Adapted from Attachment D:

Predation and Soft-shell Clams
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Predation is one of the most important biotic factors affecting clam populations along the Maine coast. Communities that manage clam stocks should be aware of the major predators and, if possible, vary their field activities to enhance stocks (transplanting wild seed; planting hatchery-reared seed; brushing; etc.) accordingly. Predation occurs year-round; however, most mortality by non-human predators occurs during the late summer, fall, and early winter. March through late May are months when predation rates are typically low and, therefore, this should be the time of year when most transplanting and re-seeding activities should occur.

The major predators of clams greater than ¼" shell length fall into several categories: crustaceans, worms, snails, fish and birds.

Crabs

The most notorious crustacean predator in Maine is actually an "exotic" species, the green crab *Carcinus maenas*. This predator was accidently introduced to the United States (around Long Island Sound) during the mid-1800's. By 1900, it was first reported in Casco Bay and by the late 1940's it had reached downeast. Green crab population abundance appears to be related to water temperature. The warmer the average annual water temperature, the more crabs. Crab populations were highest during the early to mid 1950's when seawater temperatures were the warmest of the 1900's. During the early 1960's, extremely cold winters occurred and that was correlated with decreasing crab numbers. Today, green crab populations appear to be increasing, especially along the southern two-thirds of the coast. Today, there are only two effective measures communities and/or individuals can use to deter crab predation. In early spring, plant seed clams that are larger than the size most green crabs can attack (1 ½" to 1 ¾") or plant smaller seed in early spring and use protective, flexible netting (usually ¼" netting works best). Neither of these measures is 100% effective. There are other crab species that venture onto clam flats when the tide is high (rock crabs, *Cancer irroratus*-the ones that are picked for their meat-and small "xanthid" crabs), but these are not terribly important.

One of the most important research topics would be to develop truly effective measures to protect clams from green crabs. One activity could be to develop

a fishery for green crabs and/or learn how to create "shedder" green crabs that would be able to compete in the market with soft blue crabs. A fishery for green crabs could, potentially, decrease their population numbers and help increase clam numbers.

Worms

Although sand worms (*Neanthes virens*) and blood worms (*Glycera dibranchiata*) are predators of clams, the sizes of clams on which these organisms prey are too small to be able to do much about. These commercially important worms can prey on clams smaller than 3mm. (One might see a large sand worm in a clam's shell feeding on the clam's tissue, however, the clam was either dead before the worm began to eat, or was weakened by something else).

The most voracious worm predators of soft-shell clams are not closely related to sand and blood worms (*Phylum Annelida*, Class *Polychaeta*). These predators are called milky ribbon worms (*Cerebratulus lacteus*) and they are in a completely different group (*Phylum Nemertea*, Class *Anopia*). These worms are long, slender, and have no segments with feet-like parapodia (as do sand and blood worms) to move around within the mud. This does not mean they are not mobile. On the contrary, they are highly mobile and the only way to deal with them is to avoid them. They can prey on clams from the very smallest sizes to the very largest by everting their long proboscis into the siphon holes of clams and eating them from the inside out. The smallest netting available (1/6") may help deter adult milky ribbon worms from preying on clams, but will do little to stop juveniles. The best solution today is to place clams where this species does not exist. (editor's comment: Keeping green crabs away from clams is almost impossible to do.)

Snails

There are many intertidal gastropods, or snails, along the Maine coast but there is only one that is a soft-shell clam predator. Moon snails (*Euspira heros*) are "boring gastropods" that drill a countersunk hole (usually near the oldest portion of the shell called the umbo) through the shell and evert their proboscis through this hole and consume the clam. These snails can be found at low population densities in most coastal locations except eastern Maine (Washington County) where densities are very high especially in the mid to upper intertidal zone. Although much work has occurred involving the predator-prey dynamics of moon snails and clams, there is much research to be done primarily on the population dynamics of the predator. At many locations, snails are smaller than 1 ¼". Since there is a close relationship (1:1) between snail size and size of its clam prey, in many locations clams can attain

a size refuge (editor's note: a size that is large enough to keep the clam safe) from moon snail predation at sizes greater than 1 ¼" in length. Many communities in eastern Maine have planted hatchery-reared soft-shell clam seed in areas with abundant numbers of moon snails. Although the seed have been "protected" with flexible netting, most of the clams have fallen victim to moon snail attack. These snails can burrow beneath the nets and can forage undeterred on the seed clams. To date, the only remedy for moon snails is the same as that described for the milky ribbon worm – plant the clams in locations with low moon snail densities(editor's comment: Since this again is almost impossible to do, research may help in the discovery of better locations and better times of year to plant the clams).

Fish and Birds

Fish and birds are also important predators, but, for the most part, clams can escape predation by these vertebrate organisms by reaching a size/depth refuge(editor's note: a size/depth that keeps them safe from a particular predator). Communities that wish to guard against most benthic fish that forage intertidally can adopt one of two measures: protective netting or planting large clams (greater than 1 ¼"). Most of the fish that venture into the intertidal zone at high tide that prey on clams are small such as the mummichog (*Fundulus Heteroclitus*). These fish may reach sizes of 4-6" in length and they are voracious predators of small (less than 20mm) soft-shell clams. Another fish that few see or pay much attention to are called wrymouth eels. These benthic (bottom-dwelling) fish live in burrows or galleries they dig in muddy bottoms at the extreme low intertidal and into the sub tidal regions. The entrance to their burrows sometimes contains fragments of clamshells, but most that have been caught and examined closely contain small worms and bottom shrimp in their stomachs.

Bird predation is confined mostly to black ducks (*Anas rubripes*) feeding during the winter months, especially January and February. Black ducks prey on small clams that are burrowed shallowly in the mud and can nip the ends of the siphons of larger clams. Although this latter predation does not kill the clams, it "forces" them to reposition themselves higher in the sediments where they can become more susceptible to green crab attack. Usually clams that have had their siphons nipped will divert energy from shell growth to regenerating the siphons allowing them to reach a depth refuge from most predators.

There have been no studies in Maine to quantify predation due specifically to fish and birds.