Best Practices for the East Coast Shellfish Aquaculture Industry

Revised September 2023

EAST COAST SHELLFISH GROWERS ASSOCIATION

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

USDA NIFA United States Department of Agriculture National Institute of Food and Agriculture

Northeastern Regional Aquaculture CENTER

The Nature Conservancy

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Introduction to Codes and Best Practices

In 2023 the East Coast shellfish aquaculture industry harvested over $177 million of sustainably reared shellfish on about 1,500 farms from Maine to Florida. Most farms on the East Coast are small enterprises with fewer than 10 employees, but the industry is growing rapidly, both in numbers of farms and in the efficiency and size of individual farms. Over the past decade most of the growth has been in oyster production, which has nearly doubled in the past five to seven years.

The industry is quite diverse, with a wide range of species grown in highly variable environments. Shellfish growers employ a diversity of gear types, and recent years have seen the development of several innovative culture methods and devices. The pace of innovation makes it difficult to regulate such an industry in ways that do not stifle the invention of new gear types and the development of novel solutions to vexing challenges.

Unlike land-based farmers, who often own or rent the land they farm, shellfish farmers work on (or over) leased submerged public-trust lands that are owned by the states and managed for the benefit of the "Sovereign" (i.e., the people of the state.) Even in the rare cases where states allow growers to buy tidelands or where King's Grant Leases convey ownership rights, the states and federal authorities have significant regulatory authority over what can and cannot be done on these grounds. The National Aquaculture Association counts at least 23 federal Acts of Congress and 15 federal agencies with some regulatory authority over aquaculture.

Regulations and Best Practices (BPs) each have their place in achieving compliance from the regulated community. Regulations are used to protect public health, safety and resources, while Best Practices are intended to direct behaviors that allow shellfish farmers to work in harmony with the other users of the public-trust waters. Best Practices define specific farm-management and operational practices that address environmental concerns and stress a good-neighbor business strategy while preserving the ability of the farmer to innovate.

It is not intended that these Best Practices be incorporated into laws and regulations because laws and regulations tend to lack flexibility and fail to anticipate novel advancements in techniques and gear developments. It can take years to alter laws and regulations, which hinders innovation. Best Practices can be written with outcome-oriented goals and objectives in mind, allowing for innovation and rapid evolution.

People who write regulations often have only a modest understanding of the tools and practices that growers use. Enforcement of regulations relies on active surveillance, penalties and fines for non-compliance. From a practical standpoint, it is often unrealistic to employ adequate enforcement staff to achieve desired compliance rates.

On the other hand, Best Practices are developed with grower input, so they often achieve higher rates of acceptance and compliance than regulations, simply because there is a greater level of buy-in. Grower-developed rules often give rise to an ethic of peer pressure and self-enforcement.

Shellfish farming is regulated by a variety of federal, state and often local agencies. The subject of shellfish regulations could fill several books, and because the rules are constantly in flux, they would be obsolete soon after they were written. We have included a description of some of the most important regulations in Appendix 1: Laws Pertaining to Shellfish Farming. Following is a very brief overview.

Regulatory Overview

Lease applications are usually handled by state authorities, but certain states have local town control. Leasing is overseen by the U.S. Army Corps of Engineers (ACOE), which regulates structures in navigable waters. There are eight ACOE districts on the East Coast, but despite ACOE Nationwide Permits for shellfish aquaculture, there are often significant differences between permit requirements among districts and even among states. The ACOE seeks comment on aquaculture applications from both the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) Office of Protected Resources on matters relating to threatened or endangered species interactions, essential fish habitat, and marine mammal or migratory bird interactions.

States are required to regulate matters related to shellfish sanitation through authority delegated from the Food and Drug Administration (FDA). These regulations are set forth in the National Shellfish Sanitation Program (NSSP) Model Ordinance, which is developed by the Interstate Shellfish Sanitation Conference (ISSC). States must comply with the minimum requirements of the NSSP, but they can impose additional, more restrictive requirements on harvesters, shellfish farmers and dealers. At a minimum, states must monitor water quality and determine harvest-area classifications, develop and enforce harvest controls and tagging requirements, and regulate the handling and shipping of shellfish designated for interstate transport.

Since state and federal regulations are in a constant state of flux, the East Coast Shellfish Growers Association maintains updated lists of appropriate state and federal regulatory authorities (ECSGA.org/regulations) and state extension agent/federal regional coordinator contacts (ecsga.org/extension-agents) on our website. (See also NOAA's summary of state-by-state leasing and permitting requirements[1]).

Environmental Sustainability

The shellfish farming community is aware of a growing trend by seafood distributors and retailers to source only products that meet certain environmental or sustainability standards, or that have certifications from various environmental groups. To meet these demands, the shellfish-farming community has developed Environmental Codes of Conduct and/or Best Practices. The development of the original 2010 Best Management Practices manual was made possible by funding from the USDA's National Institute of Food and Agriculture's Northeastern Regional Aquaculture Center and NOAA's Office of Aquaculture. This 2023 revised Best Practices Manual was made possible by support from The Nature Conservancy, through the SOAR initiative[2] Shellfish Growers Resiliency Fund.

Shellfish aquaculture ranks high on the list of the most environmentally positive uses of the coastal zone. In most states, unproductive acreage may be leased for farming, and applicants must ensure that their farming practices will cause minimal adverse impacts to public fisheries and other public resources. It is well documented that shellfish aquaculture provides tangible ecosystem services by improving water clarity and removing excess nitrogen from sensitive estuarine waters, (visit ECSGA.org/sustainability). Most ecologists agree that shellfish farming is restorative[3] and believe that increasing shellfish farming activity is consistent with the goals of resource managers. Studies[3a] show that shellfish farms can enhance the survival of juvenile fish, resulting in about 1 ton of additional fish harvest for every hectare (~2 acres) of farm.

Shellfish aquaculture done right will make a positive contribution to the environment and to the local community. It is unquestionably one of the most sustainable ways to produce protein with extremely low greenhouse gas emissions, no use of fertilizers or drugs, and no feed inputs. Abundant references are listed in Appendix 3: Bibliography.

Since shellfish for human consumption must come from water that meets very high public-health criteria, the typical shellfish farmer serves as a watchdog against pollution and as a passionate advocate for clean water. In addition, substantial benefits accrue to jobs and local economies associated with shellfish farming and the ancillary businesses the farms rely on.

Shellfish farmers intuitively understand the positive aspects of growing shellfish, but it can be a challenge to convince regulators and the public that shellfish farming is a net-positive for the environment and for the community. Best Practices can help growers explain how their farms achieve the goals of addressing environmental concerns. Stakeholder-driven Codes of Conduct and BPs can lead to greater environmental accountability, reduce multi-user conflicts, improve production efficiency, instill consumer confidence in products, and result in a higher degree of self-regulation.

The ECSGA Code/BP Project

The original 2010 Best Management Practices project relied on extensive communication with people involved with shellfish aquaculture, including growers, regulators, academics, non-government agencies (NGOs) and other stakeholders. That effort entailed holding 20 workshops involving 370 individuals.

This 2023 revision was undertaken with the intent of adding a section addressing floating gear issues that were not fully addressed in the 2010 BP project. The revision also included upgrading the software used to produce individualized Best Practices documents for farms.

How to Use the Best Practices Form for Your Farm

The Best Practices Form[3b] on ECSGA.org contains all the Best Practices described in this manual, presented as a series of checkboxes. Simply select any practices used on your farm and submit the form. This triggers the sending of an email with an attached pdf containing some generic principles and explanations, along with the specific BPs you selected. The email contains a link to a free version of Adobe's pdf-to-MS-Word file converter, so you can download a Word file that you can tweak, re-format, add images to and save however you want.

A farm-specific BP document should be viewed as a "living document" that can be modified whenever you make significant changes in management or operations. These modifications could be made to address new problems or changes to regulations, or to improve farm efficiency. Perhaps a good time to update your BP document would be at the end of the growing season when there is time to reflect on what worked and where improvements could be made.

The personalized BP document can serve as a guide for employees, familiarizing them with the expectations you have for processes and behaviors on the farm. It could be streamlined and presented as a marketing tool, highlighting how your farm operates in an environmentally responsible fashion. Inserting photographs and emphasizing certain sections can help you tell your story to the public. Some growers have used their BP documents to help in permit applications and to reassure aquaculture opponents that their farm takes environmental concerns seriously.

Description of Shellfish Culture Methods

This section provides a brief overview of methods used to grow shellfish in coastal areas of the Eastern United States. Since the species and methods used are diverse and evolving rapidly, this section is not meant to be comprehensive. For more detailed descriptions of shellfish farming methods and gear we encourage you to visit our website, ECSGA.org, where you can find a wealth of information on permitting, regulations, educational programs and culture methods, along with an abundant variety of helpful resources for novice and seasoned growers alike.

Fundamentally, growing filter-feeding shellfish involves buying seed from a hatchery (or collecting wild spat), protecting it from predators, allowing it to feed from the natural microscopic food in the water, and eventually harvesting the product for sale.

Planting oysters on the bottom saves money on gear and maintenance, but usually comes with losses due to predation.

For over 100 years traditional oyster growers have collected seed by spreading shell in low-salinity areas to catch wild spat. These seed oysters are then planted on leased bottom without the use of cages or gear. Management of a traditional bottom-planted farm consists of monitoring the crop and perhaps trapping or removing predators such as crabs and starfish. Oysters are harvested using hand rakes or towed rakes (commonly called dredges). Unprotected shellfish seed typically suffer massive losses to predation, but because maintenance and gear costs are negligible, farmers are often able to prosper with survival rates of 5% or less.

Modern intensive shellfish aquaculture was only made possible by the development of shellfish hatcheries and various types of cages, trays and netting materials. The introduction of plastic-mesh netting, vinyl-coated wire and injection-molded plastics in the 1980s ushered in a rapid

evolution of shellfish farming techniques. Modern intensive shellfish aquaculture now involves three phases: hatcheries that raise and sell larvae and small seed, nurseries that rear small seed to intermediate sizes, and grow-out to market size that involves a wide variety of cages, trays and mesh bags or netting to protect the crop. Some firms are vertically integrated and have their own hatchery and nursery operations, while many have become shellfish dealers so they can market directly to restaurants and consumers.

It is beyond the scope of this document to discuss hatchery and nursery Best Practices or the multitude of regulations and practices involving post-harvest handling, shipping and sales. The Regional Shellfish Seed Biosecurity Program (RSSBP.org) has developed Best Practices and a hatchery certification program[8b] to minimize the risk of shellfish-disease introductions associated with interstate shipments of seed. Regulations pertaining to human health and interstate harvest and shipping are described in the National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish [4]. For a comprehensive discussion of current shellfish aquaculture practices, we recommend consulting the text book, "Molluscan Shellfish Aquaculture: A Practical Guide" (S. Shumway ed. ISBN 9781789180107).

The essence of modern intensive shellfish aquaculture boils down to protecting shellfish crops from predation by holding them in various types of nets, cages, bags or trays while ensuring a good flow of phytoplankton-rich water by removing the various types of fouling organisms that attach themselves to the gear. Keeping the shellfish alive while battling the forces of nature involves tending the gear on a regular basis to control fouling and dealing with the exponential growth of the crop volume. At scale, intensive aquaculture requires significant investments in gear and seed, and usually requires large amounts of manual labor, often under adverse conditions.

Seed

Clam and oyster farms generally buy seed from hatcheries to begin the cultivation process, but some oyster and mussel farmers still collect wild seed on spat collectors or shell. Another approach for oyster cultivation involves placing bagged, clean shell into large tanks of seawater and introducing hatchery-reared larvae that settle on the shell. The spat-on-shell are then planted on leased grounds for several years until the oysters reach harvest size. While predation losses can be high, free-planted crops don't require expensive gear and have low labor costs.

In the hopes of eliminating predation losses, many growers buy hatchery-reared seed and hold it in various types of cages, trays or mesh bags. Smaller seed and larvae are much cheaper, but rearing small seed through the nursery process can be challenging, which is why many growers prefer to spend more and purchase larger seed. Moving seed from state to state (or sometimes within states) usually requires a pathology inspection and importation permits from the receiving state authority.

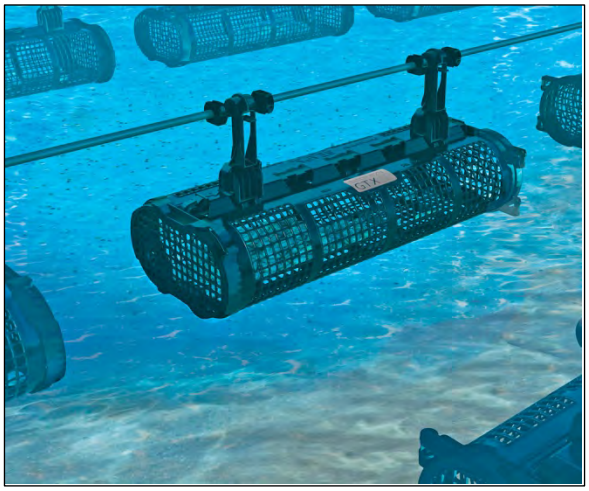
Floating upweller systems, known as FLUPSYs, are a great way to protect seed from predation and provide them with plenty of food for rapid growth.

Nursery culture of small hatchery seed is commonly done in land-based upwellers or raceways, or in floating upwellers known as FLUPSYs. Small seed also can be reared in fine-mesh spat bags. Free planting of small seed clams or oysters on the bottom is likely to result in rapid, massive predation losses. Depending on the predator assemblage in the grow-out location, small, unprotected seed will commonly suffer losses of over 90% in just a few weeks.

At some point, shellfish seed attain a "size of refuge" where they are more resistant to predators and can be free-planted with only moderate losses. The size of refuge (often called field-planting size) will vary greatly from site to site, again depending largely on the nature of the predators. In some areas predators will devour free-planted shellfish of any size, and the only way to ensure a harvest is to grow seed in some sort of protective enclosure.

Grow-out

In most East Coast states hard clams are planted under ½-inch-mesh predator-barrier netting (similar to bird netting) to protect the crop from crabs, rays and diving ducks. Rolls of netting up to 16 feet wide are placed on the bottom, and the edges are pinned or held down with weights or stakes to keep the net tight to the sediment. Growers in Florida have developed cloth mesh bags that can be partially buried, allowing the clams to dig into the sediment while they grow. Periodically the mesh must be scrubbed to remove fouling and allow the flow of food-rich water to the clams.



SEAPA baskets are one of many injection-molded plastic baskets that come in a variety of mesh sizes and capacities.

Oyster farming is carried out in a wide variety of gear types. Plastic-mesh bags of various mesh sizes can be held on bottom, on racks, stacked in bottom cages, suspended below the surface or floating on the surface. After vinyl-coated wire mesh became available in the 1980s growers developed a range of gear designs, including stacked trays, Taylor Floats and different cage designs used to hold the mesh bags. Injection-molded, rigid plastic trays have been developed in a variety of shapes, including Dark Sea Trays[5], SEAPA Baskets[6], Hexcyl™ Baskets[7], FlipFarm[8] and more. Growers in Australia developed a longline system suspended between poles that involves hanging baskets at different heights, which determines how many

hours of air exposure the crop will experience at low tide, to control the growth of fouling on the gear.

A Canadian inventor developed a method of suspending two to six oyster grow-out bags held in a cage floating just below the surface under two large floats. This novel floating cage system allows farmers to treat fouling organisms by flipping the cage and air drying the cage and the oysters for 12-24 hours. Removing the end caps on the floats allows growers to sink the gear to avoid winter ice or severe storms. A variety of similar designs are now being marketed.

In much of the world mussels are grown in long socks, suspended from longlines that can be floating at the surface or suspended at depth. The blue mussel does not thrive south of New York, and mussel farming has been slow to develop in New England. Growers in Maine either plant seed directly on the bottom or suspend lines from rafts that are encircled by netting to deter diving-duck predation. Suspended mussels get much better access to food and have higher meat quality, but as with oysters, the gear and labor add to production costs. Although those added expenses are not a factor bottom-planted crops, the trade-off is lower production due to predation.

Growers are also experimenting with a variety of other shellfish species, each with its own challenges and unique culture gear. They have found some measure of success with bay scallops, surf clams, soft-shelled clams, sunray Venus clams, sea scallops and blood arc clams.

Code of Conduct for Molluscan Shellfish Culture

The shellfish culture code of conduct is modeled after the Code of Conduct for Responsible Fisheries developed by the United Nations Food and Agriculture Organization (FAO). The shellfish code encompasses a set of common-sense precepts that most growers follow instinctively as good stewards of the environment and as producers of wholesome food. We believe that these statements belong at the beginning of every farm BP document.

Shellfish farmers shall:

1. Conduct aquaculture operations in accordance with all applicable laws and regulations, and acquire and maintain all pertinent permits.
2. Make the best effort to produce and handle products of the highest quality and ensure product safety.
3. Make a best effort to communicate early and openly with water-based and land-based neighbors about any facet of their operation that might affect them.
4. Work to benefit the local economy by patronizing local businesses and through employment and contributions to the tax base and infrastructure.
5. Site, plan, develop and manage aquaculture operations in a manner that minimizes negative environmental impacts.
6. Site, plan, develop and manage aquaculture operations in a manner that ensures the economic and social sustainability of the operation.
7. Take all appropriate measures to avoid and contain disease outbreaks and report them quickly to the proper authorities if suspected.
8. Dispose of culturing waste in a manner that does not constitute a hazard to human

health or to the environment.

9. Consult and collaborate with government and authorities, researchers, other producers and stakeholders for the development and implementation of regulations, technologies and standards to achieve environmentally, economically and socially sustainable shellfish culture when feasible.
10. Encourage other growers to adopt the shellfish code of conduct and better management practices.

BP Elements

A substantial number of permits are required in most jurisdictions where shellfish farming occurs. General industry or specific farm permits may be required from state agencies, counties, towns and/or the U.S. Army Corps of Engineers. Each grower should check with state extension agents or resource managers to learn which permits are necessary; once these permits have been obtained it is important to keep them current. The specific permits required for shellfish-farming activities are in a constant state of flux. The East Coast Shellfish Growers Association endeavors to maintain a list of current permit requirements, agency contacts and extension contacts on our website.

Site Selection

Site selection is crucial to the success of any shellfish farm over the long term. To be successful, many factors must be considered. Biological, logistical and physical factors are obvious, but social concerns and policy considerations often dictate where farms can be placed.

Most states do not allow leasing of sites that support active commercial or recreational fisheries. Similarly, authorities will not allow farms that interfere unnecessarily with navigation, and will also deny leases in areas that have submerged aquatic vegetation because it is considered essential fish habitat.

While some states have established pre-permitted aquaculture zones, most allow growers to try and find their own locations. The physical and biological conditions necessary for aquaculture will vary according to the species being grown and the gear type being deployed. In broad terms, a farmer is looking for a site that has rich food and strong currents to ensure good growth. Protection from wave action and storms, and proximity to public access are also compelling factors. Quite often lease sites will be dictated by the degree of public opposition and the aesthetic concerns of waterfront homeowners.

Biological/Physical/Social Factors

At a minimum, the most important factors to consider include:

- Salinity and temperature.
- Phytoplankton abundance.
- Sediment type.
- Water depth and current velocities.

- Protection from severe storms, winter ice and boat wakes.
- Prevailing wind fetch.
- Water-quality classification.
- Riparian owners and other stakeholders of the resource (navigation, fishing activity etc.).
- Access to a marina or public boat launch (or by vehicle at low tide).

Scale of the operation is also important; if future expansion is contemplated, it should be incorporated in the initial site selection. Most farmers begin with modest aquaculture operations and, if successful, may consider expansion opportunities. In rare cases, if there are many farms in a given area, the carrying capacity of the area may need to be evaluated to see if additional shellfish culture can be accommodated. (See Byron et al., 2011[8a])

Gear type will have a strong impact on site selection. Soft, muddy bottom is not usually suitable for bottom planting, but bottom cages or floating gear may work well. Floating gear may not be acceptable in areas frequented by recreational boaters or where waterfront homeowners may object due to aesthetic concerns, but bottom gear or bottom planting might be a viable choice.

User conflicts with groups such as fishermen or recreational boaters are quite often the key factor in determining whether a lease will be granted. Identifying the other existing users of a potential spot is a critical step in siting a farm. While aesthetic concerns are subjective, they can be an overriding factor at some sites, especially if floating gear is being proposed. Many states require scoping sessions prior to submitting an application, to allow regulators and stakeholders to discuss the proposal, identify problems and seek solutions. (See section on Site Selection and User Conflicts).

Site Marking

Clearly marking the farm site is usually advantageous to the farmer and usually is dictated by the permit. A well-marked farm can help with farm operations, prevent damage to the crop or gear from non-farm vessels and may reduce crop loss from theft. The ECSGA is working with NOAA to have lease boundaries noted on charts and on electronic chart plotters in order to help boaters avoid causing damage to farm gear and to clarify what activities may be restricted within the bounds of the lease.

Heavy-duty floating PVC buoys are a good way to warn boaters away from encroaching on shellfish leases.
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The most common boundary markers are buoys or stakes. If the farm is large, markers may be required along the perimeter rather than at just the corners. The types of markers, their color and the

number and location of markers are usually dictated in the permit. In some jurisdictions lights or radar reflectors may be required (especially for leases with floating gear).

When buoys are used for floating gear, the choice of color is usually left up to the farm operator, but uniform coloration is recommended. When the farm is within the view of landowners, dark buoys are generally preferable since they create less of a visual impact, but since they are difficult to see at night reflective buoy tape is recommended. Leases near channels should have markings that are easily distinguishable from channel markers. Local communities may dictate the size and type of corner markers, but more often the state regulates the marking of leases, and in many cases may require lights on corner markers. Commonly, corner markers will need to meet specifications set by the Coast Guard Aids to Navigation Division. For leases out of the public view, and where specific marker colors are not required, it is usually advantageous for growers to use brightly colored buoys to alert boaters to the presence of a farm.

Most stakes are made of PVC. Consider using gray PVC since it is visually less offensive to upland property owners. Remove and replace stakes and corner markers damaged by ice and other environmental events in a timely manner. This is especially important in cases where marking farm sites is a regulatory requirement, and/or where the site marking serves to keep non-farm vessels away from the site to avoid damage to those vessels or to farm gear or crops. Try to minimize the use of stakes and buoys to reduce visual impact to upland property owners where appropriate.

Site Security–Theft and Vandalism

Theft and vandalism are pervasive challenges for shellfish farmers coastwide. Constant surveillance is not practical and remote cameras (especially with night-vision capability) are very expensive. Most of the crops on any given farm are usually sub-market size, which may deter most thieves, but some thieves have turned to stealing the cages with the oysters inside.

Confronting thieves in the act is not recommended, but having enforcement officers on speed dial could bring help in time. Take pictures and record video from a safe distance.

Perhaps the best anti-theft tactic is to befriend waterfront homeowners (farm tours and gifts of shellfish help) so that when they see a strange vessel on your lease they can give you a call. Make sure your neighbors have your number handy and encourage them to call you if they have any complaints or concerns. Be friendly and be a good neighbor.

Site Access

One of the biggest threats to shellfish aquaculture is the loss of working waterfront access. Commercial docks are being turned into condominiums, while marinas are pushing out commercial boats in favor of recreational yachts. Some states are even restricting public boat-ramp access to recreational users only. If you can’t access your farm or land your crop, you can’t have a farm.

If you use a public boat ramp, be courteous of others. Don't leave smelly gear on the beach and don't take too long tying up the ramp. If you drive across beach or tide flats to access your site, avoid protected resources and sensitive habitats such as dune grass, nesting sites or submerged aquatic vegetation.

Some states are restricting public boat ramps to recreational users only. If shellfish growers can't access their farms it's game over for their business.

Some farm sites are lost due to declines in water quality. While commercial fishermen can often fish other areas when closures occur, your farm is tied to one spot, and getting a new lease can often prove difficult. Some states view this loss as a "taking" and have legal provisions that allow for financial recourse against the polluters, but the lease laws in most states specify that you have no such recourse.

These issues are best dealt with by grower associations as opposed to individual farmers. Strong state grower associations are key to accomplishing legislative changes and ensuring that Right-to-Farm laws include aquaculture. State associations should build alliances with key legislators and work with local Farm Bureau representatives to fend off anti-aquaculture legislation.

Good Neighbor Policy

Most state lease laws grant the leaseholder some degree of exclusive use, but most try to allow multiple uses as long as they are compatible with farm operations. If boats can safely traverse the lease or if fishing is possible, these activities are usually encouraged, as long as the farmer's gear is not damaged and the safety of boaters is ensured. Farms with floating gear (or gear exposed at low tide) are usually "exclusive use" areas and must be well marked as such. Often, navigation lanes must be provided to allow safe transit through the lease, especially for riparian (shoreline) access.

Growers need to remember they are operating in the commons and their ability to farm there is a privilege, not a right. A state's Right-to-Farm laws may grant specific rights, such as the right to make noise at dawn or to generate foul smells, but that does not mean it is prudent to do so. Activities that cause conflicts with neighbors and other users of the commons are likely to cause repercussions for both your farm and for all the other farms in the area.

Being a good neighbor involves what you do both on the water and in your community. Participation in civic groups and legislative affairs, harbor management committees and your state aquaculture association are highly recommended.

BPs for being a good neighbor:

- Take every opportunity to inform and educate the public on the benefits of shellfish aquaculture.

- Be courteous and minimize disruptions to other users of the area.
- Introduce yourself to your neighbors, and look for opportunities to be friendly.
- Join or create a local or state aquaculture association.
- Encourage communities to maintain traditional uses of the water.
- Volunteer for appointments to decision-making boards or committees.
- Pro-actively engage with your elected officials and regulators, and offer farm tours.
- Encourage policy makers to make room for shellfish leases and to preserve commercial access to farm sites.

BPs on how to inform and educate your neighbors throughout the life of the farm:

- Consider sending an annual newsletter or card to update neighbors on the farm's activities and plans.
- Posting and maintaining good signage on the farm explaining what is allowed and what is prohibited or dangerous is a good investment.
- Welcome public discourse and use it as an educational opportunity to explain the regulations and what it takes to run a safe operation.
- Consider sharing info about your operations on social media.

BPs on improving the social license to farm by keeping your operations neat and tidy:

- Follow all regulations–replace missing corner markers promptly.
- Clean up promptly after storms and regularly check the shoreline for stray gear.
- Wash off gear and boats when docked at a marina.
- Be respectful at public boat launches with your gear: do not leave waste behind, and avoid using the space for excessive periods.
- Respect private property: avoid staging gear on private property unless specific permission has been granted.

The following sections describe some potential problems and conflicts with neighbors that may arise.

Noise

Pumps, power washers, tumblers/sorters and audio players all make noise that may be annoying to others. Sound carries over water for great distances, particularly on calm days. If you need to yell to a co-worker in order to be heard over the sound of your machinery, be aware that you can often be heard for a half-mile or more. It is wise to be considerate of other boaters and waterfront homeowners (even if you find the sound of their leaf blowers and lawn mowers annoying). Fishermen and aquaculture farmers often need to start early in the morning or run late into the evening due to weather constraints, wind conditions and tides. But, if at all possible, avoid excessive noise when it is likely to irritate others.

BPs to reduce noise:

- Dampen noise from loud machines by applying mufflers and baffles to motors, and painting metal tumblers with a rubberized coating.
- Use quiet, four-stroke engines.
- Adjust the work schedule and use common sense to avoid noisy activities on busy weekend afternoons and early in the morning.
- Be aware that sound carries over water; if you have to yell to be heard or are playing a loud radio, it is likely that people can hear it on shore.

Loud machinery can annoy nearby boaters and neighbors. Dampening noise by using mufflers or rubberized coatings can help. HOOPERSISLAND.COM

Odors

Most people living near the shore recognize that low tide will bring certain smells. Decaying sea squirts and dead shellfish can be especially foul, and if your farm is upwind of a residential area it is likely that conflicts will arise and offended homeowners may seek legislative redress. Disposal of fouling material can be difficult if there is a large volume or if it is far from a disposal site that will accept it, but it is the farmer's responsibility to keep the noxious odors to a minimum.

BPs to reduce odors:

- Remove the offensive material as rapidly as possible, especially in warmer weather.
- Avoid placing fouled gear or decaying material in public areas.
- Adhere to a schedule of routine fouling control so that fouling does not become so bad that it requires mitigation measures that generate noise or produce excessive odors.

Multiple Use

Most states allow other users certain types of access over leased areas. Depending on the culture methods, activities such as fishing, kayaking or boating are often permitted, as long as shellfishing and anchoring are avoided. Regulations governing these activities differ from state to state and in some cases from lease to lease. Often a lease-holder has exclusive use of an area for floating gear, but other uses might be allowed over bottom gear or bottom-planted shellfish. Some growers may permit lobster traps, fish pots or conch traps around the periphery of their leases. Shellfish farms often make great fishing spots as long as the fishermen know where to go so they don't get hung up on growers' gear.

BPs to avoid multiple use conflicts:

- Post clear signage explaining what is allowed and what is prohibited on the lease (such as, “no anchoring or shellfishing”) in order to avoid conflicts and gear damage.
- Practice good communication by engaging folks you see on the water, explaining what you are doing, what other uses are permitted and which activities should be avoided.

Upland Gear Storage

Most states do not allow storage of culture gear in the coastal zone so most shellfish farms require upland areas to store gear that is not being used. The actions you take on private property, such as processing shellfish or storing gear, are commonly regulated by private property laws and town zoning laws. While it may be legal to make noise or store smelly gear right up to your property line, it will probably not endear you to the neighbors.

It is advisable to clean as much fouling off your gear as possible before bringing it ashore in order to minimize the stench (unless you have no neighbors). Some fishing ports have designated sites for storing lobster pots and fish traps, and may allow storage of aquaculture gear there as well. Pressure washing is an option, but you can also air-dry cages and bags to kill the fouling organisms and then splash it again for a week to allow fish and crabs to clean it up for you.

BPs for upland gear storage:

- Clean gear well before bringing it ashore.
- Put up a fence or consider leasing storage space from a nearby farm to avoid potential conflict with neighbors.

Growing Shellfish

Seed Sourcing

Almost all the shellfish grown on the East Coast are considered native species (or established non-natives). It is highly unlikely that states or the federal government will allow the intentional introduction of non-native species for aquaculture, but invasive species that have been introduced to our waters intentionally, in ballast water or on the hulls of vessels (such as the green-lipped mussel *Perna sp*. or the European flat oyster *Ostrea edulis*) may be considered for culture. Nevertheless, getting permits for established non-natives may be challenging.

While some seed shellfish are still collected for aquaculture from wild larval sources, the majority of growers now depend on hatchery-reared larvae and seed. When selecting seed sources it is usually preferable to use seed bred from animals that are adapted to local growing conditions. Clam and oyster seed from northern stocks sometimes perform better in southern states, but the reverse is rarely true.

Of paramount concern is preventing the introduction of novel diseases into growing waters where these diseases have yet to be established. Several known pathogens affecting clams and oysters can cause mass mortalities. After decades of moving seed up and down the East Coast

and introducing devastating pathogens and parasites, resource managers are much more cautious now. Currently, every state has regulations pertaining to the transport of shellfish seed across state lines. Most require that seed first be inspected by professional pathologists and certified free of disease.

The Regional Shellfish Seed Biosecurity Program (RSSBP) was developed by shellfish growers, scientists, extension specialists and state resource managers to minimize risks associated with interstate transfers of shellfish seed.

The resulting patchwork of regulations and moratoriums have made it difficult to acquire seed in certain states. After years of work trying to harmonize the regulations, a group called the Regional Shellfish Seed Biosecurity Program (RSSBP.org) has developed maps showing the distribution of known pathogens, and has created an advisory panel to help provide resource managers with guidance on seed transfers. They have developed Best Practices for hatcheries and a hatchery certification program[8b] that calls for inspections and audits.

The RSSBP emphasizes the prudence of shipping small seed or larvae that have never been exposed to unfiltered water. Certified seed from RSSBP-inspected hatcheries are highly unlikely to be carrying pathogens. However, once seed has been exposed to raw, unfiltered seawater, it is possible that the seed can be carriers of pathogens from those waters. In an effort to avoid the spread of pathogens to other states, the RSSBP recommends that those seed be transported only to areas that already have endemic populations of similar pathogens, or that batch testing for pathogen screening be employed.

Since shellfish have primitive immune systems, it is unlikely that vaccines or treatments will ever be developed to treat these diseases. In some cases, we have succeeded in developing management practices (such as reducing densities or stressors) that may prevent the pathogens from causing mortalities or reduce their impact. The most promising way to develop disease-resistant seed is through selective breeding of survivors of past disease outbreaks. Some promising work is being done to develop probiotics to limit mortalities from certain pathogens in hatcheries, but it is not likely that these will be legal to use (or effective) once seed are planted in open waters.

Scientists have spent decades trying to develop lines of oysters that are resistant to the most devastating pathogens: MSX (*Haplosporidium nelsoni*) and Dermo (*Perkinsus marinus*). While Dermo resistance remains elusive, geneticists at Rutgers University and the Virginia Institute of Marine Science have developed lines of oysters that are highly tolerant of MSX. Since MSX has been known to cause devastating mass mortalities from Maine to South Carolina, it is advisable that growers employ stocks bred from these lines.

Other known oyster pathogens include the bacterium *Roseovarius crassostreae,* which causes Roseovarius Oyster Disease (ROD); and *Haplosporidium costale,* also known as Seaside Organism (SSO), a parasite similar to MSX. Clams are susceptible to Quahog Parasite Unknown (QPX) and a communicable form of clam leukemia. We also hear periodic reports of mass mortalities of undetermined cause. Many other parasites and bacterial pathogens infect oysters and clams, but most are not likely to cause mortalities.

If you detect an unexplained mass mortality on your site it's a good idea to send a sample for inspection to your local shellfish pathologist. Early detection of novel pathogens might be the best hope of limiting the spread and preventing a widespread calamity. (See ECSGA.org/OsHV)

All growers are encouraged to obtain seed from hatcheries that operate in a responsible fashion. Rutgers University Cooperative Extension annually updates a comprehensive list[9] of the numerous East Coast and Gulf Coast hatcheries and nursery seed purveyors.

Thanks to the efforts of the ECSGA and supportive legislators, there is now an established East Coast shellfish breeding program to develop regionally adapted lines of oysters that are resistant to all known pathogens. As this work progresses and these lines become available to commercial growers, we hope that mass mortalities resulting from infection with these pathogens will become rare events.

BPs to avoid the transfer and introduction of diseased seed:

- Follow state regulations regarding the inspection of seed by a competent pathologist prior to import.
- Use RSSBP-certified seed if possible.
- Purchase seed reared from stocks that are adapted to local growing conditions.
- Transfer small seed or larvae to minimize the potential of transferring infected seed.
- Lightly infected seed may often be moved between sites with similar established pathogen populations (depending on state regulations).
- Purchase lines of seed that have been selected for disease resistance where possible.
- If an unexplained mortality event is observed, promptly send a sample to a pathologist for evaluation.

Nursery Systems

Setting up in-water nurseries can be as simple as putting the shellfish seed into fine-mesh bags, either on racks or floating on the surface. Many growers prefer to use upwellers to pump food-rich water to small seed, either on land or in floating upweller systems (FLUPSYs). Water does not easily flow through fine-mesh bags, so growth is usually much faster in pumped upwellers compared to very fine-mesh (<2-mm) spat bags.

Land-based systems such as upwellers and raceways require access to waterfront property and involve high costs to pump water uphill. FLUPSYs cut pumping and real estate costs, but require access to private or public docks and electricity. Floating bags are often the cheapest solution.

Each of these approaches requires regular maintenance to ensure the fine mesh does not become fouled, blocking the flow of water. Given that investing in a crop of seed can run to tens of thousands of dollars, it pays to check pumped systems twice a day to ensure that flow is maintained and the pump has not tripped a breaker or gotten fouled with fishing line or seaweed. Since the volume of the crop can double several times in a week, sorting and restocking is often needed weekly. If the screens become clogged, the flow to the seed will be impaired and the pumps on FLUPSYs may begin to cavitate, which can be noisy and eventually result in pump failure.

Fine-mesh bags on submerged racks or floating on the surface also may require fouling removal once a week. Frequent flipping will help avoid fouling buildup and ensure the seed has access to food. Overcrowded or underfed seed will grow slowly and suffer from stress. As the seed graduate to larger mesh sizes, the fouling removal schedule can often become less frequent, depending on the growth rate of fouling organisms at your site. Floating mesh bags are often flipped, allowing the fouled surface to dry out, while upwellers must be emptied and the screens treated. Scrubbing the screen with a stiff brush or blasting it with a pressure washer or a fresh water hose is usually adequate. A light spray of acetic acid or dilute chlorine is usually quite effective and the chemicals can be allowed to evaporate or to quickly dissipate in seawater. Saturated brine solutions are quite benign when added to seawater.

If seed become infested with sea squirts or encrusting tunicates it may be necessary to treat the seed as well. Some fouling organisms will be killed by freshwater or saturated brine dips, but for small seed be sure to test the treatments on small batches of seed before treating the whole crop to ensure the treatment is not fatal to the seed. Although acetic acid or chlorine will quickly break down in seawater to harmless component chemicals, the bath or dip water should be heavily diluted before dumping into growing waters or disposed of in a sewer.

BPs for nursery systems:

- Thin stock often to prevent overcrowding.
- If a power washer is being used for cleaning, be considerate of the noise and spray generated and the timing of the cleaning operation.
- If working in a marina setting be sure to clean up adjacent boats and the surrounding dock area after fouling treatment to reduce odors.
- Clean gear often to prevent the accumulation of fouling material.
- If possible, access a floating-dock FLUPSY in a marina when foot traffic is low.

Fouling Control

Most of this section applies to containerized intensive oyster farming, which allows for gear to be moved and treated, as opposed to clam farming, where the crop is buried in the sediment. For a comprehensive look at fouling control options, see UNESCO's Best Practices guide, Biofouling Prevention and Management in the Marine Aquaculture Industry. [10]

Most growers use netting, mesh bags or cages to protect the crop from predation. Invariably, these hard surfaces will attract various types of fouling organisms, such as seaweed, tunicates,

Fouling control can account for much of the work on the farm. Fouling organisms can block the flow of food-rich water to the shellfish, resulting in slower growth and even degradation of quality. No flow, no grow, no dough.

bryozoans, sponges, worms, barnacles, oyster overset and mussels. Fouling organisms hinder the flow of food-rich water to the crop and result in slower growth. Some fouling organisms also compete for food or degrade the quality of the product. In extreme cases fouling can smother the crop altogether. Fouling control is one of the chief challenges of shellfish farming and often accounts for much of the work expended on a farm.

The options for fouling control consist of prevention, avoidance, mechanical removal, air-drying, heat treatment and chemical treatment. Each method has advantages and drawbacks, and may be effective for different crops and different types of fouling organisms. Whichever fouling control methods are used, it is important to recognize that accumulations of dead fouling organisms may result in localized increases in oxygen demand as the dead material decays, which may itself stress the crop.

Fouling control typically takes place on the farm site. Cleaning gear at a land-based facility with subsequent land-based disposal of fouling material is an option, but is usually impractical and cost-prohibitive. Some farms regularly swap out fouled gear with clean gear and treat the fouled gear on land, but most farms combine fouling control with the cleaning of gear on land only when gear is ready to be repaired or stored.

Prevention

Most anti-fouling coatings rely on toxins (copper) or Teflon derivatives (which are now recognized as toxic) to deter the settlement of fouling organisms. Non-toxic alternatives include ablative coatings, which slough off over time; irritants like capsaicin (hot pepper extracts); photo-oxidants; and wax-release coatings. Farmers should exercise extreme caution when using chemical coatings for fouling control, and use only environmentally friendly materials.

Avoidance

Some fouling can be prevented by avoiding the time or location where fouling organisms are setting. On Cape Cod (Massachusetts), where many growers hold seed oysters over the winter in land-based, refrigerated storage, growers have learned to wait until after the annual barnacle set before they redeploy their crop in the spring. Keeping good records on when and where fouling organisms set in your area may allow you to develop an avoidance strategy, but most growers don’t have the ability to move their farms to avoid fouling organisms.

Mechanical removal

A simple-but labor intensive-method of removing fouling is to manually scrub the organisms away with brushes or scrapers. Clam farmers often use stiff brooms or squeegees to remove growth from bottom netting. There have been efforts to capture the material so it doesn't get carried downstream onto a neighbor's farm, but economical and efficient means of capturing the waste material remain elusive.

Blasting the gear and the crop with high-pressure seawater spray is highly effective in removing soft-bodied organisms and algae. Pressure washers can be set to a range of pressures and can be used with a variety of wand tips to adjust the force of the spray. "Trash pumps" are a lower pressure, high-volume option that is effective in clearing mud-worm tubes and more delicate fouling organisms. It is rarely practical to use freshwater on the farm site, but for land-based treatment it can be quite effective for certain soft bodied fouling organisms.

The impact of cleaning activities will depend largely on the scale of the farm. Any situation where removal results in the accumulation of dead and decaying material may result in areas of low oxygen. If the material washes ashore it is likely to cause foul odors. Pressure washers and trash pumps are quite loud, (even if the motors are muffled) and the use of ear and eye protection is highly recommended. If you are operating in proximity to waterfront homes or recreational boaters you will need to be respectful about the noise levels and the time of day.

Air-drying

One of the most effective methods of fouling removal is air-drying. Most marine fouling organisms cannot live long out of water, so many growers deploy gear to allow tidal exposure to dry out the gear and the crop on a regular basis. Many gear types allow growers to rotate the fouled parts of the gear out of the water for 12-24 hours to control fouling; this technology is evolving rapidly. Some growers pull cages (with the oysters still inside) out onto floats on a rotating basis.

The amount of time needed for the gear to air-dry is site specific and depends on air temperature and humidity. If the crop is left in the gear while drying, it is important to determine the thermal tolerance of the crop organisms versus the fouling organisms that you are trying to eliminate. Barnacles, oyster overset and mussels can be quite resilient. During the summer in southern climates where air temperatures regularly exceed 95°F, growers often dry their gear overnight to avoid killing their crop.

Once the fouling material is dead, the gear can be returned to the water, where crabs and fish will consume the material as it decays. As a bonus, the coating of dead fouling material may deter subsequent resettlement of new fouling organisms and allow an extra week between cleaning cycles. The key with air drying is for it to be a routine practice. Your goal is to be killing off the organisms that settled while they are still microscopic and most susceptible to air drying. If you wait until you can see the fouling organisms, they may require more aggressive treatments.

Heat treatment

Some growers have adopted the approach of dipping the oysters in hot water for brief periods, which can be especially effective for recalcitrant fouling organisms like barnacles, oyster overset and mussels. The temperature and duration of the dip must be tightly regulated to kill target fouling organisms, but not the crop itself. One grower recommends 140°F (60°C) for two seconds followed by rapid cooling in ambient water, but trial and error will determine what works for oysters of different sizes and shell thicknesses, and for different types of fouling organisms.

Chemical treatment, brine or fresh-water dips

Another effective fouling control method is to dip the gear (often with the crop still inside) into a saturated solution of brine (roughly 30% salt by weight). The amount of time for soaking in brine depends on the types of fouling organisms you are trying to control. Allowing the brine to dry on the gear and the shellfish following the dip will further concentrate the salt and make the treatment more effective. A 10-minute dip followed by a 10-minute air-dry is often effective even for very small (1-mm) barnacles and young oyster overset, both of which are can be very tough to kill without harming the crop itself. There are limits to how long young oysters or clam seed can tolerate a brine soak that will vary with the size of the animals and the temperature of the bath.

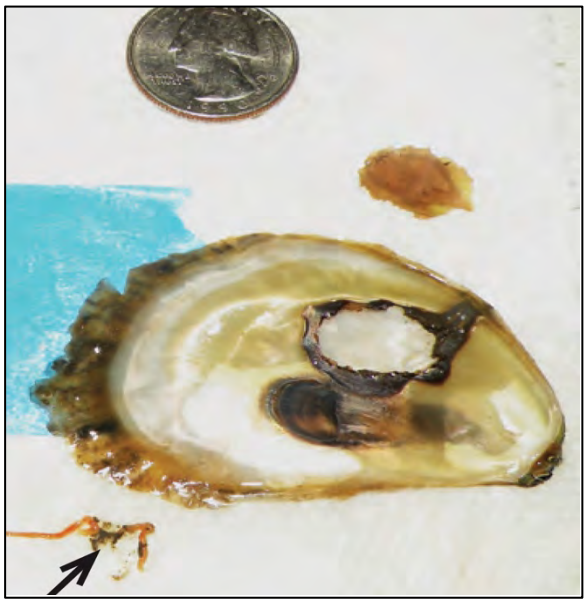
Freshwater dips can be an effective way to control fouling, especially for small seed, but after a few treatments the salinity of the bath typically goes up and it loses its effectiveness.

Dilute acetic acid spray is occasionally used on mussel lines to control soft-bodied ascidian tunicates. Acetic acid is harmless to the environment once diluted.

Brine, freshwater dips, acetic acid and heat treatments are not appropriate for species such as scallops or soft-shell clams that cannot close tightly. Dipping crops is also quite labor intensive and time consuming and may not be practical for a large-scale operation.

Shell-boring organisms

Boring sponge (*Cliona spp*.) and the mud-blister worm (*Polydora websteri*) are species that actually bore into the shells of shellfish and can cause significant damage to shell quality and crop value. Once established they are very difficult to kill, and even brine dips will achieve only partial elimination. In areas where these species are prevalent the best control is often frequent air-drying.



A large blister worm excavated from a well-established burrow in an oyster. The chip of shell that had covered the burrow is shown next to the quarter. DANA MORSE/DARLING MARINE CENTER

Frequency of treatment

The time between fouling treatments will vary based on the gear type being used and the growth and recruitment rate of the fouling organisms in your area. Northern growers might be able to get away with a monthly treatment regime during the growing season, while southern growers may need weekly treatments year-round. Minimizing fouling will ensure maximum flow to your crops and reduce the chances that boring sponge can get established. It is always easier to get rid of small organisms than to deal with larger, established ones. As a practical matter, the farmer is always balancing the available labor with the jobs that need doing, and fouling control is highly labor intensive. Nevertheless, growers should try to stay ahead of the worst fouling to ensure it does not interfere with the growth and survival of the crop.

BPs for fouling control:

- Schedule fouling-control efforts to prevent significant reductions in water flow to crops.
- Avoid accumulations of decaying fouling material in areas that could result in environmental impacts or foul odors.
- Remove decaying fouling debris from public areas such as landings, docks and marinas.
- Do not store fouled gear in public areas such as landings, docks and marinas.
- When storing gear on land, remove fouling prior to storage if neighbors are close enough to object to odors.
- If using pressure washers or trash pumps within earshot of others, try to be respectful by avoiding their use during odd hours.
- Minimize pump noise with mufflers and baffles.
- Use only non-toxic, “environmentally friendly,” anti-fouling coatings on gear.
- Store approved dips or chemical treatments in approved locations, and ensure they are properly labeled and disposed of after use.

Predator Control

Shellfish predators can sometimes appear in significant numbers and cause a lot of damage to the crop. For shellfish in bags, cages or other gear or under netting, the mesh material is usually quite effective at excluding most large predators like crabs, fish and sea stars (star fish). Uniquely, sea stars are able to consume shellfish inside the mesh bag while remaining on the outside by everting their stomachs right through the mesh. Crabs and sea stars can also get into bags and cages as larvae or juveniles and then grow inside the gear to a size where they can prey on the crop. Vigilance is key: if you see empty shells or predators inside the gear, remove them.

Sea stars are voracious consumers of many types of shellfish. They can get into mesh bags or cages as larvae or juveniles and eat shellfish from the inside when they grow large enough, or even evert their stomachs to penetrate protective netting and wreak havoc from the outside.

In the case of clams grown under nets, some crabs, rays and predatory gastropods can reach the crop and cause damage despite the presence of netting, and it is important to control them. Keep in mind that some shellfish predators such as blue crabs and conchs are of value in other fisheries, so you should use non-lethal removal methods for these when possible. The harvest of invasive green crabs (*Carcinus maenas*) is usually unregulated and they may be sold as bait or fertilizer.

Several species of birds are voracious consumers of shellfish. Diving ducks can eat huge numbers of seed clams and mussels each day, and large flocks can wipe out a crop in a few weeks. Because some birds are considered protected resources, lethal control is not an option (even repellents may be frowned upon). In these cases, the farmer should work with the NOAA Fisheries Office of Protected Resources[23], USDA APHIS Wildlife Services[24] and state authorities to decide on an appropriate course of action. Although clam netting is usually an effective deterrent to diving ducks, mussel farmers have found it quite challenging to deter them. Growing mussels suspended from rafts allows growers to encircle the crop with netting to keep the ducks away, but this becomes yet another item that demands fouling control. Scare kites, green lasers, drones and other tactics have proven marginally effective against birds.

BPs for predator control:

- For predators like conchs and blue crabs that are considered valuable in fisheries, practice non-lethal removal and focus on predator barriers.
- Encourage fishermen to trap these predators near your lease.
- Trapping and removal of sea stars and invasive green crabs is not regulated (and green crabs can often be sold as bait).
- Be vigilant looking for predators that may get into your gear or under your netting and remove them before they cause significant damage.
- Deter or repel protected resources using only methods approved by the NOAA Fisheries Office of Protected Resources and USDA APHIS Wildlife Services.

Siltation

Siltation is generally more of a problem with subtidal culture than intertidal, and can occur either in the normal maintenance of the farm gear or in the harvesting procedures. Hydraulic harvesting equipment can cause significant sediment disturbance, but only the fine particles remain suspended in the water for more than a few minutes and the fines will be dispersed over great distances. The mass and volume of the fine sediment depend on the scale of the harvest activity and the nature of the sediment where the hydraulic harvest is occurring. Most studies indicate that sediments from hydraulic harvesters rarely accumulate in significant amounts beyond 100 feet from the dredge. For more information and links to scientific papers, including extensive literature reviews, on the impacts of hydraulic harvesters visit ecsga.org/dredging).

Siltation can also be caused by storm events. Severe winds and waves can bury clam nets under sediments to the point where the clams' siphons cannot reach the water and they are smothered. Growers can save the crops by promptly going out and raising the cover net back above the sediment surface.

When sediment levels are high, oysters (and mud worms) can accelerate the deposition of sediment by depositing feces and pseudo-feces. When bags of oysters are stacked in cages the material dropping from the top bags can smother animals in the bags below. Again, vigilance is key to avoid mortalities.

Storm and Hurricane Preparation

A written plan for storm and hurricane preparation is a good idea for all gear types, and every farm should have a written storm-contingency plan describing what steps to take depending on the predicted intensity of the storm. (For examples and guidance visit UFL's Storm and Hurricane Preparedness page[13])

In the hectic days and hours before the storm is predicted to hit, your crew may be distracted protecting their own boats and homes. Boat ramps and marina lifts will get crowded. Having a written plan in hand could save a lot of angst. Your plan should note appropriate emergency numbers and tasks, such as: filling gas cans, sharpening chain saw blades and filling scuba tanks.

Plan for power to go out for a few days. Decide if you will pull your boat(s), and if you plan to have them ride it out, how you will secure them at the dock or mooring. These decisions will vary depending on predicted storm severity and whether

Storm surge from Hurricane Fiona tossed mussel trays onto the beach on Prince Edward Island, Canada, in late fall 2022. Having a written storm contingency plan before bad weather strikes can help growers hit the ground running before it's too late to prepare. SALTWIRE.COM

you are in a sheltered cove or in an area with considerable fetch.

After the storm it may be prudent to patrol the waterways around your farm and remove debris (pilings, floating docks, wood, etc.). This is good regular practice at any time, but especially important after hurricanes.

BP for storm and hurricane prep:

- Develop a written storm-contingency plan describing steps to take depending on the predicted intensity of the storm.

Gear Maintenance, Disposal and Recycling

One of the biggest potential adverse impacts of aquaculture is generating derelict gear and marine debris. Loose netting, rope and other gear can get wrapped around propellers and is both a nuisance and dangerous. Gear that washes up on shore or in marshes can entangle wildlife, is unsightly, and can negatively impact the public enjoyment of coastal areas.

Although not all gear loss can be prevented, especially in severe weather, it is important to be as diligent as possible to minimize gear loss. Examples of good management practices include using proper anchoring and mooring systems, using sufficient tie-downs for nets, and promptly removing unused or derelict netting and cages from farms. Some growers tag their gear with an identifying marker that enables wayward items to be returned to the farm by people who find them, but more importantly shows the public that the farm takes responsibility for its gear. Increasingly, gear marking is becoming a regulatory requirement because it identifies bad actors and encourages gear recovery. Unfortunately, if not properly affixed to the gear, the labels themselves can become another source of marine debris.

We strongly recommend that growers avoid single-use zip ties when bungees, straps, stainless steel hooks and clips or twine can be used instead. Newly introduced biodegradable zip ties may be an option to consider. Zip ties that are used for the life of the gear can often be replaced with stainless steel hog rings. The proliferation of zip ties (and other aquaculture-related debris) in shoreline wrack gives the industry a bad name and may make it harder for established farms to get permission to expand or for new farms to obtain permits.

For most types of shellfish aquaculture some loss of gear is inevitable, but periodically organizing or participating in a beach clean-up is a great way to demonstrate the farm's environmental stewardship.

Most gear—such as rebar, ADPI bags, clam bags and cages—can be cleaned, repaired and reused for several years. Some netting, cages and ropes can be recycled. As rebar rusts away it becomes a dangerous rusty spike in the sediment and should be removed. Once gear has passed its useful life it must be disposed of in an appropriate manner and in accordance with local regulations.

BPs for gear maintenance, disposal and recycling:

- Properly anchor and tie down all gear (see also BPs for floating gear).
- Inspect anchor lines, bridles and other rigging on a routine basis; repair as needed to prevent breakage.
- Promptly survey the farm after storms to look for damaged or lost gear.
- Promptly recover lost or damaged gear.
- Avoid single-use plastic fasteners and instead opt for reusable bungees, hooks, clips or twine.
- Label gear so that it can be returned if lost, and ensure that labels are well fastened.
- Remove derelict gear for recycling or disposal in accordance with local regulations.
- Organize and participate in beach clean-up events.

Fuel Handling and Waste

(note: technically some of these are regulations and not BPs)

Fuel, lubricating or hydraulic oils and other hydrocarbons can have a deleterious environmental impact on coastal waters and cultured shellfish. These compounds usually come from boat operations, but can also come from farm vehicles and other machinery. All precautions should be taken to minimize any spills or leaks of these fluids, and waste oils should be disposed of properly. It is prudent to keep a supply of oil-absorbent towels or socks on boats in case of inadvertent spills.

Federal law mandates an approved Marine Sanitary Device aboard every harvest vessel. Even small amounts of untreated human waste can contaminate large areas.

Federal law requires that any chemicals, lubricants or fuel on harvest vessels must be properly labeled and stored to prevent contamination of shellfish. In cases where harvesters use a truck instead of a boat to access their farms, the truck is considered the "harvest vessel." It is also a violation of federal law to dispose of waste material overboard. Every vessel should have a container for any waste brought aboard, such as food wrappers or bottles, and for garbage that may be recovered from the water.

Human waste is subject to special regulations. It is illegal to dispose of human (or pet) waste overboard. Untreated waste can carry millions of pathogens and can contaminate large areas. Vomit can also be a source of pathogens and should not be disposed of overboard. Federal law requires every harvest vessel to have an approved Marine Sanitary Device (MSD) on board. At a minimum an MSD may consist of a bucket with a tight-fitting lid that is labeled "HUMAN WASTE" in 2-inch, capital letters.

BPs for fuel handling and waste:

- All vessels should have designated trash containers, and no waste may be disposed of overboard.
- Keep chemicals and fuel properly stowed in well-marked containers.
- Keep oil-absorbent towels or socks on board to capture spilled oil or fuel.
- Harvest vessels (or trucks used for harvest) are required to have an approved MSD on board.
- If someone is observed vomiting overboard, notify authorities so they may initiate an investigation to ensure that the shellfish in the area is safe for harvest. (This is preferable to potentially sickening hundreds with contaminated shellfish.)

Record Keeping

Like land farmers, successful shellfish growers keep detailed records that serve as guides to review and predict fluctuations on the farm. But accurate record keeping goes beyond just recording observations and data. Growers must also analyze this information periodically and use it to inform decisions about changes to their operations that will increase efficiency and profitability. Improved management practices will usually translate into increased production and lower operating costs.

Luckily, the tools for recording and analyzing farm data have evolved from waterproof notebooks and pencils to digital farm-management apps like Oceanfarmr[19], which promises to "get the farm out of your head." Some growers swear by ArcGIS Survey123[20 21], a customizable data-gathering and analysis system that uses forms.

But investing in digital apps may not be for everyone at every phase in the life of the farm, so the old ways of paper and pencil still have their place. Try to get in the habit of regularly recording observations, measurements and counts in writing as soon as possible. Do not trust your memory! Always keep a note pad, two soft lead (#2) pencils (pens are useless in a wet environment) and a clipboard covered with a clear sheet of plastic with you, or use waterproof notebooks and pens (available through forestry-suppliers.com).

Digital apps like Oceanfarmr can streamline and simplify keeping track of farm information and preparing reports.
OCEANFARMR.COM

If digital farm-management apps are not appealing, waterproof notebooks and pens are viable options, and can serve as a permanent record. You can enter data into a computer or ledger later on.
FORESTRY-SUPPLIERS.COM

Summarize important information obtained from the field into a computer or ledger later. A two-ledger system (one for the field and one for home) has the benefit of providing a back-up version, which will be neater and easier to read in the future. Keep field data sheets and permanent records in separate locations. Precise and accurate facts recorded in a timely fashion yield better information for future decisions and will help you file an insurance claim in the event of a weather-related loss.

It would also be prudent to establish a regular maintenance schedule, noting when each line or cage was treated for fouling or was split or tumbled. Determine how often you need to check lines for chafing or examine anchor chains for rust. Establishing a regular maintenance schedule for your outboard and other expensive machinery is the best way to ensure these critical tasks don't get put off during the inevitable crush of the growing season. Having a list of maintenance chores on hand is a great way to fill those days when it is blowing too hard to get out to the farm.

Monitoring the Environment

Two major categories of environmental factors affect the growth and survival rates of shellfish: temperature and food supply. Recording temperatures is a chore often best left to an electronic data logger. Since prices for these devices have come down considerably over the years, it makes sense to tie several inexpensive loggers to a corner marker or a cage and periodically download the data.

Unfortunately, monitoring the food supply is more challenging, and depends on both food quality and quantity. Food quality will vary with the types of phytoplankton present in the water, while the quantity available to the crop depends on current speed and the amount of fouling on the gear containing the shellfish. At a minimum, growers can take notes on water clarity, such as the presence of unusual blooms (like rust tide) or washout events after rainstorms that leave the water clearer than usual.

Since these environmental variables are beyond the grower's control, the only thing to do is make notes of anomalies: heat waves, big storms, washout events or big swings in salinity. Certain types of data will be especially helpful to note: the date when ice cover appeared or melted, times when temperatures dropped below or climbed above 50°F (10°C)– the temperature at which clams and oysters become physiologically active. Cumulative rainfall data are available online from NOAA (water.weather.gov/precip) as are regional data like degree days. Localized weather-station data and forecasts from websites like wunderground.com and weather.gov provide valuable tools for growers.

Monitoring the Crop

Since the goal of record keeping is correlating growth data with environmental information to optimize production, environmental records have limited value unless matched with records of shellfish growth. It is also important to periodically measure and note the condition of the shellfish. The most obvious biological parameters to record are growth and survival. Other important observations include:

- Predation
- Planting densities
- Differences in conditions between different batches or groups of shellfish
- Equipment failures (and successes)

Many growers hedge their bets and purchase seed from different hatcheries or from different genetic lineages. Keeping these groups separated and noting successes and failures will help you decide which hatcheries to buy from next year and to identify which lines of animals perform best on your site.

Every time you sort and restock your gear or plant new seed you should note how many bags were planted and at what density, and perform seed counts if you are stocking by volume. If you use a sorter, note the approximate percentage of the crop that was retained at each mesh size. This is a simple way to roughly track and compare growth rates. Periodically shucking a few animals to look at the amount of meat in the shell will provide a quick assessment on the condition of the crop.

Disaster Assistance

Since it is almost inevitable that you will experience a weather-related crop loss at some point in the life of the farm, it is crucial to keep a handle on crop inventory. Your county Farm Service Agency[28] offers two programs that every grower should enroll in: the Non-insured Crop Disaster Assistance Program [29] (NAP) and the Emergency Livestock Assistance Program[30] (ELAP). NAP requires registering your crop acreage before the annual September 30 deadline and paying a small fee. ELAP is free and reimburses growers for crops lost to weather-related disasters. These programs can reimburse 50%-90% of the value of the loss.

Thanks to the efforts of the ECSGA, the National Aquaculture Association and others, ELAP was expanded to include shellfish farmers in 2021. To qualify for

Extreme heat events, like those that hit the West Coast and Cape Cod in the summer of 2021, can prove deadly to shellfish and result in severe crop losses. ELAP coverage from the Farm Service Agency is free and can reimburse growers up to 90% for weather-related disasters.
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disaster assistance, you will need to be able to document your inventory before disaster hits. Be sure to save receipts from seed purchases and keep records of sales so you can demonstrate the typical background mortality rates on your farm and document the inventory you had before the disaster struck.

Regulatory Requirements

Often you will need accurate records to meet various regulatory requirements. In addition to the obvious tagging requirements for harvest, product that has been air dried for fouling control must be resubmerged for a period of time required by your state's Vibrio Control Plan[31]. Seed grown in uncertified or closed growing areas during the nursery phase typically must be held in clean waters for four months before harvest. Tyvek tags in various fluorescent colors can be marked with a Sharpie and stuffed in the bag with the crop to help document when desiccation occurred or when seed was transferred so you know when it can legally be harvested for sale.

Best Practices for Floating Gear Management

This section attempts to address specific concerns associated with floating gear (aesthetics, site design, anchoring, storm preparation and bird deterrence.) Many growers are opting for floating gear because mortality rates are lower, growth may be more rapid and product is more uniform. In addition, managing fouling can be easier with floating gear. While many of the considerations and Best Practices recommended in this section are covered in other sections, they are repeated here because floating gear has unique characteristics that demand special treatment.

Definition of Floating Gear

For the purposes of this section, floating gear is broadly defined. The common denominator for these systems is that they involve highly visible gear on the surface that generally is not going to be passable by most recreational boaters. Kayaks and canoes might be able to transit through a floating-gear lease, but in most cases these leases need to be designated as exclusive-use areas.

According to the manufacturer, FlipFarm systems provide an ideal environment for oyster growth, conditioning and hardening, while giving growers control over fouling, pests and predators. WWW.FLIPFARM.CO.NZ

Examples of floating gear include simple grow-out bags with floats attached; Taylor Floats; FlipFarm[8]systems; floating cages that hold multiple bags; gear suspended from long-line surface floats (including lantern nets or Dark Sea Trays[5] and similar suspended cages or trays); and suspended longlines known as the Australian Longline System that use rigid posts with cables stretched between them to hold various types of baskets or cages (SEAPA Baskets[6], Hexcyl™ Baskets[7] or similar). This is not an exhaustive list

and novel gear types are being developed and introduced at a rapid pace.

Site Selection and User Conflicts

From a practical standpoint it is virtually impossible to find a site with no existing uses, but simply because there are some existing uses does not mean a site cannot be explored. If it is heavily used for recreational boating or is in the viewscape of many upland homeowners, a potential site is likely to draw more complaints in the application process and may result in delays in the permit process or even in an outright denial. Researching a potential site usually involves consulting with harbormasters, fishing groups and town planners. It may be advisable or required to study town tax maps and to notify abutters. Since floating gear poses more conflicts with boating, it is important to consider how the site could accommodate public/private navigation needs, including proximity to public and private rights-of-way or mooring areas.

Winter Ice Considerations

For floating gear and intertidally exposed bottom cages you may need a plan for winter ice conditions, depending on the latitude. Growers in Maine typically sink floating gear or move it to sites that never ice up, while many growers on Cape Cod store their crop on land or move intertidal gear to deeper waters to avoid ice damage. In areas with intermittent or moderate ice, some growers are able to leave their gear floating and regularly check it to ensure it doesn't get carried away. You should talk to other growers or extension agents in your area to learn about what to expect in winter.

Protected Resources Considerations

Your site may be in an area that requires break-away links to prevent entanglement of turtles or marine mammals. These and other regulations about potential impacts to protected resources and essential fish habitat need to be considered.

BP for protected resources:

Check with NOAA's office of Protected Resources[11] or your NOAA Regional Aquaculture Coordinator[12] for a list of potential protected-resources concerns at your site.

Site Design

It is especially important to consider the prevailing winds, currents and other environmental factors when choosing a site. Working a string of gear aligned with the prevailing wind is generally easier than working a line in a crosswind.

Design and install your farm so that the final product is neat, tidy and professional looking—if your farm looks like a junkyard it is going to draw far more complaints.

BPs for site design:

- Orient gear according to environmental conditions and in line with regular wind patterns.

- Uniform buoy colors and sizes are recommended.
- Prioritize aesthetic concerns such as keeping lines of floating gear straight.
- Space the cages far apart to facilitate sinking and refloating them if that is your strategy for storm preparation or ice avoidance. The gear manufacturer should have recommendations on spacing.

Startup Management Considerations

Once your site is permitted and you are starting production, you may have to balance how you manage your operation for the highest-quality product and highest profit (practical growing considerations) with how you manage it for the best possible relationship with the surrounding community (good neighbor practices). Sometimes the two objectives may be at odds; investments you make to be a good neighbor may cost you in terms of profit, but more often than not the two will go hand in hand.

Farm Management Considerations

Gear selection. Select gear that is best suited for the site, your budget and target grow-out numbers. Because of the diversity of gear types and environments, it is impossible to offer Best Practices that will work for every gear type and every site. When starting up, consider trying a few different types of gear (if your permit allows) so you can learn what gear type works best at your site. Visit other growers to see what options are available before you make large investments in gear that may not work at your site.

BPs for deploying floating gear:

- Use uniform float colors.
- Use low-profile floats with subtle coloration, where appropriate.
- Use reflective buoy tape on gear to prevent nighttime collisions by boaters.
- Add signage or information on corner markers explaining what types of multiple uses might be acceptable (fishing) or unacceptable (anchoring), or what types of submerged hazards exist (include contact information).

Scale. During the start-up phase, consider trying small numbers of a few different types of gear as a test (if your permit allows). Add gear as you learn how to manage the gear and the site most effectively. This may take longer, but making mistakes on a small scale can save a lot of money. Don't order more seed than you have gear to hold it (or labor to maintain it), as it will result in overstocked gear, poor growth, inferior quality and often high mortalities.

Anchors. Floating gear can place a huge strain on anchors during storms, so proper sizing is critical; the gear manufacturer should be able to provide guidance. Although each site needs an individual assessment, it is generally advisable to over-size your lines, chains and fasteners. This may cost more up front, but pinching pennies here is often an expensive choice.

The four basic anchor options each can be sized appropriately for different load calculations:

1. Auger or helical screw anchors.
2. Danforth-, plow- or mushroom-type anchors.
3. Dead-weight anchors like heavy blocks of cement or granite, or rail-car wheels.
4. Driven-plate anchors like Manta and Platipus brands.

Local or state regulations may constrain your choices. If your substrate is rock ledge, then your only option may be to drill into the rock or use massive blocks.

Auger anchors or drive-plate anchors of the right size placed in the proper sediment (sand, mud or gravel) can be the most affordable and least likely to give. They come in a wide variety of shaft lengths, with different sizes of plates and shaft diameters for different levels of stress, based on the size of the array, the current and fetch at the site. Auger anchors and driven-plate anchors can hold significant loads and don't require the scope (length in relation to the depth) that a conventional anchor needs, meaning that you may not need a length of chain at the bottom as you would with conventional Danforth or mushroom designs.

This will reduce or eliminate the damage to benthic biota around the anchor known as "scour." Augers and driven-plate anchors are usually quite suitable for corner markers since they won't move around. If you set the eye of the auger below the re-dox zone (where the sediment turns black) you won't have to worry about rust, because there is no oxygen. Corner markers are sometimes a target for vandalism and can be carried away by ice. Affordable GPS tracking devices may help you recover these often-expensive investments.

Pictured left to right: Danforth, screw and driven-plate (Platipus) anchors. All have pros and cons, but it pays to calculate loads to make sure they will hold in the worst conditions.

But auger anchors do have some drawbacks. They typically need to be installed by a specialized equipment firm or by a diver (either jetting them in, screwing them in or both). Because augers won't move, if you don't sink your gear in winter and an ice floe hits your array, the lines may part and the entire array may get carried away.

Danforths, plow anchors, mushrooms and blocks all can be sized to have some "give," which means that the lines are less likely to part under severe strain, but also means that you may need to reset your anchors after a big storm to keep your farm on your lease.

The driven-plate anchors like Manta and Platipus brands have some pros and cons compared to auger anchors. The plate-anchor design has been around for decades, but has only recently begun to be used in floating-gear operations. The anchor is driven vertically and then tilts once at depth to provide resistance. Pros include moderately low cost and easier installation than with

other anchors. But large floating arrays can exert a lot of force, so it's crucial to perform load calculations and size the anchors accordingly.

BPs for floating-gear anchors:

- Consult with an engineer or gear manufacturer for advice on anchor size and type, as well as the size of chain and lines needed to hold your array on site given the potential wave heights and currents.
- In certain circumstances it may be advisable to use double anchors set at 45° from the main lines at the ends of floating arrays. This will help hold the strain in the case of a storm delivering wind forces against the side of a longline, which might dislodge a single-point Danforth-type anchor.
- For anchors other than augers it is imperative to use chain at the bottom to avoid abrasion and chafe of the mooring lines. The scope of chain used is critical to keeping Danforth-type anchors embedded in the sediment.
- Inspect anchors and chain regularly, since rust and chafe will eventually cause these systems to fail. If rust reduces the diameter of a chain link by one-third of its initial thickness, it loses more than half its rated strength.
- Maintain taught lines as much as possible. This will help keep the lines of cages straight at low tide and avoid the potential for adjacent lines to become entangled. Sites that experience large tides may require substantial weights to be installed on main anchor lines to take up slack at low tide.

Hurricane Preparation. Develop a written storm-contingency plan describing steps to take depending on the predicted intensity of the storm. (For examples and guidance visit UFL's Storm and Hurricane Preparedness page[13]) A written plan for hurricane preparation is a good idea for all gear types, but since floating gear is more susceptible to damage, and sinking the gear takes quite a bit of time and effort, planning is even more important for farms with floating gear.

Similarly, it is advisable for all farms to develop a regular inspection schedule to evaluate anchors and lines for rust or chafe, but even more critical for farms with floating gear. Examining your lines for chafe right before a storm is probably too late. You will likely be preoccupied pulling boats and making other preparations, so unless you have replacement lines already spliced up and ready to deploy (highly recommended) you won't have time to go out and purchase replacement gear and install it.

In the hectic days and hours before the storm is predicted to hit, your crew may be distracted protecting their own boats or homes. Boat ramps and marina lifts will get crowded. Having a written plan in hand could save a lot of angst. Your plan should note appropriate emergency numbers and tasks such as: filling gas cans, sharpening chain-saw blades and filling scuba tanks. Plan for the power to go out for a few days. Decide if you will pull your boat(s), and if you plan to have them ride it out, how you will secure them at the dock or mooring. These decisions will vary depending on predicted storm severity and whether you are in a sheltered cove or in an area with considerable fetch.

When storms are predicted to cause a significant tidal surge it is often advisable to add a few feet of slack to the main anchor lines of your floating array because a few feet of surge at high tide may dislodge anchors or break floating bags/cages off the longline. Being prepared with 6-foot lengths of line and quick-release links spliced to each end will make adding and removing these lines much easier.

Some farms deploy additional anchors in advance of a storm, but it is probably easier to size your main farm anchors for the worst-case scenario as opposed to adding and removing anchors for storms.

Some floating cages allow you to sink the gear to avoid the worst forces of waves and surge, but you need to be quite deep to avoid serious wave energy, and there is a danger that, if not sunk properly (with the pontoons down) then cages on the bottom may become filled with sand, suffocating the animals inside. If caps are left off of floats when they are sunk, the floats may fill with sand or mud and will need to be washed out when they are refloated. For farms with floating cages it is advisable to outfit your boat with a davit and motorized winch to refloat cages that were sunk before the storm. Since this setup can also be used on a daily basis to work the cages, it is a worthwhile investment. Plan on not being able to work your gear the day before the storm is due to make landfall, as the weather will be too rough. If you're planning to sink your gear, make sure you have the crew and time required to do it.

Since severe storms may cause certain types of anchors to drag, it is important to survey your site after the storm to ensure that everything is where it is permitted to be. Some growers have used drone flyovers to facilitate pre- and post-storm inventory assessments, and for regular inspections of gear.

After the storm it may be prudent to patrol the waterways around your farm and remove debris (pilings, floating docks, wood, etc.) that could get snagged in your floating array before you re-float your gear. This is a good practice at all times, but is especially important after storms and hurricanes.

BPs for hurricane prep:

- Develop a written storm-contingency plan describing steps to take depending on the predicted intensity of the storm.
- Develop a regular inspection schedule to evaluate anchors and lines for rust or chafe.
- If significant storm surge is projected, consider adding additional scope (length) to vertical lines.

Gear Loss. Gear loss and marine debris should be avoided at all costs. Floating gear is especially susceptible to loss if lines part. When washed-up gear is left on beaches it gives the entire industry a black eye, damaging the social license to farm and making it harder for the next grower to get a permit or for you to get permission to expand your farm.

BPs for gear loss:

- Label each cage with your name and phone number to facilitate recovery.
- Conduct regular gear inventories prior to storm events and immediately thereafter to determine if you are missing gear after the storm. Drone fly-overs may be helpful here.
- Return other growers' wayward gear, even if you don't like them. Any loose gear is a bad look for everyone in the aquaculture community.

Good Neighbor Practices

(most of these are not specific to floating gear)

1. Noise management:

- Dampen noise from loud machines by using mufflers and baffles, and painting aluminum tumblers with a rubberized coating.
- Avoid noisy activities on weekend afternoons and early in the morning.
- Be aware that sound carries over water—if you have to yell to be heard or are blasting an audio player or radio, it is likely that people can hear it on shore.

2. Inform and educate your neighbors throughout the life of the farm:

- Consider sending an annual newsletter or card updating neighbors on the farm's activities and plans.
- Welcome public discourse and use it as an educational opportunity. Explain the regulations you must follow and what it takes to run a safe operation.
- Consider sharing info about your operations on social media.

3. Keep your operations neat and tidy. Because neat farms improve the social license to farm:

- Follow all regulations.
- Replace missing corner markers promptly.
- Clean up promptly after storms.
- Regularly wash off gear and boats if docked at a marina.
- Be respectful at public launches with your gear: do not leave waste behind, and avoid tying up the space for excessive periods.
- Respect private property: avoid staging gear on private property unless specific permission has been granted.

Since birds are smart and quickly acclimate to deterrents, you may have to use a variety of approaches and mix them up. These could include monofilament line, zip-tie or wire "ticklers," scare kites like the OysterGro® BirdAway hawk system, sprinklers and wire tufts.

Bird Deterrence and Bird-Waste Management

Somewhat unique to floating and intertidal gear is the potential to attract roosting birds or mammals, with the possibility of pathogens in their waste contaminating your product and making consumers ill. In extreme cases, bird guano can elevate coliform levels, forcing regulators to downgrade the status of your harvest area or close it altogether. While almost any structure—buoy, piling, float or boat—can attract birds, the impacts on food safety and water quality will depend on the numbers and size of birds (or mammals) in relation to the size of the area, the depth of the water and the velocity of the flushing tidal currents.

The goal is to deter birds from landing on your gear, not to harm them. Any devices used to repel birds are likely to be species-specific. Ideally, deterrents are easy to maintain, durable, economical and don't interfere with operating (flipping) the gear. Most birds will acclimate to deterrents quickly, so you may need to use multiple deterrents and switch them up often.

The ISSC National Shellfish Sanitation Program (NSSP)[14] requires that you have an Operational Plan if your gear may attract birds or mammals. Your State Shellfish Control Authority determines the rules you must follow in your state. Use your Operational Plan as an opportunity to educate the public on the potential harms caused by excessive bird populations (ecological, public health, economic) and how you are working to deter the birds without harming them. Be aware that if bird waste is significant enough to impact water quality, regulators may be obligated to close your harvest area.

Most bacterial pathogens will be purged within 48 hours, so if guano is observed on floats, proposing a one-week submergence period in your Operational Plan to protect consumers from impacted shellfish is a strategy that might protect customers and satisfy regulators.

Many birds fall under the category of Protected Resources, so you will need to determine if regulations in your area prohibit the use of certain deterrents. (Contact NOAA's Office of Protected Resources[11] or your state resource management agency.)

BPs for bird deterrence:

- Observe and record which birds frequent your lease area and during which months.
- Check with other growers or with your extension agent to learn which deterrents work best in your area (See ECSGA.org[15] for ideas and examples).
- If you believe that guano may have impacted your market-ready product, it may be advisable to sink the shellfish for a period in deeper water to allow the animals to purge any pathogens.
- Regularly flip floating gear (or otherwise control fouling) to minimize the growth of fouling organisms, in order to make the floating gear less attractive as a forage site.

Scare kites like the OysterGro® BirdAway hawk system can repel birds by fooling them into thinking a predator is on the wing.

Zip-tie "ticklers" can keep larger birds from landing on gear, but smaller birds will be able to perch between the zip-ties.

To deter medium-sized birds like seagulls, wire or plastic spike arrays can be attached to floats. Many varieties are sold by online retailers, including BirdBGone.com.

Appendix 1: Laws Pertaining to Shellfish Farming

A "Brief" Overview of Federal and State Regulations Protecting Wildlife

A number of federal laws and state regulations protecting certain species of plants and animals are relevant to shellfish farmers. At the federal level, the Endangered Species Act (ESA)[25] is the most well-known, but the Migratory Bird Treaty Act[32], the Marine Mammal Protection Act[33], and the Essential Fish Habitat provisions of the Magnuson Stevens Fisheries Conservation and Management Act[26] can also apply to shellfish growers.

According to NOAA***, ALL*** marine mammals are protected under the Marine Mammal Protection Act, which prohibits their "taking"—including "harassment, hunting, capturing, collecting, or killing—in U.S. waters and by U.S. citizens on the high seas."

NOAA defines marine mammals as any mammals that rely on the ocean to survive, not just those that live in seawater full time. They include whales, dolphins, porpoises, seals, sea lions, sea otters, manatees, dugongs, walruses and polar bears.

The Endangered Species Act of 1973 protects plants and animals listed by the federal government as "endangered" or "threatened." As of this writing, 26 charismatic macrofauna, such as certain whales, dolphins, seals, sea lions and turtles are protected. Fish account for 18 species (including Atlantic salmon and sturgeon), while invertebrates and corals account for 17. In addition, some plant species are also listed. NOAA Fisheries maintains a directory[16] of endangered and threatened marine species, searchable by species name, species category, protected status and region, on its website.

The consequences of a "take" of marine mammals or any plant or animal listed as endangered or threatened under the Endangered Species Act can be severe, and you should be aware of which species might be found in the area of your farm and take measures to avoid interactions with them. A "take" also extends to actions that cause significant habitat modifications or degradations that lead to killing or injuring wildlife by significantly impacting essential behavioral patterns, including breeding, feeding or sheltering.

The Migratory Bird Treaty Act of 1918 forbids anyone to "hunt, take, capture, kill or possess" any bird protected by one of the treaties or to disturb their nesting sites. More than 800 species of migratory birds can be found in the U.S., including many common ones like Canada geese, barn swallows and two kinds of starlings. In fact, very few birds are not migratory for regulatory purposes. Courts have held that even the accidental killing of a migratory bird can be a criminal act under this law. The Department of the Interior and the states can pass regulations allowing for activities such as hunting migratory species, as long as they are consistent with the intentions of the treaties.

Submerged aquatic vegetation (SAV) is considered a high-quality habitat that is especially important for the young stages of many fish and invertebrate species. In the New England and northern mid-Atlantic regions, eelgrass (*Zostera marina*) is the dominant species, but other species[22] play important roles further south. Generally, aquaculture siting is not allowed in areas where SAV is present, and many states have specific regulations to preserve and enhance SAV.

Shellfish growers have found that in some cases, areas where no SAV was present when farms were first established, subsequently showed SAV growth[18]. Changes to the substrate, reduced turbidity and increased light penetration from farm activities are probably responsible for creating habitat where the SAV can become established and grow. It is important to pay attention to this possibility to avoid conflicts with SAV regulations. According to NOAA's Office of Protected Resources, submerged aquatic vegetation is considered to be a critical habitat and a protected resource.

Different Army Corps Districts have different SAV regulations and may allow farming in areas if the area of impacted SAV can be restricted to a limited portion of the lease. Some states have regulations that consider shellfish farming to be a "grandfathered activity" that can continue even if SAV encroaches on your lease. It is usually prudent to inform officials of changes in SAV if it starts encroaching on the boundaries of your lease. Take credit for improving water quality and use it as an opportunity to advocate for regulations that allow farms to be "grandfathered" if SAV encroaches. In some areas SAV can be quite ephemeral and unpredictable year to year. Use that fact as a rationale for leniency and know that entire books have been written on the subject of SAV.

Shellfish Sanitation–Protecting Human Health

The U.S. national regulatory authority for public protection and seafood regulation is vested in the Food and Drug Administration (FDA). The FDA is required to cooperate with and aid state and local authorities in enforcing their health regulations, and is authorized to assist states in preventing and suppressing communicable diseases. Under this authority, the FDA participates with state regulatory agencies, some foreign nations and the molluscan shellfish industry in the National Shellfish Sanitation Program (NSSP).

The NSSP is a voluntary, cooperative program to promote the safety of molluscan shellfish by providing for the classification and patrol of shellfish growing waters and for the inspection and certification of shellfish processors. Twenty-three coastal shellfish-producing states are part of the program, along with nine foreign countries. The rules and regulations for the NSSP come from the Interstate Shellfish Sanitation Conference (ISSC) which meets formally every two years to review and modify the regulations. However, implementing and enforcing these regulations falls to the state public health agencies and marine law enforcement.

The NSSP regulates three main areas in order to ensure that shellfish are safe to eat:

1. *Setting standards for shellfish growing waters to ensure that harvest areas have acceptable numbers of the bacteria that can cause human illness.* The NSSP also sets standards for "red tide" organisms in growing waters. These standards are used by the state authorities to classify the growing areas, which is accomplished by frequent sampling of the water. Many coastal areas become degraded after rains, when pollution from runoff—and occasionally from sewage plant failures—enters the water. Many "conditional" areas are automatically closed to shellfish harvest after a certain amount of rainfall, and are opened again only after bacterial sampling shows that they meet the NSSP standard.

2. *Establishing a system of product identification that enables trace-back to the harvest waters.* This is accomplished by putting a tag containing information about the harvester, date of harvest and harvest area on every unit of harvested shellfish. This tag must remain with the shellfish at every step in the chain from harvester to final point of sale, where the tag must be retained for 90 days. This allows for a rapid and orderly trace-back to the harvest area if the shellfish causes illnesses.
3. *Publishing a monthly list of all state and foreign shellfish processors and dealers that are certified under the NSSP.* This Interstate Certified Shellfish Shippers List[27] allows participating states to identify and prevent shellfish processed by uncertified processors in other states and foreign nations from entering the market, thereby controlling the distribution of uncertified and possibly unsafe shellfish in interstate commerce.

Most illnesses from shellfish on the East Coast stem from one particular species of bacteria, *Vibrio parahaemolyticus* (Vp), which can cause nausea, diarrhea and fever in affected people. Another *Vibrio* species, *Vibrio vulnificus*, (Vv) can be much more dangerous. Although in most healthy people Vv causes symptoms similar to those of Vp, it can result in severe illness and even death in the very young or old, and in immune-compromised individuals.

Vibrio bacteria will multiply in shellfish if the shellfish are not kept cold, but growth is arrested below 50°F. The specific state control plans for *Vibrio*s are based on time-temperature regimes. Some states restrict harvest of shellfish in warm months, while others mandate that shellfish harvested in the warmer months be put into refrigeration shortly after harvest. (Visit ecsga.org/vibrio-resources for fact sheets, informational brochures, training videos and other resources.)

Having a disease outbreak caused by your shellfish is just about the last thing you ever want to happen. The reputational damage can be severe, but the cost and challenges of going through a product recall is a nightmare. Compliance with your state's regulations regarding the harvest and post-harvest handling of shellfish is not only required by law, but also critical to your business and your reputation.

If you use floating gear, which may attract birds or mammals, the ISSC NSSP requires that you have an Operational Plan to address the risk of guano contamination. How that plan is presented will be up to your State Shellfish Control Authority. It may include a description of the seasonality of the problems, the deterrents you plan to deploy and how you intend to delay harvest (or submerge at depth) shellfish that may have been impacted by guano. States are encouraged to develop guidance on how many birds are an issue (and that may vary with tidal flushing and water depth) as well as re-submergence times required after exposure.

Regulation and Permitting Resources on ECSGA.org

Navigating regulations is one of the most challenging aspects of the aquaculture industry. It always makes sense to talk to your state permitting authority or extension agent about regulations in your area.

The following links will take you to the relevant sections on the ECSGA's Regulations and Permitting webpage (ecsga.org/regulations):

What the Jones Act exemption for aquaculture workers means for the industry

State by State Leasing and Permitting Requirements Summary

Best Management Practices Guide for Regulators

EPA Effluent Guidelines

Evaluation of U.S. Shellfish Aquaculture Permitting Systems

Massachusetts Aquaculture Permitting

NOAA Fisheries Guide to Permitting Marine Aquaculture in the U.S. (2022)

NOAA Fisheries Marine Aquaculture Regulations and Policies

NOAA Shellfish Best Management Practices, Standards and Certification Programs

NSSP Guide to Molluscan Shellfish

Nationwide Permit Re-Issuance Comments

Strategic Plan to Enhance Regulatory Efficiency in Aquaculture Comments (on draft plan, October 2021)

Summary of Shellfish Aquaculture Leasing/Permitting Rules with the State and Army Corps

East Coast Extension Agents and Regional Aquaculture Coordinators

For a comprehensive list of state extension agents visit ecsga.org/extension-agents.

On the federal level, the National Oceanic and Atmospheric Administration (NOAA) maintains the contact information for its regional aquaculture coordinators at www.fisheries.noaa.gov/contact-directory/regional-aquaculture-coordinators.

Appendix 2: Hyperlink End Notes

1. www.fisheries.noaa.gov/resource/document/state-state-summary-shellfish-aquaculture-leasing-permitting-requirements-2021

2. www.nature.org/en-us/what-we-do/our-priorities/provide-food-and-water-sustainably/food-and-water-stories/oyster-covid-relief-restoration

3. www.nature.org/content/dam/tnc/nature/en/documents/TNC_PrinciplesofRestorativeAquaculture.pdf

3a. www.sciencedirect.com/science/article/pii/S2212041621001546

3b. ecsga.org/best-practices-form

4. www.issc.org/nssp-guide

5. fukuina.com/shellfish/dark_sea_trays.htm

6. seapausa.com/oyster-baskets

7. www.hexcylsystems.com.au

8. www.flipfarm.co.nz

8a. ecsga.org/wp-content/uploads/2023/07/ByronCarryingCapacity.pdf

8b. rssbp.org/hatchery-certification-program

9. ocean.njaes.rutgers.edu/marine/east-coast-shellfish-hatchery-nursery-directory

10. www.glofouling.imo.org/_files/ugd/34a7be_acc7b7afa09246638040128a2134dc02.pdf

11. www.fisheries.noaa.gov/about/office-protected-resources

12. www.fisheries.noaa.gov/contact-directory/regional-aquaculture-coordinators

13. shellfish.ifas.ufl.edu/hurricane-resources

14. www.fda.gov/food/federalstate-food-programs/national-shellfish-sanitation-program-nssp

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This document, “Best Practices for the East Coast Shellfish Aquaculture Industry” incorporates the opinions of many seasoned growers, hundreds of meeting attendees and a team of editors. The advice here is not meant to be comprehensive or to be adequate in protecting every farm from all foreseeable circumstances, and adherence to these Best Practices does not relieve farm owners and growers of the responsibility to do their own risk management for their unique farm operations.