

Welcome to the **CRAB CAPITAL**



SHELLFISH FARMING RISKS PREDATORS AND PESTS

**BIOLOGICAL
SHELLFISH
FARMING RISKS**

Disease – can cause mass mortality

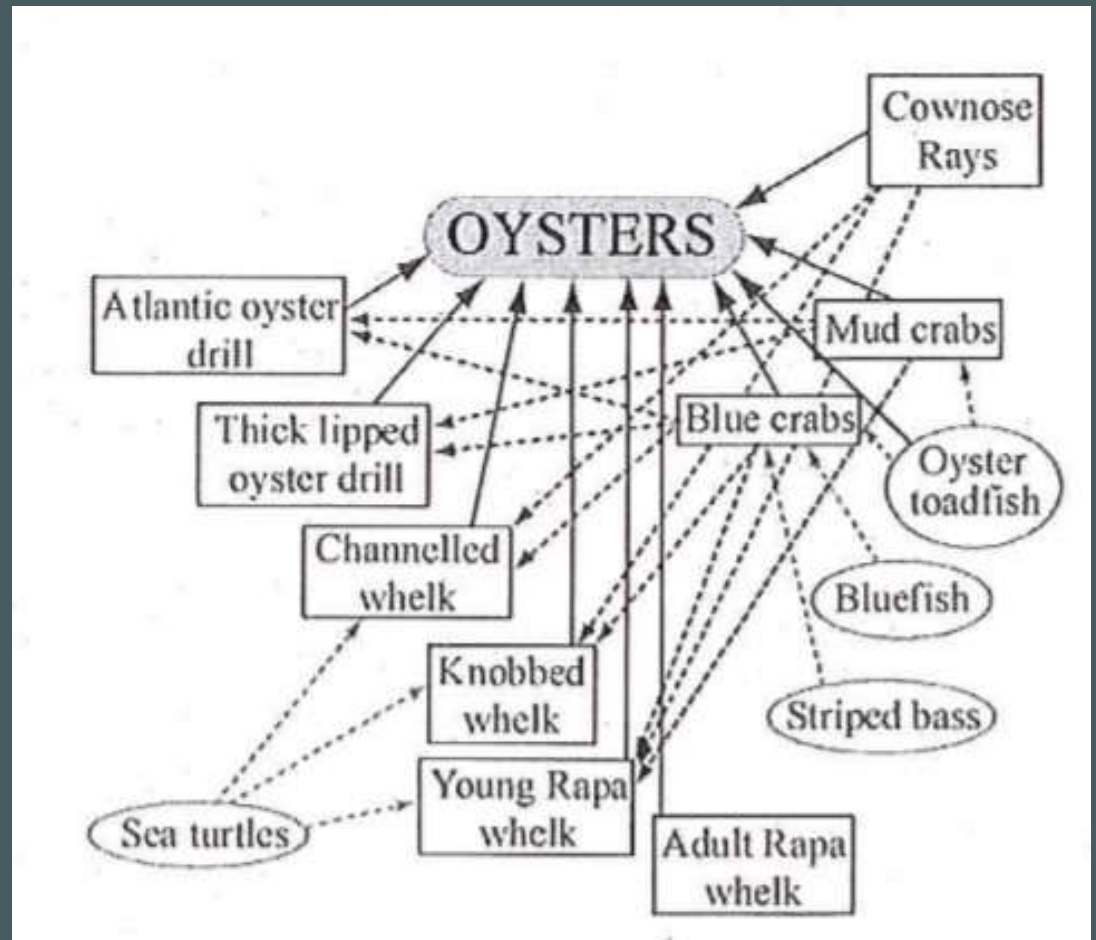
Parasites – can kill host, but most often lead to slower growth and/or impaired reproduction

Predators – kill and consume prey

Fouling – competition and/or impacting flow can impede feeding, slow growth, reduce market value, etc.

PREDATION IS EVERYWHERE

- In the wild, predation occurs at all life stages
 - Larvae
 - Newly settled recruits
 - Seed
 - Adults
- For shellfish farmers, predation occurs on seed and adults





OYSTER DRILL CONSUMING SPAT

THE ART OF WAR

- Identify your enemies
 - Cast of characters
- Assess the threat posed by each
- Determine available methods of predation loss
 - Technology/operating procedures
- Allocate resources as effectively as possible (cost-benefit)



PREDATION IN QUAHOGS & OYSTERS

- As clams grow, they become less vulnerable to a succession of predators
- Outgrowing
 - Mud crabs at a length of about 15-20mm
 - Oyster drills at about 20mm
 - Moon snails at about 50mm
 - Starfish at about 70mm

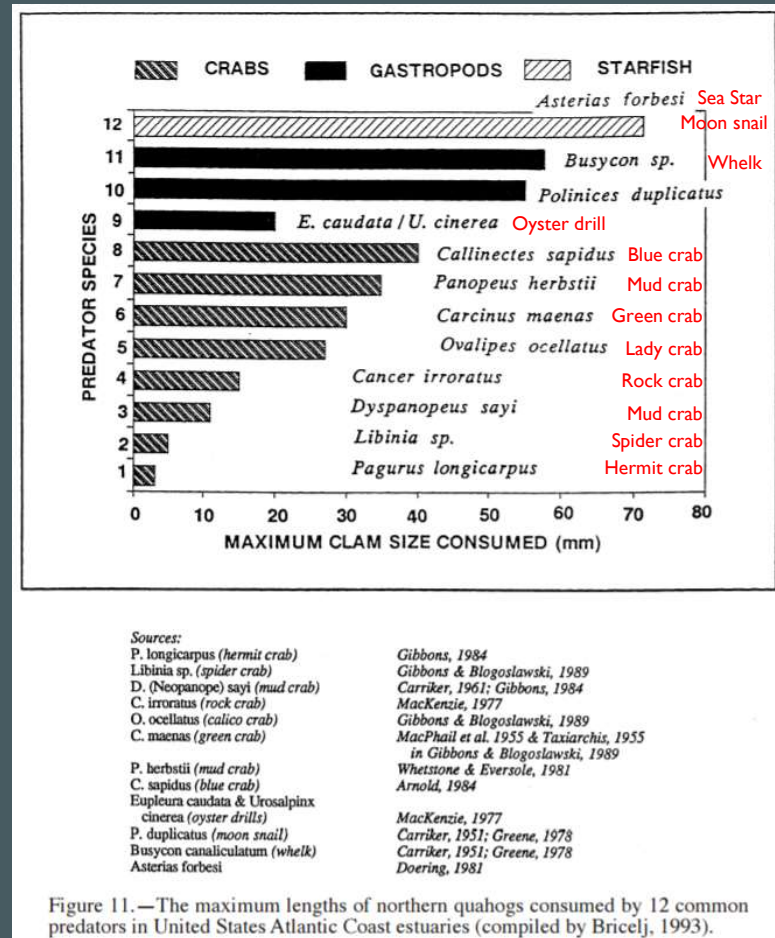


Figure 11.—The maximum lengths of northern quahogs consumed by 12 common predators in United States Atlantic Coast estuaries (compiled by Bricej, 1993).

IDENTIFY
PREDATORS

Worms

Crabs

Starfish

Snails

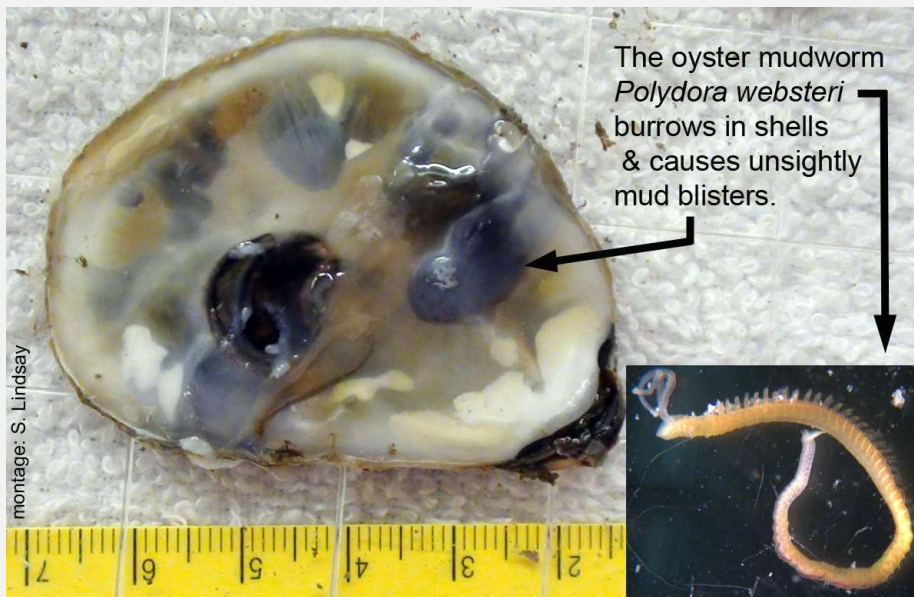
Fish, skates & rays

Birds

Humans?

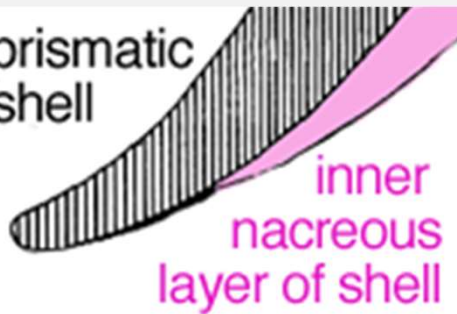
BLISTER WORM

- *Polydora Websteri*
- Larvae - potential predator
- Post-set – not a true predator but damage to oyster shell (marketability)

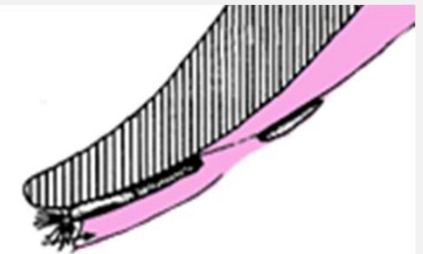


FORMATION OF A MUD BLISTER

outside prismatic
layer of shell



**Normal growth involves
secretion of prism and nacre by
the mantle edge**



nacreous layer is
secreted over a
settled worm

**Settlement of a worm
disrupts prismatic secretion
and protective nacre is
secreted**

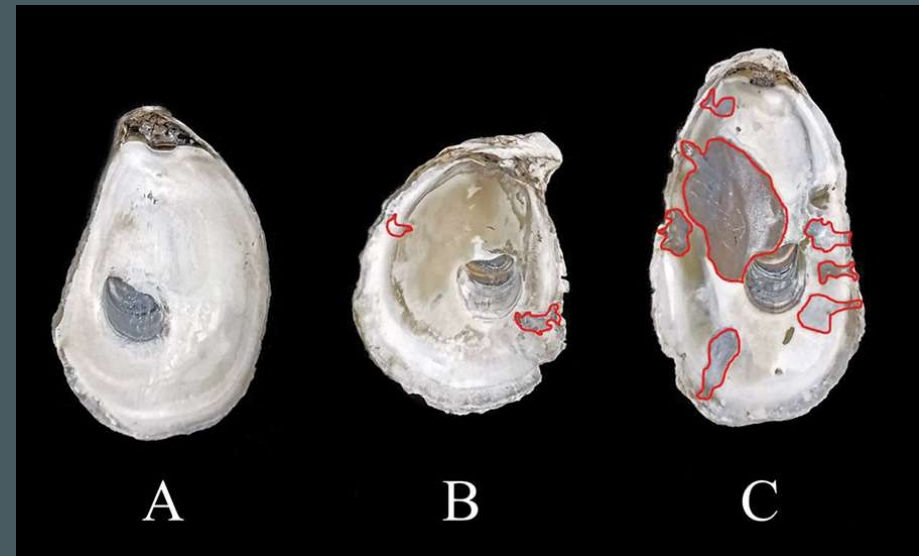
BLISTER WORM - MITIGATION

- Treat with high salinity/brine dip
 - But need to hit when larvae are first settling
- Freshwater immersion
 - 300 minutes in freshwater (NZ study)
- Once burrows are established then tough to eradicate



BISTER WORM MITIGATION

- Recent SARE study in Maine
 - Put infested oysters in a moist air-storage refrigerator unit at 38°F
 - After three weeks of storage, they found nearly 100% worm mortality
- **Air dry and or brine dip as part of your regular maintenance**



- *Cerebratulus lacteus*
- Infuanal predator
- Up to 3-4' long, but less than $\frac{3}{4}$ " wide
- Generally Cape Cod north
- Major predator of soft-shell clams
- Attacks through valves
- Infuanal but can swim

MILKY RIBBON WORM



MILKY RIBBON WORM

- Originally thought to prey primarily on polychaetes (segmented worms)
- 1990 – implicated in the complete eradication of soft shell clams on a flat in Nova Scotia
- Mostly hits clams that can't completely close their shell
 - Soft shell clam - most preferred species
 - Also observed attacking razor clams
- In Canada – thought to prey on seed quahogs



MILKY RIBBON WORM METHOD OF ATTACK

- Searches at the surface (chemical cues)
- Will attack on surface but tries to pull clam under sediment
 - “endobenthic” predator
- Attacks
 - Razor clams from below and engulfs bottom of clam with mouth
 - Soft-shell clam from siphon or foot opening and inserts proboscis

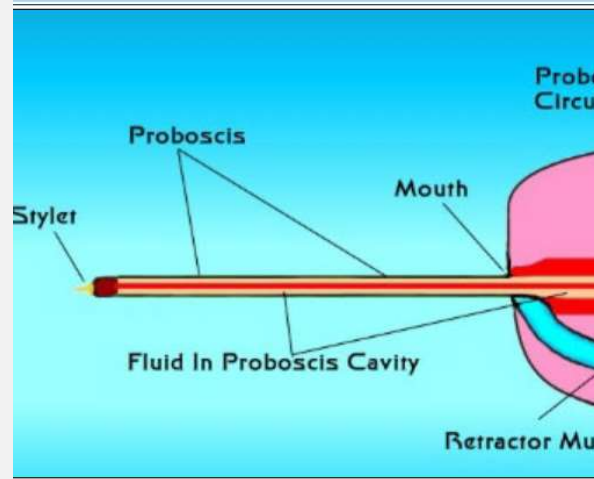
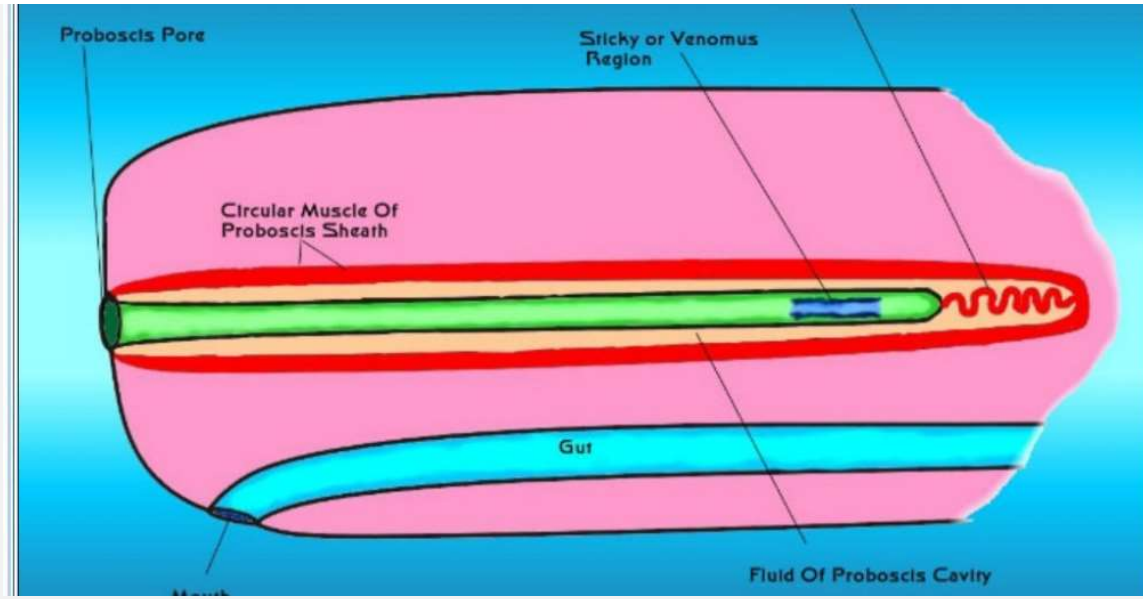


Figure 7. A diagram of the basic structure of the front end of the everted proboscis. Note that the proboscis can be as long as the animal.

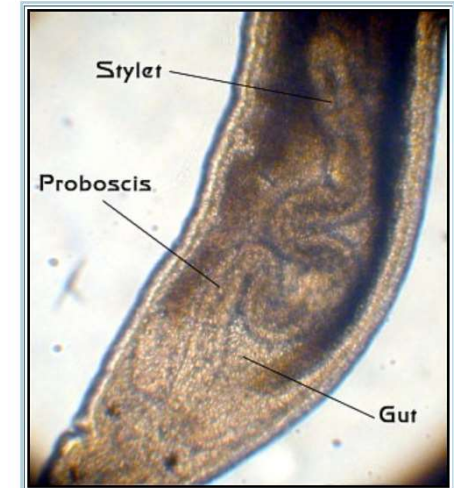


Figure 9. This is the same nemertean as shown in the previous figure. The piercing stylet is visible in the introverted proboscis, as is the gut underlying the proboscis.

MILKY RIBBON WORM METHODS OF CONTROL

- Unsuccessful
 - Turning sediment with hydraulic rake (prior to seeding)
- Marginally successful
 - Increasing the bloodworm density
- Might be successful
 - Buried/exposed barriers (boards)
- Unknown
 - Chemical attraction to a trap?

OYSTER FLAT WORM

- *Stylochus epplipticus*
- AKA oyster leach
- Slides between the oyster's valves and consume meat
- Primarily attacks seed
- **Methods of Control**
 - Brine and freshwater dip??



IDENTIFY
PREDATORS

Worms

Crabs

Starfish

Snails

Fish, skates & rays

Birds

Humans?



GREEN CRAB

- *Carcinus maenas*
- Introduced in late 1800's
- Thought to be responsible for ME soft shell clam crash?
- Consume shellfish up to ~ 2 inches

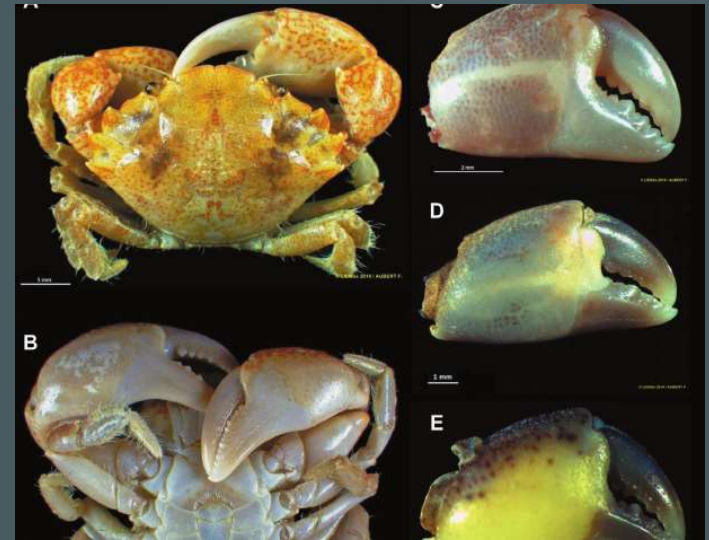


BLUE CRAB & LADY CRABS

- Blue Crab (*Callinectes ocellatus*)
- Lady Crab (*Ovalipes ocellatus*)
- Portunidae – Family of swimming crabs

MUD CRABS

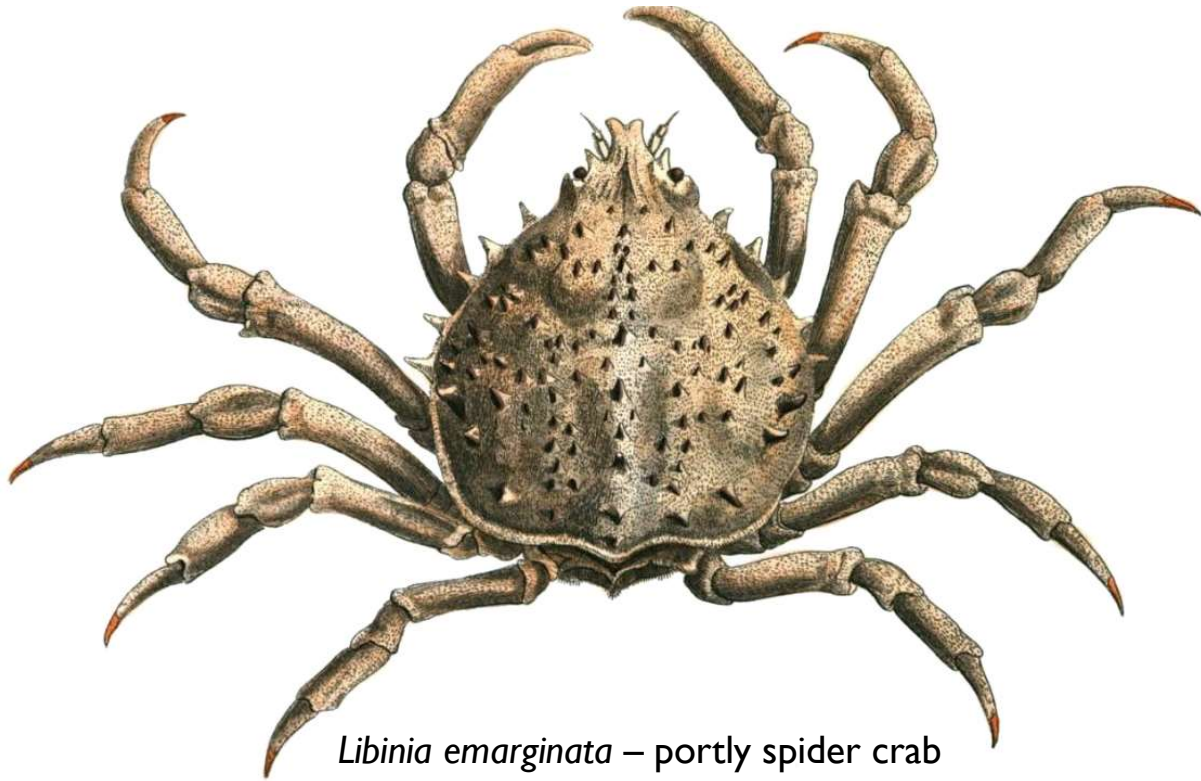
- *Panopeus herbstii* – Black clawed mud crab, Atlantic mud crab
4 cm in width
Thick strong claws
- *Dyspanopeus sayi*
2 cm in width
Native to Atlantic coast of North America
- **Major predators of seed**
Can recruit into gear and upwellers



ASIAN SHORE CRAB

- *Hemigrapsus sanguineus*
- Introduced in the 1990's in NJ
- Now along much of the eastern seaboard
- Displaced green crabs
- Feeds primarily on algae





Libinia emarginata – portly spider crab



Libinia dubia – longnose spider crab

SPIDER CRABS

HORSESHOE CRABS

- *Limulus Polyphemus*
- Feeds primarily on clam seed (particularly soft shell)



BASIC CRAB BIOLOGY & ECOLOGY

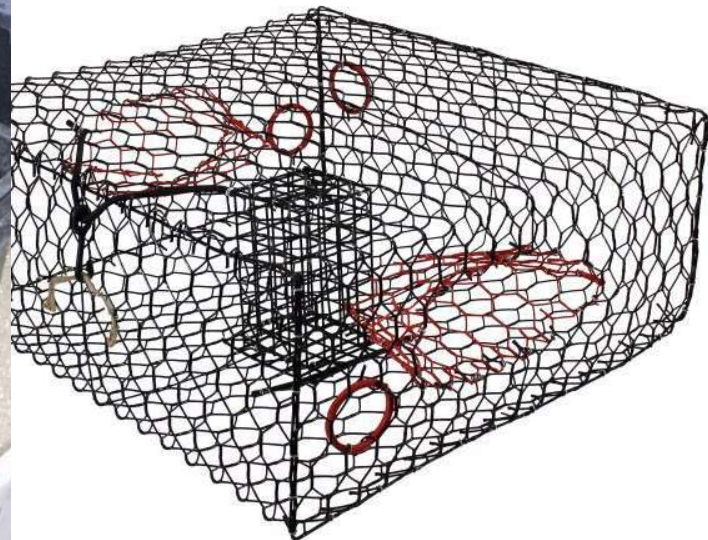
- Larval dispersal in plankton
- Prey heavily on seed up to 25 mm
- Can prey on seed up to almost market size
 - Size of prey relative to the size of the crab
- Crabs have been observed to destroy entire runs when left unprotected
- Leave distinctive shell chips





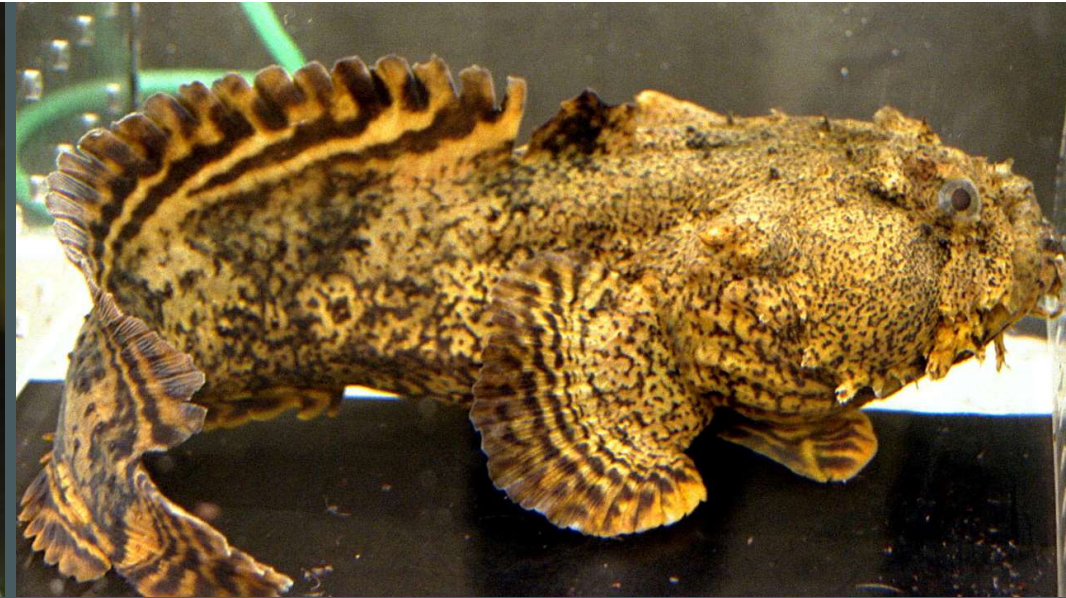
REDUCING CRAB PREDATION

- **Physical barriers**
 - Fences, nets, suspended culture, crushed stone or other barriers (marginally successful)
 - Does not prevent crab recruitment into container



REDUCING CRAB PREDATION

- **Crab traps**
 - Reduce population or distract from other prey
 - Short-term solution



REDUCING CRAB PREDATION

- **Biological control**
 - Oyster toad fish as a 'guard dog'

REDUCING CRAB
PREDATION

FREE PLANTING

Timing of seeding

- Most predators slow down or stop feeding as water gets colder
- Usually consider 10°C (50°F) a cut-off

Size of seed planting

- As seed gets larger it takes a bigger predator to consume it
- Oyster >2" for free planting
- Quahog > 3/4-1" for free planting

PEA CRABS

- **Parasitic crab that lives in the mantle cavity of many bivalves**
 - Oysters
 - Mussels
 - Bay scallops
- **Life Cycle**
 - Enters the crab as a larvae
 - Females remains in their host for life
 - Males will move between individual shellfish to mate
- **Not sure of overall impact**
 - Causes reduced gonad state in bay scallops
 - May actually consume mussel or oyster flesh
- **Reduced marketability of product**



PEA CRAB CONTROL

- If you are in an area with pea crabs, not much you can do to avoid them
- Convince your shucker to flick them out when setting up the raw bar
- Eat them, they are sweet and not very crunchy



IDENTIFY
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Sea Stars

Snails

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SEA STARS

- Water vascular system – similar to hydraulics
- Intertidal to 6,000 meters
- Tropics to polar regions
- Mostly predators of benthic invertebrates







Asterias vulgaris



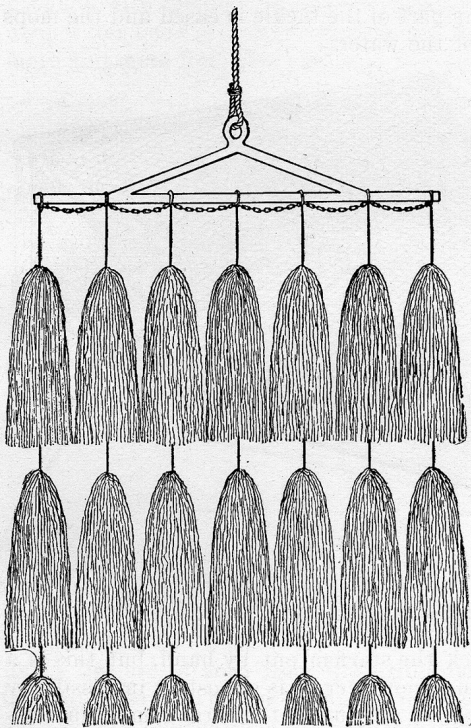
Asterias forbesi

Controlled with

- Traps
- Mops
- Granular quicklime

Regeneration of tissue

- Do not cut up and throw overboard
- Immersion in boiling water is advisable



Cut 2.—Tangle.

Cut 2.—Tangle.



SEA STAR MOPS



Sea Stars

LIME TREATMENTS

Quicklime (on bottom application) NOT RECOMMENDED

- Calcium oxide
 - With small amounts of calcium carbonate
- Relatively insoluble in water
 - Will remain effective for longer periods of time
- Application rate
 - 300 lbs/acre = $\sim 0.16 \text{ kg/m}^2$
- Doesn't seem to impair other marine organisms
 - Not sure of status for using on farm?
 - 1988 paper suggests EPA removed from hazardous substances list

• **Hydrated lime** (dip application)

- aka "Slaked lime"
- Calcium hydroxide – quicklime with water added
- 40 g/L in a tank – 30 second dip
- Mussel growers have used in combination with a brine dip

THE GOOD NEWS

- There was been a dramatic die-off of starfish in the bay a few years ago
- Attributable to a disease but we don't know much about it!
 - Recent paper suggests a densovirus
 - But most virologists are not convinced!
 - Currently being investigated
- More recently, starfish seem to be coming back
 - Not known if disease will recur

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SNAIL PREDATION

WHELK – MOON SNAILS – OYSTER DRILLS

BASIC SNAIL
BIOLOGY
&
ECOLOGY

- Prey on all sizes of shellfish
- Moon snails and whelks burrow and are often not seen
- Moon snails can drill ~one clam per day
 - Distinctive countersunk bore hole
- Oyster drill holes are often hard to see
- All leave egg cases, from which the juveniles hatch and crawl away

EGG CASES



WHELKS/CONCHS

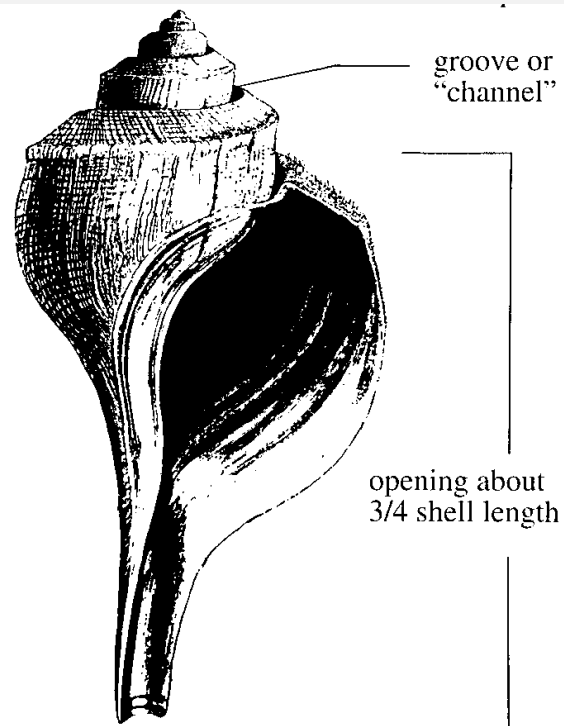


Fig.B. *BUSYCOTYPUS CANALICULATUS*
(=*Busycon c.*), CHANNELED WHELK:

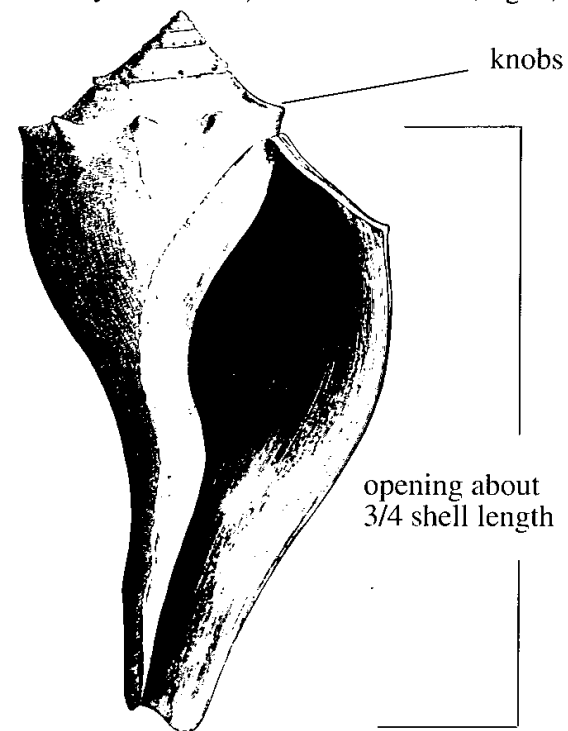


Fig.C. *BUSYCON CARICA*, KNOBBED WHELK

WHELK PREDATION STRATEGY



- **Forage below sediment surface**
- **Method of attack:** Wedges beak between valves > Inserts proboscis > Consumes shellfish
- **Consumes:** Quahogs, oysters, soft shell clams, bay scallops, razor clams, surf clams

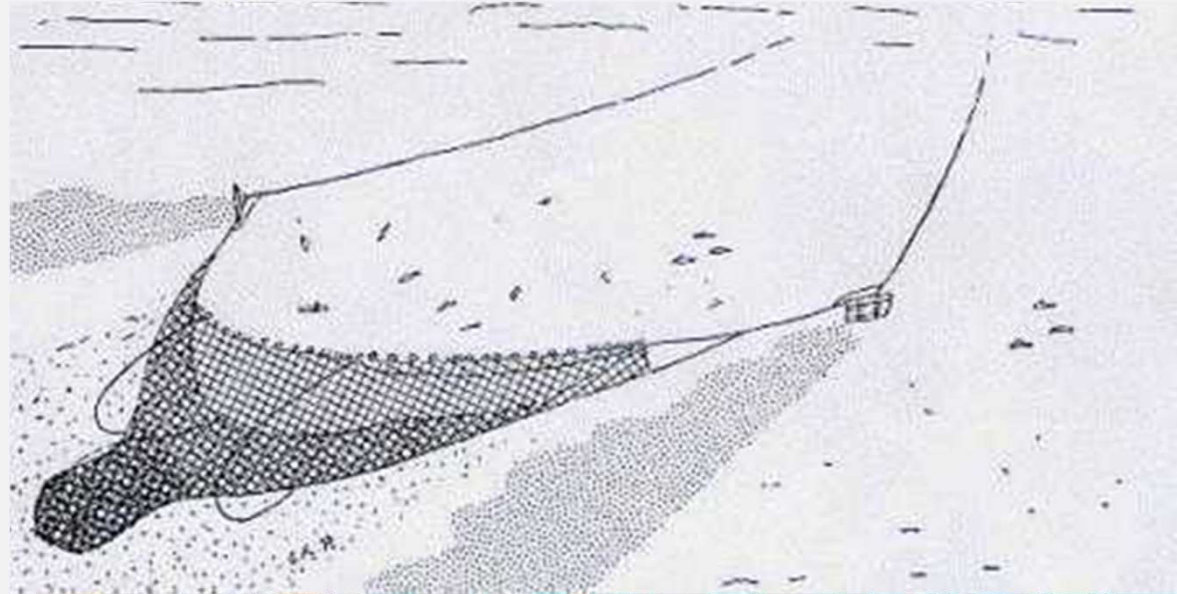
OTHER IMPACTS

- Presence of whelk in vicinity of clam
 - Not in contact with clam
- Clam detection
 - Chemical cues from conch
- Suppresses growth - due to behavioral response of clams to presence of conch
 - Reduced feeding?



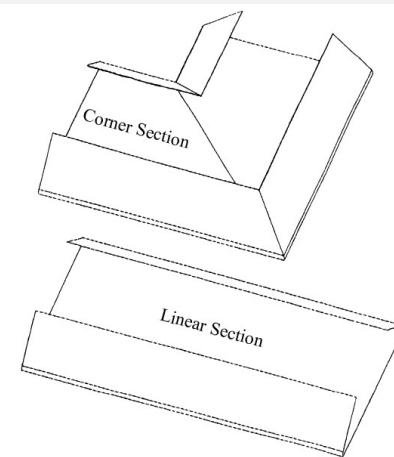
WHELK CONTROL

- Trawling
 - Common in south (NC, SC, & GA)
- Trapping
 - Primarily smooth whelk



WHELK CONTROL

- Trawling
 - Common in south (NC, SC, & GA)
- Trapping
 - Primarily smooth whelk
- Exclusion
 - Nets & bags
 - Buried boards
 - Fences



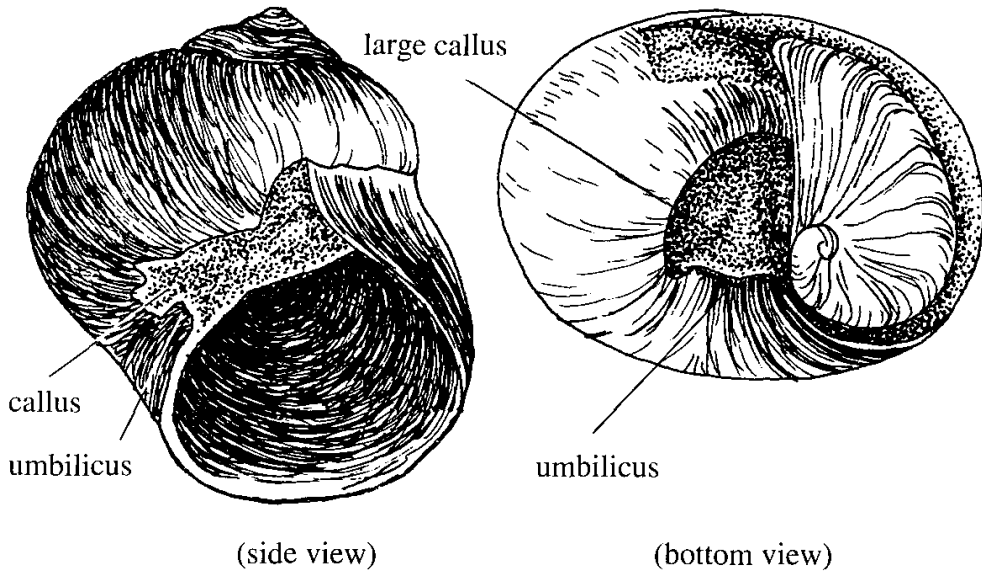


Fig.A. *NEVERITA DUPLICATA* (=Polinices d.), SHARK EYE (

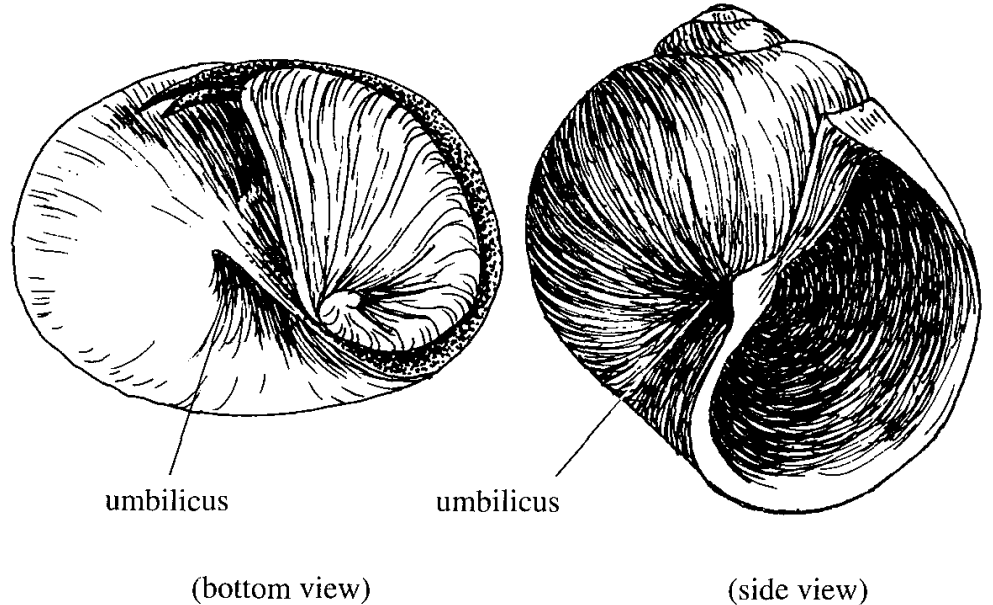


Fig.B. *EUSPIRA HEROS* (=Lunatia h., =Polinices h.), NORTHERN MOONSNAIL

MOON SNAIL

*NEVERITA
DUPLICATUS*

- Moon snail or shark eye
- South of Cape Cod



EUSPIRA HEROS

- Northern moon snail
- North of cape cod



MOON SNAIL FEEDING BEHAVIOR

- Primarily feeds on other mollusks
 - Including con-specifics
- Bores through shell
 - Grinds with radula
 - Secretes acid to dissolve shell
- Always attacks in a similar way
 - Bores through near umbo



MOON SNAIL FEEDING

- Has limits to what it can successfully attack
 - Shell thickness
 - The bigger the moonie ~ the bigger the prey!
- **Prey Species**
 - Soft shell clam
 - <30mm (<1.2 inches)
 - Surf Clam
 - <80mm (<3.15 inches)
 - Quahog
 - <55mm (<2.15 inches)
 - **Oyster?**



MOON SNAIL CONTROL

- Eradication
 - Removal of adults = futile?
 - Removal of egg cases?





OYSTER DRILLS

Voracious feeds on small oysters
Prefer barnacles

Small egg case – vase shaped
Lay on underside of structures

Fully developed juvenile emerges from egg case
Can't travel very far





REDUCING SNAIL PREDATION

- Removal by traps, dredges, suction dredges and hand-picking
- Physical barriers
 - Copper foil wrapped around structures
 - But remember that they burrow
- Dip in brine?????

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Snails

Fish, skates & rays

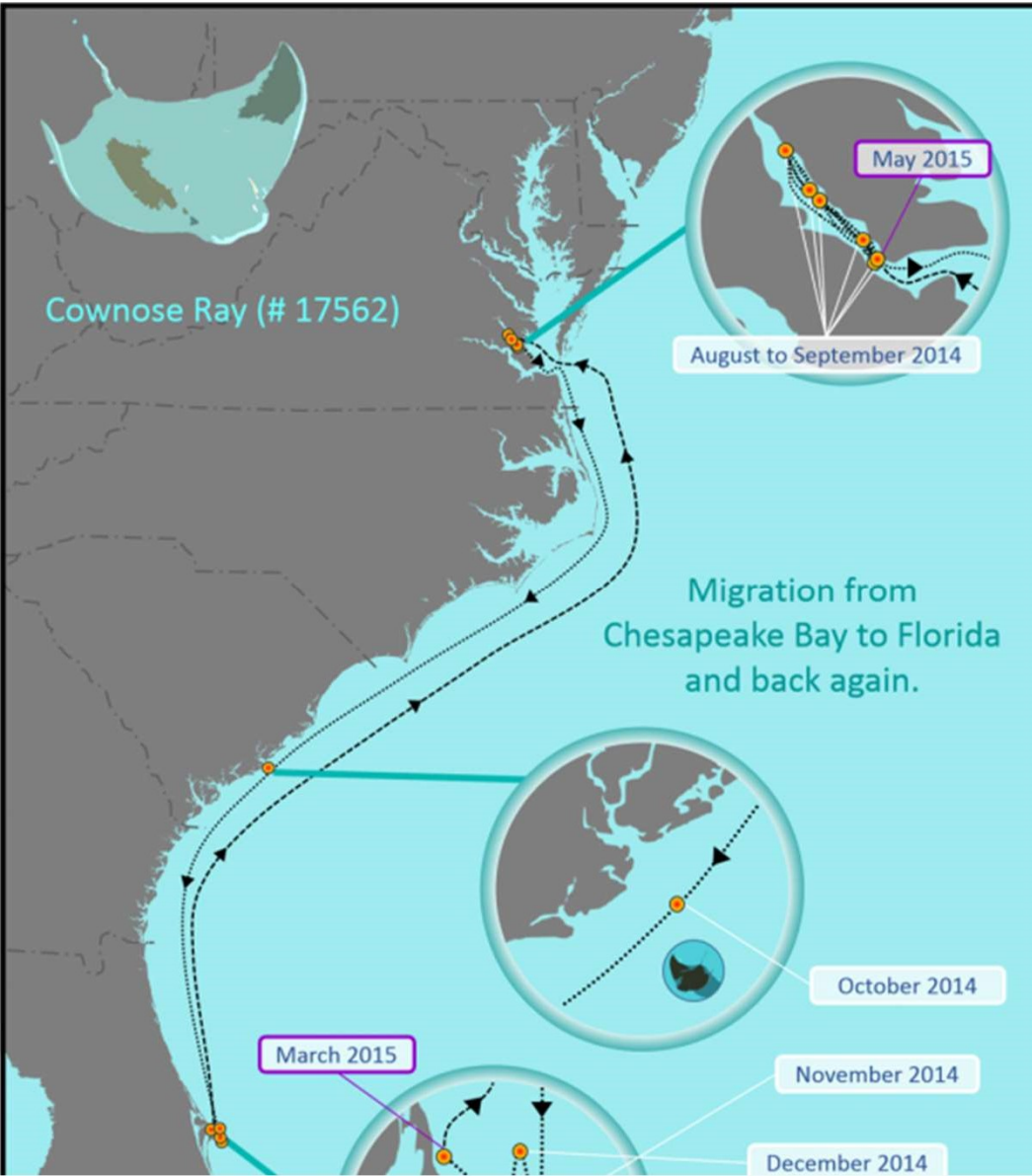
Birds

Humans?

FISH, SKATES AND RAYS

- Cownose Ray
 - Stir up bottom and then crush exposed shellfish
 - Leave 2-3' wide depressions with shell parts







COWNOSE RAY CONTROL

- **Exclusion**
 - Elevate your nets to not allow the ray to puddle up your clams
 - Place a wire mesh exclusion barrier over softer meshes

FISH, SKATES AND RAYS

- **Siphon Nipping**
- Other fish (flounder, drum, northern puffer, tautog) are not recognized as major predators
 - but may nip siphons (clams) and slow growth
- Exclusion is best mitigation



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WATERFOWL

- **Eiders and other ducks**
 - ‘puddle’ and consume small clams exposed
 - Can consume huge amount of suspended mussels
- **Oyster catchers**
 - Can prey on market sized oysters
- **Gulls**
 - Drop clams on Cadillacs

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MUSSEL RAFT ANTI-PREDATOR NET

IDENTIFY
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DETERRENTS TO POACHING

Use gear that is not easily accessible

- e.g. 200 lb oyster cages
- May need specialized equipment to handle

On-site video camera system

- Currently being used by a few growers
- Night vision?

Make friends with your neighbors

- Have them “drop a dime” if someone is on your site
- A few oysters on occasion helps

ASSESSMENT OF PREDATION RISK?

Consider time of day, state of the tide, seasonal changes and possible differences across years

- e.g. predation pressure is very low in the winter for most invertebrate predators

Predator density

- Visually assess predator densities

Is predation part of your bivalve loss?

- Scratch around and examine the shells
- Basically forensic science

ONCE YOU HAVE IDENTIFIED THE THREAT

Assess methods available for control

- Each method takes time and money
- It's important to be sure it works before you invest in the technology
- e.g. do copper bands on the legs of the racks reduce predation by oyster drills?

Quantify Cost-Benefit of control

- It costs \$10 per unit to implement but you are only protecting an extra 5 oysters?
- Is it worth the cost?