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Control of Predators on Cultured Shellfish: Exclusion Strategies

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Introduction

Predation is one of the most significant means by which shellfish farmers lose their crop during the field nursery and grow-out stages of production. All field culture technologies are susceptible to predation if not properly designed and maintained. Under some circumstances, farmers have reported up to 100% mortality resulting from the unintentional introduction of predators into the culture system.

Flimlin and Beal (1993) have previously discussed the principal predators on cultured shellfish (Flimlin, G.F. and B.F. Beal. 1993. *Major Predators of Cultured Shellfish.* NRAC Bulletin No. 180-1993. Northeast Regional Aquaculture Center, Dartmouth, MA. 6 pgs.) In addition, the authors provided general descriptions of methods to control each type of predator. The objectives of this Technical Bulletin are to elaborate on one specific type of technology, namely exclusion, to minimize the impact of shellfish predators on shellfish farms and to report on one apparatus that has recently been developed that shows promise as a means to exclude predators, primarily large gastropod whelks of the genera *Busycon* and *Busycotypus.*

Mobile predators, such as crabs and snails, generally rely on chemical cues to lead them to high concentrations of prey. In response to a chemical scent they follow the track of the cue until they encounter the desired food item. The primary means that a shellfish farmer has to reduce losses due to predators converging into the active growing area is to either remove the predator from the area of the farm or exclude it from moving into the vicinity of the shellfish.

Predator removal, either through trapping or other means to eradicate the predator, is a strategy that generates significant debate in both scientific and resource management circles.

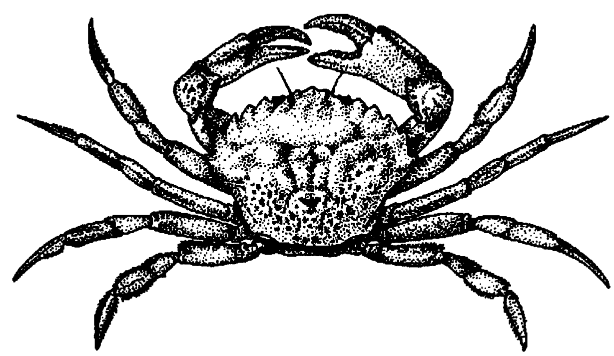

Figure 1: A common predator of farmed oysters and clams in the northeastern U.S. is the green crab, *Carcinus maenas.* Reprinted with permission from: Weiss, H.M. 1995. *Marine Animals of Southern New England and New York.*

While some argue that trapping and removal reduces the density of predators within a specific area, others suggest that by reducing the local density of a predator, the manager is opening up areas for recruitment of new individual predators due to locally reduced population densities. The scientific research community is currently studying these questions to try to evaluate the efficacy of predator removal programs.

The most reliable option available to shellfish farmers is to provide a barrier to prevent specific predators from gaining access to their prey, also known as the crop. This can be in the form of a physical barrier, such as a cage surrounding the shellfish or a fence enclosing the growing area, or a spatial barrier, such as growing shellfish in suspended culture systems to prevent benthic, non-swimming predators from gaining access to the culture system.

As suggested above, barrier systems can be effective against some types of predators and less effective against others. For example, straight vertical fencing was tested exclusively in the early 1950's as a means to exclude the booming green crab (*Carcinus maenas*) populations from devastating soft shell clam (*Mya arenaria*) resources in Maine. The fences were 18" wire mesh strung vertically along stakes placed in the tidal flat. Although the fencing prevented crabs from preying on clams, the work required to maintain the fencing and the recruitment of juvenile crabs into the enclosed culture area, where they subsequently grew to a size that was able to prey on soft shell clams, diminished the shellfish manager's enthusiasm for vertical fencing.

A more effective means to exclude surface crawling predators, i.e. crabs, is netting or screening placed over the planting area. A net with a mesh size smaller than the size of the bivalves planted under it not only excludes predators but it also prevents the seed clams or oysters from washing out of the system if exposed to any wave or high current action. The placement of the netting is dependent on the species being cultured.

For oysters, or other epifaunal shellfish, the netting can be laid down on the sediment and the seed oysters placed on top of one-half of the netted area. The other half of the net is then folded over the top of the oyster bed and the edges are sealed down by burial and/or by wire staples. The oyster "envelopes" are then in place and will exclude those predators larger than the mesh size of the net.

For hard clams, or other infaunal shellfish, the bed is turned over by raking or hydraulic means and any predators exposed are removed. The clams are seeded onto the bed and a single layer of netting is stretched over the planted clams. The edges can be tacked down either to boards buried on edge in the sediment, effectively forming a large box, or by burying the edge of the netting that has been previously attached to lead line or steel rebar along the perimeter. To exclude the majority of burrowing predators (crabs and gastropods) the sides of the net should be buried eight inches or more.

Figure 2: Another common predator of farmed oysters and clams, south of Cape Cod, is the knobbed whelk, *Busycon carica.* Reprinted with permission from: *A Manual of Fish Culture.* U.S. Fish Commission Report for 1897.

In either case, maintenance is paramount to the successful exclusion of predators when using netting. The first concern is small predators that have recruited under the net and subsequently grown to a size large enough to consume your shellfish. The other concern is to remove biofouling that can reduce water flow under the net and across the planted clams to the point where it can lead to impaired productivity and even mortality.

Gastropod mollusks, primarily whelks of the genus *Busycon* and *Busycotypus*, can be significant predators on oysters and hard clams planted in subtidal areas. It has been demonstrated that the presence of the knobbed whelk (*Busycon carica*) can inhibit hard clam growth if in the vicinity of the clam bed even if it cannot directly prey on the population (Nakoaka, M. 1996. The predator decreases not only survivorship but also growth of the prey: a caging experiment with the clam *Mercenaria mercenaria* and the whelk *Busycon carica.* 24th Benthic Ecology Meeting). With the recent introduction of the Veined Rapa whelk (*Rapana venosa*) into the Mid-Atlantic area, another large gastropod predator is on the scene.

A barrier system that has shown promise for excluding large gastropod predators on oyster and hard clam beds has recently been developed through funding provided by the Northeastern Regional Aquaculture Center. The Predator Exclusion Device (PED) was developed by Cotuit and Cape Cod Oyster Companies (Osterville, MA) under NRAC Grant # 95-6. The overall design was to construct a barrier around the shellfish planting area in the form of a fence-type system. The unique aspect to this system is that the barrier is a trough modeled after pyramidal "conch pots" and constructed from wire mesh that acts not only as a barricade but also as an elongated trap that holds the whelks within its structure until removed by the farmer. Whelks are a commercially exploited marine resource and, with the proper permits, the farmer can reduce local predator populations while producing a small income stream for the farm.

Following testing of various designs of the PED system, the final product consisted of a truncated triangle shaped trough, when viewed in cross-section, with a base width of 24" and two sides attached at 45° to the base and each 10" long (Figure 3). The base is constructed of 12 gauge vinyl coated wire (1" mesh) on the bottom and 16 gauge vinyl coated wire (1" mesh) on the sides. The PED deployment simply corrals an area of bottom where one wishes to plant shellfish. In an attempt to reach the shellfish, the whelks will climb the outside wall, fall into the space between the two walls but will be unable to make the turn up the inverted inside wall to continue to pursue the oyster scent trail. They become entrapped until removed.

Stabilizers, or upright pieces of wire, are inserted into the PED every two feet to keep the sides in the correct position.

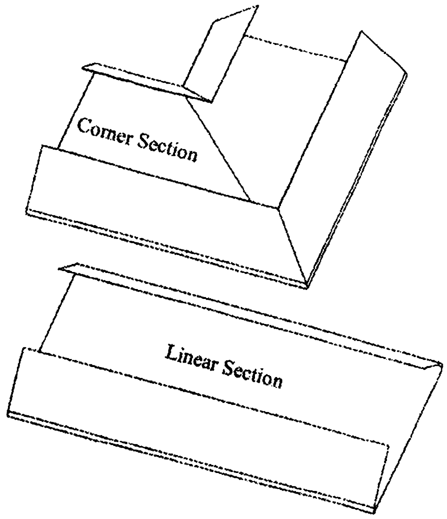

Figure 3. A schematic of two sections of the PED where, in the linear section, the length is 4 feet, the base width is 24 inches, and each side is 10 inches.

These also act as blocks that minimize the ability of a whelk to travel along the length of the PED. Although they were not designed to block the channel and are not 100% effective in blocking movement, the stabilizers are effective in limiting movement within the PED as the openings on either side of the stiffener become clogged with limpet shells, hermit crabs, or a live whelk.

The PED is built in four foot long modules that are deployed end to end to form a fence line but are not connected. This provides a "break away" type action if the structure is hit by a boat motor or fouled by ground tackle resulting in a small section of the barricade moving rather than distorting one whole side. Each section is anchored to the ground using three or more wire staples, similar to those used to anchor netting down.

To use the PED, the planting area is cleared by dredging, hand raking and/or hand removal via swimming. The PED is installed and, before bottom planting, bags of oysters are placed within the enclosure to lure any concealed whelks to the area of the oyster as a final cleaning. Following the final cleaning, the area enclosed within the PED can be planted with small oysters (30mm valve length).

To study the efficacy of the PED, the NRAC investigators planted areas enclosed by a PED with oysters (five per square foot) while maintaining control areas planted to the same density but without the fencing. The oyster mortality attributable to whelks within six separate PED deployments at three locations, totaling 45,000 square feet of bottom and 8,800 oysters, averaged 7.7% with 826 whelks removed from the PED channel. This can be compared to a mean whelk induced oyster mortality of 96.4% (n=1,400) in control deployments on unprotected bottom within the same oyster grounds.

Maintenance of the PED requires observing the integrity of the barricade on a regular basis while removing whelks as they populate the interior of the PED. Damaged sections should be replaced and the channel cleared of debris and/or living material that may accumulate within the channel. This is to prevent the whelks from over running the barrier. During the PED development program, a large accumulation of limpet shells, hermit crabs, and several live whelks were observed in a corner section. One live whelk was observed climbing on top of another whelk, putting it very near the height of the top of the PED. It appeared to be in a position where it could have escaped the PED in this manner.

During PED development, several times whelks were found stuck and partially buried under the outside of the PED. It is thought that twenty-four inches is too long a linear distance for a whelk to travel under the substrate and still maintain the scent trail. Therefore they must surface at short intervals to maintain orientation to the scent. Whelks found stuck under the PED were never more than a few inches away from the outside perimeter and were entangled in the wire mesh while attempting to come to the surface.

A summary of the costs for constructing a 100 by 100 ft (10,000 ft^2) PED are provided in Tables 1 and 2.

Table 1: Cost of materials and labor associated with PED construction.

Vinyl coated wire mesh	
16 gauge for sides, 12 gauge for bottom, 48" section	$14.00
labor (assembly per linear foot)	$ 0.50
stainless steel hog rings (per lb.)	$ 5.50
stakes (each)	$ 0.25
corner pieces (each)	$25.00
labor (deployment per linear foot)	$ 1.00

Table 2: The cost for purchasing, assembling, and deploying a 100' x 100' PED.

Site preparation	$ 400
PED material	$1400
Four corners	$ 100
4 lbs SS hog rings	$ 20
Assembly labor	$ 200
Deployment labor	$ 400
Total	**$2520**

Maintenance costs of a commercially deployed system would be minimal. The PED does not need to be cleared of whelks on a daily or even weekly basis. It is recommended that a regular schedule of observation to check for damage should be maintained. This can be done quickly in shallow sites by motoring along the perimeter of the PED by boat, identifying and repairing damaged sections as needed. Whelks could be cleared weekly or biweekly, at times of high whelk movement early in the season. Monthly removal of whelks would be adequate after the peak of activity in June. The $1000 per year budgeted for maintenance (parts and labor) should be more than adequate for a 10,000 square foot PED.

Exclusion of predators on shellfish growing areas is an economic and effective means to minimize losses in an environmentally responsible manner. Many strategies are available to exclude predators. The predator exclusion device developed by Cotuit and Cape Cod Oyster Companies (funded by NRAC) provides one option to effectively control for predation by large gastropods.

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