The Soft-Shelled Clam and Its Environment: a study in Jonesboro, Maine

JANE ARBUCKLE

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Jane Arbuckle
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University of Maine
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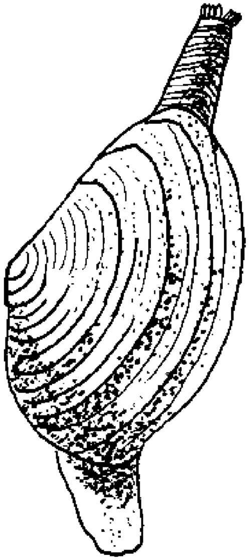
THE SOFT-SHELLED CLAM AND ITS ENVIRONMENT:
A STUDY IN JONESBORO, MAINE



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INTRODUCTION

This study of clams and their mudflat environment began in Jonesboro in 1980. It was initiated by the town's Clam Committee and the Planning Board to try to determine what, if anything, could be done to increase the recruitment of young clams onto the flats. Productivity appeared to be falling, and the clammers decided to try to do something about it. Five major factors affecting low productivity are 1) predation, 2) sporadic or nonexistent sets of juveniles, 3) overdigging, and 4) changes in either substrate or 5) water quality. Because the sets in Jonesboro have been sporadic, two options exist in this case: to either transplant seed, or to enhance the recruitment of any spat that exist in the vicinity. The Clam Committee decided to try the latter.

A massive effort followed, in which 45,000 square feet of mounds and furrows were dug, 700 feet of snowfence was erected, and small pools were created on the mudflat. All of the areas were sampled before and immediately after these disturbances. Five months later, in October, 620 mud samples were taken and then sorted under microscopes to look for small clams. The disappointing result was that there were so few clams that no conclusions could be drawn about the effectiveness of the furrowing, snowfence, or pools. Apparently, there was no set anywhere on the experimental mudflat (see Interim Report).

In 1981, the approach was different. Experiments were again set up to see if roughing up the flat and erecting obstacles would increase the set, but they were done on a much smaller scale. In addition, a number of other factors effecting productivity were investigated:

1. What is the growth of clams on these flats? Does it differ with total elevation? Does it really take 4½ years to grow a 2-inch clam in Jonesboro?

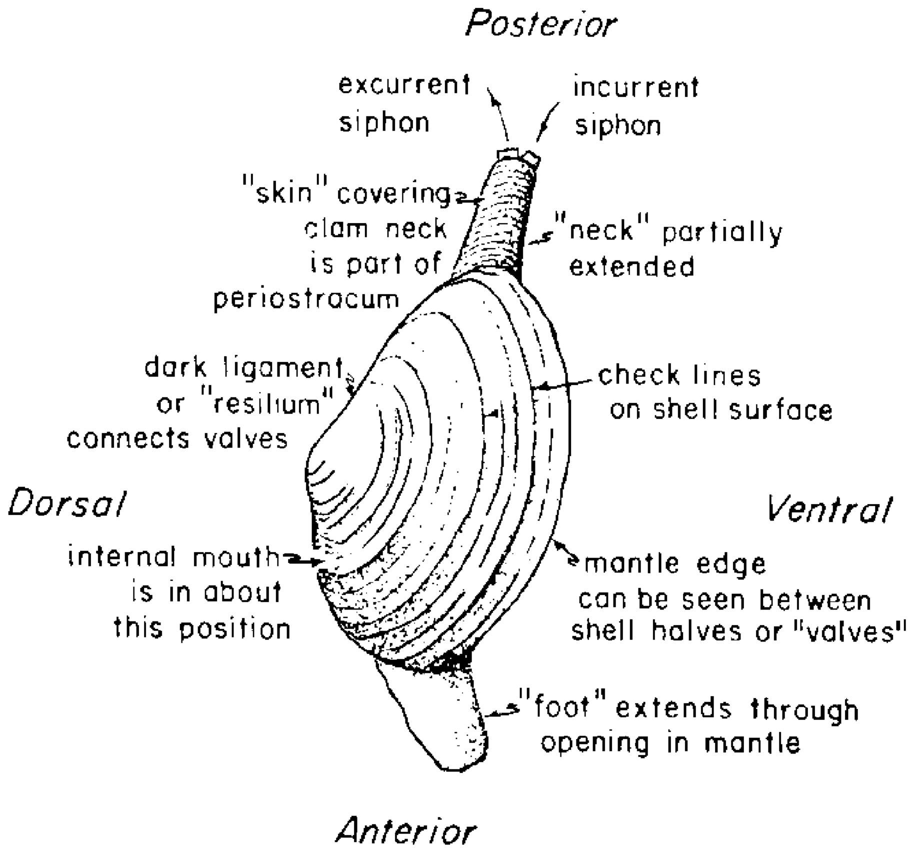
2. Is predation a limiting factor for clams in Jonesboro? Which animals, if any, are eating the clams?

3. Are the flats gaining sediment, possibly from the surrounding erosion of cliffs, or are they losing mud? Is this effecting clam abundances?

4. Could production be enhanced by seeding the flats with hatchery-raised seed? Would it work? Is it economically feasible?

5. Do tiny clams move, and how much? Trying to recruit ¼-inch clams onto the flat won't do much good if they won't stay put.

This report has a threefold purpose: 1) to describe the experiments and procedures undertaken in attempting to answer these questions; 2) to report the results; and 3) to suggest what these results might mean to the management of the clam resource in Jonesboro and elsewhere.



Soft-Shell Clam External Anatomy

(note that a clam lives "bottoms up")

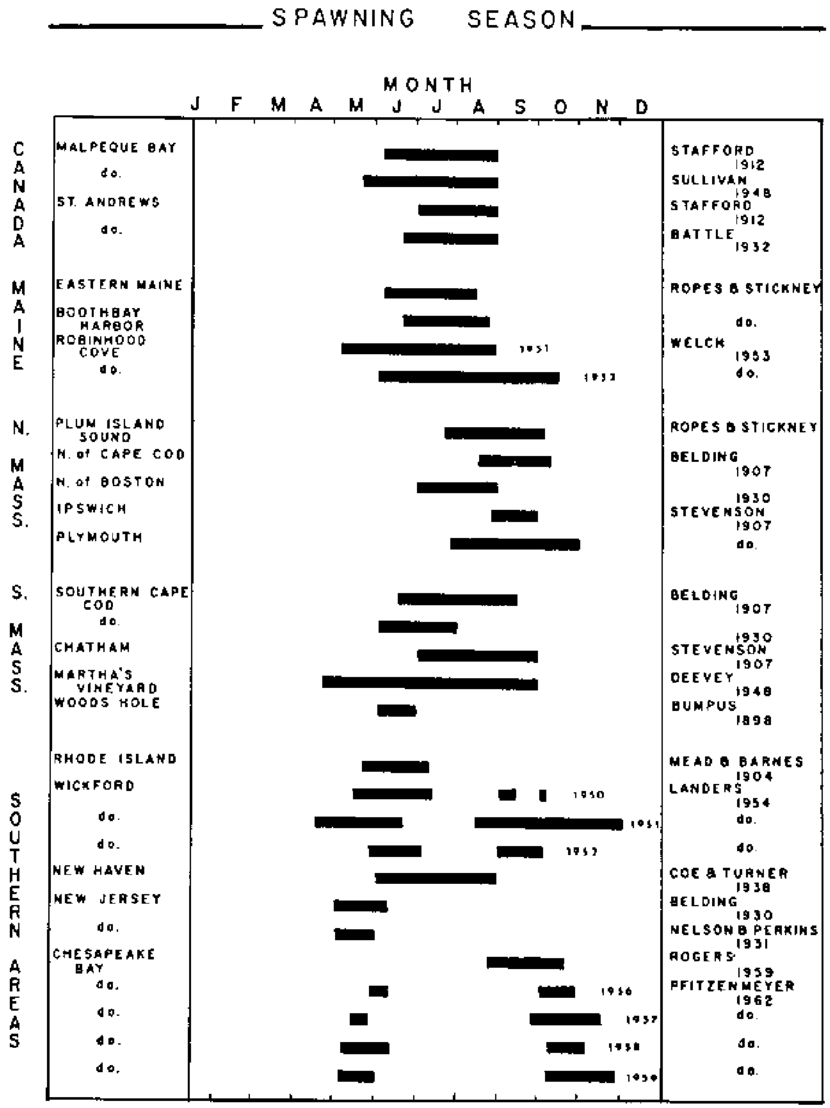
Figure 1.

BIOLOGY OF A CLAM

In order to conduct experiments with clams, it is necessary to understand the life cycle of the clam, its habitat, and its behavior. Following is a brief review of the biology of the soft-shelled clam, Mya arenaria.

An average clam in Maine spawns in the summer. Further south, where the water is warmer, clams spawn in the late spring and early fall, but in eastern Maine, the major period stretches from late June to August (Figure 2). A mature female soft-shelled clam releases about 1-3 million eggs into the water. The timing is dependent on water temperatures and possibly food supply. Male clams release billions of sperm at the same time, and it appears that the release of sperm triggers the release of eggs. The eggs are fertilized within a few minutes to a few hours. The resulting organism is called the larva.

The cells rapidly divide through the first 24 hours, and within one day, the larva has developed into a trochophore larva, with heart, cilia, and digestive tract (Figure 3). Throughout the larval stage, which lasts about two weeks, the larvae float and swim in the water, being moved wherever the currents take them. They filter microscopic algae for food, and many are eaten by small swimming animals called zooplankton.



The duration of the spawning season of *Mya arenaria* reported in the literature for areas along the Northwestern Atlantic coast.

Figure 2. From Ropes and Stickney, 1965.

By about Day 12, their foot becomes active (Figure 4). At this point they are called pediveliger larvae. They begin to sense the bottom and touch up and down. By Day 14, they are about 1/100 inch long, and settle onto the bottom, attach with a byssus thread, lose their cilia, and move around on the surface, or burrow in and out of the sediment. They continue to filter the water for food, eating microscopic plants called phytoplankton, and are very active, crawling around and occasionally getting back up into the water column and moving with the water currents. By ½-1 inch size, most clams have burrowed into the sediment. They have been observed living in gravel, clay, sawdust, peat, sand, and mud. Harder sediments tend to stunt their growth. They stay in the sediment, filtering seawater whenever it covers them, and closing up at low tide if they are in an intertidal area.

When they are about ½ inch, they become sexually mature. The gonads start developing in the spring, and by summer they are ready to reproduce. In some areas, predators are a major problem. Small clams are eaten by glass shrimp, mummichogs, and moon snails. And as they grow larger, flounder, green crabs, horseshoe crabs, ducks, and raccoons may eat them. If a clam can survive the predators, disease, and environmental extremes, it may live to be 10-12 years old.

Figure 3. Trochophore larvae

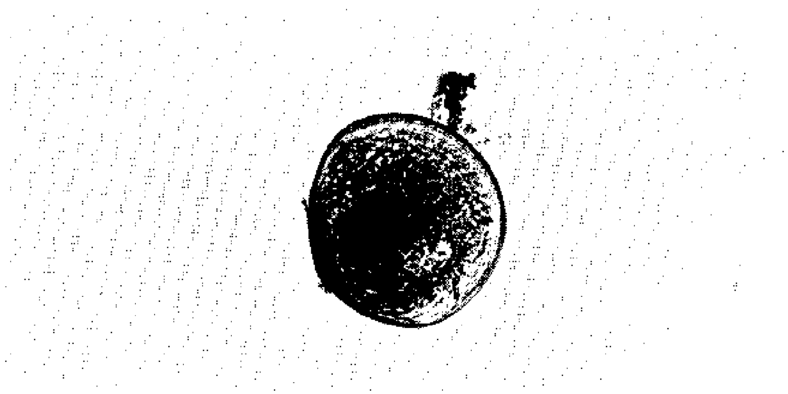
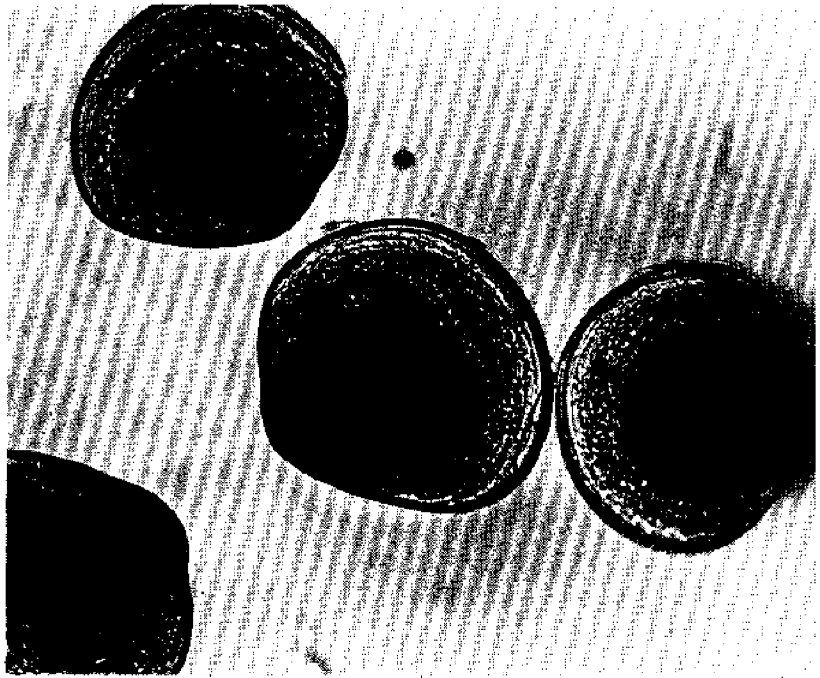


Figure 4. 12-day old clam larvae



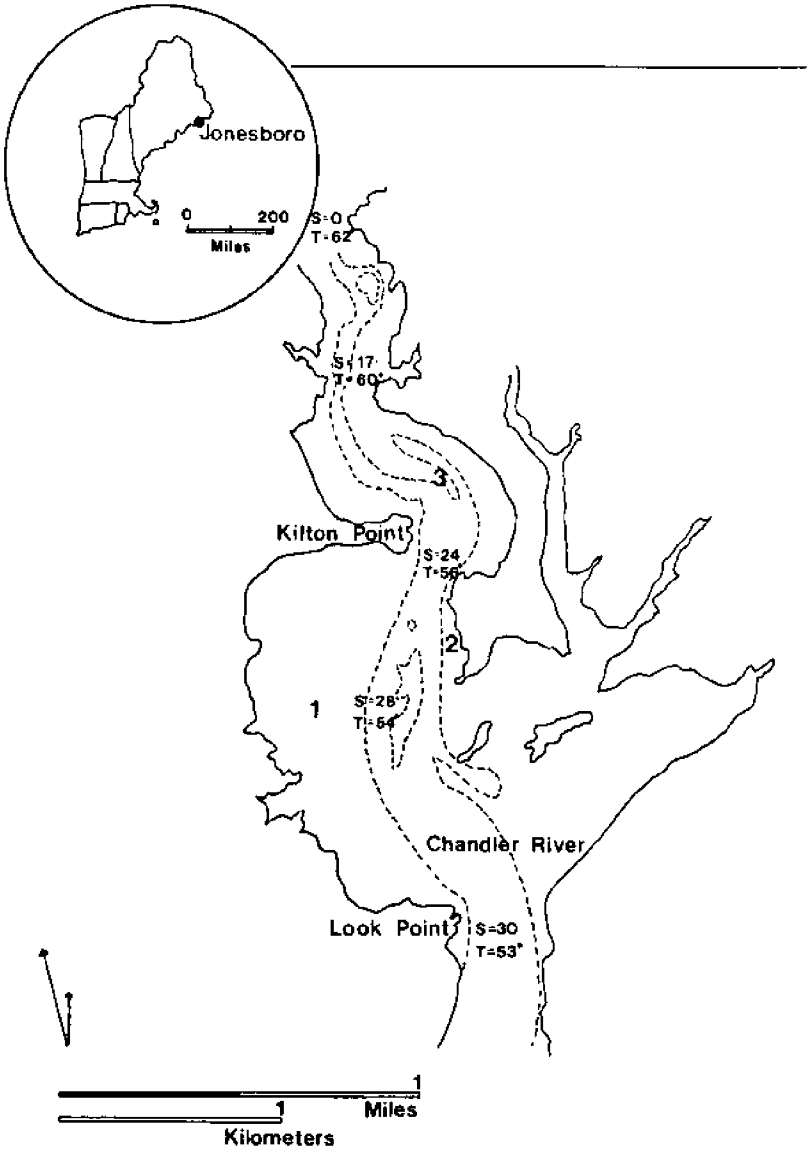


FIGURE 5. Location map for Jonesboro, Maine, with experimental plots. Latitude 44°39' N, Longitude 67°33'W. S = salinity in o/oo; T = temperature in °F.

SITE DESCRIPTION

The three mudflats used in this research border the Chandler River (Figure 5). The largest is between Kilton and Look Points, on the west side of the river, and will be referred to as Flat #1. This flat is actively dug, particularly in the middle area of the flat. The 1980 survey done by the Clam Committee indicated that the average yield per acre was about 35 bushels on this flat. The area is very broad, about 4921 feet (1500 m) long, north to south, and 1640 feet (500 m) wide at its largest dimension. The sediment here is generally fine clay-silt. The heavily dug area has a slightly coarser sediment.

Flat #2 is located on the east side of the river, between Board Point and the Fieldman's house. This is a relatively small flat which has been closed to digging for several years. There is more gravel here and the currents are faster than on Flat #1.

The third flat, which was used only for seeding clams, is Noble's Middle Ground, located just north of the Fieldman house. This flat is uncovered only at the very low tides and was closed in October, 1981, solely for experimental purposes.

All of these flats have been dug for many years. Some years the flats yield more clams than other years, and the areas of greatest abundance appear to change. In the 1700's and 1800's, schooners sailed up the river to load cargoes of wood and granite, and saw mills operated even further upriver. Many of the clay cliffs surrounding the mudflats have eroded into the river, and the direction and rate of transport of this sediment is not known.

The Chandler River

The Chandler River is the estuary which brings food to and flushes wastes from the mudflats in Jonesboro. Within a relatively short distance, about two miles, the salinity of the river changes from 30 o/oo to 0 o/oo and the temperature changes from 53°F to 62°F (Figure 5). In the summer months, the incoming tides produce a marked boundary line which delineates the colder, higher salinity ocean water from the warmer, lower salinity river water. This line is very visible across the river, and moves upriver as the tide advances. It goes as far as the granite pier and then retreats. The ocean water is blue and the river water, brown. Temperature and salinity measurements taken on either side of this line, within five feet of each other, showed marked differences. Figure 6 illustrates this marked "boundary" phenomenon which is a common occurrence in estuarine systems.

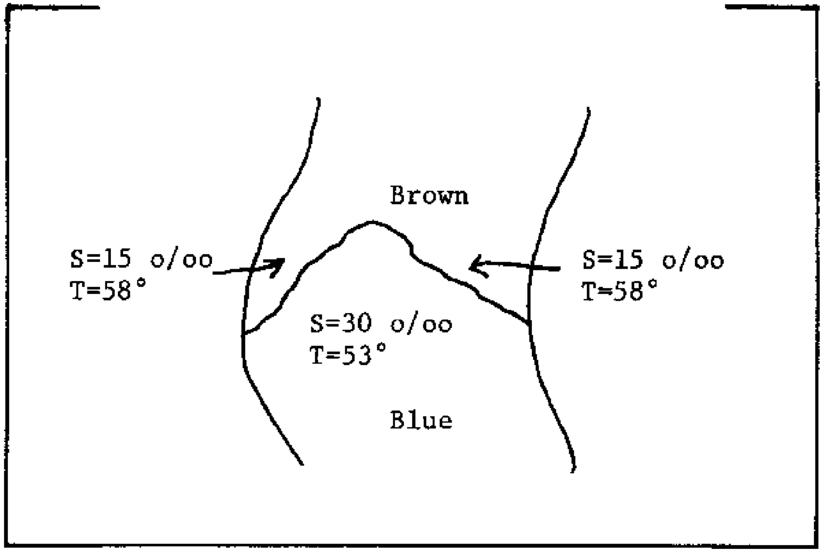


Figure 6. Boundary between ocean and river waters. S = salinity o/oo; T = temperature in °F.

Concurrent with these temperature and salinity measurements, plankton tows were taken. Results showed that the ocean water was a much richer source of small plants and animals than the river water.

DOES FURROWING OR ERECTING SNOWFENCE ENHANCE THE RECRUITMENT OF YOUNG CLAMS?

The concept of furrowing mudflats, or erecting obstacles such as brush, netting, trees, etc., has long been considered a potential method for recruiting small clams. A few successes have been reported, and many failures. The Department of Marine Resources reported placing brush on flats in the 1940's and as recently as 1980, but could draw no conclusions. They have also tried sod and netting, but again, results were either unsuccessful or confusing. A clammer in Jonesboro reported success with brushing, but others in Maine have found the method a failure. As clam populations decrease, these ideas become increasingly appealing. Unfortunately, however, few records have been kept, and others have been lost. Consequently, we find ourselves repeating experiments done long ago.

In 1898 Kellogg reported that, on Narragansett Bay, "In some localities, where clams were abundant four or five years ago, very few can now be obtained." And in 1930, Belding wrote "Years of good set may be followed by poor, owing to the condition of the weather during the spawning season. Localities which have a large set one year may have none the next, merely because the conditions which brought about the set have changed. At best, the set is but a happy combination of two factors, the presence of larvae in the water, a fairly constant item, and the variable tide and current conditions of the particular locality." This is exactly the same type of situation that periodically recurs on flats throughout Maine--good years followed by bad.

Below are several excerpts describing the situation in Maine about 80 years ago.

> *"I have at this time no suggestions to offer as to restrictive legislation. To limit the size of the clam marketed as proposed by some, would be impossible of enforcement. The demand for the State of Maine clams is certainly rapidly increasing and as certainly the store is being depleted, the demand being more than the supply, therefore the price should naturally be enhanced--the supply gradually decreasing, the price as gradually increasing--then by the law of compensation where the price gets beyond a certain limit the pendulum will swing back, the demand will be less, the price will go down, and perhaps upon that theory of economics the clams will protect themselves and the State be as well off without a change in the present law."*
> (S&SF Biennial Report, 1899-1900, pp. 30, 31)

"About 1875 the fishermen began using fresh bait, and the clam digging practically stopped until 1885, when orders began to be received from Boston for clams in the shell to supply hotels and clambakes in the summer, and the public at large in the winter. Then commenced the depletion of these bivalves. Without any close time, and digging summer and winter, they began to diminish rapidly until the winter of 1905 and '06, when flats that had yielded six or seven thousand barrels the first years of their output only brought forth eleven hundred barrels last, and in the fall on 1906 the men who dug the most of the clams that were shipped last winter ordered three or four hundred empty barrels, and when they started to fill them, found there were no clams with which to do it, and were obliged to go to work at something else.

"The flats along the coast at the present time are in much the same condition."
(S&SF Biennial Report, 1905-1906, p. 51)

"The shore line of the State of Maine including the Islands is approximately two thousand five hundred miles in extent. Included in this territory are many thousand acres of more or less depleted clam bottoms, many entirely so, each succeeding year finds the situation becoming worse and the time is here when a remedy must be applied. In other branches of industry intensive cultivation of our natural resources is receiving grave consideration, more especailly where in any given instance the heritage of the masses is seriously threatened with extinction. A forcible illustration and object lesson is the present deplorable condition of our clam bottoms, which in many localities are nearly depleted, and in other places entirely destitute of clams."
(S&SF Biennial Report, 1917-1918, p. 43)

"Clams are dug on both sides of the York River for a mile and a half from its mouth, and about 2,375 bushels are taken annually, of which the greater part are sold to peddlers and sent to the interior; but of late years the species is said to have decreased in abundance."
(The Fisheries and Fishery Industries of the United States, George Brown Goode, 1887, p. 102)

Brushing, furrowing, etc., tend to create eddies and slow the water, allowing clams to drop to the sediment surface or to create currents which carry the larvae along the bottom, increasing their chance of setting. This phenomenon was noted at the beginning of the century. The problem with these methods is that they cannot improve the situation if there are no larvae in the water column. In years of abundant sets, the treatments are not necessary, although they may increase the set in a particular area and in years of no set, it appears that there are no clam larvae to be recruited. These methods are potentially the most effective in areas where there are young clams in the water column, but due to unfavorable currents they are unable to set.

For two years, furrowing and fencing experiments were tried in Jonesboro. For those two years, we found no set on the experimental flats. Both water sampling by plankton tows and mudflat sampling resulted in almost no clam larvae. This does not mean that the treatments won't work; it just means that they didn't make a difference in years of poor sets. We don't know how they would affect clam populations had there been a set. However, due to the tremendous output of energy and disappointing lack of results in 1980, the experiment was scaled down in 1981.

Experiment

Purpose:

To enhance the juvenile clams by erecting snowfence and digging furrows on the mudflat.

Background:

Young clams actively move around, crawling on the sediment surface, and occasionally entering the water column. Older larvae which are almost ready to set also inhabit the water column until they set on the sediment. These experiments were designed to encourage the setting of both larvae and juvenile clams—any clam less than 3/4 inch (2 cm). The snowfence and mounds both change the water currents immediately surrounding them. The water is slowed and redirected by the obstacles. It has long been suggested that this changed current regime might allow larvae or young clams to drop out of the water column more easily—either onto the sediment, or onto the snowfence directly in their path. Belding, in 1930, noticed increased clam abundances where natural obstacles occurred, and clammers have long observed dense concentrations of clams around rocks and fish weirs. Furrows have been suggested and tried by others—with the idea that roughing up the flat will provide the clams with a place to "hold onto" or with pools of water in which to set, burrow, and even continue feeding at low

tide. The clammers in Jonesboro decided to try some of these ideas in a methodical manner and document the results. If they worked, fine; if they didn't work, then they could establish that fact and try something else.

Procedure:

In June, 1981, three plots measuring 3 m x 2 m (1 m = approx. 1 yd.) were marked off on both Flat #1 and Flat #2. On either side of the river, one plot was dug with furrows (Figure 7); one plot had snowfence erected down the center (Figure 8); and one plot was left undisturbed, as a control plot.

Five random samples were taken in each plot both before and after the disturbances with a coring device measuring 10.5 cm diameter (Figure 9). Samples were taken 5 cm deep. Five more samples were taken in each plot once a month through October. At the site, each sample was sieved through a 1/50 inch (.5 mm) mesh screen, and preserved in 10% buffered formalin. In the laboratory, these samples were sorted under a dissecting microscope. The organisms which were found were counted and stored in 70% ethanol.

Figure 7. Furrow treatment (top left)

Figure 8. Snowfence treatment (bottom left)

Results:

Once again, there was no set on these flats between June and October. In 200 samples, only 54 juvenile clams were found. Consequently, we couldn't determine whether or not the treatments had any effect.

Management Implications:

1. Treatments of this type have occasionally been used in the past in shellfish management projects, but not on a continual basis: their success remains hazy. At this time, they should not be used as a management tool.

2. Given the uncertainty of a set in Jonesboro, experiments of this type should be done on a small scale.

3. Any town thinking about doing this type of experiment should realistically consider the time and effort required to get meaningful results. If the sampling regime is not carried through, then the work is wasted.

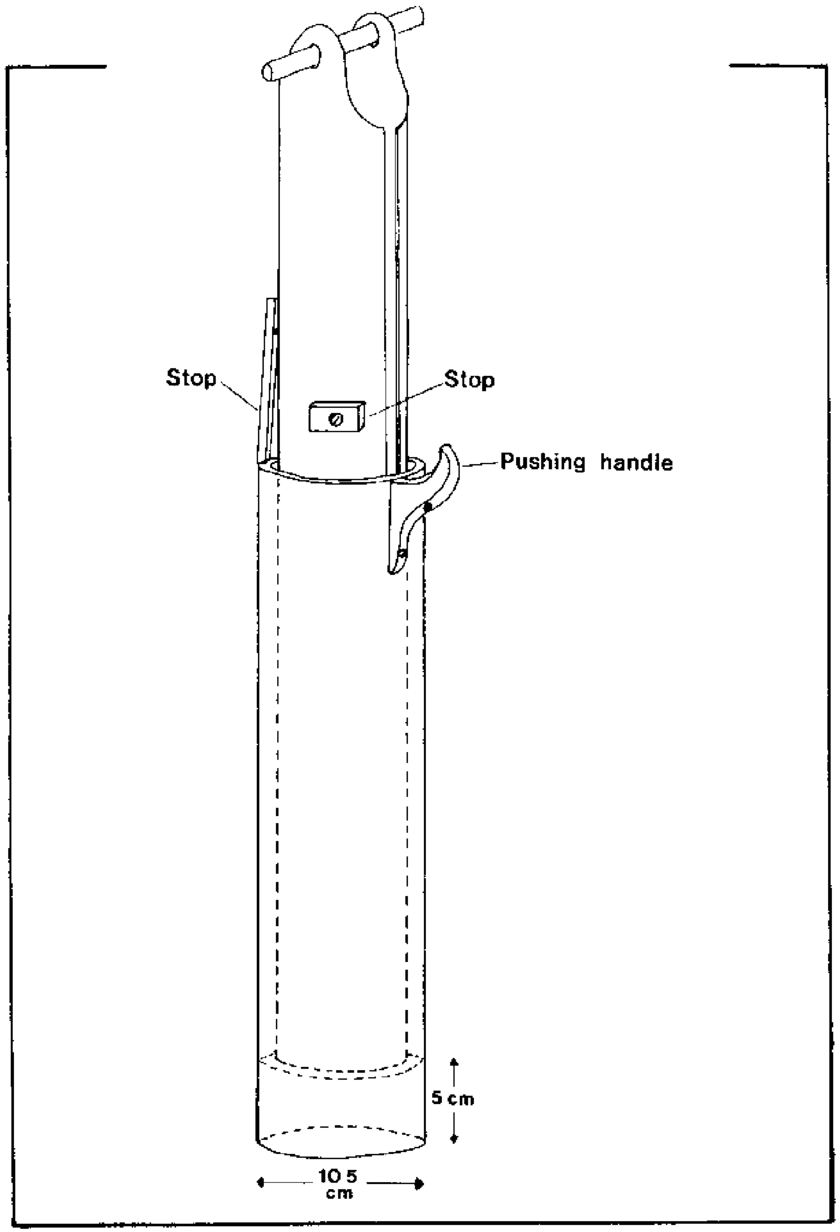


FIGURE 9. Coring device used for sampling the mudflat in Jonesboro, Maine.

HOW FAST DO CLAMS GROW IN JONESBORO?

Growth of soft-shelled clams is a subject which has been discussed and studied for many years. In 1930, Dr. Belding of Massachusetts noted that three major factors determine the growth rate of Mya. These were: 1) currents - faster currents bring more food past the clam; 2) length of time submerged - clams in upper intertidal areas grow slowly because they cannot feed during low tide periods; and 3) soil - a gravelly or rocky sediment may stunt the growth of a clam. All of these factors hold true 50 years later, and studies are presently investigating them in more detailed fashion.

In 1951, Dow and Wallace of the Department of Maine Resources published a report on mean growth per year for different areas of the state of Maine. The mean sizes estimated for the Jonesboro area were:

1 year	12.69 mm
2 year	22.3
3 year	32.23
4 year	41.85

By the Dow and Wallace estimates, on average, a clam needed four to five years to grow to market size in the area from Cutler to Portland. These figures vary from flat to flat. For any given flat, knowledge of the growth rate is an important management tool. It can help in determining time periods of flat closings and rotations, and the suitability of transplanting seed to or from an area. It is also useful in projecting the economic future.

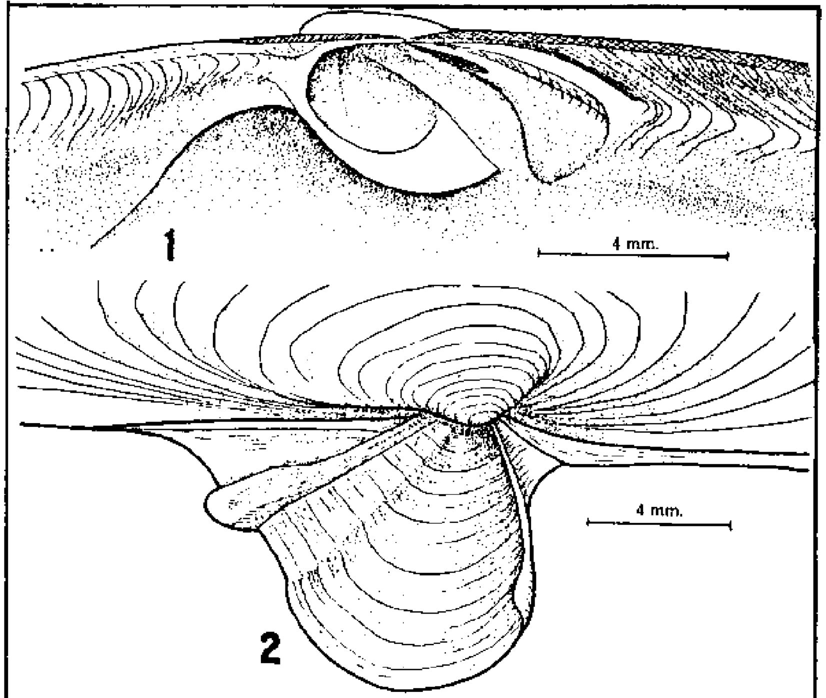


Plate 21. *Mya arenaria* Linné
Chondrophore of the right valve. Fig. 2. Chondrophore of the left valve.
Ruth D. Turner del.

Figure 10.

From Johnsonia. 1946. Mus. Comp. Zoo. Harvard University, Cambridge, Mass.

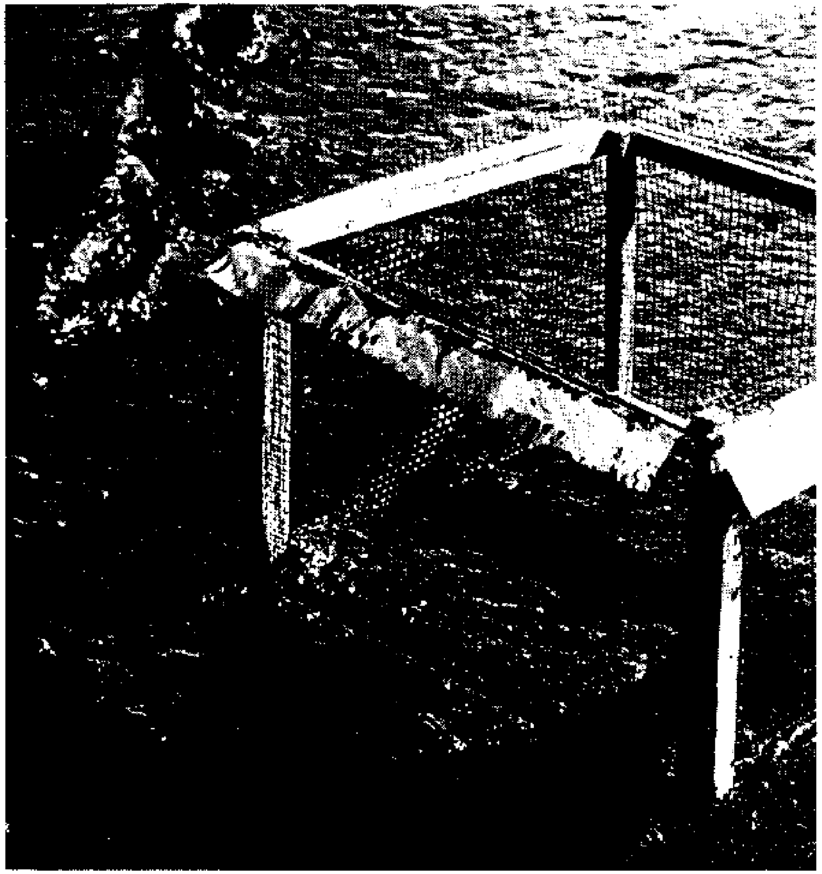


Figure 11. Cage to prevent predation

Experiment

Purpose:

To determine the growth rate of soft-shelled clams at three different tidal levels on a mudflat in Jonesboro.

Procedure:

Because most clam shell growth occurs from March to November, this experiment was seasonal, conducted from April through September. Clams averaging 15.15 mm length were stained with Alizarin (see section on Movement for procedure). It is a biological stain which is incorporated into new shell growth of a clam while it is exposed to the Alizarin. A line which is created on the chondrophore (Figure 10) of the clam, remains through its life.

In April, 1981, two plots measuring $(2\frac{1}{2}\ \text{ft})^2$ were marked off at each of three tidal elevations: -1.2 ft., -2 ft., and +1.2 ft. One plot at each level was enclosed with a cage to prevent predation by crabs and other large invaders (Figure 11). The second plot was left uncaged. One hundred and twenty clams, mean size 15.15 mm, were evenly placed in each plot, on a flood tide. The clams dug in rapidly, and were covered with water within 30 minutes.

The uncaged plot was sampled monthly from June to September to measure monthly growth increments. Clams in the caged plots were all retrieved in September to determine total growth over the entire summer.

The results were very encouraging. By September, at the age of 15 months, the clams averaged 33.00 mm at the mid-tide station and 36.78 mm (1½ inch) at the low tide station—the average size of a 3½ year clam according to the Dow and Wallace report. This means average growth of 17.85 mm - 21.63 mm in five months, with the largest growth increment occurring in June. Figure 12 illustrates the progression through the summer. Apparently the experimental Flat #1 was a very favorable growth area in 1981. This experiment should be repeated for several years to determine whether or not this growth rate persists. Although growth rate will slow as the clams get larger, the potential for a 2-2½ year 2-inch clam is very real.

The growth of the clams in Jonesboro compares very favorably with that of clams in other areas of Maine, according to preliminary results of experiments at the Darling Center, University of Maine, Orono (pers. comm., C. Newell). Growth of clams set out in trays for nursery culture was not as rapid, reaching roughly 2/3 of the length of juvenile clams grown in trays in Brunswick, Maine (see Clam Seeding section).

Management Implications:

The results indicate that Flat #1, and likely others along the Chandler River, is a potentially, highly productive flat.

1. If sets of small clams are found there, the length of time required for growout would be short, perhaps two years. This flat might well benefit from two-year closings.

2. If no seed appears on the flat, it might be a perfect location for transplanted seed.

3. The uncaged plots lost most of the clams planted in them, indicating predation problems.

4. At the upper plots, all clams, caged and uncaged, were lost—either to unknown causes or to predation by moon snails. The cages were effective, perhaps, in keeping out larger predators, such as crabs and seagulls, but had no apparent effect on the moon snails in the upper intertidal areas. Transplanting activities on this flat would probably be most successful at the mid and lower tidal elevations.

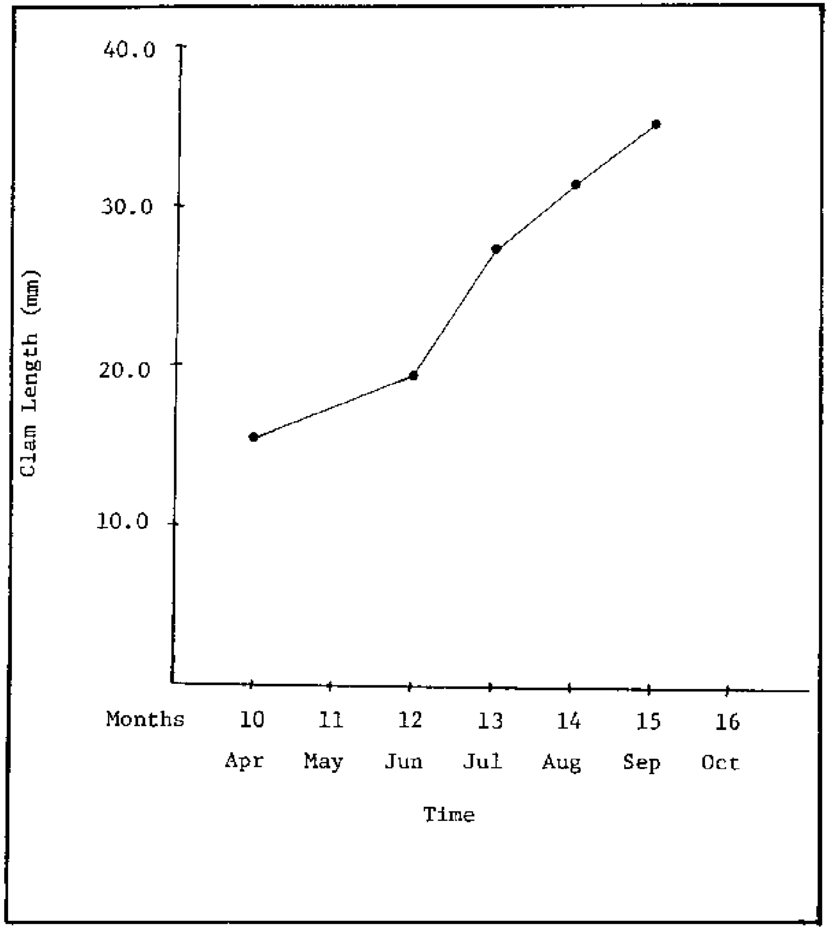


Figure 12. Chart showing growth of clams in low intertidal of Flat #1 from April, 1981 to September, 1981.

WHAT IS EATING THE CLAMS? IS PREDATION A LIMITING FACTOR?

Throughout its life, a soft-shelled clam has many different predators which change as the clams grow from a water-borne speck to a 2- or 3-inch steamer. During its first one to two months, while it floats in the water column, a clam may be eaten by zooplankton, small fish, or other, larger filter feeders who sieve the clams out of the water. As soon as it sets on the mud or sand, it probably becomes prey to almost any deposit-feeder who can swallow particles of a size similar to the clam. As it develops further, the clam outgrows some predators and becomes a perfect size for others. Research has shown that mummichogs eat clams less than 12 mm. A study done in Essex Bay, Massachusetts, found up to 49 small clams in the stomachs of these fish. Green crabs, moon snails, horseshoe crabs, and winter flounder are known to wreak havoc on clam populations when large numbers of the predators are around. When the clams grow large enough, they reach a "refuge size" where they are either too large or burrow too deeply for the predators to eat them.

Mortality of the larval clams is tremendous—a very high percentage will die or be eaten, and mortality of larger clams from green crabs has been well-documented by Department of Marine Resources biologists. Some years the crabs totally destroy the resource. This occurs more frequently in Southern Maine than it does on the eastern coast, because it appears that warmer waters mean more crabs. The juvenile stage, just after a clam has set, when it is on or almost on the surface of the sediment, is a time of high vulnerability to predation.

The object of this predation study was to determine whether or not predation is a problem in Jonesboro. The work was done in three sections:

1. Lab experiments were conducted to see if three common mudflat animals could and would eat *Mya*.

2. Crab and fish traps were set out in Jonesboro.

3. Observations of the mudflat at high tide were made to watch for predators which either come in with the flooding tide or emerge at high tide from hiding places.

Experiments

Purpose:

To determine if three common mudflat organisms can and will eat the soft-shelled clam, *Mya arenaria*.

Procedure:

Three common deposit-feeders were chosen due to their abundance and feeding patterns. They were the two-necked clam (*Macoma balthica*), the glass shrimp (*Crangon septemspinosus*), and a tiny shrimp-like animal (*Corophium volutator*).

Plastic pint containers were used for the experiments. In each run of the experiment, six replicates of each of the three animals plus controls were used. The containers were half-filled with sea water. One hundred clams were placed in each container. Shortly afterwards, a predator was placed in the container (Figure 13). Depending upon the

experiment, predators were removed and preserved in 10% buffered formalin 1-12 hours after being put into the containers. The remaining clams were then counted. The experiments were conducted both with and without mud in the containers. The size of the clams progressed from ¼ mm in Runs 1 and 2 to 1.5 mm in Run 5.

Results:

Crangon is clearly the most effective predator of the three used in this experiment (Figure 14). Macoma was next and Corophium the least effective. In all cases, however, there was some predation. In experiments sampled hourly, it was demonstrated that most of the predation occurred in the first six hours. Although these animals can and will eat small clams in the lab, this does not prove that the same relationship exists on the mudflat. However, in the case of Crangon, the possibility of large-scale predation of newly set Mya is likely. When these results are coupled with the field observations below, a potentially important pattern emerges.

Predator Traps and Snorkeling Observations:

Crab traps from the Department of Marine Resources and standard small fish traps were set out both on the mudflat and in channels leading out to the Chandler River on both sides of the river. The traps were set out during both day and night, and they were baited with a variety of foods, including clams, bread, and peanut butter. Only one crab was caught in the crab trap, while the fish traps caught no fish but did catch between 28 and 110 Crangon per tide!

While snorkeling at high tide, only two green crabs were seen, but literally thousands of Crangon were observed covering the surface of the mudflat. If Crangon do eat clams on the mudflat—and it appears that they do—then any juvenile clam would have had difficulty surviving with the high numbers of Crangon evident on the Jonesboro flats in the summer of 1981.

At the higher intertidal level, many shells were observed with moon snail drill holes, and moon snails were also seen. In addition, no clams in the growth experiment were retrieved from the upper intertidal section of the flat. Most had disappeared, although a few were found still in place with drill holes. Apparently, moon snails, along with raccoons and other terrestrial animals play a role as Mya predators in the upper intertidal zone.

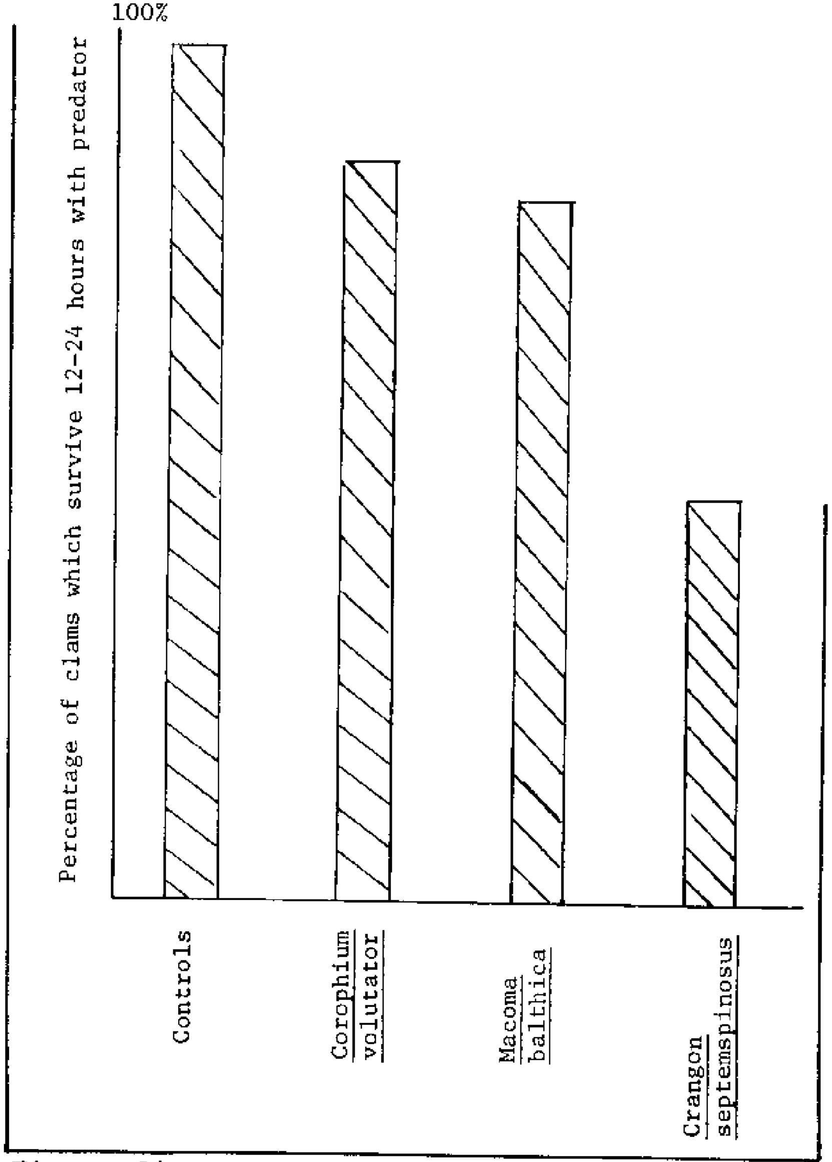


Figure 14. Precentage of clams, average size 1/100", which survived 12-24 hours with various predators

Management Implications:

1. Jonesboro does not appear at present to have a major green crab problem. Therefore, crab control devices such as fences and netting are unnecessary and likely impractical since the flats are very broad.

2. It appears that smaller predators such as the glass shrimp, may be numerous enough to have an effect on the clam population. Particularly in years when sets are sparse, this may may effect the yield of a flat. Because the size clam upon which Crangon may prey is very tiny—probably less than 1/16 inch—a clam will reach a "refuge size" quite rapidly. However, Mya has so many natural predators, that "refuge size" from Crangon probably means eating size for another predator. The biological response of soft-shelled clams to this predation has been to produce millions of eggs per female. Unless the clams are grown in a hatchery, protection from predators at this tiny size is difficult, if not impossible, as well as economically unfeasible.

IS THE MUD MOVING?

The mudflats along the Chandler River are, in large sections, bordered by eroding clay cliffs. The river itself is lined with mud and has, by some accounts, been silting in over the past 50-100 years. This study investigated whether or not large amounts of this mud were being desposited on the mudflat and therefore possibly effecting clam populations.

In Walpole, Maine, a detailed study conducted by Franz Anderson et al. (1981) measured sediment elevations on an intertidal mudflat to determine the changes in sediment volume. Their conclusion was that erosion occurred in the winter, and rapid accretion took place in the spring. Also, "...both erosion and deposition took place during the same time interval but on different areas of the mudflat. The data suggest that areas of erosion quickly became sites of accretion, indicating that an equilibrium surface level is being maintained." Results from the study in Jonesboro indicated the same pattern. Some areas gained sediment and some lost it, but there appeared to be no pattern according either to tidal elevation or location on the flat.

The sediment type on the Jonesboro mudflats is predominantly a fine silt-clay. In the fall, the sediment texture is the same over the flat. By the spring, however, the lower intertidal areas are much coarser than in the fall, with a higher percentage of gravel.

Siltation patterns in the river were not studied, but the U.S. Coast and Geodetic Survey of 1885 showed patterns similar to those of today (Figure 15).

Study

Purpose:

To determine whether or not mud is eroding and/or accumulating on the Jonesboro mudflats.

Procedure:

In June, 1981, steel stakes were driven into the mud in 15 locations on Flat #1 (Figure 16). Twelve stakes were also driven into the surrounding clay cliffs on both the east and west sides of the Chandler River. Sediment changes at the stakes were measured monthly from June-October, 1981. The measuring device, which was slipped over the stake, was accurate to ±.1 cm. It was constructed of clear plastic pipe about 18 inches long, with an attached disc 12 inches in diamter on one end. This disc rested on the average mudflat surface rather than in the local scoured area around the stake.

Results:

The results indicated monthly changes—sometimes accumulating mud, sometimes eroding. There were

Var'n 1887
Chandler's R.
Jonesboro
MACHIAS
Pond Cove
Pond Cove I.
Great Hd.
Shoppees Pt.
Squire's Pt.
Parker's Head
Bar I.
Natts Pt.
Bonney Pt.
Marsh I.
Gull Rk.
Calf Pt.
Hickey I.
Cod Head
Lakemans
Howard Mt.

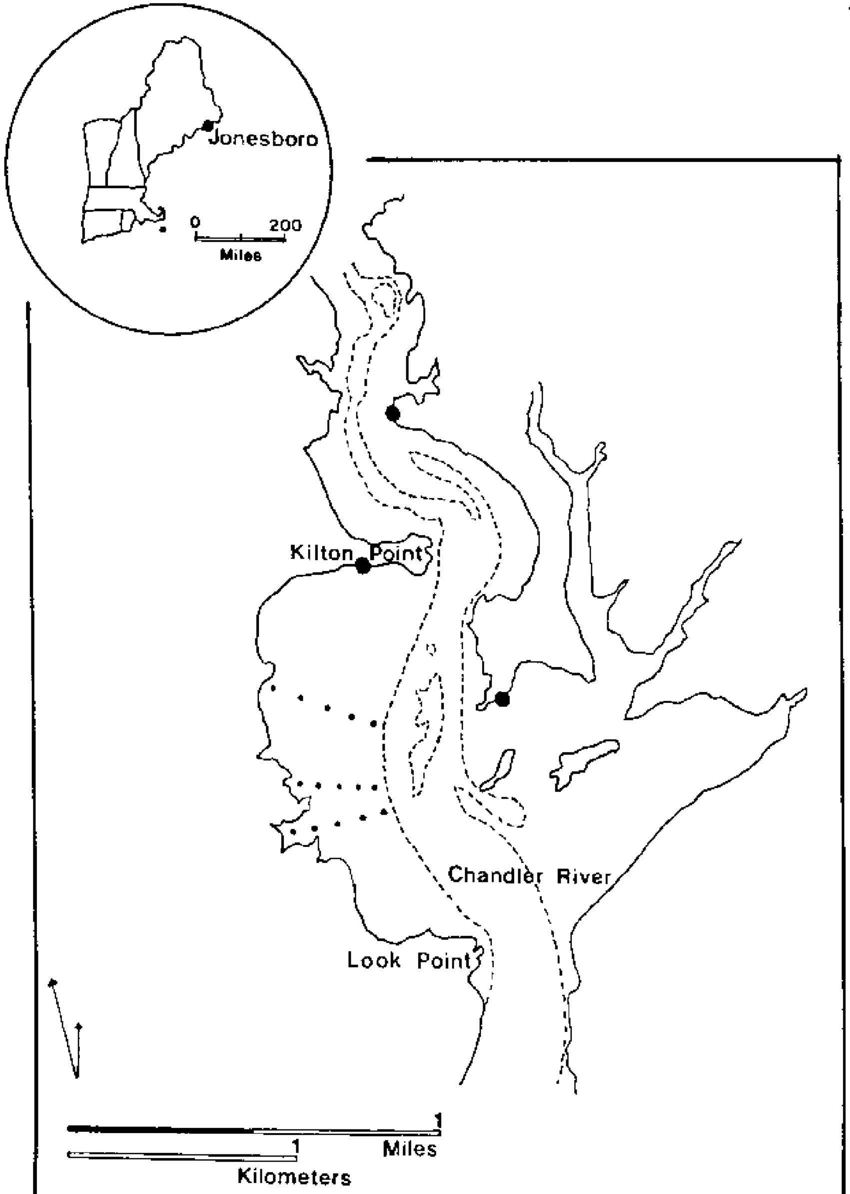
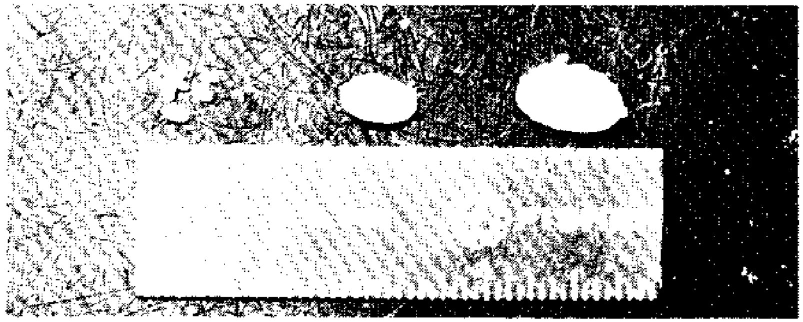


Figure 16.
Location of sediment stakes. • Individual stakes ● Group of three stakes on clay cliff.

no major changes and no overall trends. Although the measurements were taken in the season of least expected change, it is expected that the Jonesboro mudflats are similar to other slowly accreting flats in Maine.

Management Implications:

Results from this preliminary study indicate that rapid deposition or erosion is not a major factor effecting clam populations in Jonesboro. Most erosion occurs, however, in the winter months due to the higher energy wind conditions, affects of freezing and thawing, and the incorporation of surface mud into ice. A more extensive investigation would be required to pinpoint the relationship between the clay cliffs and the mudflat sediments.



From July to October, clams grew from 1/8" (.3 cm) to 1/2" (1.5 cm)

CAN HATCHERY-RAISED CLAMS BE SUCCESSFULLY SEEDED ON JONESBORO'S MUDFLATS?

As productivity of the clam flats in many Maine towns has dropped—primarily due to overdigging and lack of natural recruitment—attempts have been made to increase clam abundances through transplanting seed clams. The Town of Brunswick has been doing this successfully with a hydraulic dredge. Other towns have also attempted this procedure using dredges or, more frequently, by manually digging up the clams.

The latter method has been used for many years. Transplanting natural seed, however, is very cost- and labor-intensive, and many towns do not have an area of a consistent, dense set. The Clam Seed Program was created to test the viability of planting hatchery-raised seed on mudflats which have a history of high productivity, but which for various reasons have not been productive in the recent past. Jonesboro was a part of this project in conjunction with eight other coastal Maine towns. The four different phases of the project: 1) the hatchery, 2) the nursery, 3) seeding, and 4) follow-up sampling, will be discussed below. A more detailed report on this project, with results from all of the involved towns, will be completed and distributed later in 1982.

The Hatchery Phase

The aquaculture facility at the Ira C. Darling Center of the University of Maine at Orono, located in Walpole, was the site of hatchery activities. In this phase of the project, broodstock were brought to the hatchery from several different towns including Jonesboro. They were induced to spawn, and the young clams were raised to about 1/18 inch size, at which time they were shipped to the nursery sites.

Broodstock were placed into trays of seawater in rows. The temperature of the water was slowly raised to about 74-76°F, and food in the form of algae was added (Figure 17), as was sperm from one

Figure 17. Arrangement of clams during spawning procedure

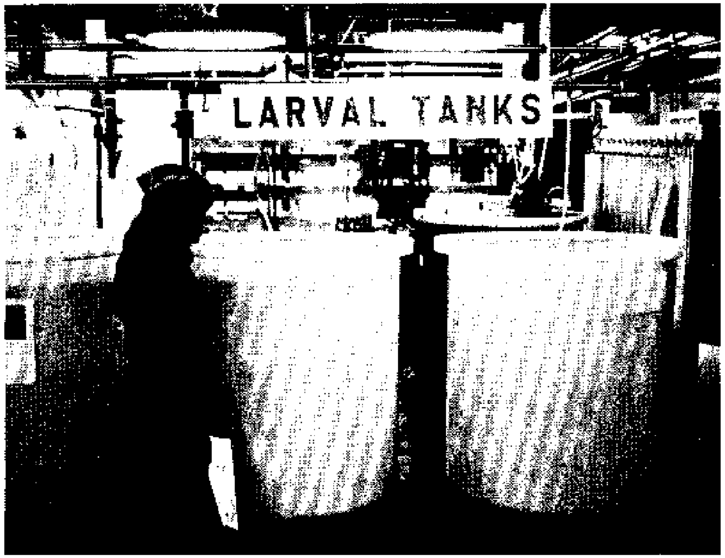


Figure 18. 100-gallon larval tanks

or more male clams. This usually stimulated the clams to spawn. As the clams began to release a white stream of sperm or eggs, they were each placed in a separate container of warm water. This sometimes happened within 30 minutes, or sometimes took 12 hours, or sometimes didn't happen at all, depending upon the stage of development of the clams' gonads. When an individual had stopped spawning, its bowl of sperm or eggs was placed in a larger bucket with other sperm or eggs—the two sexes were kept separate to this point.

When several million eggs had been collected, sperm were added to fertilize them, and they were placed in 100-gallon larval tanks (Figure 18) in 68°F, aerated water. The larvae quickly developed into a swimming stage and remained in the larval tanks for about two weeks (Figure 19). At the end of this period, when they measured about 1/100 inch, the clams settled out of the water column and were transferred to the juvenile system. Here they were placed in trays (figure 20), until they grew to 1/8 inch. Throughout the hatchery phase the clams were fed cultured algae from the algae room (Figure 21). In the summer of 1981, the clams were consuming over 200 gallons of algae per day.

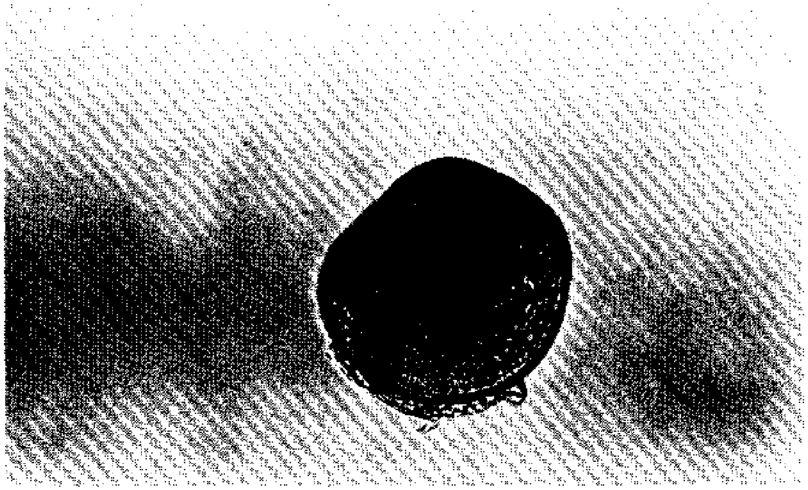
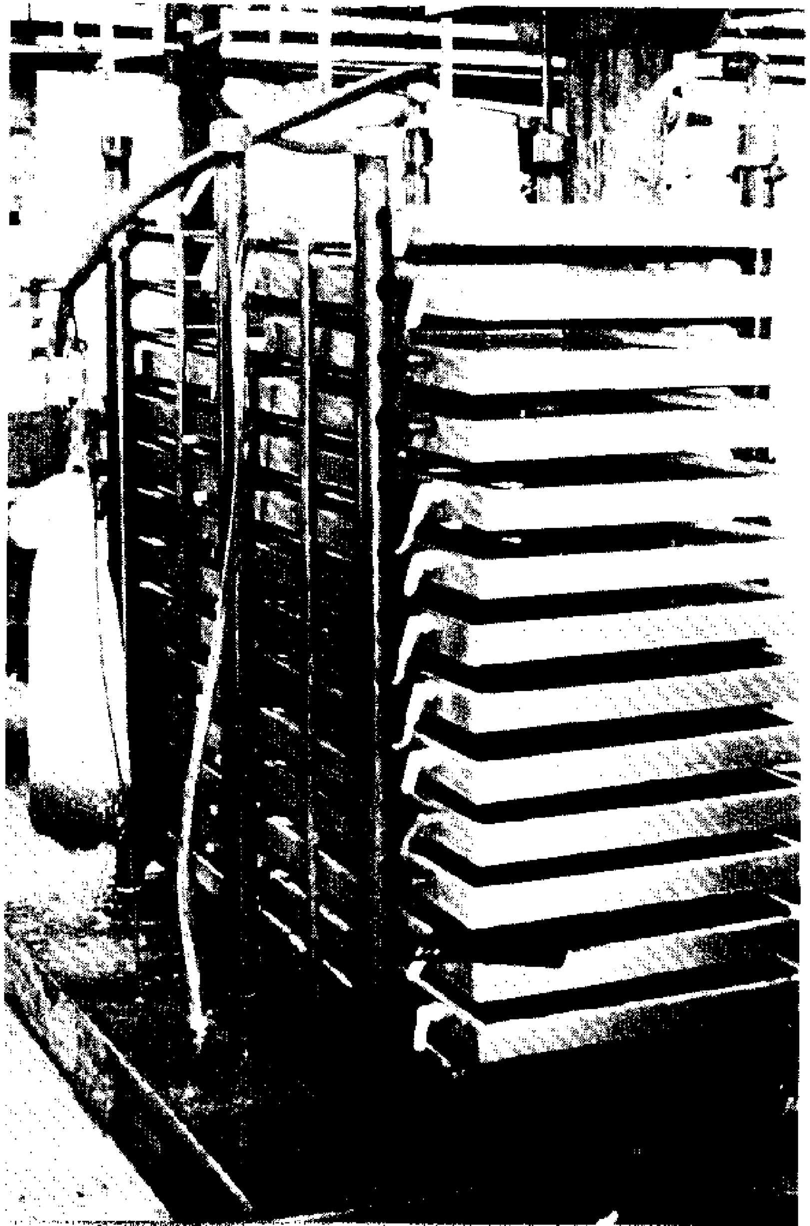


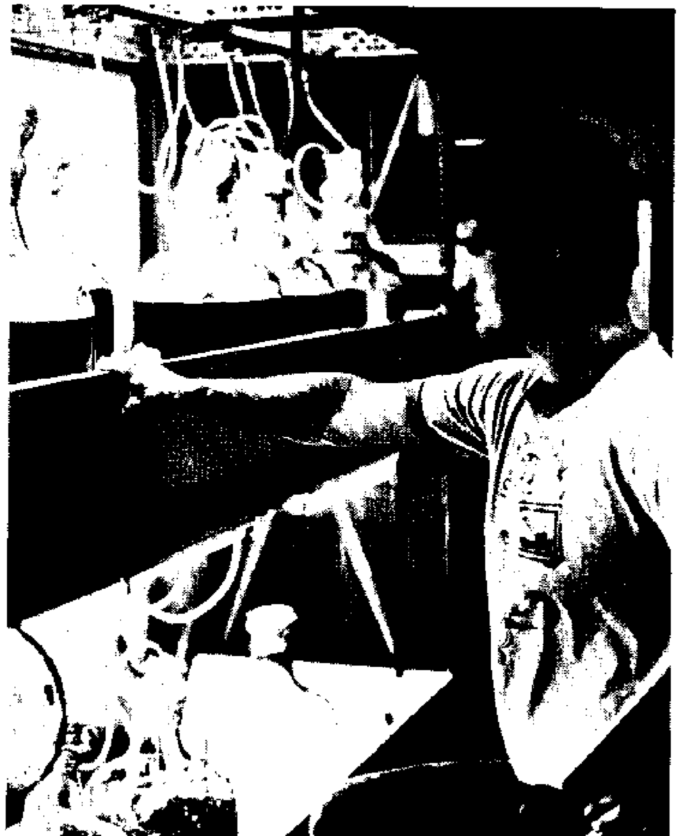
Figure 19. Clam larva

Figure 20. Clams placed in trays and left to grow until 1/8"



Clams were spawned on May 20, June 4, 5, 29, and 30. The juvenile clams were shipped to the nursery site in Brunswick every 7-10 days from July 20 - September 30, 1981. A shipment of about 50,000 clams was made to Jonesboro on July 30 to compare growth in trays in Jonesboro with growth at the Brunswick site.

Figure 21. Algae room



Nursery

The nursery site was located in Brunswick, Maine, in a warm, calm, protected section of the New Meadows River, where rapid bivalve growth had previously been observed (Figure 22).

About 7-10,000 clams were placed in floating trays at a density of 1000 clams/square foot (Figure 23). They fed on natural algae which circulated through the trays. The trays were cleaned at least once per week to reduce fouling. Three hundred trays were built and used in Brunswick. Six trays were used in Jonesboro. These trays were reinforced with silicon and cotton batting due to the rougher water conditions in Jonesboro. The Jonesboro trays were attached to the stern of a lobster boat moored in the Chandler River. Growth in these trays was good, but by September the average length was 8.1 mm as compared to 13.4 mm for clams from the Brunswick site. This difference was probably due to warmer water temperature and a greater food supply in Brunswick. The clams were removed from the floating trays in Brunswick in October for planting on the flats in Jonesboro and other participating towns.

Planting

On October 19, 55,000 clams averaging ½ inch were planted at two sites in Jonesboro: Flats 2 (Fieldman's) and 3 (Noble's Middle Ground). Plots measuring 50' x 20' were marked off with tires, and the clams were scattered evenly within these plots at an average density of $25/ft^2$. Five thousand stained clams were planted in the corner of each plot to aid in future growth calculations.

Figure 22. Nursery site

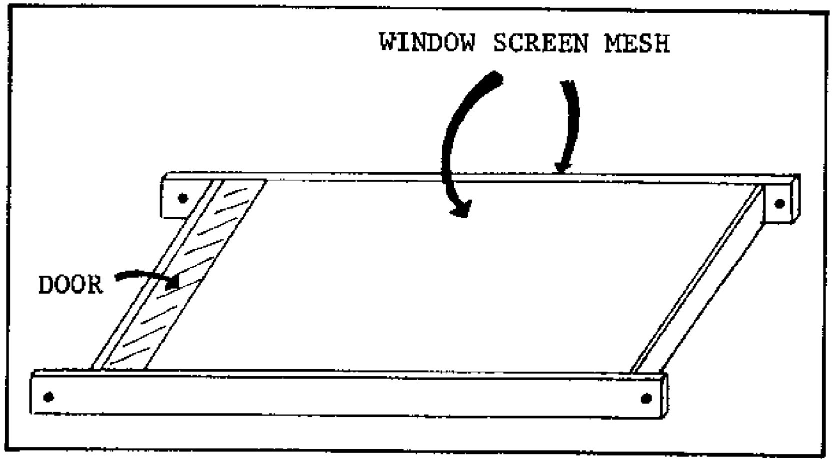


Figure 23. Floating Nursery Tray

Sampling

One seed plot was sampled before the planting, and both were sampled shortly after. A sampling regime will continue until harvest time. In March, July and November, 1982, five 2 ft.^{2} plots will be sampled for seed clams and five 36 in.^{2} areas will be sampled for spat. The clams will be measured and counted and results sent to the Darling Center, Walpole, Maine. Unless this sampling regime is adhered to, the success of this project cannot be assessed.

Results

The hatchery produced over three million 1/8 inch clams in 1981. Approximately 50% of those clams survived the nursery phase and reached an average size of almost ½ inch. These clams were distributed among the participating towns. Jonesboro received about 55,000 seed clams. An additional 50,000 were deployed in floating trays in Jonesboro and were put on bottom for the winter. They disappeared over the winter. The seeded plots will be sampled during the last week of March. Results of this project will be compiled by the Darling Center.

Management Implications

1. It is clear that raising clam seed in this manner is not at this time economically feasible. The cost per clam to ½ inch equalled about .6¢. This does not include the volunteer labor of many people in all phases of the project. Consequently, mature clams are selling for about 1/2¢ per clam or $24/bushel. Depending upon the mortality rate of the seed clams between planting and harvest, they could easily end up costing 1/2¢ per clam (with 50% mortality) to produce.

2. Until the project is completed, it is difficult to determine its success and potential for modification.

3. If the transplated clams do survive and grow well, the Town of Jonesboro might consider investigating a low-cost local hatchery operated by townspeople. Labor is the most expensive item in raising seed—if that can be volunteered, more options are possible.

4. If poor sets continue to be a problem in Jonesboro, transplanting seed from another source might be considered, keeping in mind predation problems.

5. Protection of clam management sites is of utmost importance for effective management and improvement of the clam fishery. Clearly no one will be willing to invest their time and/or money if the chances of poaching and destruction of experimental areas is likely.

A NOTE: It is very important that Jonesboro continue to sample and protect the seed plots. It may help the town determine whether or not transplanting seed, whether natural or hatchery-raised, is a viable possiblity for the future.

DO SMALL CLAMS MOVE?

As production for the Clam Seed Project got underway, spawning clams, clam eggs, swimming clams, and crawling clams were all represented. It was a prime opportunity to learn more about the behavior of young clams as they change from swimming to bottom dwelling animals.

As a young clam's swimming organ, or velum, becomes less and less functional, the clam goes into an intermediate lifestyle where it alternates between burrowing into the mud, attaching to objects by means of a threadlike byssus, and crawling along the surface of the sediments with its lobelike foot (Figure 25). With what seems to be a "adventurous spirit," a small clam explores its new benthic environment. This movement probably helps to prevent overcrowding. The young clams have a better chance of getting adequate food, oxygen, and burrowing space if they are well spaced.

Preliminary Experiment

Purpose:

To learn how much small clams can move.

Procedure:

Cut-off, plastic gallon milk containers were half filled with mud which had been sieved to remove clam predators. Two of the walls on each

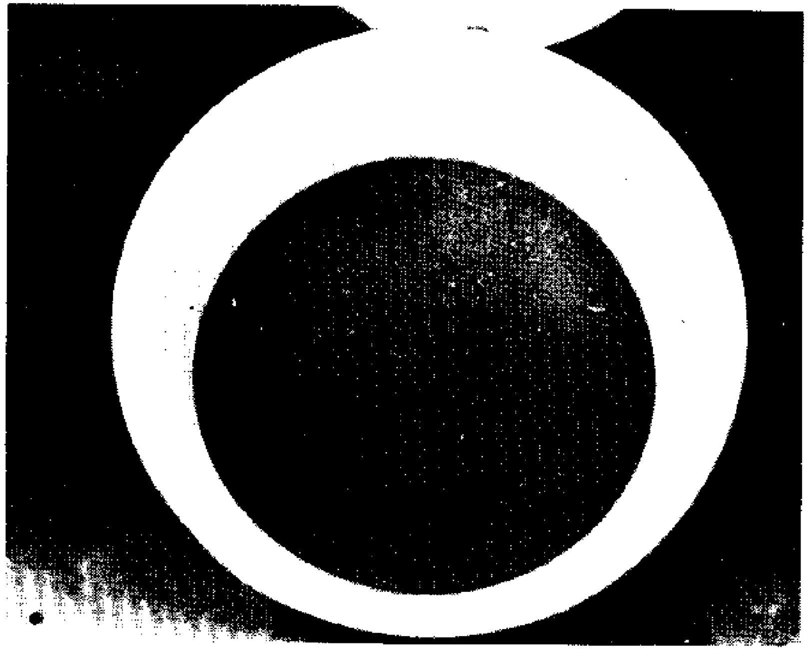


Figure 25. Juvenile clam tracks and burrows

container were replaced with 90µ mesh screen to allow circulation. The resultant tiny mudflats were then transferred to a flowing seawater tank. The water level rose above the mud surface but was not high enough to flood over the top of the container and allow the clams to escape. The circulation was continuous though not swift enough to physically carry the clams. The clams were then transferred into the experimental containers. They were initially placed within a one-inch circular barrier at the center of each container. After all the containers had been prepared in this way, the barriers were removed to allow movement (Figure 26).

A central circular area three inches in diameter was designated as Area A. From there out to the edge of the container was called Area B. This helped to categorize their movements (Figure 27). Samples were taken by randomly choosing a section of the container from which both Area A and B were sampled. No spot was sampled twice. The sampling device consisted of a length of ½ inch glass tubing with a plastic hose attached. By gently sucking on the hose, one could extract a small core of mud without disturbing the

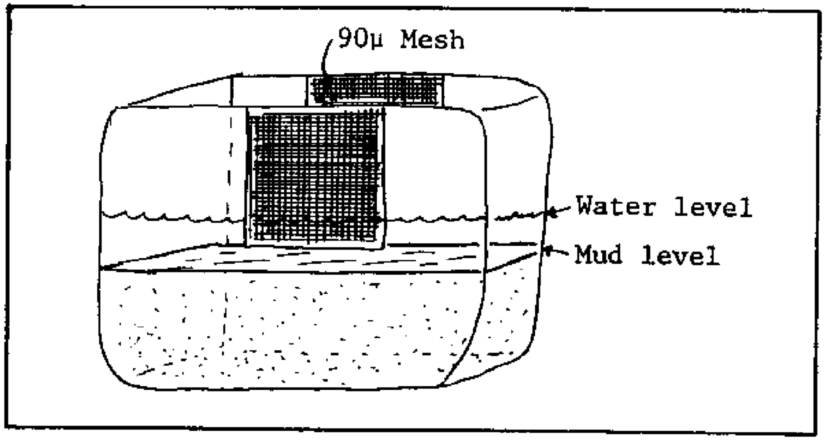
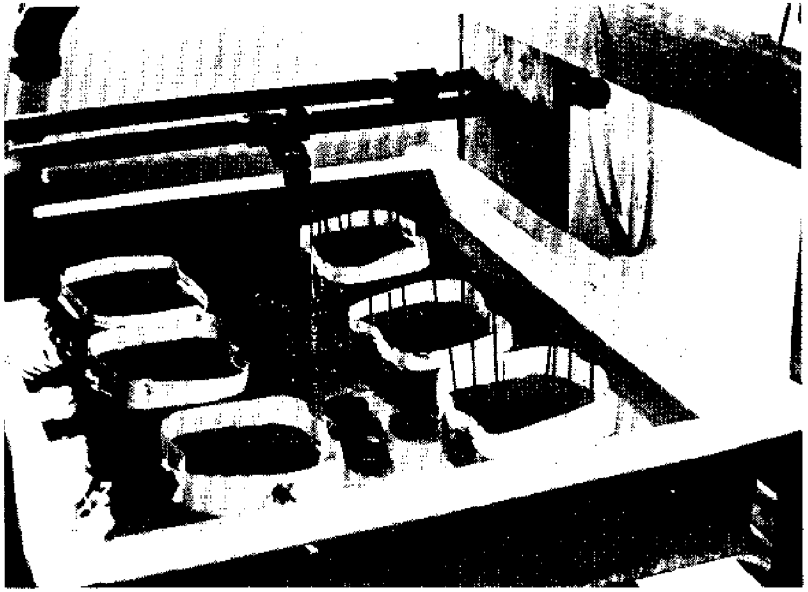


Figure 26. Sample Container - Side View



Arrangement of containers in clam movement experiment

surrounding sediment. The sample was then blown into a small jar and preserved in 10% buffered formalin until it could be examined. In the lab, the samples were individually sieved through 90u mesh screen to remove the mud, leaving the clams to be counted under a microscope. At first the samples were taken every few hours, then less frequently.

Results:

Of all the samples taken over a two-day period, none showed a trace of the juvenile clams. An examination of some mud from the center of the containers showed that the clams were still in the spot in which they had been originally placed. Some had burrowed in, but most lay on the surface.

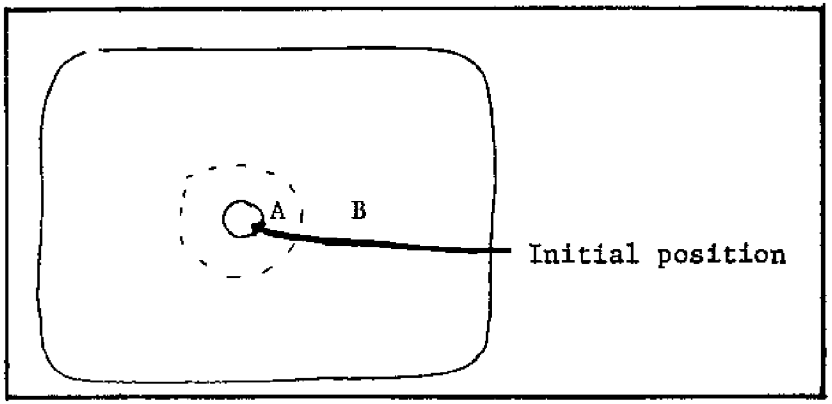


Figure 27. Sample Container - Top View

Main Experiment

The preliminary experiment led the way for a second. It was clear from the earlier results that samples should be taken less frequently and over a greater length of time. Nine containers with freshly sieved mud were set up in the flow-through tank. Juvenile clams of three size classes, 1/75," 1/50," and 1/25" were used. A total of 3,000 clams allowed for three replicate experiments of each size class.

The possibility that other small bivalves would enter the experiment through the water line and confuse the results was eliminated by staining the clams. The experimental clams were held in an aerated tank containing 25 ppm Alizarin red stain and fed a constant food supply for four days. They could be identified later by the concentration of red stain in the kidney which could be seen through the still transparent shell.

The clams were divided into nine groups, three of each size class, and were placed on the sediment. Initially they were confined to a one-inch circle with a barrier as in the preliminary experiment. All barriers were removed simultaneously. Samples were taken no less than four days apart over a five-week period. Preserved samples were sieved as before and counts made under a microscope.

		Numbers of Clams Found				
Size	clams/area	A-B	A-B	A-B	A-B	A-B
1/75"	A1	7-1	2-0	2-0	0-1	0-0
	A2	0-0	0-0	0-0	2-0	0-0
	A3	0-0	0-0	0-0	1-0	0-0
1/50"	B1	0-0	0-0	2-0	19-4	13-1
	B2	2-0	4-0	7-1	31-1	5-1
	B3	2-0	0-0	-	-	-
1/25"	C1	6-2	9-3	1-0	11-0	30-20
	C2	11-1	6-0	7-0	13-2	11-0
	C3	37-5	21-0	14-0	9-0	18-2
Date (1981)		7/23	7/27	8/8	8/12	8/28

Results:

The sampling dates were initially at regular intervals, but became less frequent when it became evident that the clam movement was very slow. As shown by the data in the above table and the graphic interpretation in Figure 28, it is obvious that all of the size classes were capable of actively moving. The largest clams were more active from the start, with the small clams moving more slowing and for shorter distances. Throughout the five weeks of the experiment, an equal distribution of clams over the area of their container was never observed. The more active

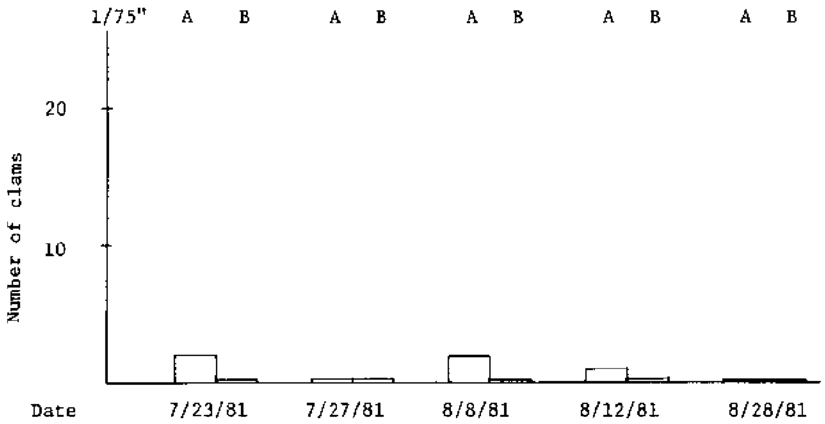
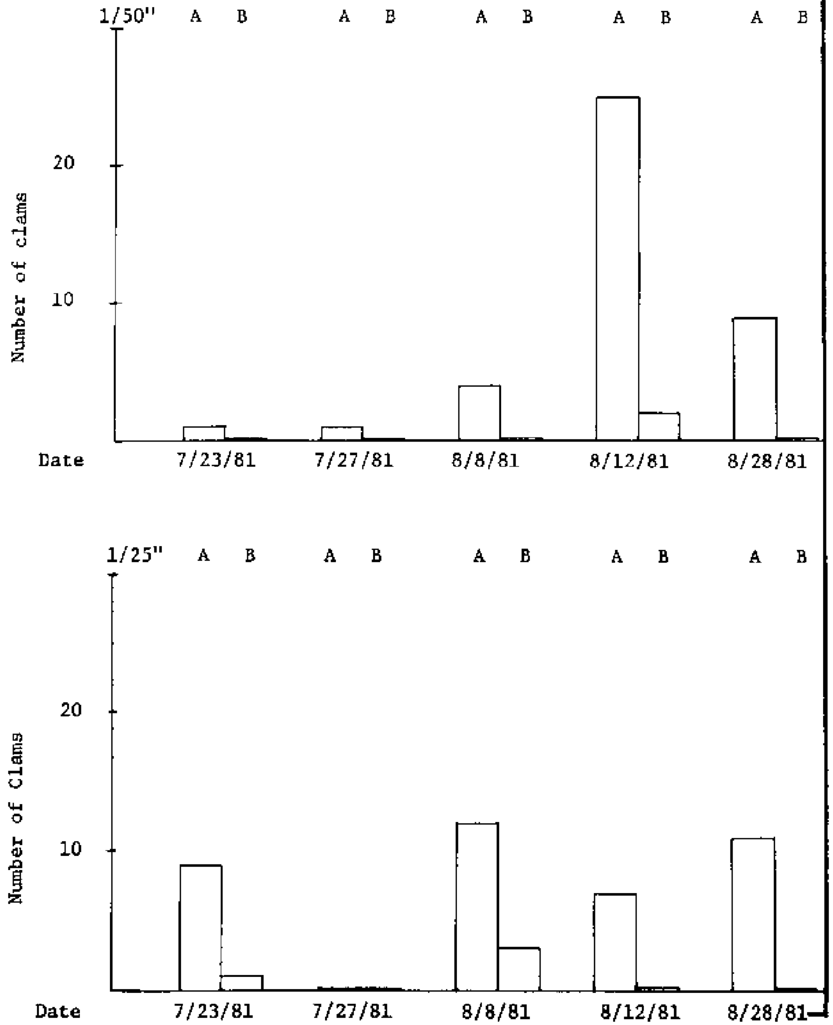


Figure 28. Movement of clams into Areas A and B over time.



movements of the largest clams may have been due to their greater competition for food, etc.

Management Implications:

1. Probably a larger, more sedentary size of clam would be more suitable for transplanting efforts.

2. Because small clams are so active, the value of manipulating them—to set on flats or to use for seed—must be seriously questioned.

SUMMARY

Some of the questions proposed at the start of this project have been answered, while others have not. In any case, a great deal of information has been gathered which will help to explain a little more clearly the processes in action on the mudflat. With this greater understanding, sound mangement of the clam fishery becomes more feasible.

1. Will obstacles set out on the flats, or furrows, or pools enhance the recruitment of young clams?

   Not consistently, and maybe not at all. They didn't help in the years of poor set. Perhaps in a more bountiful year they would make a difference.

2. What is the growth rate of clams on the flats in Jonesboro?

   The hatchery-raised clams grew an average of 19.5 mm from April to September. This is excellent growth, indicating the possibility of growing 2-inch clams in two to three years. This may vary, however, from flat to flat or year to year.

   Does growth differ with tidal elevation?

   Yes. Clams at the lowest intertidal stations had greater average growth than upper intertidal clams.

3. Is predation a limiting factor for clams in Jonesboro? What clam predators live there?

   Predation may be a limiting factor, particularly predation of very small clams. Glass shrimp appear to eat many clams and were very abundant. Moon snails also appear to have some effect in the upper intertidal areas. Green crabs were not dangerously abundant. Raccoons prowl the mudflat, and small fish may eat some clams. None of these larger predators, however, appeared to be destroying the clam populations.

4. Are the flats gaining sediment? Is this affecting clam abundances?

   This short-term study gave no indication that any unusually rapid changes in sediment composition of the mudflat were occurring. More detailed and longer term investigations may *be warranted to determine the rate and direction of sediment transport.*

5. Do tiny clams move?

   Yes. Small clams move, apparently more rapidly when they have reached a certain "threshold" size. They were observed moving over sediment and bare surfaces and clinging to obstacles in the water column. The rate of movement appears to be highly variable.

6. Can production of the clam fishery be enhanced by seeding flats with hatchery-raised clams?

   Until the results of the clam seeding program are in, the answer remains a question mark. At present, the system needs improvement if this type of management is to become economically feasible.

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