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Major Predators of Cultured Shellfish

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Eastern oysters, *Crassostrea virginica,* Northern hard clams, *Mercenaria mercenaria,* soft-shell clams, *Mya arenaria,* and bay scallops, *Argopeclen irradians* are routinely cultured in shellfish hatcheries throughout the northeastern United States for private sale, public stock enhancement and management programs. The culture process involves spawning adults, rearing the resultant larvae in large tanks, and raising the juveniles to a field plantable size.

The hatchery and nursery phases of most commercial shellfish culture facilities are largely standardized. Successful culture to market size, however, depends on several variables. Whether placed on a bottom lease, transplanted into trays, or suspended from floating docks or buoys, bivalves are affected by a variety of factors in- -cluding weather, disease, and. especially,predation.

This fact sheet introduces the shellfish culturist to the major predators of clams and oysters cultured commercially along the northeastern coast of the United States. Clues such as shell damage and/or bottom sediment modifications that may help growers identify a particular predator or groups of predators are emphasized. information on predator biology and ecology is also provided. Once a molluscan predator is identified, suitable remedial or prophylactic actions can be taken. A general description of predator control methods is given.

Crustacean and Crustacean-like Predators

Perhaps the best known predators of cultured clams and oysters are the larger crustaceans such as the blue crab, *Callinectes sapidus,* the green crab, *Carcinus maenas,* and the mud crabs. *Dsypanopeus sayi* and *Panopeus herbstii.* These and other crab species are responsible for much of the clam and oyster mortality observed by culturists. Crabs can effectively-prey on seed or plantable size animals of 1/4 to 1/2 inch (6 to 12 mm) as well as shellfish nearly market size (1-1/2 to 2 inches; 38 to 51 mm) (figure 1).

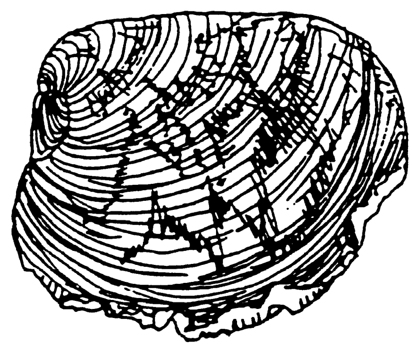
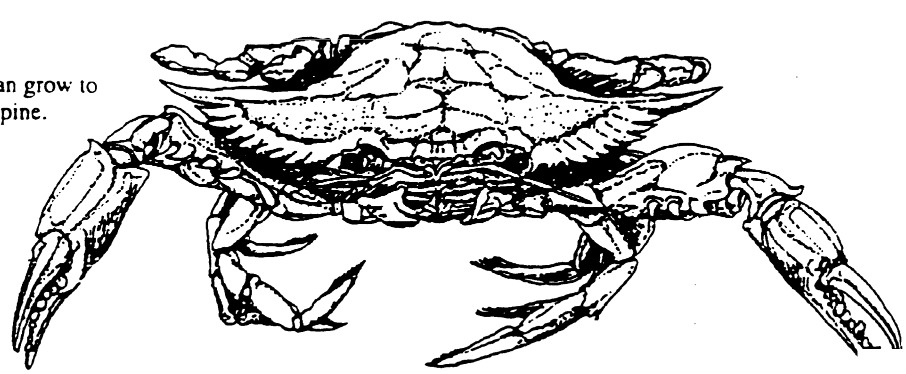


Figure 1.
Crab damage to hard clam shell.

The blue crab has one of the greatest geographic ranges of any crustacean predator affecting shellfish culture in the Northeast (figure 2). It is fished commercially as far south as Venezuela and has been recorded north of Cape Cod

Figure 2.
The blue crab, *Callinectes sapidus*, can grow to nine inches (225 mm) from spine to spine.



during warm periods. In the northeastern United States, it is significant both as a commercial species and major predator from Maryland to Cape Cod.

Considered a scavenger, the blue crab will prey on oysters, soft-shell clams, and hard clams. Blue crabs, like most crustacean predators, typically open shellfish with their claws by crushing the entire clam, chipping a valve edge, or forcing the valves apart. Predation rates can be quite high (575 clams/day) on unprotected shellfish beds. If crabs exist in the culture area predator control and effective protection are imperative.

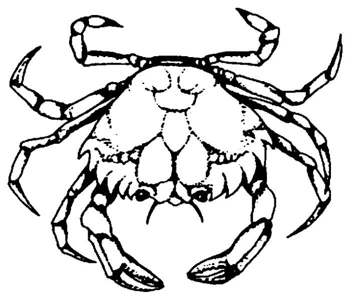


Figure 3.
Green crabs, *Carcinus maenas,* can grow to three and a quarter inches (80 mm) and prefer bivalves in their diet.

Green crabs, (figure 3) were accidentally introduced to the east coast of the United States from the British Isles around the time of the America Civil War (1860-1865). Today, they range from southern Nova Scotia to Virginia. Existing both intertidally and subtidally, they attain highest densities in sheltered habitats. Green crabs live underseaweeds along the shore, or burrow into the sediments to obtain food and seek shelter from gulls and other bird predators. The soft-shell clam is the most important food item in the green crab's diet in terms of volume and frequency of occurrence (figure 4). Green crabs with a three-inch (76 mm) carapace width can crush and devour a two-inch (51 mm) soft-shell clam but usually they prey on small clam seed or mussels.

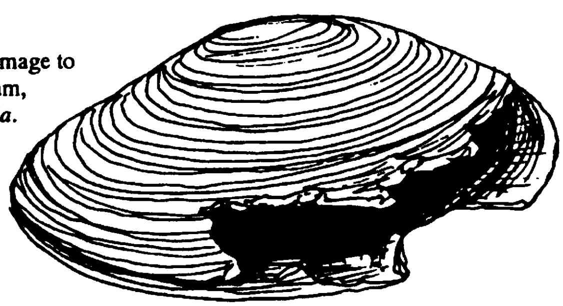


Figure 4. Damage to soft-shell clam, *Mya arenaria.*

Mud crabs, in the Family Xanthidae, are another group of important predators of cultured oysters and clams (figures 5 and 6). These animals attack bivalves by patiently chipping away at the shell margin with the large, tooth-like structure on their larger claw. *P. herbstii* (figure 5), the Atlantic mud crab, ranges from Boston Harbor south, to Brazil. Predatory activity of *Panopeus* is limited by clam size. The crab selects smaller clam seed in the 1/2 to 3/4 inch

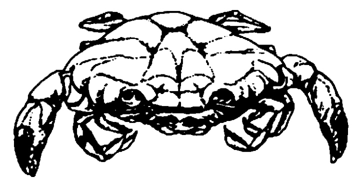


Figure 5. Mud crab, *Panopeus herbstii*

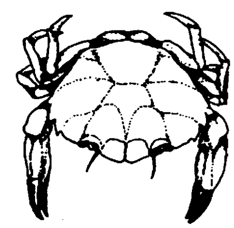


Figure 6. Mud crab, *Dyspanopeus sayi.*

range (12 to 19 mm). The crab can prey on hard clams up to 65% of its carapace width. Another mud crab, Dyspano*peus sayi* (formerly Neopanope sayi, figure 6), is considered the most abundant mud crab in Delaware Bay. Studies from Narragansett Bay report this crab as a serious predator of young hard clams.

Similar to crustaceans in appearance, the horseshoe crab, *Limulus polyphemus,* is a significant predator of the soft-shell clam. It will also eat hard clam seed up to the 5/8 inch range (15 mm). Horseshoe crabs burrow under the sediments to find their prey.

Addressing Crustacean Predation

Crab predation can be reduced by covering or enclosing the cultured shellfish with plastic or nylon screen flexible netting, or a heavy extruded mesh. All coverings keep out predators, while permitting good water flow. Suspended culture of oysters is another technique to keep growing seed away from non-swimming predators.

Crabs commonly prey on shellfish as large as 30% of their carapace width. Predator netting or screening will exclude adult crabs, but does little to stop small juveniles which use the protected area under the netting to escape their own predators. Very small crabs can easily enter a growout box or screen then molt or shed several times. With each successive molt, their size increases. They can become large enough to eat a significant number of older clams or oysters.

Control of crab predation can be a full-time occupation for the culturist. The most common method of control involves continual inspection of screens. Rips or tears are immediately repaired or the in is replaced. Predators are removed by hand or killed with a sharp rod such as an ice pick that is thrust through the mesh. Selection of appropriate mesh material, suitable seed size and an appropriate time for field planting are also important management practices. Crab traps have been used by culturists to entice crabs away from lease sites. Baffles pens, chemical applications and poisoned baits for predator control, as well as the use of crushed gravel or shell for protecting shellfish have not met with complete commercial acceptance. Crushed gravel and shell increase hard clam survival, but their cost effectiveness may be low. Use of shell should be avoided in areas where oysters set.

Experimental evidence suggests the toadfish, *Opsanus* *tau,* is a potential and practical ally in crab control. Commonly known as "oyster crackers" or "Sally-growlers," this foot-long, sculpin-like fish is a year-round resident of shallow waters from Woods Hole, Massachusetts south to Florida. Toadfish are commonly found on sandy or muddy bottoms, hiding in eelgrass or under stones where they dig a den and wait for prey. Toadfish feed heavily on crabs and rarely eat clams or oysters. They can help retard biofouling on various culture materials. Some culturists have placed toadfish inside bottom screens along with their shellfish or have created toadfish habitat on their lease site with tin cans or broken pipe. Often toadfish can be obtained for the asking from commercial crabbers, who find them a nuisance. They can also be trawled with a net, regulations permitting.

Culturists should consider planting larger seed in the growout phase of their operation since it is less susceptible to some predators. For an inexperienced culturist, the increased initial cost of larger seed and reduced predator control requirements deserve careful consideration.

Gastropod Predation

Crustaceans are not the only significant predators of cultured molluscs. Several types of snails, such as whelks, moon snails, and oyster drills, prey on all sizes of commercially important bivalves. Commercial losses caused by carnivorous gastropod are much less than those inflicted by crabs.

Whelks in the genus *Busycotypus* (formerly *Busycon, figure 7)* are found in the shallow subtidal areas of bays and sounds from Cape Cod south to Florida. The whelks (knobbed and channeled) are effective burrowers and can reach unprotected clams by plowing through the sediments.

Figure 7.
Knobbed whelk, *Busycotypus carica*, can grow to nearly eight inches (200 mm).

The whelk uses its foot to grasp and position the clam The sharp edge of the whelk's shell is inserted between two valves of the clam. Using its foot and body, the whelk gently rocks the clam back and forth. In the process, its shell edge slowly chips the outer margin of the clam's shell. Gradually the clam is forced open as the whelk continues to apply-pressure. Eventually, the sharp edge of the whelk cuts into the soft tissue of the clam. The whelk then inserts its proboscis and consumes the tissue inside. This predatory activity leaves a white or chalky mark along the middle outside margin of the whelk's shell. It also leaves a very distinct chipped or scraped mark on the clamshell (figure 8).

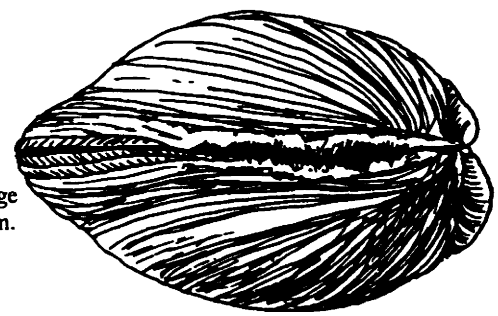


Figure 8.
Whelk damage to a hard clam.

Because of their rapid growth cultured clams may have thinner shells than their naturally occurring counterparts. Thin-shelled clams are presumably easier to chip and thus more susceptible to whelk predation if left unprotected. Some New England culturists use pieces of horseshoe crabs as bait to trap channel whelks on their leases. This reduces the predator population and provides supplement income, since whelks can be sold as food to local dealers.

The moon snails *Neverita duplicatus* and *Euspira heros* (formerly *Polinices* and *Lunatia,* respectively),also burrow to find and attack bivalves as well as other prey. *N. duplicatus (figure* 9) ranges from Cape Cod to Florida and the Gulf states, while *E. heros* has a more northern distribution and can be found from the Gulf of St. Lawrence to North Carolina. These snails are borers leaving a tiny, bevelled hole through one valve usually near the umbo (figure 10). They can drill and consume hard clams up to approximately 2 1/2 inches (63 mm) in length at a rate of nearly one per day. From Cape Cod north to Maine, these drilling predators prefer soft-shell clams and may consume up to 100 clams annually.

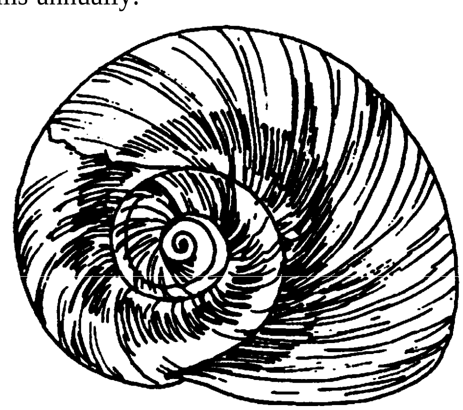


Figure 9.
Moon snail, *Neverita duplicatus*.

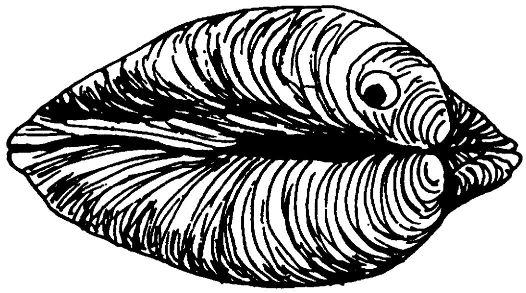


Figure 10.
Evidence of moon snail damage.

Oyster drills are major predators of the oyster, but will also prey on hard clams. *Eupleura caudata* (figure 11), the thick-lipped drill, ranges from south of Cape Cod to the southern haIf of Florida. *Urosalpinx cinerea* (figure 12),

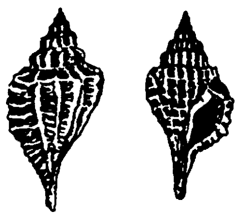


Figure 11.
Oyster drill, *Euplura caudata,* a major oyster predator.

Figure 12.
Oyster drill, *Urosalpinx cinerea,* normally grows to 1/2 to 1 inch (12 - 25 mm) in length.

the Atlantic oyster drill, can be found from Nova Scotia to northeastern Florida. Both are small snails that vary in size from 1/2 to 1 inch (12 to 25 mm) in length as adults. Both are abundant in intertidal and shallow waters. Like the moon snails, they attack clam and oyster seed by drilling a small hole through the shell. The thick-lip drill leaves a slightly bevelled hole in its prey, but the hole left by *Urosalpinx* is straight. Holes can be found practically anywhere on the bivalve shell and can be easily missed (figure 13).

Controlling Gastropod Predation

Protection from gastropod predation is achieved through the use of predator exclusion devices which prohibit access of whelks, snails, and drills to the cultured shellfish. On-bottom pens and baffles as well as floating rack culture have been used successfully for hard clams and oysters. In the 1960s, chlorinated hydrocarbon biocides were used to kill gastropod predators, but now these chemicals are strictly illegal in all states. The use of a suction dredge to prepare a lease site before planting eliminates these gastropod predators, at least temporarily. The dredge removes objects from the bottom up to four inches (100 mm) in diameter, but returns the finer sediments and sand particles. Another control method used successfully by several shellfish culturists has been to dip trays or boxes containing clams or oysters in a saturated solution of rock salt for a minute or so, followed by air drying in the sun. This method is recommended only after shellfish are at least halfway through their growout stage. Smaller shellfish may not withstand the severe salinity changes. The dipping and drying routine reduces gastropod populations in the trays and helps to control biofouling.

Other Invertebrate Predators

Starfish

The array of invertebrate predators on cultured shellfish also includes echinoderms. Starfish such *as Asterias forbesi* (figure 14) and *A. vulgaris* prey on clams and oysters in northeastern coastal waters. The starfish pulls the two shells or valves of a bivalve apart with its five arms and inserts its stomach into the exposed shell cavity. As enzymes are released, the clam meat is digested and absorbed by the starfish. A starfish can consume up to three adult bivalves per day and at least 15 oyster spat per day.

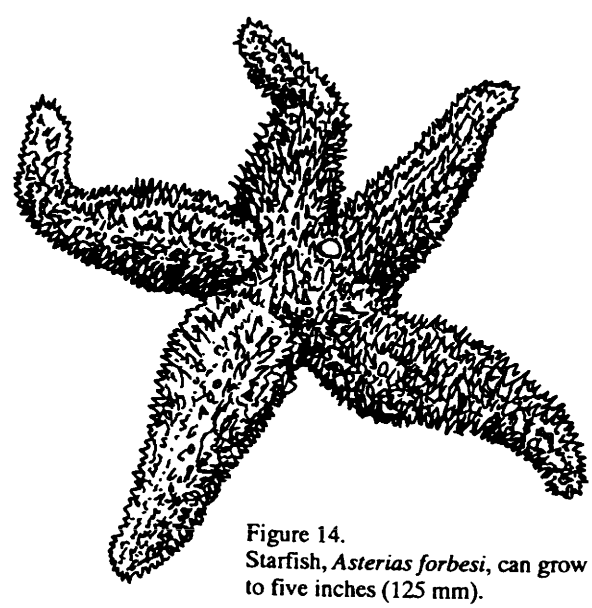


Figure 14.
Starfish, *Asterias forbesi*, can grow to five inches (125 mm).

Most control devices used for crustacean and gastropod predators will deter starfish. Destruction of captured starfish by removal from the water is beneficial. However, culturists should not cut them up and throw pieces back into the water. Starfish have the ability to regenerate their ares. Some starfish species can regenerate an entire organism from just one arm. The process is slow, requiring as much as one year.

Starfish mops can be dragged across oyster beds to snag and remove these predators. Mops, six to twelve feet (approximately two to four meters) across, consist of bundles of cotton rope attached to a frame of light chains. After being pulled over the beds and entangling the starfish, the mops are hauled on-board the dragger. The collected starfish are quickly and effectively killed by immersion in boilingwater.

Application of granular quicklime is also an effective method to control starfish on oyster leases. Applied at rates from 300 to 4000 pounds per acre (depending on water flow in the area and rendition of the bed), it attacks and destroys starfish soft tissue. Caution must be used when ap plying quicklime because it is very caustic. The use of quicklime for this purpose is approved by the U.S. Environmental Protection Agency. It is advisable to contact your State Department of Natural Resources or its equivalent when considering this chemical for predator control. Some states have stringent regulations restricting the use of quicklime.

Worms

A variety of worm species can cause substantial mortalities in cultured shellfish. The oyster flatworm, *Stylochus ellipticus*, ranges from the mid-coast of Maine to Cape Hatteras, North Carolina. It is a flattened, pale, cream-colored worm with a band of eye specks along 1/3 or more of the front margin. Additional eyes are scattered on the head. The worm possesses a pair of tiny tentacles that can best be seen from the side of the worm. Commonly called the oyster leech, it is typically one inch (25mm) or less in length. The worm slides between the valves of oysters; once inside it consumes the meat.

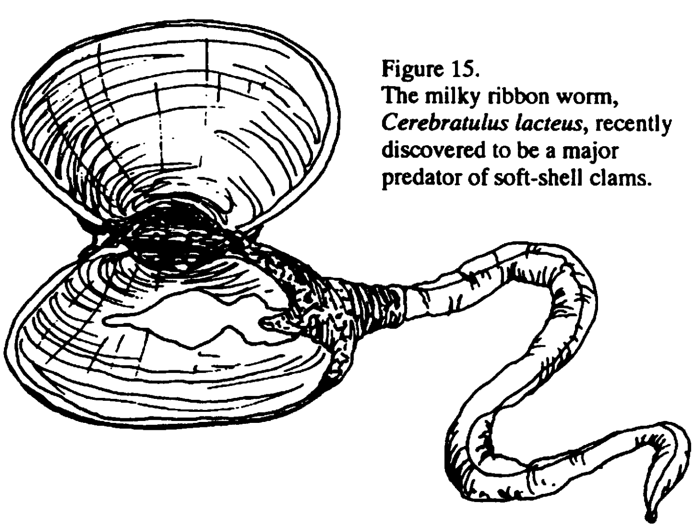


Figure 15. The milky ribbon worm, *Cerebratulus lacteus*, recently discovered to be a major predator of soft-shell clams.

The milky ribbon worm, *Cerebratulus lacteus* (figure 15), was recently characterized as a major predator of soft-shell clams. It is the largest nemertean worm in this region and may attain lengths of three to four feet (0.9 to 1.2 meters) by 1/2 to 5/8 inches (12 to 16 mm) wide. The ribbon worm consumes soft-shell clams from seed size to adult at rates great enough to be considered a threat in natural clam beds. No practical control method exists.

Although not a true predator, the polychaete worm *Polydora* can damage or kill oysters. The worm produces numerous blisters at the base of the adductor muscle inside the shell, weakening the muscle to the point that the oyster cannot completely close its valves. Mortalities can be reduced by thinning the number of shellfish in the grow-out container or by transferring the oysters to a high salinity area (over 30 o/oo). Higher salinity water is usually associated with better water flow and facilitates shell hardening, improved growth rate and reduction, if not eradication, of the *Polydora* problem.

Vertebrate Predators

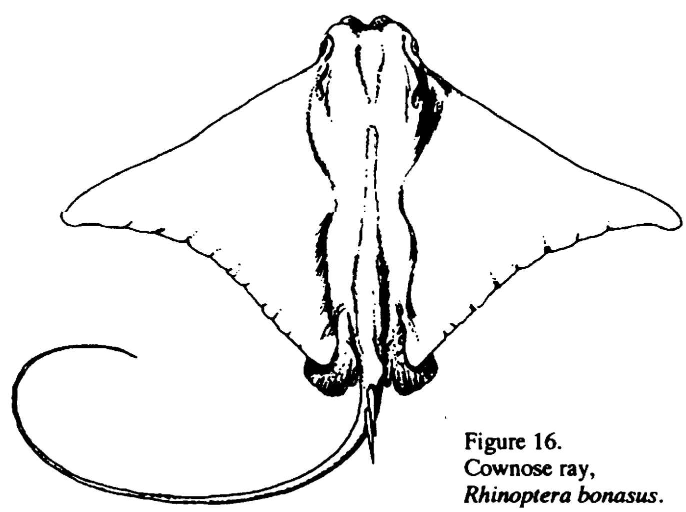


Figure 16. Cownose ray, *Rhinoptera bonasus*.

Many people that work in coastal estuaries have undoubtedly observed the effects of large, vertebrate predators such as skates and rays on natural oyster and clam beds. The cownose ray, *Rhinoptera bonascus* (figure 16), ranges from southern New England to Brazil. It is brownish above, white or yellowish-white below. Some are marked both above and below with many narrow faint dark lines radiating out from the center of the disc. These animals stir up the bottom sediments with their wings, thereby exposing bivalves which they then crush with their teeth and consume. As evidence of their predatory presence, skates and rays leave two to three feet (0.6 to 0.9 m) wide depressions in the sediments which are littered with bits of broken shells.

Bottom screens are one of the best exclusion devices to protect shellfish from crustacean and gastropod predators. They are also the best protection from ray damage. Rays can enter a culture area lay over the screens, and beat their wings to uncover the clams but they are unable to consume the clams through the screening. However, the exposed clams may become prey for other predators such as small mud crabs, hence the importance of regularly tending the screens.

Other common estuarine vertebrates, such as flounder (Families Bothidae and Pleuronectidae), drum (Family Sciaenidae), northern puffer *(Sphoeroides maculatus,* Family Tetradontidae), and tautog *(Tautoga onitis,* Family Labridae), do not typically consume whole clams from a well-protected bed. However, they may inhibit or reduce bivalve growth by nipping at the siphons of the adults.

Waterfowl such as the Eider ducks *(Somateria* sp.) commonly "puddle" in shallow water with their webbed feet to stir up small clams to consume. Gulls (Family Laridae) will take larger clams off the bottom in shallow water. They crack the clams open by dropping them on rocks or other hard surfaces. Gulls generally do not dig bivalves from the sediments, but will pick them up off the bottom if they are uncovered. In the intertidal zone, the Oyster catchers *(Haematopus* sp.) can consume market-sized hard clams. Generally, vertebrates such as fish or birds are not the major predator problem of a commercial culturing operation.

One of the most cunning and discriminating predators of cultured bivalves is man. Control of this predator/poacher is problematic. In fact human intervention maybe the most difficult and expensive to control. Many shellfish farms employ continuous security to prevent significant losses of bivalves from their leases. Losses due to poaching can be as high as 5,000 to 1O,O00 shellfish per hour depending on harvesting method. This type of predation, paradoxically, may be a function of diminished natural stocks and habitat. Reduced abundance of natural shellfish drives some people to steal from others, while still others turn to aquaculture.

Conclusion

In general, the most effective way to reduce shellfish losses is to exclude the predators from the bivalves, using a variety of materials. The manner in which predator exclusion devices are used depends on experience of the culturist site, seed size, and kinds of predators present. Each culturist will use the control materials in a slightly different way so as to maximize shellfish growth potential while minimizing loss to predators. Even the most expensive predator control methods will fail, however, if the operator does not use them appropriately and diligently.

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