date of this section.

Section 58. Transfer or renewal of licenses.

Any license granted under section fifty-seven or corresponding provisions of earlier laws may be transferred with the approval of the city council or selectmen to any person to whom it might originally have been granted, and, whether or not so transferred, may, within two years before the expiration of its then current term, be renewed from the expiration of the original term for a further term or terms, each term not to exceed fifteen years. The provisions of this chapter or of corresponding provisions of earlier laws applicable to the original issuance of such license shall, so far as apt, apply to a transfer or a renewal thereof hereunder.



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Section 59. Application for license; request for survey and plan.

Any person, firm or corporation qualified as provided in section fifty-seven and desiring to obtain a license thereunder shall present to the city council or selectmen a written application setting forth the name and residence of the applicant, a definite description made by reference to a survey conducted by the applicant, and a request that such license be granted to the applicant.

Section 60. Hearing on issuance of license; notice; publication.

No license referred to in section fifty-seven shall be granted, transferred or renewed until after a public hearing, due notice of which has been posted in three or more public places, and published in a newspaper, if any, published in the city or town where the territory described in the application is situated at least ten days before the time fixed for the hearing, stating the name and residence of the applicant or transferee, as the case may be, the date of the filing of the application for such license, transfer or renewal, and the location, area and description of said territory.

Section 61. Marking of territory covered by license; maintenance of markings; penalty for failure thereof.

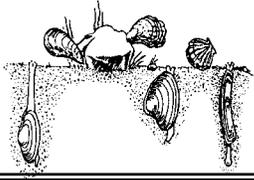
The licensee upon receiving his license shall cause the territory covered thereby to be plainly marked out by monuments, marks or ranges and by stakes or buoys, with the number of his license painted in figures at least two inches in height in a conspicuous place on each of said stakes or buoys or on flags attached thereto, which shall be maintained by him or his transferee during the term of the license or of any renewal thereof. Failure to place or reasonably to maintain the same shall be sufficient cause for revocation of the license.

Section 62. Records of licensed areas, licenses granted, transfers and renewals; recording; fee; inspection of records.

The aldermen, city council or selectmen shall keep in their offices plans showing all such licensed areas, and, in a book devoted to that purpose only, a record of each license granted and of all transfers or renewals thereof, which shall include the name and residence of the licensee or transferee, the dates of issue, transfer, renewal and expiration thereof, and a copy of the description of the licensed areas as the same appears in the license. Each license, and all transfers or renewals thereof, shall forthwith after the granting or approval thereof be transmitted by the board so granting or approving the same to the city or town clerk, who shall record the same in a book kept especially therefor in his office. The licensee or transferee shall within thirty days after such issue or approval pay to said clerk for each license or renewal issued or transfer approved one dollar for such recording, and for each license issued shall also pay four dollars as reimbursement of said city or town for the cost incurred in granting said license, a record of which payment shall forthwith be entered upon said record by said clerk, and such license, transfer or renewal shall not take effect until said fees are paid and entry thereof made as aforesaid. Said records shall be open to public inspection at all reasonable times. Forms for such license and for the transfer or renewal of the same shall be provided by the aldermen, city council or selectmen at the expense of their city or town.

Section 63. Exclusive rights of licensees or transferees; trespass on licensed area; treble damages.

The licensee or transferee, or his legal representatives, shall, for the purposes set



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forth in section fifty-seven and in accord with the terms set forth in said license, have during the term of the license or of any renewal thereof the exclusive use of the waters, flats or creeks described in the license, and the exclusive right to take all shellfish therefrom during the time therein specified, notwithstanding any regulations made by the aldermen, city council or selectmen of the city or town, subsequent to the issuance of such license or to the renewal thereof, as the case may be; provided, that this section shall not be construed to authorize any taking prohibited by law. The licensee or transferee, or his legal representatives, may in tort recover treble damages of any person who without his or their consent, unless otherwise authorized by law or by lawful regulation so to do, digs or takes shellfish of any kind, or shells, from such waters, flats or creeks, or disturbs the same thereon, during the continuance of the license or of any renewal thereof.

Section 64. Annual fee for license; non-payment.

Every such licensee or transferee shall pay to the city or town, on or before a date to be fixed by the aldermen, city council or selectmen, an annual fee of not less than five nor more than twenty-five dollars per acre, or part thereof. If any such fee is not paid within six months after it becomes due the license shall thereupon be forfeited.

Section 65. Annual report of shellfish planted, produced and marketed; estimate of growing shellfish; forfeiture for deficiency.

Every licensee or transferee of a license referred to in section fifty-seven shall submit on oath on or before December thirty-first in each year to the director and to the city council or selectmen of the city or town wherein the licensed area is situated a report of the total

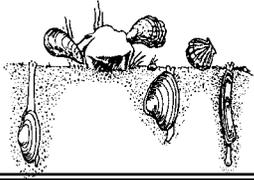
number of each kind of shellfish planted, produced or marketed during the preceding year upon or from such licensed area, and an estimate of the total number of each kind of shellfish at the time of such report planted or growing thereon. The city council or selectmen may specify a reasonable yearly market value to be produced by each shellfish project licensed pursuant to section fifty-seven. Failure of the licensed shellfish project to meet such a value for any three consecutive years thereafter may result in a forfeiture of the shellfish aquaculture license and licensed area.

Section 66. Destruction or removal of marks or bounds; double damages.

Whoever wilfully injures, defaces, destroys or removes any mark or bound used to define the extent of any shellfish license or grant, or places any unauthorized mark thereon, or ties or fastens any boat or vessel thereto, shall be punished by a fine of not less than three nor more than twenty dollars and shall be liable in tort for double damages and costs to the licensee or transferee injured by such act.

Section 67. Taking shellfish from licensed grounds or beds without consent.

Whoever works a dredge, oyster tongs or rakes, or any other implement for the taking of shellfish of any description upon any shellfish grounds or beds covered by a license granted under section fifty-seven or corresponding provisions of earlier laws, or in any way disturbs the growth of the shellfish thereon, or whoever discharges any substance which may directly or indirectly injure the shellfish upon any such grounds or beds, without the consent of the licensee or transferee, as the case may be, or whoever, while upon or sailing over any such grounds or beds, casts, hauls, or has overboard any such dredge, tongs, rake or other implement



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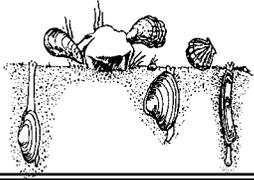
for the taking of shellfish of any description, under any pretence or for any purpose whatever, without the consent of the licensee or transferee, as the case may be, shall for the first offence be punished by a fine of not more than twenty dollars or by imprisonment for not more than one month, and for a subsequent offence by a fine of not more than fifty dollars or by imprisonment for not more than six months.

Section 68. Digging, taking or carrying away shellfish from licensed waters, flats or creeks at night

No person shall dig, take or carry away any shellfish or shells between one half hour after sunset and one half hour before sunrise, by any method whatever, from any waters, flats or creeks as to which a license under section fifty-seven or corresponding provisions of earlier laws is outstanding. A licensee or transferee of such a license violating this section shall, in addition to all other penalties provided, forfeit his license and the shellfish remaining on the licensed premises.

Whoever violates any provision of this section, or whoever, without the consent of the licensee or transferee, digs or takes any shellfish or shells from any waters, flats or creeks described in any license granted under section fifty-seven, or corresponding provisions of earlier laws, during the continuance of such license or of any renewal thereof, shall be punished by a fine of not more than one hundred dollars or by imprisonment for not less than one nor more than six months, or both.

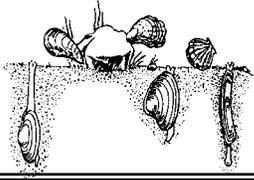
(25 November 2002)



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Appendix 3:

Application No.: 200300120
Applicant: General Public in the
Commonwealth of Massachusetts

Effective Date: January 11, 2000
Expiration Date: January 11, 2005
Modification Date: June 30, 2003

DEPARTMENT OF THE ARMY
PROGRAMMATIC GENERAL PERMIT
COMMONWEALTH OF MASSACHUSETTS
{<http://www.nae.usace.army.mil/reg/mapgp.pdf>}

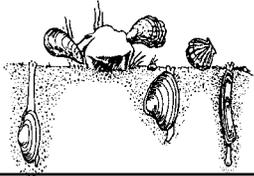
The New England District of the U.S. Army Corps of Engineers (Corps) hereby modifies the previously issued Programmatic General Permit (PGP). The PGP expedites review of minimal impact work in coastal and inland waters and wetlands within the Commonwealth of Massachusetts.....

VIII. AQUACULTURE GUIDELINES

NOTE: The following guidelines are excerpted from Corps Aquaculture Letter of Permission dated September 1, 1991, with some modern clarifications.

Shellfish Aquacultural Facilities are used for bottom and/or suspended culturing and harvesting of bivalve molluscs in the inter-tidal and immediate sub-tidal area of navigable waters. Activities covered include: deployment and maintenance of buoys, rafts, trays, lines, and other equipment associated with the activity; discharge of minor quantities of fill material (i.e. as mineral growth medium) and work, including seed placement, transplanting, temporary wet storage, and harvesting. Activity must be found to have minimal impacts on navigation and the environment and must meet the following specific criteria:

- A. The area authorized for this activity shall not exceed 10 acres, except where the permittee is a duly authorized municipality, for which the maximum size shall be 25 acres;
- B. The area and any elevated structures within it are marked in conformance with 33 CFR 64, and permittee has contacted the U.S. Coast Guard, *First District*, Aids to Navigation Branch (617) 223-8385 to coordinate the proper

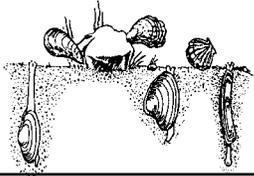


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buoy markings for the activity. Buoys shall be deployed and maintained as appropriate.

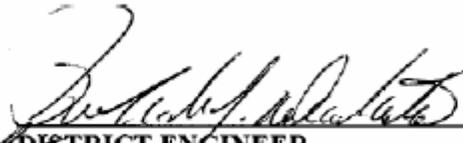
- C. No structure or device (except for marking buoys and as noted in D below) shall protrude more than 18" above the substrate;
- D. Rafts and other floating equipment may be allowed to the extent that they cover no more than 10% of the project area, or 20,000 square feet, whichever is greater. An area shall be considered to be covered with floating equipment if normal navigation through the area is precluded. Projects which are in-place and authorized by the municipality (and State Division of Marine Fisheries if applicable) *by 1 September 1991* which have areas containing floating equipment exceeding the aforementioned limits may be authorized if they meet the remaining criteria. All rafts shall be securely anchored to the bottom, and all "lines" shall be attached to fixed mooring points at both ends;
- E. Mineral growth medium used in culture trays shall be clean and of comparable grain size to the native substrate;
- F. No activity shall occur within a distance of 25 feet from beds of eelgrass, widgeon grass, or salt marsh, nor shall such vegetation be damaged or removed;
- G. An activity is not authorized by any general permit if it can be shown that the activity, including any vehicular access, will have more than minimal negative impacts on avian resources such as, but not limited to: shore birds, wading birds, or members of the waterfowl group. This is meant to include migratory bird nesting, feeding or resting activities (see 50 CFR 10.13);
- H. An activity is not authorized by any general permit if it can be shown that the activity, including any vehicular access, will have more than minimal negative impacts on existing or naturally occurring beds or population of shellfish, marine worms or other invertebrates that could be used by humans, other mammals, birds, reptiles, or predatory fish;

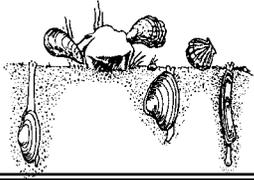


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- I. No activity nor vehicular access to an activity shall occur in such a way as to negatively impact coastal or freshwater wetlands, or any endangered or threatened species on either the Federal or Massachusetts species list.

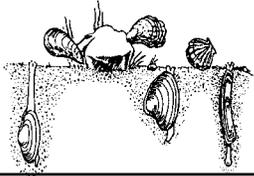

DISTRICT ENGINEER 6/30/03
DATE



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Best Management Practices for the Shellfish Culture Industry in Southeastern Massachusetts

Appendix 4:



THIS FACT SHEET POINTS OUT CERTAIN FEATURES OF CROP INSURANCE AND IS NOT INTENDED TO BE COMPREHENSIVE. THE INFORMATION BELOW NEITHER MODIFIES NOR REPLACES TERMS AND CONDITIONS OF THE BASIC POLICY, THE CROP PROVISIONS, OR THE COUNTY ACTUARIAL DOCUMENTS. CONTACT A CROP INSURANCE AGENT FOR FURTHER DETAILS.

CROP INSURED

Insurance may be provided for all of your clams in the county that are at least 10 mm in size and that meet all other requirements for insurability.

COUNTIES

In the Raleigh Region, clams are insurable under a pilot program in the following states and counties:

Massachusetts	Barnstable	Bristol	Dukes	Nantucket	Plymouth
Virginia	Accomack	Northampton			

CAUSES OF LOSS

A recognized marine authority must document the cause of loss and a copy of the documentation included with the claim before a loss payment can be made.

Insurance is provided for mortality of clams caused only by the following causes of loss:

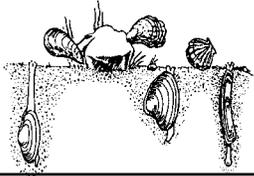
Oxygen Depletion	Disease	Freeze	Hurricane
Decrease of Salinity	Tidal Wave	Storm Surge	Ice Floe

IMPORTANT DATES

Sales Closing and Inventory Reporting Date >>> **November 30, 2003**

DEFINITIONS

- Amount of Insurance** Your dollar amount of coverage determined by multiplying the number of all insurable clams seeded in each basic unit **X** the survival factor (60%) **X** the price **X** the price factor **X** the coverage level percentage you elect **X** your share.
- Inventory Value Report** A report submitted no later than November 30 by the insured declaring the dollar value of insurable clams.
- Stage 2 Clams** Clams that are at least 10 mm in size seeded **after** July 15 of the most recent past crop year.
- Stage 3 Clams** Clams that are at least 10 mm in size seeded **before** July 16 of the most recent past crop year.



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DUTIES IN THE EVENT OF DAMAGE OR LOSS

- Notify your agent within 72 hours of your initial discovery of damage;
- Obtain written permission prior to changing or discontinuing normal practices with respect to care and maintenance of clams.

2004 Clams

PRICES	Established Price Per Clam	CAT Price Per Clam
Massachusetts	18 ¢	9.90 ¢
Virginia	14 ¢	7.70 ¢

Price Factor:

Stage 2 Clams >>> >0.50

Stage 3 Clams >>> >1.00

COVERAGE & PREMIUM

Coverage levels range from 50 to 75 percent average APH yield. **Catastrophic (CAT) Coverage** is fixed at **50%** of your average yield and **55%** of the Price Election. CAT coverage costs an administrative fee of \$100 per crop per county, regardless of the acreage.

Crop insurance premiums are subsidized as shown in the following table. For example, if you selected the 75 percent coverage level, your premium share would be 45 percent of the base premium:

Coverage Level	50%	55%	60%	65%	70%	75%
Premium Subsidy	67%	64%	64%	59%	59%	55%
Your Premium Share	33%	36%	36%	41%	41%	45%

INSURANCE PERIOD

Coverage begins December 1 when application/inventory value report are submitted by October 30, or the 31st day if the application/inventory value report are submitted between November 1 and 30, and ends at the earlier of:

- The date of final adjustment of a loss when total indemnity equals the amount of insurance
- November 30, 2004.

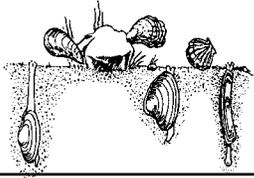
Insurance coverage ends on any clams that remain on the lease as of the:

- Third anniversary of their seeding date in Virginia
- Fourth anniversary of their seeding date in Massachusetts.

INSURANCE UNITS

In addition to optional units based on non-contiguous lease sites optional units will also be available based on stage 2 or 3 clams as identified in the special provisions. Clams seeded during the year of insurance will be classified as stage 2 and are considered part of the appropriate optional unit.

Liability of the stage 2 optional unit may be adjusted upward at loss time to reflect additional seeding as long as the total liability of the insurance contract does not exceed the total reported liability of the insurance contract. Otherwise, a timely revised inventory report must have been submitted.



Best Management Practices

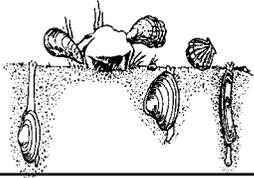
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LOSS EXAMPLE

Assume a clam inventory value of \$100,000. At the 75% coverage level, insurable inventory = \$75,000.

\$100,000	Field Market Value Before Loss
- \$50,000	Field Market Value After Loss
	\$50,000 Value of Loss
- \$25,000	Deductible (1 - .75 coverage level X \$100,000 clam inventory value) \$25,000
	Indemnity Payment (before premium)

For more information, visit the Risk Management Agency web site at www.rma.usda.gov



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Crop Insurance Agents Serving Massachusetts 10/30/03

Note: Many agents are licensed to sell insurance in more than one state; therefore, your search results may return agents who sell in one state and reside in another.

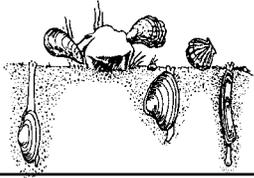
For Sales In:	Name:	Telephone:	City:	State:
Massachusetts	Campbell, E	(618) 656-4240	Edwardsville	IL
Massachusetts	Pettiford, S	(618) 656-4240	Edwardsville	IL
Massachusetts	Smucker, K	(618) 656-4240	Edwardsville	IL
Massachusetts	Blair, R	(508) 866-9150	Carver	MA
Massachusetts	Cross, J	(508) 867-7538	East Brookfield	MA
Massachusetts	Maxwell, S	(508) 867-7538	East Brookfield	MA
Massachusetts	Wilson Jr, C	(508) 867-7538	East Brookfield	MA
Massachusetts	Loranger, C	(508) 763-5772	East Freetown	MA
Massachusetts	Plastridge, P	(978) 486-3575	Littleton	MA
Massachusetts	Sylvia, M	(508) 428-0440	Osterville	MA
Massachusetts	Spencer, E	(508) 747-8181	Plymouth	MA
Massachusetts	Martin, D	(508) 295-2007	West Wareham	MA
Massachusetts	Carroll, A	(270) 793-8988	Limerick	ME
Massachusetts	Kisselburgh, C	(207) 793-8988	Limerick	ME
Massachusetts	Bodley, K	(800) 234-7012	Cortland	NY
Massachusetts	Forrett, J	(800) 234-7012	Cortland	NY
Massachusetts	Blasco, J	(814) 774-9212	Lake City	PA

Note: Information contained in these agent listings is provided by insurance providers under a reinsurance agreement with RMA. Questions or comments about the information in these lists should be referred to the appropriate insurance provider.



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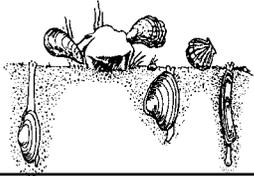
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Appendix 5:

Contact information for shellfish aquaculture professionals in
the southeastern Massachusetts region.

- **William Burt**
Cape Cod Cooperative Extension &
SouthEastern Massachusetts
Aquaculture Center
Registry of Deeds/Probate Building,
Railroad Avenue, P.O. Box 367,
Barnstable, MA 02630
508 375-6702
wburt@umext.umass.edu
- **William Clark**
Cape Cod Cooperative Extension
Registry of Deeds/Probate Building
Railroad Avenue, P.O. Box 367
Barnstable, MA 02630
508 375-6701
wclark@umext.umass.edu
- **Robert Garrison**
Wampanoag Aquinnah Shellfish
Hatchery
20 Black Brook Road
Aquinnah, MA 02535
508-645-9420
rdgarrison@attbi.com
- **J. Michael Hickey**
Massachusetts Division of Marine
Fisheries
50A Portside Drive
Pocasset, MA 02559
508 563-1779 ext. 122
- **Richard Karney**
P.O. Box 1552
Oak Bluffs, MA 02557
508-693-0391
mvsg@capecod.net
- **Richard Kraus**
Aquaculture Research Corporation
P.O. Box 2028, Chapin Beach Road
Dennis, Massachusetts 02638
800-334-1380
- **Dale Leavitt**
Roger Williams University
220 M&NS Bldg
One Old Ferry Road
Bristol, RI 02809
401 254-3047
dleavitt@rwu.edu
- **Massachusetts Aquaculture
Association**
P.O. Box 500
North Eastham, MA 02651
508 247-9122
info@massaqua.org
- **Jerome Moles**
Massachusetts Division of Marine
Fisheries
50A Portside Drive
Pocasset, MA 02559
508 563-1779 ext. 129



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- **Diane Murphy**
Cape Cod Cooperative Extension &
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Barnstable, MA 02630
508 375-6953
dianecmurphy@hotmail.com
- **Roxanna Smolowitz, DVM**
Marine Biological Laboratory
Water Street
Woods Hole, MA 02543
508 289-7400
rsmol@mbl.edu
- **Scott Soares**
Massachusetts Department of
Agricultural Resources
251 Causeway Street, Suite 500
Boston, MA 02114
617 626-1730
Scott.Soares@state.ma.us
- **Bethany Walton**
Aquaculture Laboratory
Massachusetts Maritime Academy
101 Academy Drive
Buzzards Bay, MA 02532
508 830-6691
bethanywalton@comcast.net
- **William Walton**
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Woods Hole Sea Grant, and
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