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MERCENARIA CULTURE USING STONE AGGREGATE FOR PREDATOR PROTECTION[1]

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ABSTRACT

A low technology method utilizing hatchery-raised seed clams and field grow-out techniques is presented. This technique appears to be economically feasible and can be carried out by non-technical personnel with a minimum of training.

The hatchery uses the Wells-Glancy (centrifuged, incubated seawater) method for raising food for the larval clams. The larvae set in 8 - 10 days and the seed are supplied with flowing seawater until they grow to 2 mm. The 2 mm seed were placed in nursery plots and protected from predation by a layer of gravel or crushed stone aggregate. Movement of the small clams was prevented by a system of baffles which enclosed and dissected the nursery areas. Field survival of a 1975 test group of 600,000 clams approached 75%. Costs of raising the clams for the first year are included.

INTRODUCTION

The hard clam or quahog, *Mercenaria mercenaria* (Linne, 1758), is a commercially important bivalve species along the Atlantic coast of the United States. Larval culture of *Mercenaria* has been carried out in laboratories (Calabrese and Davis, 1966; Chanley, 1961; Chanley and Andrews, 1971; Davis, 1958; Davis and Calabrese, 1964; Loosanoff, 1937, 1954; Loosanoff and Davis, 1950, 1963; Loosanoff, et al, 1951; and Wells, 1924, 1926) and a series of growth rate data for hybrid and natural populations in a number of geographical areas have been summarized by Ansell (1968). Most other work of commercial interest centers on enumeration of local stocks or the examination of habitat variables (Kerswill, 1941; Loesch and Haven, 1973; Pratt, 1953; Pratt and Campbell, 1956).

In spite of this extensive knowledge, no economic culture system for quahogs has been developed. In order to be economically feasible and competitive with wild harvest, mariculture of *M. mercenaria* must be based on simple inexpensive hatchery and culture techniques. In order to grow clams inexpensively, it appears that they must be grown in natural waters for at least part of their lives and harvested when they reach the most desirable size. Control of the seed population during field growth is critical. Predation and loss of small clams that are washed out of the substrate by currents and/or wave action are the most serious problems in field maintenance of clams.

The method described here eliminated or controlled many of these problems. Seed clams as small as 2 mm were successfully reared in prepared beds and predation was controlled to acceptable levels. This simplified method appears to be adaptable to culture of other infaunal species, if appropriate alterations are incorporated for local conditions. We have chosen to explain in detail the equipment and methods utilized because there are no literature sources we are aware of that provide this information.

The methods adopted and described provided a

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compromise between cost-effective methods and available technology.

Description of Area

The hatchery and grow-out facilities were located on the eastern side of the Delmarva Peninsula in Wachapreague, Virginia. The nursery area was located in Bradford's Bay about ¼ mile from the hatchery. This small shallow bay was part of a logoon system separated from the Atlantic by a series of barrier islands on the east and the peninsula to the west (Newman and Munsart, 1968). The bay has a muddy substrate fringed with *Spartina alterniflora*-dominated salt marshes and a mean tidal amplitude of 1.2 m. The salinity and temperature of this area ranged from 17-32 ‰ and 2-28 °C respectively. Due to the winds, tide and the shallowness of the bay, it was usually extremely turbid. Ice cover formed over the entire bay for short periods in cold years, and fringing ice was common in January and February.

The nursery area was subtidal except for spring tides when approximately half to two-thirds of the bottom was exposed. At mean low tide it was covered by about 20 cm of water.

EQUIPMENT AND METHODS

Larval rearing facilities

The larval food and larvae culture was housed in a 7.3 × 19.2 × 3.2 m wood-framed solarium covered by corrugated fiberglass panels. The 8 tanks for culturing unicellular algal food were 1.2 × 2.4 × 1.2 m and held about 3000 L. The tanks for growing larvae were 1.2 × 1.2 × 1.2 m and held approximately 950 L. Both types of tanks were constructed of plywood coated with fiberglass and had exterior wood and metal braces. In addition, larvae were also grown in cylindrical tanks referred to as conicals. The conicals held 1000 L and were 1.2 m in diameter and 70 cm tall with a 30 cm deep cone shape bottom. These containers were formed fiberglass and were used interchangeably with the wooden larval containers.

Screens

Assorted screens were used for separating eggs and larvae from seawater, and for sorting larvae and post-set plantigrades into different size groups. These screens were constructed of 25 or 30 cm diameter plexiglass tubing cut to the proper length to act as frames for the various screens. Woven nylon mesh cloth (Nitex) was then glued to the tubing using 1, 2-dichloroethane.

Heat exchanger

A 7.6 m coil of polyethylene tubing 1.2 cm in diameter immersed in a fresh water bath was used to raise water temperature in the spawning trough. The water bath was a 75 liter polyethylene container (trash can) with a 40 amp electric calrod immersed in the water. The temperature of the water in the spawning trough was controlled by diluting the flow of warmed seawater (flowing through the tubing in the water bath) with ambient seawater.

Seawater system

Seawater was pumped from a tidal creek in front of the laboratory. Water temperature ranged from 12.0 °C to 28 °C during the period of operation, and salinity was similar to that reported for Bradford's Bay.

The pumps were 5 cm cast iron centrifugal single volute pumps driven by a 3 hp electric motor. The intake and all saltwater lines and valves were plastic. Seawater entering the grow-out facility was used without modification. The seawater pumped to the solarium passed through an industrial model (Sharples AS-14 clarifier) continuous flow centrifuge which spun the water at 15,000 RPM in a 15 cm stainless steel tube, exerting a centrifugal force of 13,200 x G.

Centrifuging seawater removed most of the silt and clay particles, larger diatoms and all zooplankton and eggs from 1700 L/hr and only particles and algae with a density about equal to seawater remained. The centrifuged water was piped to 3000 L algal growing tanks, where the water was gently aerated to prevent the algae from settling. This water remained in these tanks while the algae bloomed. At temperatures over 22 °C blooms occurred within 24 hours, but at lower temperatures (14 °C) 48 hours or longer were necessary. A typical mid-summer bloom would contain *Heteromastix*, *Chaetoceros*, *Nitzschia*, *Chorella* and others. This culture of mixed wild algal species varied in quantity and composition

from season to season, but under most conditions there was more than sufficient food for the developing larvae. The incubated water was used undiluted as the growing media for the eggs through early post larval seed.

Ultraviolet light

To control bacterial infections of larvae, the incubated seawater was flowed through an ultraviolet radiation unit similar to the Kelly- Purdy unit (described by Kelly, 1961) before it was pumped into the larval tanks. The UV unit is 2.8 m long, 90 cm wide, 10 cm deep, and water being sterilized flowed over a series of staggered baffles 1.5 cm high. A reservoir and dam at the intake end of the unit and an overflow reservoir at the discharge end controlled the depth of the water being treated to 5 mm. The unit had 12 40-watt sterilamps 92 cm long spaced equidistant across the unit. Tests indicated the Kelly-Purdy unit reduced the bacterial content of seawater to acceptable densities at a flow rate of 150 L/min (Presnell and Cummins, 1972). Since the maximum flow in our system was 126 L/min, it was assumed that bacterial densities were reduced to acceptable levels. This ultraviolet unit was used only when high mortality rates, high densities of bacterial-feeding protozoans or obvious bacteria swarms were observed in cultures.

Cleaning

All containers used for larvae were washed after each use with mild biodegradable detergent and fresh water, thoroughly rinsed with hot water and allowed to drain dry. Immediately before use they were rinsed with clarified seawater, drained and filled with clarified incubated water.

Larval culture technique

Spawning stocks. Adult clams were collected primarily from wild populations. By utilizing clams from the southern coastal states of Georgia, South Carolina and North Carolina, culture of larvae was started in early March without conditioning. Spawning was accomplished through October by selecting clams from different regions, moving north as the wild clam stocks become ripe. Since clams were easily shipped from place to place, this system eliminated the need, equipment and cost of conditioning. In addition, the faster growing clams from previously grown groups were also used as spawners when they became ripe.

Spawning. Spawning was accomplished in a fiberglass trough 3 m long x 30 cm wide x 13 cm deep. Incubated seawater at about 22-24°C was streamed over 50 to 100 clams for about 30 minutes or until most of the clams had siphons extended. The temperature of the seawater was then increased to as high as 32°C and dropped back to 24°C by draining and adding cooler water at about 30-minute intervals to induce spawning. If these temperatures and depth fluctuations did not induce spawning, a clam was sacrificed, and the gonadal material stripped and added to the trough. This usually induced spawning in a few individuals, and since clams are gregarious spawners, a mass spawning followed. The water containing the sperm and eggs was drained through a 25 μ nylon screen. The sperm water passing through the screen was collected in a container and, if necessary, returned to the spawning trough to further stimulate the clams. The eggs were trapped on the screen. As the screen clogged with eggs, cultured water was used to rinse them into a calibrated 20 L container. When several million eggs were in the container, they were thoroughly mixed by stirring with a plastic plunger and subsampled. The 1 ml subsample was withdrawn by pipette and placed on a 1 ml Sedgwick-Rafter counting cell and the eggs were counted under a microscope.

While the eggs were being counted, the larval growing containers were filled with the clarified incubated seawater. The eggs were distributed into the filled containers at a density of approximately 15-20 eggs/ml.

About 40 hours after fertilization the larval tanks were drained through 35 μ mesh screen which caught the veliger larvae. These were concentrated in 10-15 liters of clarified water and poured through a series of screens ranging from 80 μ to 35 μ mesh. The larvae collected by each screen were placed in separate 20 L calibrated containers, the containers were filled to 10 or 15 liters and subsampled and counted using the same technique described above. The larvae were measured and observed microscopically. If large numbers of abnormal or poorly developing larvae

were present in a given screen size, they were usually discarded. After counting, larvae were redistributed in clean larval growth tanks filled with new clarified and incubated water. This procedure was followed on Monday, Wednesday and Friday until the larvae metamorphosed and set.

Setting. Metamorphosis and setting occurred after 8-12 days under normal operating temperatures. During this process the velum degenerates and the plantigrades creep about with a well-developed foot or fasten to the slide with a byssus (Carriker, 1961). Setting was apparent when the larval tanks were drained. The set clams were attached by a byssus to the tank sides and bottom and often required a jet of water to dislodge them. The larvae did not all set at the same time, but the set clams were easily separated from the veliger larvae by pouring the water and swimming veligers from the containers in which they were concentrated into another container. The set clams remained attached to the bottom by their byssus and were then taken to the grow-out facility.

Grow-out facility

Equipment. The grow-out wet tables were 1.2 x 2.4 m and 6 cm deep constructed of wood and coated with fiberglass resin. There was a dam 8 cm high at the head end and a 6 cm dike at the outlet end. The tables were supplied with a continuous flow of unaltered seawater.

The salt water system in the grow-out facility was similar to that in the solarium. It had duplicate intakes, pumps and pipes, which allowed one set to be in use for one week while the other system was allowed to stand without draining. The stagnant water in the pipes becomes anoxic, causing the death of fouling organisms which may have attached in the pipes. After a week this line was flushed out and put into use while the other line was allowed to stagnate.

Grow-out techniques

Grow out of seed. The newly settled clams were moved from the larval facility and washed onto the grow-out tables. The flow rate was regulated to about 1 L /min when clams were first placed on the table, and later increased to about 10 L/min.

Fouling organisms, especially sea squirts, *Molgula manhattensis*, were a problem on the grow out tables. The *Molgula* larvae entered with the water, set on the tables, and smothered the clams. The *Molgula* were controlled by draining the tables and allowing the clams on the tables to air dry for about 3 hours per day, 5 consecutive days of each week. Any remaining squirts were removed during the two to three week screening when accumulated sediments were removed and the clams sorted by size.

The clams were kept in this system about 6 weeks or until they could be collected on a 2 mm mesh sieve. They were then planted in the field nursery plots.

Field nursery techniques

Equipment. Current baffles were constructed of 1 cm diameter steel rod and 7 × 7 mm mesh plastic screen. The steel rod was made into a rectangular frame 0.6 m high and 1.5 m long with a 0.9 m leg extending down on each side. The plastic screen was fastened to the 0.6 × 1.5 m frame with 3 mm polypropylene line. To install current baffles the legs were pushed into the bottom until the plastic touched the substrate.

A 13 mm mesh plastic net 2 m tall surrounded the clam planting site. This net was supported by 10 × 10 cm poles pushed into the bottom approximately every 3 meters. The net bottom was weighted down by a 6 mm chain fastened to the bottom with 3 mm polypropylene line. This chain was embedded about 10 cm into the soft mud bottom.

Predator protection. A major predator of small clams is the blue crab, *Callinectes sapidus.* Preliminary experiments indicated that crushed rock aggregate provided some protection against this predator. Approximately 75% more small clams survived in aggregate than in control plots. To further reduce crab predation, baited commercial crab traps were also placed in the clam planting area and fished 3 to 5 times per week.

Another group of major predators on juvenile and adult clams are rays of the families Dasyatidae, Myliobatidae and Rhinopteridae. Large schools of these rays may enter an area and destroy the clam populations. The 2 m high net protects the seed clams against these predators and prevents larger blue crabs from entering the plots.

Wash out prevention. The second major problem, when 2 mm seed clams were used, was that they pushed out or were washed out of the bottom by waves and were carried away by tidal currents. Laboratory experiments indicated that clams 3 mm in width could be moved by current velocities as low as 15 cm/sec (0.3 knot current). The baffles prevented the current from moving small clams from the aggregate bed.

Preparation and planting of nursery plot. The nursery area was prepared by first placing a series of current baffles in squares. To conserve baffles, they were placed next to each other to share a common panel between two squares (Fig. 1).

A crushed stone aggregate of 1-3 cm chips was then broadcast into each square to a depth of approximately 4 cm. The aggregate was then leveled with a rake and allowed to stand. After about one week the nursery pens were examined. The pens should contain a thin layer of silt over the gravel or aggregate. If this layer does not appear, the currents across the bottom are too strong and more baffles should be implanted. If the silt becomes too heavy, some baffles should be removed or the small clams will work up into this layer above the protecting aggregate. Once the area had been stabilized, small clams were broadcast over the aggregate at an average density of approximately 31/sq. m.

RESULTS

Hatchery production utilizing this method has yielded sets of 120, 97 and 55 $\times$ 10^6 *Mercenaria* in 1975, 1974 and 1973 respectively. Additonal species have been produced concurrently. Estimated hatchery production to field size for *Mercenaria* (again as one of several species) is 15 - 20% of set for each year. These latter estimates could be substantially improved with greater care given to one species.

At the growth rate exhibited by these clams, it was estimated that they would reach the desired little neck size (1" depth) in 22 to 28 months. This estimation later proved to be correct.

The cost for 600,000 clams planted in the field averaged \$0.015 per clam. This cost included estimated interest on a loan sufficient to begin a hatchery, labor, utilities and all supplies. The only additional charges would be maintenance of the field plots and harvesting. Maintenance costs for two years should not exceed \$0.005 per clam and harvesting cost is estimated to be about \$0.002. The curent market value for prime sized little neck clams in this area is about \$0.05.

Following the first winter's growth, five samples were taken in each of 41 squares of aggregate (½ of the test squares). Average survival was in excess of 75%, and included samples of 5 squares of clams planted at less than 2 mm which were lost.

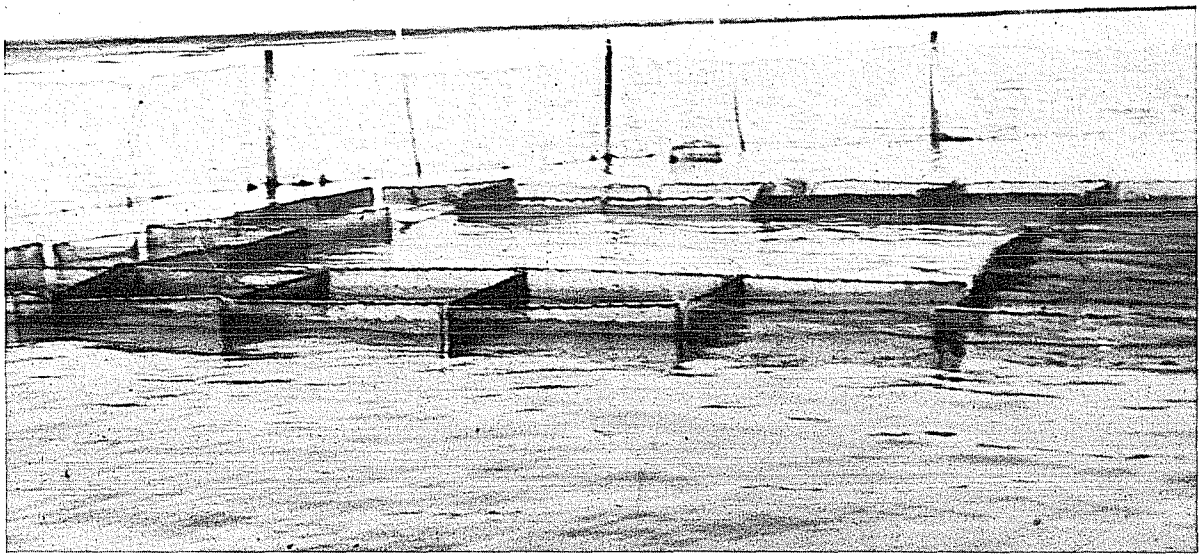

FIG. 1. *View of nursery area showing baffles in foreground and 2 m net in background.*

During the summer some severe predation was observed, but this was controlled by raising the height of the fence so that it was submerged only during spring tides. In addition the number of crab pots inside the fence was increased from 4 to 8. Preliminary calculations indicated that a commercial operation would be economical with 40% survival of the planted clams.

Experiments to reduce the cost of the clams planted in the field are being conducted this summer. These experiments are designed to eliminate unnecessary components and thus reduce costs.

LITERATURE CITED

Ansell, A.D. 1968. The rate of growth of the hard clam *Mercenaria mercenaria* (L.) throughout the geographical range. J. Cons. Perm. Int. Explor. Mer. **31**:364-409.

Calabrese, A. and H. C. Davis. 1966. The pH tolerance of embryos and larvae of *Mercenaria mercenaria* and *Crassostrea virginica*. Biol. Bull. **131**:427-436.

Carriker, M. R. 1961. Interrelation of functional morphology, behavior and autecology in early stages of the bivalve *Mercenaria mercenaria*. J. Elisha Mitchell Sci. Soc. **77**:168-241.

Chanley, P.E. 1961. Inheritance of shell markings and growth in the hard clam, *Venus mercenaria*. Proc. Nat. Shellfish. Assn. **50**:163-168.

Chanley, P. and J.D. Andrews. 1971. Aids for identification of bivalve larvae of Virginia. Malacologia **11**:45-110.

Davis, H. C. 1958. Survival and growth of clam and oyster larvae at different salinities. Biol. Bull. **114**:296-307.

Davis, H. C. and A. Calabrese. 1964. Combined effects of temperature and salinity on development of eggs and growth of larvae of *M. mercenaria* and *C. virginica*. U.S. Fish Wildlife Serv., Fish. Bull. **63**:643-655.

Kelly, C. B. 1961. Disinfection of sea water by ultraviolet radiation. Amer. J. Publ. Hlth. **51**:1670-1680.

Kerswill, C. J. 1941. Some environmental factors limiting growth and distribution of the quahog, *Venus mercenaria* L. Ph.D. thesis, Univ. Toronto, 104 pp.

Loesch, J. G. and D. S. Haven. 1973. Estimated growth functions and size-age relationships of the hard clam, *Mercenaria mercenaria*, in the York River, Virginia. Veliger, **16**:76-81.

Loosanoff, V. L. 1937. Spawning of *Venus mercenaria* (L.). Ecology **18**:506-515.

Loosanoff, V. L. 1954. New advances in the study of bivalve larvae. Amer Scient. **42**:607-624.

Loosanoff, V. L. and H. C. Davis. 1950. Conditioning *V. mercenaria* for spawning in winter and breeding its larvae in the laboratory. Biol. bull. **98**:60-65.

Loosanoff, V. L. and H. C. Davis. 1963. Rearing of bivalve mollusks. *In* Advances in Marine Biology, Vol. I. F. S. Russell, Ed. Academic Press Inc., London and New York, 1-136.

Loosanoff, V. L., W. S. Miller, and P. B. Smith. 1951. Growth and setting of larvae of *Venus mercenaria* in relation to temperature. J. Mar. Res. **10**:59-81.

Newman, W. S. and C. A. Munsart. 1968. Holocene geology of the Wachapreague lagoon, Eastern Shore Peninsula, Virginia. Marine Geol. **6**:81-105.

Pratt, D. M. 1953. Abundance and growth of *Venus mercenaria* and *Callocardia morrhuana* in relation to the character of bottom sediments. J. Mar. Res. **12**:60-74.

Pratt, D. M. and D. A. Campbell. 1956. Environmental factors affecting growth in *Venus mercenaria*. Limnol. Oceanogr. **1**:2-17.

Presnell, M. W. and J. M. Cummins. 1972. Effectiveness of ultra-violet radiation units in the bactericidal treatment of seawater. Water Research, **6**:1203-1212.

Wells, W. F. 1924. First report of station for shellfish culture. New York State Conservation Commission Annual Report, 98-117.

Wells, W. F. 1926. Report of experimental shellfish station. New York State Conservation Commission Annual Report, 112-130.