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Manual for Growing the Hard Clam Mercenaria

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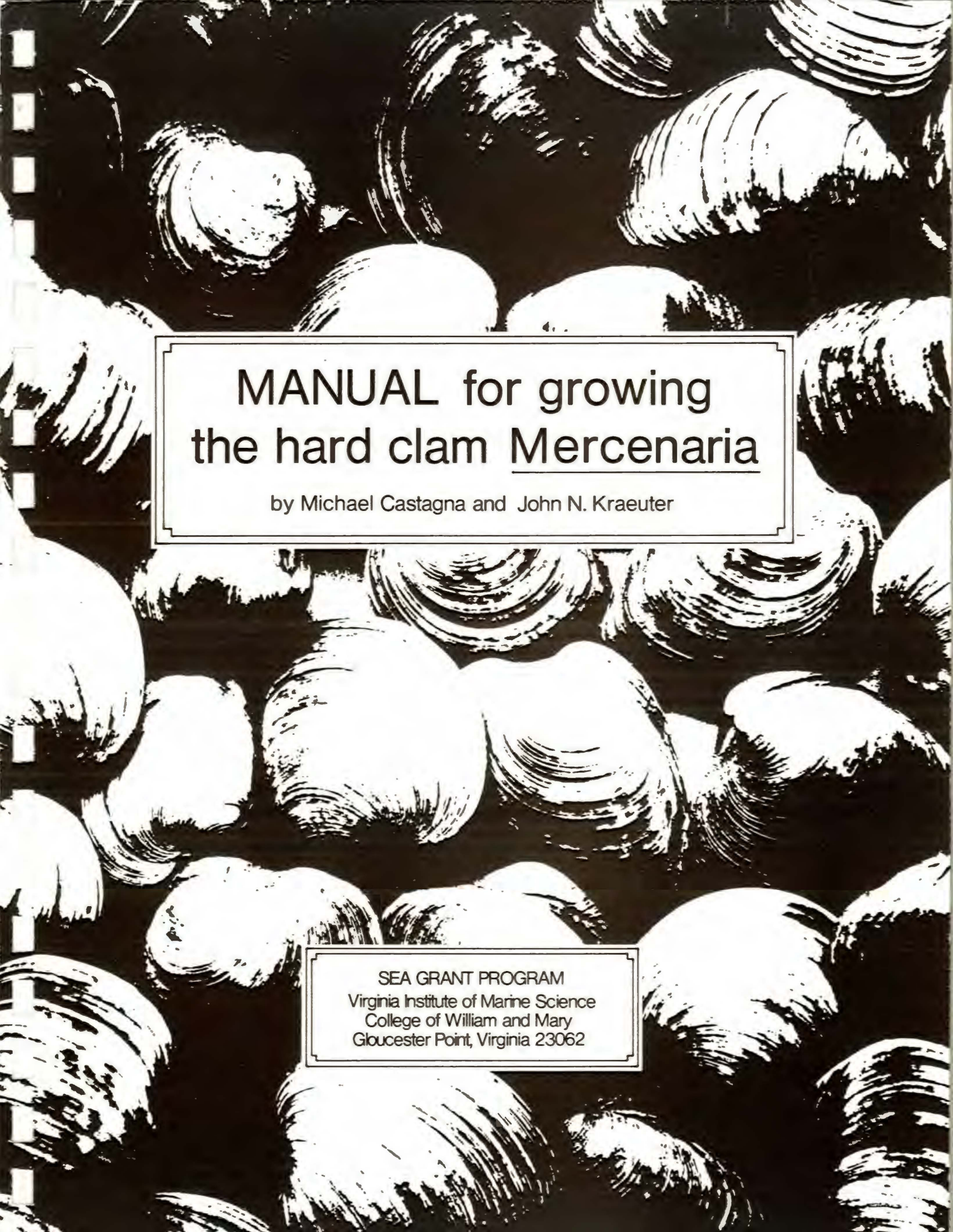

MANUAL for growing the hard clam Mercenaria

by Michael Castagna and John N. Kraeuter

SEA GRANT PROGRAM
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

MANUAL FOR GROWING THE HARD CLAM *MERCENARIA*

by

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Over the years many members of the Wachapreague Laboratory staff have contributed to the clam research and the clam courses. Their combined efforts and ideas have made this manual possible. On a regular basis, these individuals have taken on responsibilities beyond the scope of their normal jobs. These contributions require special thanks to the following:

Nancy Lewis typed the numerous versions of the manuscript, put up with our forgetfulness when we left out important parts which later had to be added, served as "registrar" and "housing supervisor" for our clam courses, and on many occasions helped with spawning the clams and maintaining the larvae, juvenile clams and spawning stocks.

Rosa Van Dessel ran the greenhouse operations, including spawning and larval work, did most of the preliminary art work, acted as critic and proofreader, and offered many suggestions for improvements to both the manuscript and the culture facility.

Jean Watkinson had the unenviable job of keeping the laboratory and dormitory clean and neat. She also assisted in the greenhouse, on numerous occasions had the responsibility for maintaining the newly set clams, has helped us develop many of the simple but efficient techniques used in the operation and served as our chief net and baffle maker.

T. W. (Tooty) Watkinson and James Moore listened to our many flights of fancy concerning changes in equipment, buildings, etc., and kept us from utilizing techniques which would have been too complex, too expensive or even hazardous. They have constructed, modified, torn out and reconstructed seawater systems, plumbing systems, electrical systems, tanks, boxes, assorted containers and special pieces of equipment on what seems to be a yearly basis. Jim Moore also helped take care of the field plots.

Special thanks are also given to the staff of the Sea Grant Advisory Service; Dr. Bill DuPaul for funding, editing, editorial management and encouragement; Dick Cook for final editing, artwork, photography and layout, including cover design.

Dr. William J. Hargis, Jr., Director of the Virginia Institute of Marine Science, edited this manual and continually supported our efforts.

The authors wish to acknowledge and thank the many participants of the clam course who have, over the years, helped us with their questions, their interest and their suggestions. We have tried to incorporate these into this manual. We especially want to thank Mr. William Nickel who has given us a great deal of his time to explain to other students the intricacies of starting a clam business, and Mr. Richard Crema and Mr. Donald Feldeisen and their wives, who as our first students, encouraged us to continue this work.

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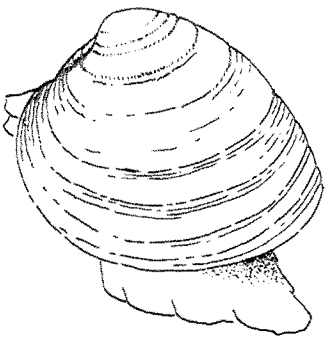
I. INTRODUCTION



This manual outlines some methods that can be used to grow the hard clam, Mercenaria mercenaria, to market size. The methods described were developed and tested by the staff of the Virginia Institute of Marine Science, College of William and Mary, Eastern Shore Laboratory. The methods described in this manual are not as technically advanced as the state of the art allows, but they work, are easy to learn and are relatively inexpensive to implement. Best of all, they are cost effective. The intent was to develop a system of growing clams that could be used by the average person to grow clams at a profit. It is poor business to grow clams for commerce if the cost exceeds the market price. Many techniques were considered and tested, and those that were not cost effective were discarded.

The techniques presented here are not the ultimate or the only way to produce clams. In fact, continual changes and optimization of these methods are necessary to keep up with new information, new techniques, new developments and new materials. Some methods may be discarded as better methods are developed. For the most part,

the methods are not interdependent, and substitutions can readily be made. Obviously, some methods will have to be modified to fit other geographical areas.

Finally, but perhaps most important, this manual was not developed for the professional culturist or scientist. It was written for the nonprofessional who knows what a clam looks like and can find his way to salt water.

II. SITING

The site of the clam growing operation is probably the most important decision to be made. A poor site can produce one failure after another. A good site requires seawater with the following characteristics:

A salinity range between 20 and 38 ppt (Salinities may go above or below this range for short periods without causing losses of large seed or adult clams, but larvae and small seed may die).

A temperature range between 8° and 28°C (Growth takes place between 8° and 28°C. Gonadal development starts between 8° and 10°C, and spawning is known to occur between 20° and 31°C.

Clams can survive at temperatures below freezing to as high as 34°C for short periods of time).

An absence of toxic substances such as industrial pollutants, pesticides, etc. (Sewage wastes can be a problem because they use oxygen and are contaminated with bacteria).

A. HATCHERY

A hatchery capable of producing 40 million seed per year does not require much waterfront land. A site adjacent to seawater is best, but the hatchery can be operated some distance away provided right-of-way for intake and discharge lines can be secured. It would be wise to plan to include enough room for a settling pond or lagoon for discharge water, even in a waterfront facility.

B. FIELD PLOTS

A planting ground has the same requirements as a hatchery but can stand short term fluctuations in water quality. Areas that are closed for the taking of shellfish should be avoided.

Clams grow intertidally and subtidally in virtually any bottom type where they can burrow.

They do well in soft mud, sand, shell or gravel bottoms, where currents run 1 knot or less (50 cm/sec). Since they do not require a firm bottom, clams do not compete for oyster growing grounds.

The best procedure to follow in choosing a site is to sample the area's natural wild clam population. If no clams are found or if clams are in poor condition, the site is probably a poor one. In more northern areas (i.e. Massachusetts and Maine) where natural spawnings are rare, hard clams might be absent even in good areas, and a trial planting might be required.

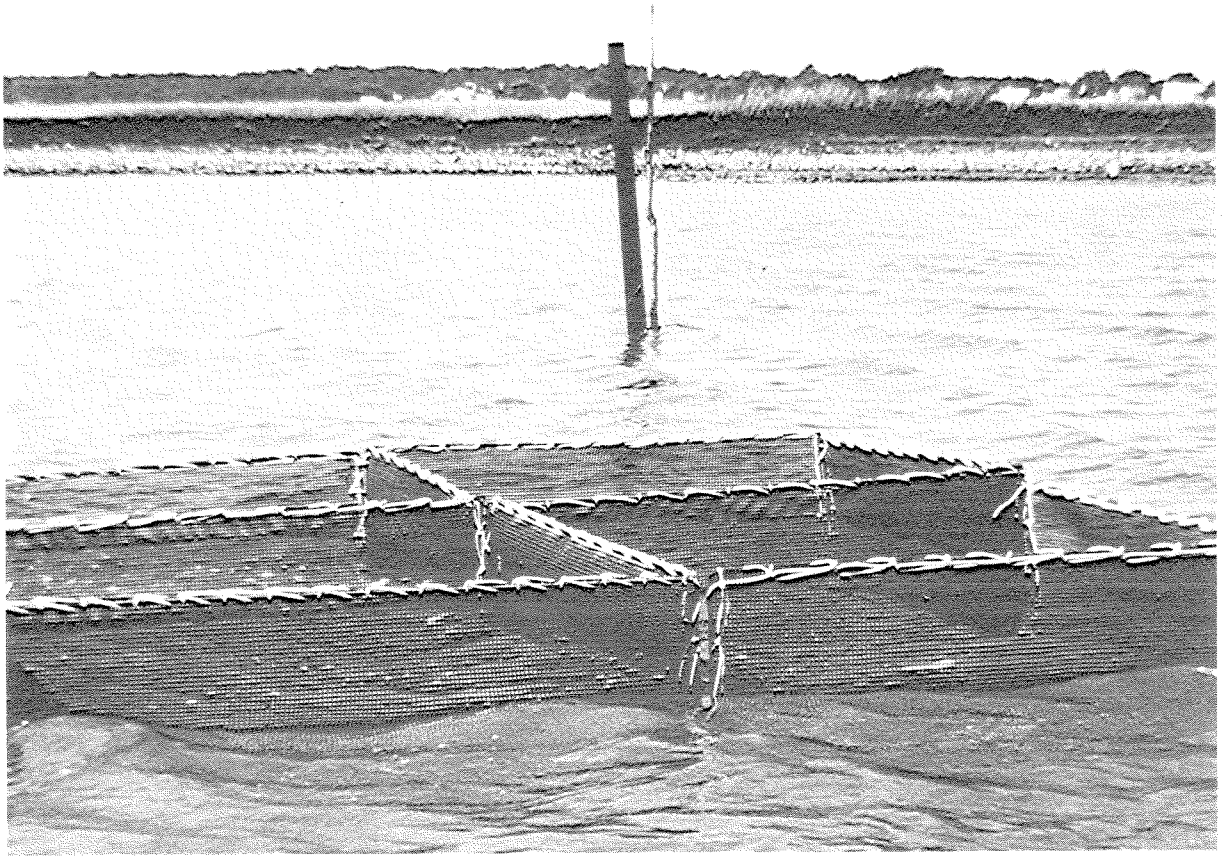
After a tentative site is selected, a careful study of the area is necessary to be sure some future ecological disaster is not imminent (i.e. a new industry or sewage plant scheduled for the area, or an insect control aerial spray program).

III. PROCEDURE

Growing clams is not too difficult, but it does require some attention to detail.

A. SPAWNING STOCK

Success with clam culture starts with good parent stock.



Baffles in position showing screen mesh exposed. Photo taken during average low water level at planting site, a good point in the tide cycle to plant clams. Ref. pp. 3 - 4, 41 - 42.

1. SIZE

Spawning stock should be selected from moderate size clams that have shown active growth throughout life. Although larger clams produce more eggs, they are often more reluctant to spawn. It is important to select clams with a history of active growth because fast growing parents usually produce fast growing offspring. Blunted or otherwise deformed individuals should be avoided because they may be diseased or slow growers. Individuals with holes in the shell indicating worm (Polydora) or boring sponge (Cliona) infestations should be avoided to prevent contamination of the larval cultures.

2. COLLECTION SITES

In general, clams from local populations are perfectly acceptable provided they meet the above requirements (III.A.1.). Clams collected from locations several hundred miles north and south of an area will provide organisms that may spawn earlier (southern stocks) or later (northern stocks) in the spring. Within an area, restricted shallow bays or intertidal mud flats will warm up sooner. Clams from these areas will ripen earlier in the spring and will spawn sooner than those

from deep water. By proper stock selection it is possible to prolong the hatchery spawning season.

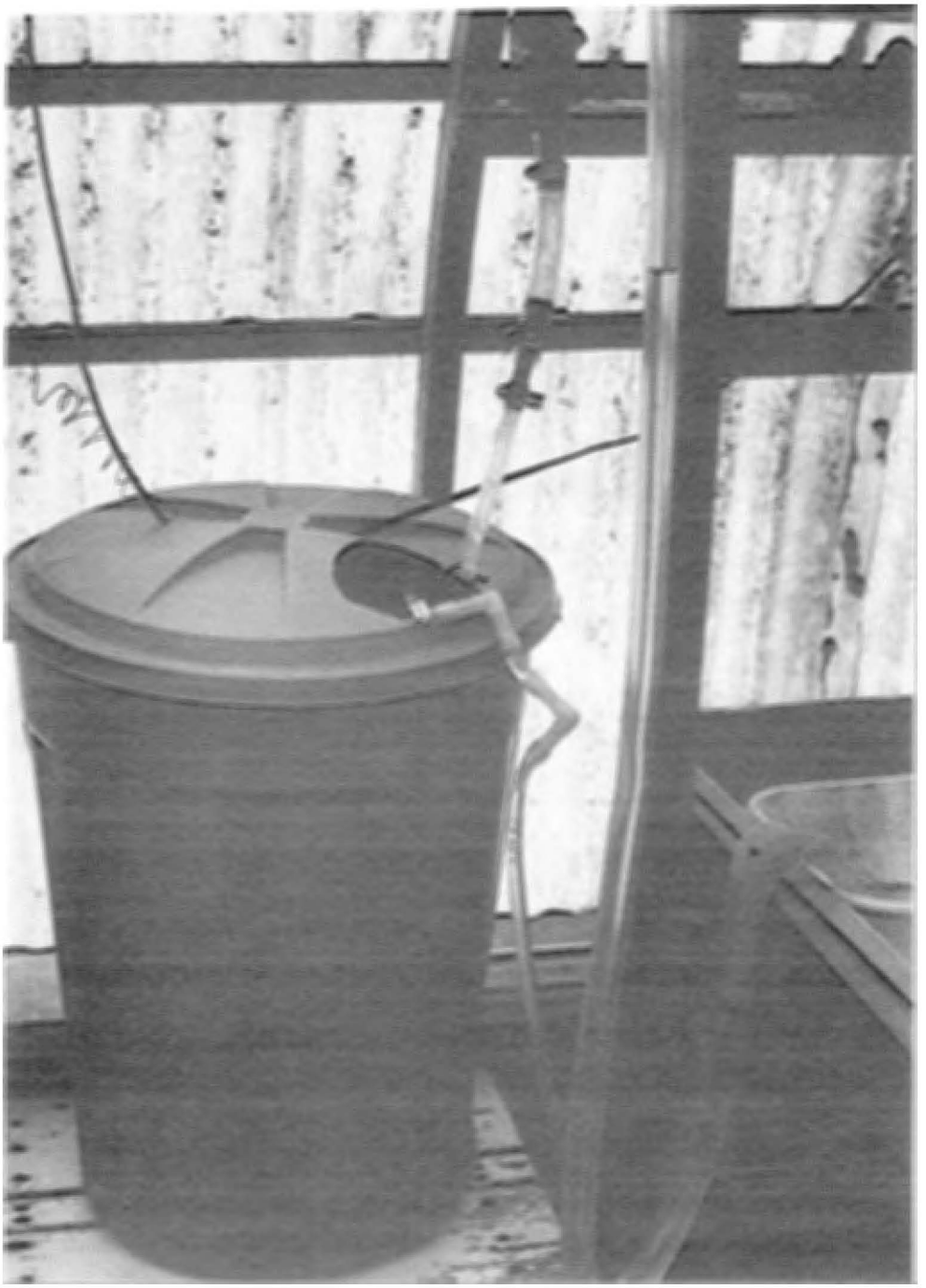
3. TRANSPORT

Like other animals, clams have certain requirements for survival. They must take in oxygen and food and discard carbon dioxide and wastes.

Clams will survive relatively long periods out of water if they are kept moist, cool, out of the sun and are not battered about or disturbed. Clams can be iced or carried in a portable cooler (not airtight) provided they are not immersed in the fresh water from the melting ice. Refrigeration is usually not recommended because of the danger of dehydration or freezing.

4. HOLDING

Clams should not be held in standing seawater unless there is a relatively large water volume and large surface area for each clam. When clams are kept out of water they survive by keeping their gill tissue moist to allow for gas exchange (breathing).



Heat exchanger, external view, showing thermostate wire (coil) leading in from left, water control valve at top right and drain into spawning trough at right. Ref. pp. 9 - 14.

B. SPAWNING STOCK AND SPAWN

A single clam may spawn several days in succession and over a breeding season may release as many as 60,000,000 eggs; however, the numbers are usually considerably less than this for any given spawn.

1. NUMBERS

It is recommended that 100 to 200 clams be placed in a 12 square foot tray for mass spawning (see F.1.). Individual clams will not spawn every day. On the days they do, the number of fertilized eggs obtained from each spawning clam will number between 5 and 30 million. The animals may spawn several days in succession or not at all. In either case all the animals should be periodically replaced with ripe, fresh stock.

2. SURVIVAL RATIOS OF SPAWN

Survival from spawn to a size that can be placed in the field is usually less than 1%. One should not plan on obtaining more than 100,000 seed clams from about 10,000,000 eggs. Survival from this stage to field and market should be about 60% or 60,000 clams. Plan spawning (and field) operations accordingly.

C. CONDITIONING OF SPAWNING STOCKS

It may be desirable to begin spawning before clams in nature are ripe in order to take advantage of a longer growing season, fewer bacteria or for economic reasons. Clams may be conditioned to ripeness or retarded from spawning to prolong spawning seasons, but these manipulations work only within certain limits, and they add cost.

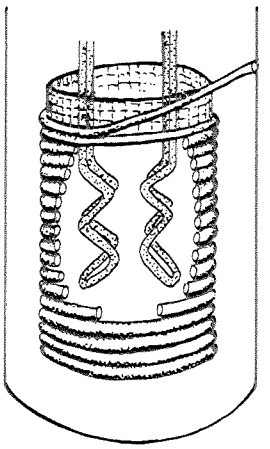
1. CONDITIONING

Conditioning to ripeness is easier with northern clams. Clams found from Delaware Bay south are more difficult to condition, and require a longer period of conditioning from the end of one spawning until they become ripe again. Conditioning clams for early spawning is accomplished by raising the water temperature to 20 to 22°C and providing sufficient food. This may be done in several ways.

a. RUNNING SEAWATER

Running seawater may be provided, but only if water exchange is limited to volumes that do not lower the temperature. Supplemental feeding with cultured algae is necessary when this method is used. Water in the tray may be heated by a heat

exchanger or by being held in a warm room. Heat exchangers can be purchased or constructed. When using heat exchangers, there is a danger of "air bubble disease" (S.2.b.1.).



b. STANDING AERATED WATER

Standing aerated water may be utilized provided clams are not crowded. Water must be changed daily and supplemental food must be added. To change the water, additional trays are required to allow the water for the next day to warm. This warm water is then added to the tray containing the clams. This warming is necessary because temperature fluctuation often causes premature spawning.

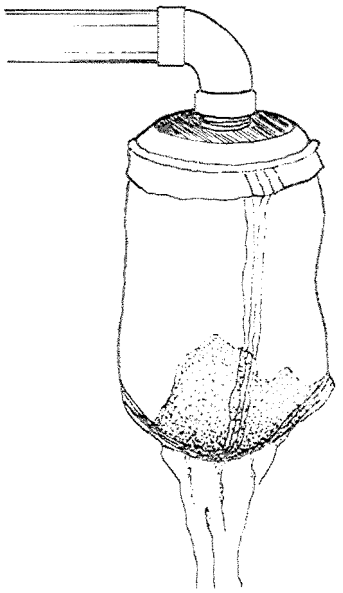
2. SUPPLEMENTAL FEEDING

Food can be grown in a variety of ways. For simplicity and low cost, the Wells-Glancy method is recommended.

a. THE WELLS-GLANCY METHOD

This method consists of clearing or removing the larger size particles from raw seawater and leaving the dissolved nutrients. By filtering or clarifying the seawater, most of the silt and

detritus, the zooplankton and the large sized phytoplankton are eliminated. The water is then allowed to warm in the presence of sunlight, causing an algal bloom of the remaining small phytoplankton. This culture then becomes a rich algal soup-like media dominated by one-celled diatoms and flagellates. These forms make up the diet of clams.



Using the Wells-Glancy method is relatively simple. The raw seawater is either filtered or clarified to remove unwanted particulates. Filtering is the least expensive method. Seawater is pumped through a bag filter. The size particles passed depends on filter size. A 10 or 25 micron bag filter is used for most applications, but a 5 micron bag filter may be used for larval food.

Seawater can also be run through a clarifier which spins the water and clears it by centrifugal force. A clarifier is an expensive machine, but water that has been clarified appears very clean and clear. Bag filtered or clarified seawater retains all chemicals, nutrients and small phytoplankton. These single-celled plants, phytoplankton, and other microorganisms (bacteria,

fungi, yeast, etc.) small enough to pass the filter or clarifier remain in the water.

The clarified or filtered water is stored in tanks, exposed to sunlight and gently aerated. This storage may be either in a greenhouse or, in warm weather, outdoors. This incubation causes the phytoplankton to multiply. The microscopic plants reproduce by cell division (i.e. one single-celled plant divides and becomes two single-celled plants), and the length of time required to establish a bloom varies with temperature. At 22°C algal cells will grow and divide about every 40 minutes, and in about 12 hours there should be about 100,000 one-celled algae per ml of incubated water. After 12 hours the rate of reproduction levels off. The phytoplankton have a high protein to carbohydrate ratio during the rapid reproduction phase (referred to as the logarithmic growth phase). The carbohydrate ratio increases in phytoplankton when reproduction rates level off (the lag phase). Higher carbohydrate levels cause faster growth of clam larvae.

Algae raised in this manner will be referred to as "cultured water" throughout this manual.

The food in cultured water is made up of five to eight dominant phytoplankton species. They are all relatively small (3 to 6 microns when clarified water is used or 5 to 10 microns when filtered water is used) and prove to be an excellent larval food. A 10 or 25 micron bag filter is used for filtering water supplied to juvenile clams.

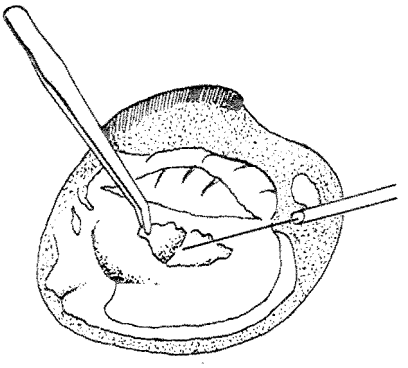
D. DELAY OF SPAWNING

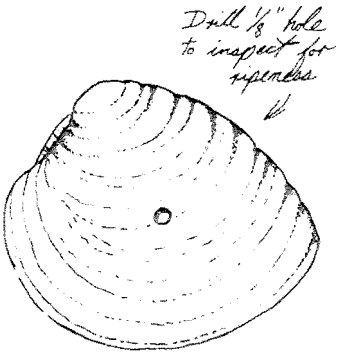
It is often useful to delay spawning to prolong the spawning season. This can be accomplished by storing ripe or nearly ripe spawning stock in trays of water which are cooled to 16 to 20°C in a refrigerator. Water should be changed daily, aerated and some supplemental food added. The water for daily changes should be cooled before use because temperature fluctuations may cause premature spawning. Clams have been held for up to 8 months using this method and then successfully spawned. Prolonging the spawning period by this method is obviously easier and less expensive than conditioning.

E. DETERMINATION OF RIPENESS

The simplest method to determine ripeness is to sacrifice two or three of the spawning stock

clams. Tease apart a piece of the gonad and place it on a microscope slide with a drop of seawater. Examine eggs or sperm under a microsope at 100X. The animal is ripe if it appears healthy, the meat nearly fills the shell cavity, the gonads are full and the sperm appears active or if the eggs are large and look well developed. A second method is to bore a small hole (a hand drill can be used, but a drill press is better) through the shell in the location shown. A bit of gonad can be gathered with a hypodermic syringe and needle. This bit of tissue can be placed on the slide and examined as above. Return the animal to the water and, in most cases, the animal will produce new shell to seal the hole. Care should be exercised to keep the area of the hole reasonably clean.

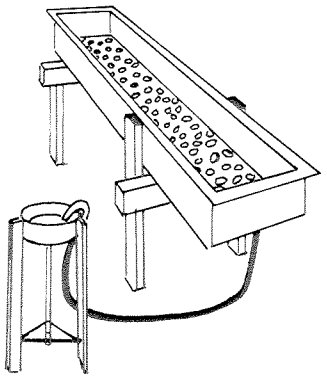




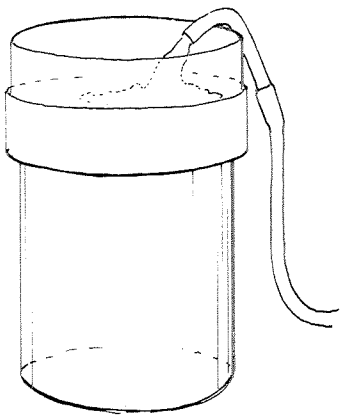
F. SPAWNING

Two methods can be used to spawn the animals: (1) mass spawning and (2) individual spawning. The first is more useful in obtaining large numbers of eggs, while the latter can be used to selectively breed certain animals.

1. MASS SPAWNING



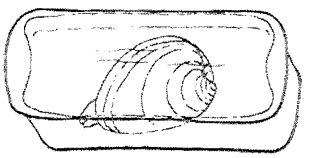
Mass spawning is preferable for a commercial operation. All the clams to be spawned should be brushed clean in cold water and placed in a large spawning tray of running seawater. The temperature can be raised to 28 to 30°C (not to exceed 32°C) with warmed cultured water from the heat exchanger. The clams should then be allowed to remain undisturbed in the warm water until about half are actively pumping. Water temperature can then be lowered to 22°C. This process should be repeated as many times as necessary in about 30-minute cycles. The duration of the cycles allows the clams to acclimate to the changes in temperature. This will often trigger spawning on the second or third cycle. If spawning is going slowly, a sieve for catching the fertilized eggs (G.) can be mounted over a bucket and the sperm water collected and introduced into the spawning trough. This additional sperm should help to further stimulate the spawning animals. If spawning does not occur after about 5 cycles of temperature change, sperm or ova (see F.3.) from sacrificed clams, diluted in filtered seawater, should be added. Eggs or sperm stimulate spawning. These gonadal products will act as a

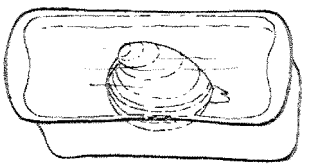


Spawning trough, showing method of collecting fertilized eggs in sieve (atop triangular bench). Copious sieve storage is apparent beneath the table. Thermometers in trough facilitate constant temperature monitoring. Ref. p. 14.

stimulant even after they have been refrigerated or frozen. Male clams usually will spawn first. Sperm appears milky and individual cells are not visible. Eggs appear less milky and have a granular texture. If clams do not spawn, they are not ripe and should be thoroughly rinsed with fresh water to remove sperm or eggs and placed back in the conditioning chambers or in running seawater. They may be induced to spawn by following the same procedure the next day. If spawning has been attempted for 3 to 5 days with no results, the clams should be examined for ripeness (see E.) before attempting further spawnings.

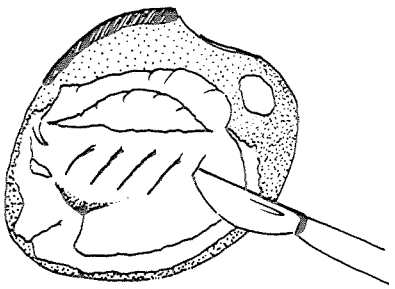
2. INDIVIDUAL SPAWNING



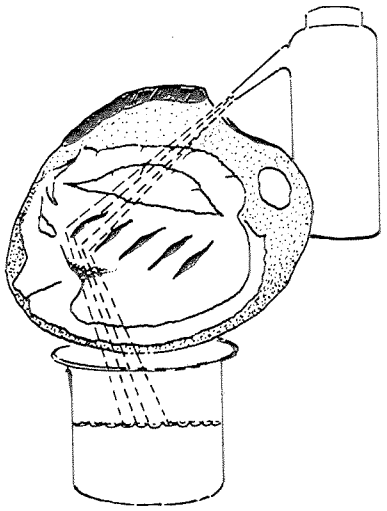


To spawn small numbers of clams, place freshly scrubbed clams separately in small dishes (pyrex glass loaf dishes are 3x5x9 inches and hold about 1 L water). Filtered or cultured water should be added to each dish. The dishes are then placed in a water bath or on a wet table. The bath or table is then flooded with hot water from the tap, raising the temperature of the water in the dishes. The table can be drained when the desired temperature is reached. Be sure that no tap water

goes into the dishes. The water should not float the dishes, but should come up only about 1 or 2 inches on their sides. Cold tap water may be flowed onto the table to cool the clams or temper the hot water. All other steps are as in F.1. with two exceptions. (1) If gonadal products are needed as a stimulant, freeze and thaw them to insure no unwanted fertilization occurs. (2) When spawning is complete, transfer the eggs of each female clam into a separate container and dilute with cultured water. A small amount of sperm from a selected parent can be added (0.5 ml/l), and thoroughly mixed with the eggs. Avoid adding too much sperm. If the sperm concentration is too high, multiple fertilization might occur (polyspermy) indirectly causing poor larval survival. Count the eggs and place them in appropriate sized containers as in H. and I.



3. SPERM OR OVUM INFUSION

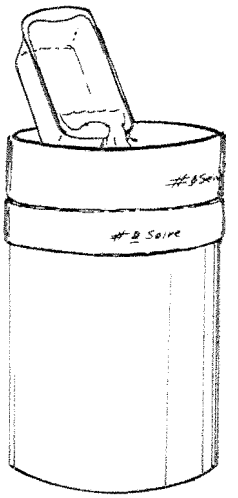


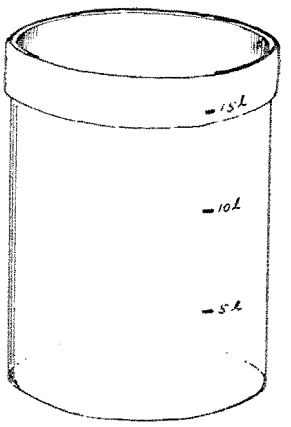
To make a sperm or ovum infusion, a clam should be opened and the gonad cut with a sharp knife and the tissue teased apart. The sperm or eggs exuding from the cut tissue can be rinsed into a beaker with filtered seawater. This infusion can then be slowly introduced with an eye

dropper into the incurrent siphon of actively pumping clams, or added to the water in the vicinity of actively pumping clams.

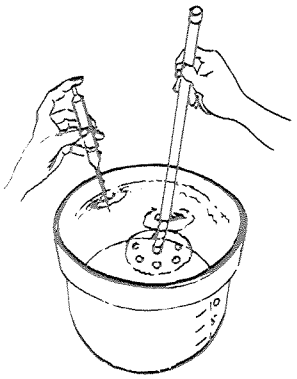
G. COLLECTING THE FERTILIZED EGGS

If spawning occurs, the eggs should be separated by draining or partially draining the water from the spawning container through a 25 micron sieve mounted as illustrated. Sperm and water will pass through the mesh and the eggs will be retained. The sieve should be replaced when it becomes clogged with eggs, mucus and feces. The material clogging the sieve should be rinsed with cultured water into a precalibrated or volumetric container through a 180 micron to 400 micron sieve. The larger debris will remain on the sieve and can be discarded. The container can then be set aside until more eggs are added. The eggs should be cared for by periodically adding cultured water to the container to dilute the concentration. Within two or three hours, the eggs should be counted and moved to the growing chambers, even if the adult clams (spawning stock) have not completed spawning.

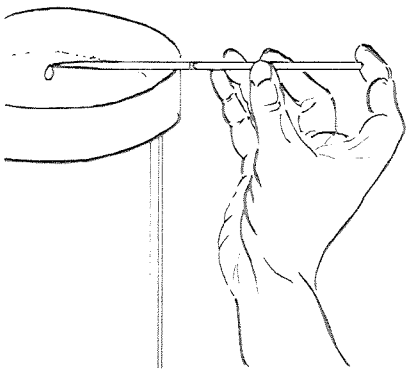


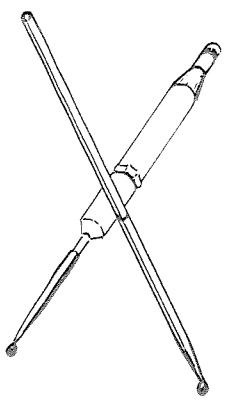


H. COUNTING THE EGGS

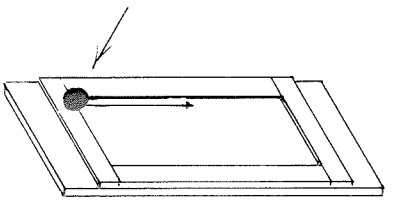


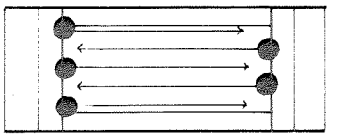
After the eggs have been washed into one or more of the precalibrated containers, the liquid can be brought up to a given volume with cultured water. The water-egg mixture should be thoroughly mixed in an up-and-down motion with a plunger. Do not stir the mixture or the eggs will be concentrated in the vortex caused by the stirring, and an improper sample and count will result. While mixing with the plunger, a 1 ml pipette is inserted into the container and a 1 ml sample is removed. Make sure the sample is on the 1 ml line; if not, some of the mixture may be put back into the container to adjust the sample to 1 ml. This is done by slightly releasing the finger from the top hole of the pipette while the pipette is held horizontally. If this is not done quickly (within 3 seconds), replace the sample into the container and repeat the entire operation. An automatic pipette is simpler to use and is relatively foolproof, but also more expensive. As soon as a good 1 ml sample is taken, it is: (1) placed on a Sedgwick-Rafter counting cell, (2) spread over the entire area of the cell with a dissecting needle or suitable instrument (a pencil works well), (3) scanned under a compound





microscope with a mechanical stage at a low power of 40 to 100 magnification (4X or 10X objective and 10X ocular). Record the number of eggs using a mechanical counter. The number of eggs/ml is recorded and multiplied by 1000 to determine the number of eggs per liter. If containers are marked in liters, then the number of eggs/liter multiplied by the number of liters of water-egg mixture the precalibrated or volumetric container held will give the number of eggs in the container.





Sample calculation:

1 ml sample on a slide has 250 eggs
There are 1000 ml in 1 liter
250 x 1000 = 250,000 eggs/liter
If there were 12 liters in the container
12 x 250,000 = 3,000,000 eggs in the container

If the number of eggs on the cell exceeds 300, the volume in the container should be increased or the egg-water mixture should be divided between two containers and diluted with additional cultured water. This will dilute the eggs and yield a lower count. Counts become inaccurate when they exceed 300, and although dilution means more counts the greater accuracy is important.

I. PLACING THE EGGS IN A GROWING CONTAINER

The total number of eggs must be estimated as described above to decide how much water to put

with the eggs in the growing containers. The initial concentration in the growing containers should be about 30 to 60 eggs per ml.

If, from the above calculations we have three million (3,000,000) eggs in 12 liters, the following calculation applies:

Desired: 30 eggs/ml = 30,000 eggs/liter
(30 eggs/ml x 1000 ml/L = 30,000 eggs/liter)
Then: 3,000,000 divided by 30,000 = 100 liters of cultured water are necessary to dilute 3,000,000 eggs to the desired 30 eggs/ml

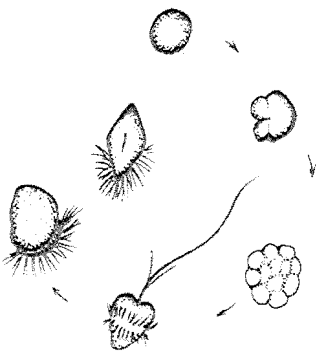
In other words, we have 3,000,000 eggs and we need to know how many ml or liters of cultured water to place them into. Thus we would fill a container of the appropriate size to 100 L and pour in the eggs. There would be no need to change the water until the eggs reach straight hinge stage (see K.). We feel it is better to allow the organisms to pass through the soft-bodied embryo stages without being subjected to possible damage from collection on sieves.

J. LABELING

The container must be carefully labeled. A piece of ordinary masking tape and felt-tipped marking pen works well. The following information

is necessary: (1) batch # or code, (2) number of organisms and (3) the size of the smallest sieve they were caught on. For example, a container labeled M23, 3,000,000 - 53 indicates that it contains the 23rd batch of Mercenaria consisting of 3 million clam larvae which were collected on a 53 micron sieve.

K. DEVELOPMENT OF EGGS TO LARVAE

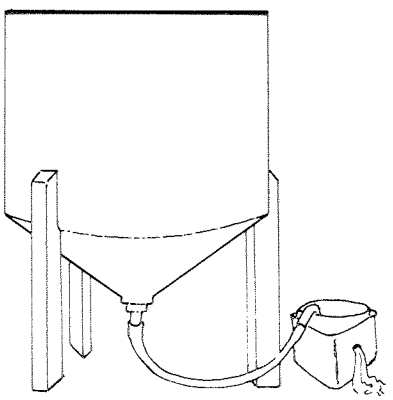


Fertilized eggs will develop best at salinities of 26 to 30 °/oo and from 18 to 28°C. More rapid development is achieved at higher temperatures. An optimum temperature range is 23 to 25°C, because disease problems are minimized at lower temperatures. Growth is faster above 25°C, but bacterial diseases are a greater problem at higher temperatures.

The tanks containing the larvae may be gently aerated, but the air stone should be suspended about 15 centimeters above the bottom of the container (above the conical portion if you are using a conical tank). This will prevent mixing dead or diseased animals from the bottom of the tank with the healthier specimens.

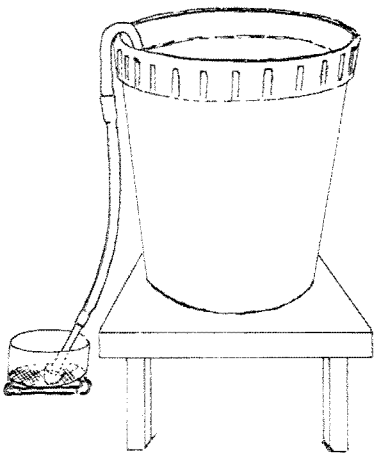
After two days, the eggs should have reached the straight hinge veliger stage. The water in the larval tanks should be drained through the appropriate sized sieve, and the animals concentrated in a prevolumed container. The tank should be cleaned and a new batch of cultured water added. It is sometimes desirable to examine the animals' development without draining the tank. This can be accomplished by taking a sample from near the edge of the container using an eye dropper. Place this sample on a clean Sedgwick-Rafter cell and examine it under the microscope (40 or 100X) for straight hinge individuals. Once this stage has been reached the water should be changed three times a week, or about every other day. The water is changed by the following procedure.

L. DRAIN DOWN OF GROWING TANK



The large larval growing tanks should be drained into tall sieves placed in support boxes. The sieve utilized for drain down should be the mesh size noted on the tank label. This corresponds to the size animals in the tank. Use of this sieve will prevent loss of animals. The support boxes are designed to partially flood the

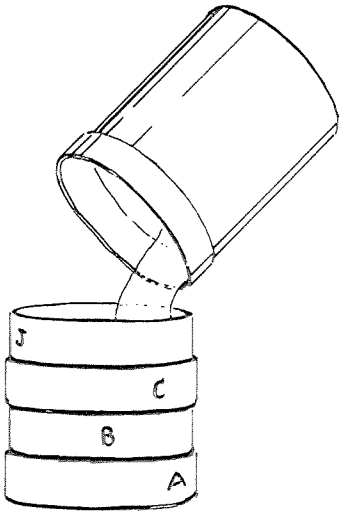
sieves with water. This prevents the larvae from striking against the mesh too vigorously and being damaged. Large tanks are emptied by gravity, but smaller tanks, such as trash cans, may be siphoned. Larvae should be periodically rinsed from the sides of the tank with cultured water. Great care should be taken to monitor the drain down process because the sieves may clog and overflow. Following drain down, the larvae on the sieve are rinsed into precalibrated containers using cultured water and diluted to 10 or 15 liters (depending on estimated densities).



Never drain to the bottom of a container; there is a greater possibility of diseased or dying animals in this water. Until the larvae are retained on an 86 micron sieve, the bottom few inches should be discarded. Beyond this point, retain all larvae.

M. SEPARATING BY SIZE AND COUNTING

At least once a week the larvae should be separated by size and counted. This is best accomplished in conjunction with a routine drain down in the following manner. After the larvae are rinsed into precalibrated containers, they are ready to be sorted by size. This is accomplished



by rinsing the larvae through a descending sized series of sieves. The top sieve should be two or three mesh sizes larger than the bottom sieve. The bottom sieve should be the same mesh size as the smallest mesh size sieve used to collect the larvae during the drain down. One or two intermediate mesh size sieves can be placed between these two. For example, if the larvae were collected on a 44 micron sieve, the sieves should be stacked in the following manner:

Sieve mesh size in microns
73 top
64
53
44 bottom

The larvae in the precalibrated container should be poured onto the stack of descending sized sieves and rinsed through to the proper sized mesh with cultured water. This should be done carefully to be sure the larvae are not flooded over the top of a sieve. The larvae from each of the sieves are then rinsed into a separate precalibrated container that is appropriately labeled (mesh size, batch number, sieve size). These are filled with cultured seawater to an appropriate volume for the counts. All the empty sieves are then washed with hot fresh water before they are used to sieve any other batches. This will help

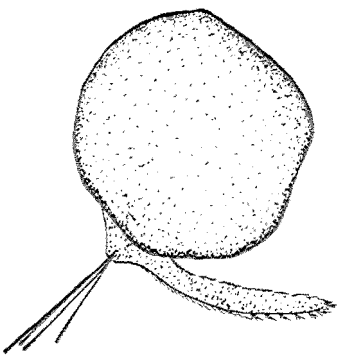
prevent cross contamination of larvae and reduce the spread of disease. The larvae are then sampled and counted as were the eggs (see H.). The bottom sieve will contain individuals that are growing slowly or are not developing well. A commercial hatchery should discard these as a matter of course. The other sieve-sized lots can be divided and placed into growing tanks or containers at densities of about 15 larvae per ml. It is desirable to keep larger larvae separate from smaller larvae to prevent competition. The above process should be repeated until the clams metamorphose and set. Setting will occur in 8 to 14 days. Care must be taken to prevent overcrowded conditions for the larvae. Overcrowded larvae compete for food, are subject to problems caused by high levels of metabolic wastes and physically damage each other by colliding. Be sure to microscopically examine the larvae each time you drain down the tanks. This will identify disease problems early, and may prevent the spread of a disease to other containers. Slow growing or diseased larvae should be discarded.

N. SETTING

Setting will take place in about 8 days if 26 to 28°C temperatures are maintained, but may take

longer (12 to 16 days) at 18 to 20°C. The larvae from one spawn, even from one pair of parents, may require 9 or 10 days to progress from a 93 micron sieve to the setting stage. The setting clams will be found attached to the sides and bottom of the growing tanks and precalibrated containers by byssal threads. The clams will be about 200 to 300 microns long at this stage. They can be freed from the containers by squirting them gently with a jet of cultured seawater. Cold tap (fresh) water can be used and is often more effective in freeing the larvae, but do not allow them to remain in fresh water, and be sure they are immediately rinsed with cultured water. Post set survival is enhanced if setting clams are treated as larvae for an additional 8 to 10 days (see O.). These well set clams should be placed in containers with greater bottom areas.

O. POST SET



The recently set larvae are called pediveligers. The foot is developed and the velum is still functional. At this stage the clams will spend part of the time swimming and part of the time fastened to the bottom or sides of the tanks or containers. They can be placed on the grow out

tables at densities of about 500,000 per square meter. There are three methods for handling post set clams.

1. HANDLING POST SET AS LARVAE

The post set clams can be treated the same as larvae, except that draining the tables and changing the water must be done more frequently. The grow out tables should be drained and filled twice daily. Cultured water should be used if it is available; if not, use seawater filtered through a 25 micron bag filter. The additional changes are required because of increased feeding and metabolism. If bag filtered water is used, avoid changes of more than 8 °/oo salinity or 10°C. If this method is used, it should be continued for 10 to 20 days before the clams are placed in flowing seawater. By then the clams should have developed to the next stage, the plantigrade.

2. RUNNING SEAWATER

An alternate method of growing early post set stages is to place them on grow out tables supplied with continuously running seawater. The seawater should be filtered through a 50 micron

bag filter. Flow rates should be about 1 L/min. With this method it is necessary to place a 100 micron sieve beneath the overflow to catch the pediveligers which are carried off the table. The sieve is placed on a frame immersed in a tray of shallow water. This prevents the individuals collecting on the sieve from drying out. The sieve should be checked 2 to 3 times daily until the post set clams are no longer found (about 7 days). The post set stages that accumulate on the sieves should be rinsed back onto the table.

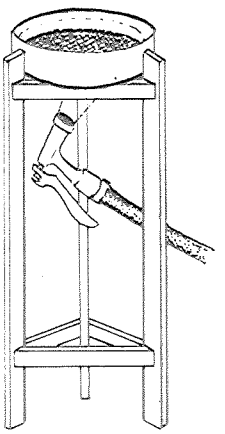
3. PULSE FEEDING

The third method for growing early post set stages is pulse feeding. Seawater is filtered through a 25 micron bag filter and stored in large tanks (similar to those in the larval culture facility). The water is either aerated or recirculated by small pumps so that phytoplankton will remain in suspension and continue to grow and multiply. Water is pumped from these tanks across the newly set clams on a 6 hour on-6 hour off cycle. Initial flow to the tables should be about 1 L/min for the first week, then doubled (if possible) during the following weeks. After the first 20 days, continuous flow of seawater should

be added, and the flow increased as the clams grow larger. After about 5 weeks the tables should receive a full flow (8 to 10 L/min) of seawater, and the pulse feeding can be discontinued.

P. DRAINING AND CLEANING OF POST SET

A sieve is mounted on a stand under the drain hole prior to draining a table to remove the accumulated feces, silt and other debris. See Handy Hint #4 before you pull the plug. As the water level drops, the tables can be tilted toward the drain hole by placing wedges between the table and the supporting stand. Check the sieve often because silt and debris will often clog the mesh and the sieve will overflow. Spraying water upward from under the sieve will help eliminate clogging. Don't spray too hard when the water is nearly out of the sieve or the clams will be squirted out the top of the sieve.



The mud on the table can be pushed off and washed through the sieve. Judicious use of a water jet will force the mud through the mesh. Once the mud has been removed, the table should be brushed clean and rinsed (through the sieve). The clams can then be returned to the table.

Do not clean the clams too often. Draining and cleaning should be scheduled about every two or three weeks. The exact schedule will depend on the amount of material that is accumulating.

The larger individuals should be separated from the slower growers at 4 to 6 week intervals. There should be approximately 200,000 0.5 to 1 mm clams per 2 ft. x 8 ft. table with an 8 L/min flow rate. By the time the clams reach 2 mm the number should be reduced to about 50,000 clams per table.

Sometimes large amounts of dead and decaying plants (detritus) can accumulate with the clams. When the clams are 0.5 mm or larger, detritus can be eliminated by placing the clams and water in a container, allowing the clams to settle and pouring off the lighter detritus. Once the clams have reached a size that will not go through a 2 mm sieve (about 6 weeks) they can be planted in nursery areas. However, planting 5 to 15 mm clams in selected nursery plots yields better survival. As a general rule, the larger the seed planted, the better the survival.

Q. PREPARING CLAMS FOR NURSERY PLOTS

Four to eight mm clams cannot be profitably grown by pumping seawater to them. A nursery plot

is necessary to grow clams from this size to the 10 to 12 mm required for final planting. Both the nursery planting and the final planting require a method for separating clams into batches of equal numbers. There are several methods of separating the clams and estimating their numbers.

1. ESTIMATING BY WEIGHT

Drain and wash clams into sieves. Divide the clams into batches of 100 to 200 clams each. Be sure to include (don't count) dead clams and debris taken from the sieve with each batch of clams. Once 3 to 5 batches of clams have been counted, these can be weighed. Use a balance that weighs to 0.01 grams, such as a triple beam laboratory balance or its equivalent. Electronic balances will speed up weighing operations. Three batches are usually sufficient, but if there is a lot of debris, four to five batches will improve accuracy. Each batch should be placed in a prewetted, preweighed container. Each batch of clams is then flooded with seawater, drained and weighed. The average weight is used as a weight of 100 clams. If the balance you are using is not sensitive enough for such small lots, you may have to increase the number of clams per batch.

Example: Container (wet) 3.50 g

Lot 1	100 clams + container	4.07 g
Lot 2	100 clams + container	4.09 g
Lot 3	100 clams + container	4.19 g
		12.35 g

3 x 3.50 = 10.50 (weight of container)
12.35 - 10.50 = 1.85 weight of 300 clams
1.85 ÷ 3 = 0.62 g weight of 100 clams

Once the average weight is established, all that is necessary is to weigh the remaining clams, debris, etc. into lots of 7,000 to 10,000.

Example:

0.62 g per 100 clams 1000 clams = 6.2 g
7000 clams = 6.2 x 7 = 43.4 g

These can be put in separate containers for placement in the field. Do not include the weight of the weighing container in your calculations.

2. ESTIMATING BY VOLUME DISPLACEMENT

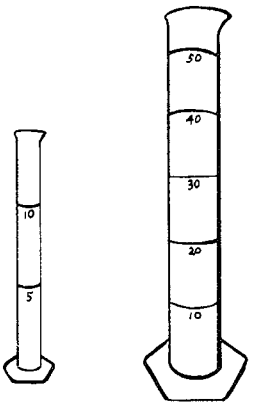
Fill a graduated cylinder with a small amount of cultured water and note the volume (how many units or ml). Add 100 clams and debris to the water and note the increase in volume. Repeat this 3 to 5 times. The total number of clams is calculated by multiplying 100 clams per unit times the number of units.

Example: Fill 100 ml cylinder to 10 ml mark.

Add 3 lots of clams and debris as follows:

Starting Volume	Add 100 Clams, etc.	Final Volume	Displacement
10.0 ml	Lot 1	13.5 ml	3.5 ml
13.5 ml	Lot 2	17.5 ml	4.0 ml
17.5 ml	Lot 3	20.8 ml	3.3 ml
		Total	10.8 ml

10.8 ml ÷ 3 = 3.6 ml per 100 clams.



Once the average volume per 100 clams is established, all that is necessary is to add the remaining clams, debris, etc. to the graduated cylinder containing a volume of water until the displacement reaches the desired amount.

Example:

3.6 ml displacement per 100 clams
1000 clams = 36 ml displacement
7000 clams = 36 ml displacement x 7 = 252 ml displacement

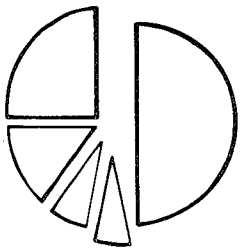
Start with 500 ml cylinder and add 100 ml of cultured water, add clams until the water reaches 352 ml (starting volume + desired volume). Place the 7000 clams in a container for transfer to the field. Repeat as many times as necessary.

To find a total number of clams, simply add 100 ml water to a 500 ml cylinder, add clams and debris and note the volume. Subtract 100 ml from final volume and divide by 36 ml to find how many thousand clams you have.

Example:

Starting Volume	Final Volume	Total Displacement	Thousand Clams
100 ml	472 ml	472-100=372 ÷36=10.33	10.33x100= 10,330 total clams

3. ESTIMATING BY THE SPLITTING METHOD



To use the splitting method, a sieve sample is placed on a smooth surface (tray or piece of glass). Using a plastic ruler or suitable substitute, arrange the clams into a round mound. Divide this round mound as though cutting a pie into segments. After the division is made, one segment is counted and the number of clams equals the number per segment multiplied by the number of segments.

R. NURSERY AREAS

Suitable nursery areas are required to grow the clams from about 4 to 6 mm to 10 to 12 mm. This is the most difficult phase of clam culture to do in an economically feasible manner. Several techniques have been tried to increase both growth and survival during this critical phase. Nursery areas require water quality similar to that of the hatchery. The salinity should average 20 °/oo or higher, and the water temperature should be above

10°C for at least half of the year. The bottom should be sandy mud or sand, and the maximum current velocities should be less than 1 knot (50 cm/sec). Observe the nursery area at different times to be sure adverse conditions are not present. Industries or other activities nearby might be undesirable. Natural conditions such as an eroding shoreline might indicate storm-driven waves; an advancing shoreline might indicate excessive sediment deposition in the area. All nursery areas require constant protection from predators and constant supervision.

A key to the suitability of the site is the natural occurrence of clams. It is a good location if clams are already present and they look healthy and appear to have grown rapidly. Avoid sites where clams have eroded shells or look blunt edged or stunted. All nurseries need some shelter from prevailing storms and, if clams are to be held during the winter, protection from ice must be considered. Be sure local customs and laws have been followed before you prepare to use a site.

Clams are preyed on by certain species of crabs, fish, birds, carnivorous snails and mammals. Unless some protection methods are used, the predators will destroy or consume most of the clams long before they are marketable size. Clams also require protection from inept boat operators, tourists, weekend watermen and poachers.

No universal solutions to all the above problems exist, but they can be ameliorated by choosing your site and methods wisely. For instance, if your plot is in a shoal area or in an out-of-the-way area, inept boat operators or tourists will not be a problem. Poaching has been a long standing problem for oyster planters. This problem is met by patrolling, by use of sophisticated equipment such as radar, star scopes and infrared photography. A few publicized convictions often reduce poaching. The best insurance against poachers is to have supportive friends working in your area. They will report unusual activity on your lease.

Controlling predators is more difficult. Crabs are found throughout the clams' geographic range and are a major predator of clams. Most species of crab can crush and eat a clam that is

1/3 the length of its carapace width. This means that small seed clams can be preyed on even by small mud crabs. From Delaware Bay south, blue crabs are abundant and can kill clams up to about the size of a 25 cent piece (15 mm). One of the best methods of protecting small clams from crab predation has been the use of crushed aggregate covering the substrate of the nursery plots. Three basic techniques are available for nursery plots: bottom culture, raft culture and tray culture. Each of these has its own use and limitations.

1. BOTTOM CULTURE

Bottom culture is the least expensive of the techniques for nursery areas, but it is also the most difficult to carry out effectively, because of the difficulty of excluding the predators and stabilizing the bottom. Often, problems are not discovered soon enough to take remedial action because it is difficult to inspect clams buried in the bottom. The substrate should be mud or sandy mud, but the muddier substrates should be firm enough so the grower will not sink in too deeply (mid-calf). We have found that areas that are covered by a foot or so of water on all but the

spring tide lows make the best compromise between ease of working and maximization of growth. Regardless of bottom type, it is wise to establish a nursery area using whatever technique you think is best. Watch the location for several weeks to a month before concluding that the site is the best one. It is not necessary to risk clam seed during this initial trial period. This is particularly important on sandy areas or in spots with large tidal amplitudes. The substrate in these latter two areas may be more motile, and a trial may indicate that shifting sediments will cover your predator exclusion devices and would smother any clams that have been planted within these devices.

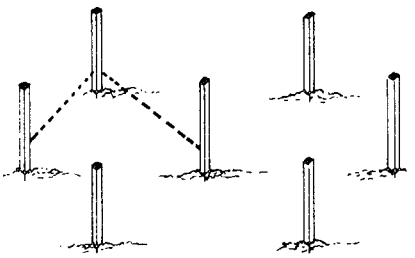
a. PREPARATION OF THE NURSERY AREA

Clams can be planted at densities of about 300 to 400 per square foot, or 3200 to 4300 per square meter. Large enough areas should be prepared for the number of clams to be planted. Long narrow rectangular-shaped beds are preferable because plots more than six or eight feet (1.83 to 2.44 m) wide are more difficult to plant, harvest or cover with predator exclusion devices. These rectangular beds should be pointed in the

predicted direction of the worst storms to minimize the effects of waves. There are two major types of protection techniques within the bottom culture category: the baffle-aggregate-pen and the aggregate-tent. The baffle technique can be used in areas with slightly more wave action than the tent, but it is more expensive. Baffles cannot be utilized in areas where drifting algae is abundant. This algae can become trapped within the baffled area and possibly smother the clams.

(1) BAFFLE-AGGREGATE-PEN

Nursery areas should be prepared while clams are still on the grow out tables. An area of 1/8 acre has 5445 square feet and will support about 1,000,000 clams. If a pen is to be placed around the area, we recommend placing it in a circle. This is not as efficient for space usage as a square or rectangle, but it does prevent buildup of floating debris against one flat side of the pen. The diameter of a circle this size is slightly more than 83 feet and the circumference is about 261 feet. The circumference (distance around) of a circle can be calculated from the diameter (distance across).



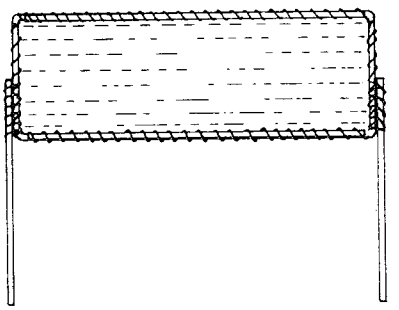
Example:

Circumference = 3.14 x diameter of the circle
i.e. Circumference = 3.14 x 83 feet =
260.62 feet

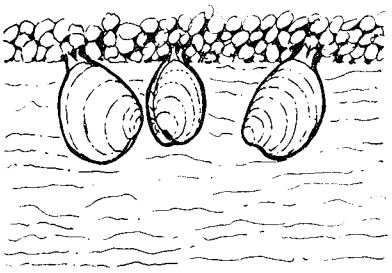
To delineate an area this size, place a pole in the approximate center and use a string 41.5 feet (radius = 1/2 the diameter) long to circumscribe the edge. Use a series of small stakes to mark the position for larger poles. Two or three people can do this job easily. One can do it if necessary. A second string can be used to mark the distance between the poles. Stretch the string from the center pole (radius) and place a stake. Measure from stake with the second string to the distance of the second stake. Where the end of the second string and the string from the center pole meet is the place to set the second stake. Continue the placement of stakes in this manner until the circle is completed. The tall poles are brought in later to replace the stakes. The method of placing these poles will depend on the area. If the bottom is soft mud with no hard layers, the poles can be pushed or forced in, but if there is sand mixed with the mud or a lot of shell, a small gasoline powered water pump can be used to jet the poles in. Creosoted 4 in. x 4 in. x 16 ft. boards placed every 10 to 13 ft. with

about 10 to 12 ft. of the pole above the bottom substrate work quite well in shallow areas.

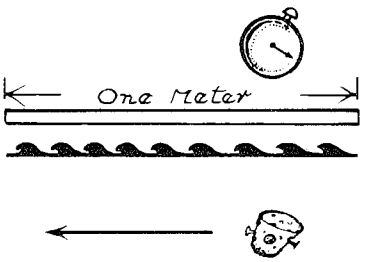
(a) INSTALLING BAFFLES



Baffles are simply rectangles of heavy plastic mesh with about 10 mm square openings (3/4 in. x 3/4 in.) that are fastened to a 2 ft. x 5 ft. rectangular steel frame constructed of 1/2 in. steel rod. Each baffle has a leg extending down its 2 ft. height so that it can be installed in an upright position by pushing the legs into the substrate. A square plot is formed by installing four baffles. Once the edges are fitted as closely as is practical, the corners should be tied together. The 5 ft. x 5 ft. enclosures of baffles should be placed in a linear fashion, pointing in the direction of the worst storms. Pea gravel, crushed shell, crushed rock or some other suitable aggregate can then be placed over the bottom inside the baffled areas. (Crushed stone or pea gravel runs 1/2 to 3/4 in. in diameter, shells should be crushed to about 1 in. to 2 in. pieces.) This material should be 1.5 in. to 2 in. deep over the bottom. These sites should be left for about a week and examined for silting. If no silt is present, additional baffles may be required. If too much silt is present (obscures



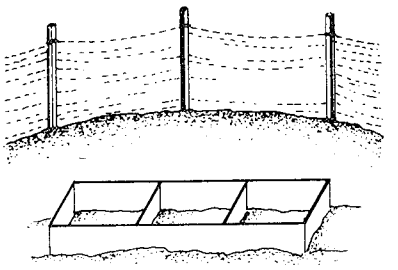
the gravel completely), some of the baffles should be removed. Too much silt will cause the clams to move to a position above the gravel so their siphons can extend into the water. The layer of aggregate will not protect them unless they are within or below the aggregate. The lack of silt indicates that the currents are too swift and the young clams will be washed away. Do not expect a large amount of silt to collect if the nursery area normally has clear water. A test should be run with a small batch of clams before large numbers are planted if no silt has collected. Ideally, a current velocity of about 15 cm per sec should be maximum at the sediment water interface. A simple current meter can be constructed from a chip of wood or small cork weighted with enough small tacks so it floats below the surface. To measure current velocity, place the meter in the water and measure how far it travels in a given length of time. Be sure measurements are made at maximum current velocity.



(b) PEN AND CRAB TRAPS

After the baffles and aggregate are installed, a pen should be erected to exclude larger predators such as rays (Rhinoptera sp.,

Note size and angularity of aggregate for planting beds. No. 8 crushed stone, shown here, is the preferred material. Ref. pp. 41 - 42.



Dasyatis. sp., Myliobatis sp., etc.) The pens are constructed of 3/8 in. square plastic mesh, commonly used in commercial vineyards and orchards to exclude birds from the fruit (Conwed netting). A chain should be sewn to the bottom of the pen and a head rope (about 3/8 in. diameter) sewn to the top. This pen should be buried about 6 in. in the bottom and extend up the poles so the top is above the height of the highest tides. The top can be supported by nails or wire staples driven into the poles. A place where the net can be lifted off the poles to allow access into the pen is desirable. Plastic net survives well under most conditions, but accumulations of barnacles and oysters on the support poles should be scraped off periodically to avoid tears. Sunlight causes deterioration of plastic. Select a dark color or a plastic containing an ultraviolet light inhibitor.

Once the pen is installed, crab traps should be placed within the penned area and fished for at least a week before the young clams are placed in the nursery area. If there is no reduction in the numbers of large crabs in the pen in this amount of time, check to be sure: (1) the net is high enough, (2) there are no tears and (3) the bottom

is completely buried and sealed off. Continue trapping until a noticeable reduction in large crabs occurs. There will probably always be some crabs in the traps. Some individuals will enter the penned area during extreme tides (high spring and storm tides) and through occasional tears in the net or burrows under the bottom edge. Crab trapping should continue until the water temperature drops below 8°C. Different species of crab will probably require that the pen and traps be modified and adjustments made to its habits. During the winter when ray and crab activity is absent, the pen can be removed and stored until spring. Reinstall the pen by the time the water temperature rises to 10°C.

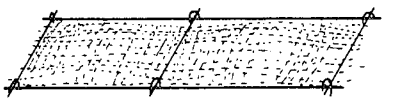
(c) TENTING

Another method that has been successfully used is to cover the aggregate with small mesh netting. This netting replaces both the baffle and the pen and is particularly useful in areas of drifting algae.

1) MATERIAL

The material used to make the tents is usually the same 3/8 in. mesh plastic netting.

Smaller mesh is often desirable, but requires more maintenance and cleaning. The netting comes in rolls (often sold by weight) that are 11 ft. wide and of variable lengths. A size that is easy to use is 11 ft. wide and 20 ft. long. A series of 5 or 6 seine net floats may be tied down the center of the net 5 ft. 6 in. from the edge to prevent the net from lying on top of the clams. A 3/16 in. chain is fastened across the two 11 ft. ends. The sides are anchored with 20 ft. lengths of 3/8 in. steel reinforcing rod laid across the edges. The rods are held in place with 2 ft. stakes made of the same material with the top bent over to form a hook. This method has obvious advantages. The tents are not as vulnerable to storms as pens and baffles, and they are less apparent to poachers. The cost is far less than the baffle and pen method. The percent survival is about equal when using seed that is 10 mm or larger, but not as good as the baffles and pen when using smaller size seed. The cost of larger seed, however, is higher than smaller seed, so some concessions must be made.



2) PROCEDURE

Spread the aggregate in strips, about 6 to 8 ft. wide, and whatever length is convenient.

These should be pointed in the direction of the most severe storms or wave action. The tents should immediately be placed over the beds and left undisturbed for 4 to 7 days. This period allows the aggregate to settle securely. After this settling period the area is ready for planting the clam seed. Tents should be checked often and repaired as needed. The net should be lifted periodically to remove any crabs that have found their way under the tents.

The cover must be constructed or supported in such a manner that it does not constantly lie on top of the clams when water covers the area. Aggregate helps to keep the net from sticking to the sediment, and floats will usually hold up the net if it is sufficiently loose. The clams may smother if the net is strapped tightly over the substrate and silt begins to accumulate.

Modification of the above system is necessary for some areas. For instance, the type of aggregate can be dictated by cost of various materials and whether or not fouling of certain types of aggregate is a problem.

b. PLANTING

When all field preparations are completed and there are sufficient clams at 4 to 6 mm or larger size, planting can begin. The clams are taken out in groups of 7,000 to 10,000 (Q.). These are then scattered over the bottom in one of the baffled squares or under the tents. The clams can be planted through the mesh on the tents, unless the seed is too large to fit through the openings of the mesh. An even distribution is desirable, but avoid placing them within 6 in. of a baffle or near the edges of the tents. The action of waves causes some scour in this zone. Distributing the clams is best done on a calm day when there is just enough water in the area to cover the gravel. The water temperature should be above 10°C so that the clams will actively burrow. Once the clams are in place they can be left alone for several months, but the predator exclusion equipment (pens and baffles or tents) should be checked weekly for tears, loose spots, disturbance, etc. This should be done at low tide so the entire net can be examined and to make sure that silt is not accumulating. Daily visits to the area are encouraged.

2. RAFT AND TRAY CULTURE

Rafts and trays are similar devices for holding the clams, except trays rest on the bottom or stand just above the bottom, while rafts float at a fixed position relative to the water surface. Extensive shallow areas near a hatchery would be ideal for tray culture. An area with low tidal amplitude and correspondingly little shallow water space may require raft culture. Rafts may be integral parts of floating docks in areas of deep water and high tidal amplitude. Independently moored rafts require quiet locations where storm waves and excessive boat traffic are minimal.

a. RAFT CULTURE

Rafts are usually simple floatation devices to which trays containing the clams can be suspended. Trays can be suspended beneath the float with ropes or cables to alleviate some of the disturbance caused by wind-driven waves and boat wakes. Unfortunately, this type of suspension makes it more difficult to tend the tray because it must either be brought ashore or lifted for inspection or to make repairs. Instead, the trays are usually an integral part of the raft and can be inspected with the raft in the water. The

most commonly used floatation devices are styrofoam logs. The lifting capacity of the various size logs can be obtained from the supplier. It is important to cover the entire upper surface of the log to protect the styrofoam from sea gulls (roosting gulls peck chunks out of the logs) or boat damage. The bottom of the logs and their supports should be painted with antifouling paint. Some antifouling paints cause the styrofoam to dissolve, so a test should be made before choosing a paint (S.3. and IV.B.).

Trays can be suspended 1 or 2 ft. beneath the floats, thus keeping them in the warm surface waters and above the bottom. Anchored rafts must conform to pertinent navigation rules and local customs. Keeping a long string of rafts along the edge of a channel requires large anchors. The rafts must be anchored in a manner or in an area where they will not become a hazard to navigation. This difficulty in anchoring is one of the disadvantages to using rafts. Other disadvantages are: 1) they require relatively quiet water or the sediment in the tray may shift, 2) large numbers of clams require a large number of rafts, and this may interfere with other water uses, 3) rafts are expensive to build, 4) they require

tending and maintenance and 5) they can be damaged by ice or severe storms.

b. TRAY CULTURE

Trays can be supported on racks built on poles placed in the bottom. The poles need not extend above the trays. The trays should be exposed for tending at low tide. The poles should be spaced to allow two trays to be examined from a central location. Cross pieces to support the trays should be placed so the trays are held slightly off the bottom. Poles and cross pieces should be treated lumber to prevent their destruction by shipworms.

The major difficulty with tray culture is the susceptibility of the trays and tray supports to damage by ice. In northern areas trays may have to be sunk in deep water for the winter. The second major problem with trays is algal fouling in areas with low tidal amplitudes and clear water. The only solution to this in the low tidal amplitude spots is frequent changing of the tops and even occasional transferring of the clams to clean trays. Algal fouling can be controlled in areas of greater tidal amplitude by adjusting the position or elevation of the trays so that they

are exposed to air during low tides. The daily drying periods serve to eliminate most of the fouling.

c. TRAYS

Trays should not be so large as to make lifting and handling impossible. The size and shape should be adaptable for use on poles and crossbeams (jackstays) or under floats (rafts). The tray should be adaptable to local conditions. A wooden tray 3 ft. x 10 ft. x 6 in. deep can be handled by two people.

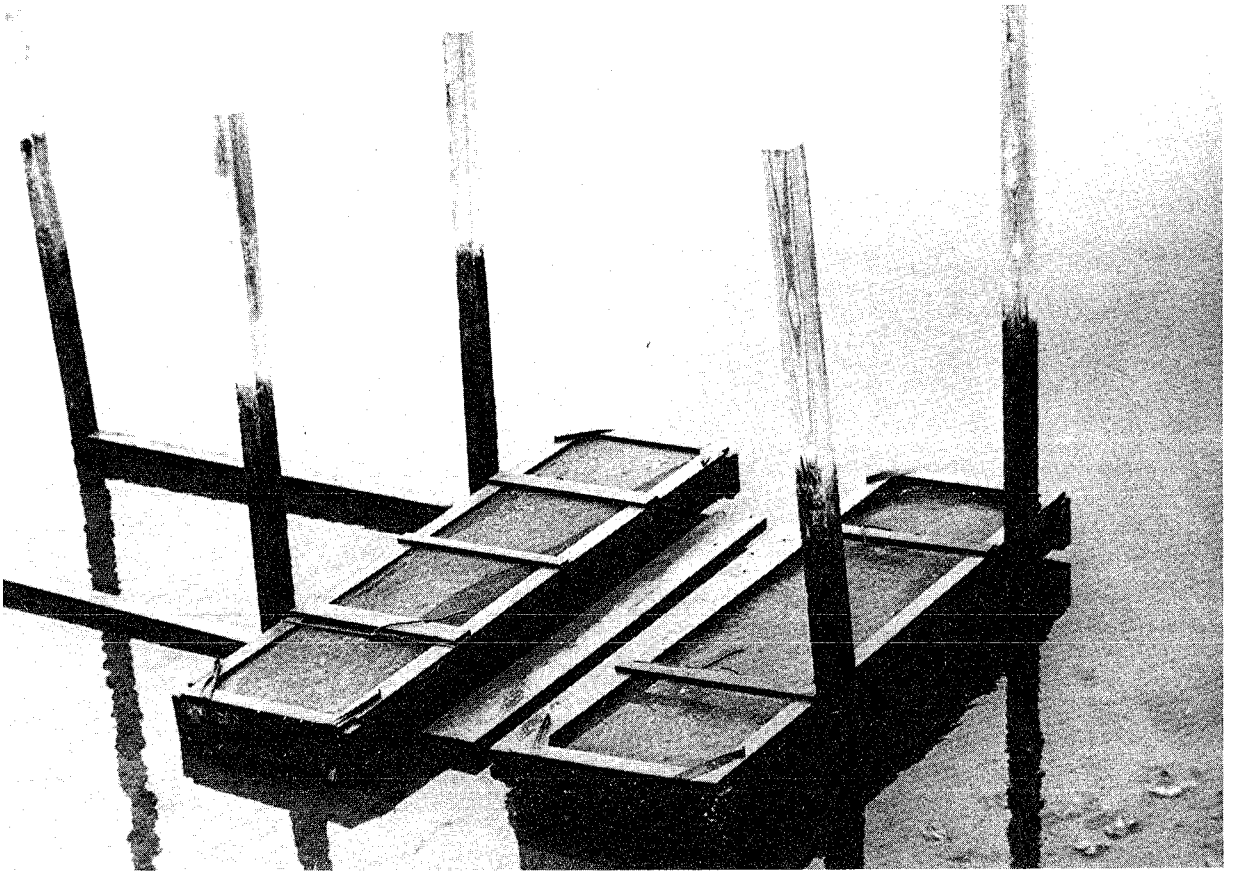
Tray sides should be 6 to 8 in. high to allow for a sand and gravel base to be put in and still leave distance between the clams and the mesh top. Trays built with both mesh tops and bottoms allow better water circulation through the substrate. Sufficient bracing to support the mesh, sand and gravel is necessary. Tops should be removable so the tray contents can be examined, and should seal tightly when replaced to prevent small crabs from entering the tray.

When building anything for immersion in seawater, it is critical to remember: 1) wood will be eaten by shipworms and gribbles,

2) fouling will cover anything not protected (the outside of the trays can be painted with anti-fouling paint) and 3) if two different metals are in close proximity, one will erode with alarming speed due to galvanic action.

3. SPREADING LARGER CLAMS

Once the clams in the nursery plots have reached about 25 mm (about 1 in.) (usually at the end of the first year's growth), you will need to thin them if they are to continue growing rapidly. Regardless of whether the tent or the baffle technique was used, if the clams were planted in rows (about 5 ft. wide), the clams and aggregate can be spread in between the original rows. Remove the tent or baffles and rake the clams and aggregate outward from the edges. The clams in the center can then be raked into the vacated space and additional aggregate spread over the thin spots. Pens or nets can be removed and stored until the next spring. Pens should be replaced by spring to keep out rays. Tents and baffles should be replaced immediately if the beds are subject to bird predation or to storms that might wash the clams out of the bottom. Be sure to spread the clams when water temperatures



Trays for raising juvenile clams to planting size are shown in position at approximate low tide. Poles and crosspieces are 4" X 4" copper-cured pine. Ref. pp. 48 - 52.

are at least 10°C so they can dig back in and re-establish themselves. If the clams were in trays or rafts, they can be thinned into other trays or rafts or placed into a prepared bed. This is the final step prior to harvest the next fall.

S. DISEASE PROBLEMS

Clam larvae and newly set clams may have diseases which cause a high death rate. Unfortunately, there has been little research on the prevention or cure of clam diseases, but a few general concepts seem to be true.

Most mortalities occurring in the hatchery and grow out phases are associated with high bacterial counts. Whether or not the bacteria are opportunistic saprophytes (bacteria whose numbers increase because clams are dying from other causes) or pathogenic (bacteria that causes mortalities) is not important. Clams in the larval and early post set stages always have high mortality rates when high numbers of bacteria are present. Constant vigilance and cleanliness are necessary to prevent bacterial problems.

1. LARVAL DISEASES

Diseases of larvae are generally quite dramatic. An infected group of larvae can be reduced to a few survivors in just a few days. Worse still, the infection may spread throughout the culture facility, greatly reducing the output.

a. INSPECTION

Approximately once a day, and certainly no less than once every other day, the larvae should be inspected with a microscope (10X ocular, 10X eyepiece). Active, swimming, well developed veligers with good clean velums are healthy larvae. Good color and fast growth rate also indicate healthy larvae (unless temperatures are below 15°C most larvae should grow about 10 microns a day).

b. DIAGNOSIS

Sick larvae exhibit slow growth, poor color, weak or no swimming activity (and finally sink to the bottom), often have debris attached to the velum and almost always have a high number of protozoans swimming around them. Protozoans feed on bacteria and are often the best indicators of bacterial infestations. Bacterial infection will often show up as swarms of bacteria and protozoans

around the gaping shell. At times the protozoans will even be inside the shells of infected larvae.

Larvae grown at low temperatures (10 to 20°C) sometimes have fungal infections. These infections may appear as finger-like projections in the tissue, or the thread-like fungal mycelium may protrude from the shell, almost like a beard.

Other more unusual diseases are known but are uncommon.

c. DISEASE TREATMENTS

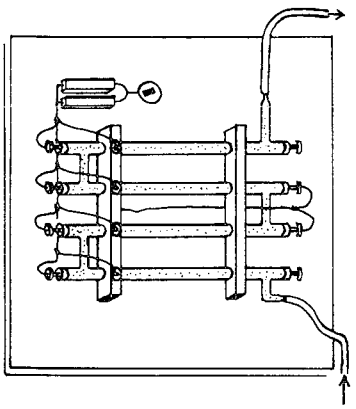
Immediate action should be taken if the larvae display symptoms of disease. Sick larvae should be discarded, the containers and sieves cleaned and a new batch or spawning started. If a decision is made to save the larvae (usually because the infection appears to be mild), the following steps should be taken.

Drain the culture and size the larvae through several sieves. Discard the larvae on the smallest size sieve. Since these larvae haven't grown, they are probably sick, moribund or dead.

Rinse the larvae to be retained with generous amounts of cultured water. Fill a carefully

cleaned container with new cultured water (avoid using water over 36 hrs old). If a short wave length ultraviolet light or sterilamp is available, the new cultured water should be UV treated prior to adding the larvae. Then, if the survival of the culture is so important that heroic methods are justified, treat with an antibiotic [see S.1.c.(2)]. The decision to use antibiotics should not be taken lightly because of costs and inherent dangers of using medications.

(1) ULTRAVIOLET LIGHT STERILIZATION



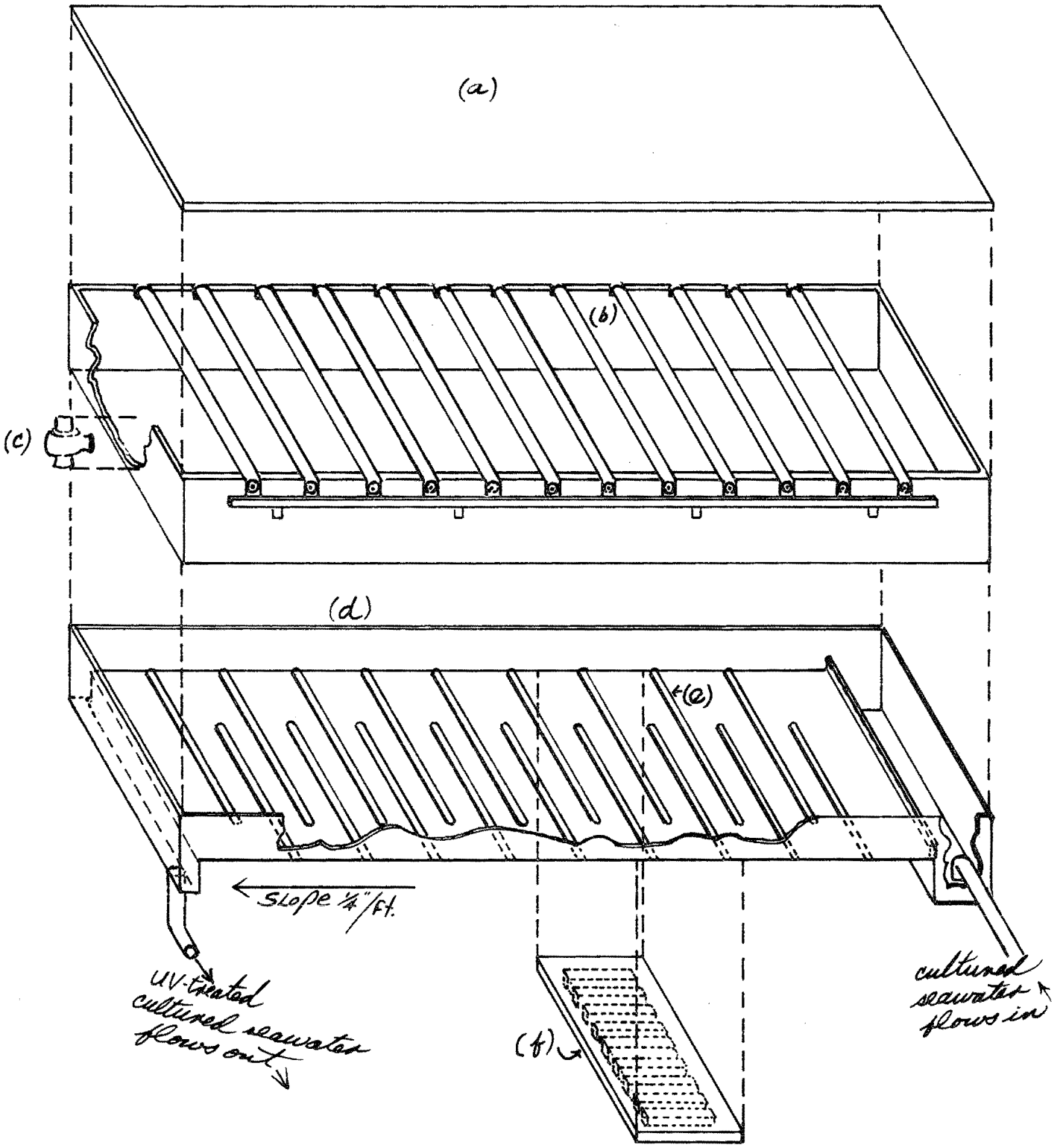
Ultraviolet light (25,000 Angstrom units) can be used to sterilize seawater in a hatchery. Ultraviolet light will greatly reduce the number of bacteria, but will also kill most planktonic organisms including clam larvae and phytoplankton. Larvae cannot be exposed to ultraviolet light. Phytoplankton will be killed by UV treatment, but will still be usable as food before they settle to the bottom.

Ultraviolet light is a good bacteriocide, with some limitations. It penetrates water only a few millimeters, and is less effective in water containing suspended sediment. Water should be filtered or centrifuged to reduce the suspended

(a) ½" plywood cover
(b) 30 watt UV bulbs
(c) Mower
(d) riffle board
(e) 1"×1" strips
(f) ballasts attached to underside of board

Large UV System

Overall Dimensions: L = 9'1½": W = 2'6½": H = 11½"



particulate matter. A trough designed to expose water to UV light requires that the water pass through a shallow layer. A shallow riffle board will expose or turn over the water as it passes through the trough. Water should be exposed to UV light just before it is used to fill a larval container. This way the larvae won't be exposed and the water won't be recontaminated. An UV light unit can be purchased (sterilamp) or constructed.

(2) ANTIBIOTIC TREATMENT

The usual treatment is with an aqueous solution of penicillin G and dihydrostreptomycin in a ratio of 100,000 units of penicillin G to 0.125 g of dihydrostreptomycin. To achieve this, add 10,000 to 15,000 units of penicillin and 0.0125 to 0.019 g of streptomycin per liter of water containing the larvae. The important measure is the volume of water, not the density of larvae. Treatment can be administered conveniently while the larvae are concentrated in calibrated containers during a water change. More stubborn infections can be treated with a wide spectrum antibiotic such as chloramphenicol sodium succinate (trade name, Chloromycetin) at 8 to

10 mg of antibiotic per liter of water containing the larvae. After 1 to 2 hours, rinse the antibiotic from the larvae by collecting them on an appropriate sieve and rinsing the larvae with filtered or cultured seawater before returning them to a clean tank.

Indiscriminate use of antibiotics or using antibiotics as a disease preventive should be avoided. There is an ever present danger of an antibiotic-resistant bacteria developing in the hatchery. Antibiotics should not be used on eggs or embryos, because they often prevent development.

Fungal infections are usually treated by increasing the temperature of the culture, since most fungicides are lethal to larvae. Temperatures as high as 29 to 34°C for 12 to 24 hrs may be used to treat fungal infections. The larvae are often lost to secondary infection or temperature stress during this treatment.

(3) CHEMICAL STERILIZATION

Other methods presently used to sterilize both seawater and containers are chemical sterilization (followed by neutralization) using acid or

sodium hypochlorite. Chemical sterilization is commonly used in phytoplankton culture before innoculation of the sterilized water with algae.

(a) ACID STERILIZATION

The acid method is as follows: (1) fill a container with seawater and add sufficient hydrochloric acid to lower the pH to 3.9, (2) allow the treated water to stand for 4 hrs and (3) add an alkaline compound such as sodium nitrate or sodium bicarbonate to raise the pH to about 6.5. This method works very well for algal culture containers because the 3.9 pH can be raised to 6.5 with sodium nitrate. This is a fertilizer commonly used in growth media for algae. Then the water can be innoculated with the chosen species of algae. Bacteria-free (axenic) cultures of algae can be maintained if the preceding steps have been done properly.

(b) BLEACH STERILIZATION

Large volumes of seawater and their containers can be sterilized using liquid home laundry bleach (sodium hypochlorite) such as Clorox®. This method is as follows: (1) add about 0.5 ml bleach per liter of seawater to be

sterilized, (2) use disposable ATI Chlorine Water Chex® to test the water to verify that the residual is about 10 ppm (indicated by a color change), add more sodium hypochlorite if necessary, (3) add stoppers and hoses, etc. to the container and draw water through them so that entire unit is wet and exposed to the hypochlorite solution, (4) tip or invert containers to make sure all surfaces are contacted by the solution so that they will be sterilized, (5) draw some chlorinated seawater into the air line, (6) after 2 to 4 hours, dechlorinate using 0.1 to 0.15 ml of normal (1N) sodium thiosulfate solution per liter of chlorinated seawater, (7) test with ATI Chlorine Water Chex® to make sure the chlorine is totally inactivated, indicated by no color change (if not, add more sodium thiosulfate and test again) and (8) aerate the chlorinated/dechlorinated seawater before use.

d. DISEASE PREVENTION

A routine washing and drying of all equipment is often the best means of preventing infection and insuring successful culture of larvae. Between uses, wash all equipment with freshwater and a biodegradable detergent. Rinse the

equipment thoroughly in cold freshwater, followed with a hot freshwater rinse and allow the items to dry completely. Sieves and hoses, if left damp, harbor bacteria. Be sure they are stored so that they will drain and dry completely. Proper air circulation will aid drying. Filters make excellent substrates for bacterial cultures; therefore, special care must be taken to either wash, sterilize or dispose of filters. Generally, if an item is washed with freshwater and then dried, bacteria will not develop on its surface.

Brushes or mops used for cleaning larval containers should not be used to clean anything else. Larval containers should not be used for anything else. When disease strikes a hatchery, it is necessary to close for a thorough cleaning of all the equipment. Be sure to include pumps, pipes and containers.

2. GROW OUT PROBLEMS

Many of the same problems that cause mortalities in larvae also affect the post set clams, but these problems are often more difficult to diagnose.

a. DISEASES

Recently set clams must be inspected daily. This means sampling the clams with a medicine dropper or a small scoop. Use a microscope to inspect the clams and appraise their general health, survival and growth. Keep a log or notes on each group of clams or on each grow out table of clams. You can assume there are disease problems if inspection reveals a high percentage of gaping clams or empty shells. A symptom of disease among larger post set or seed clams is the appearance of black spots on the tables or areas of black silty mud among the clams. The use of protozoans as indicators of bacteria (as in the larvae) is impractical with post set clams. Protozoans are often abundant in clam wastes or on detrital material in the natural waters used in the grow out.

(1) ANTIBIOTIC TREATMENT

When newly set clams become infected, collect them on a sieve and immerse the clams and the sieve in a container (10 liters) of seawater treated with antibiotic. A dose of 200,000 units of penicillin G and 0.25 g of dihydrostreptomycin or the equivalent is adequate. If other anti-

biotics are used, compute the dosage by using the weight of the water in place of weight. One gallon of seawater weighs about 8.2 lbs (1200 g per liter). The clams should be soaked for 1 hour. Scrub and rinse the tables or containers before returning the treated clams to them. Be sure to completely rinse the antibiotic from the clams before returning them to the tables.

(2) BLEACH TREATMENT

Disease can also be controlled with a treatment of sodium hypochlorite. The clams are treated the same as in S.2.a.(1), but instead of adding antibiotic, substitute 0.5 ml of bleach per liter of seawater and allow the clams to soak for 1 hour. Rinse the clams before they are returned to the running seawater. Caution - do not use sodium hypochlorite treatment until the clams are large enough to have white shells (very young post set have tan or brown shells and will be killed by this treatment).

b. OTHER GROW OUT PROBLEMS

In addition to the bacterial or microbial diseases, other problems may appear, such as air bubble "disease" and fouling.

(1) AIR BUBBLE "DISEASE"

Small clams may be found floating on the tables, larger clams may be found gaping and their tissues appear to be blistered. This is air bubble disease. By the time these symptoms are apparent, it is usually too late for the clams to recover. If the temperature of seawater is elevated in a closed container (such as a heat exchanger) or if there is even a pinhole leak on the intake side of the pump or at the pump seal, the seawater can become supersaturated with air. This may cause air bubble disease. When water temperatures drop below 15°C, several warm days may cause water to become supersaturated with air. This, too, may cause air bubble disease; therefore, when water temperatures are below 15°C, it is wise to install degassers.

Degassers will eliminate this problem by allowing gas to escape before the seawater flows over the clams. Additional means of degassing seawater are: vigorously agitating the supersaturated water, cascading the water through a series of baffles, stirring the water with a pump or mechanical stirrer or aerating the water before

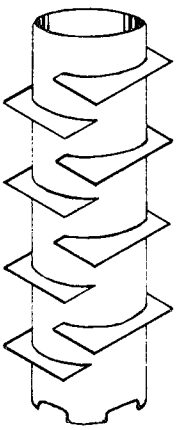
use. A degasser placed on the flowing seawater table under the incoming seawater is effective.

For flow rates below 25 liters per minute, a simple degasser can be constructed of 4 in. PVC drain pipe and fiberglass or plastic sheets. Construction is as follows:

(1) A 4 in. PVC pipe 12 in. long is sawed 1/3 of the way through the pipe every 3 inches.

(2) These saw cuts are staggered on opposing sides of the pipe.

(3) 4.5 in. x 2.5 in. rectangles of fiberglass or other suitable plastic material are pushed into the saw cuts to make a series of baffles.



(2) FOULING

A major problem caused by utilizing water pumped directly from nature is that larvae of other organisms can enter the system (see 4.A.6.). These larvae can be predators or competitors for food and space. They can cause problems by physically smothering the clams, or in many cases entangling the clams with their byssus or tentacles. Most of these larvae could be selectively filtered out with bag filters at low flow rates

(less than 4 L/min), but above that point filtering is too costly. The type of fouling prevention used for post set will depend on the method of providing food to the clams. Clams larger than 1 mm can be treated the same no matter which post set method has been used.

No fouling prevention is necessary if 25 micron bag filtered water is flowed onto the tables. If unfiltered seawater is used (0.2.), the table and the clams thereon should be drained and air dried for 1 hour daily beginning 7 to 10 days after the clams started receiving flowing unfiltered seawater. After several weeks, this drying time can be increased to 2 hours daily until the clams have grown to over 1 mm in size. At that size freshwater soaks can be used (see below). Do not expose the clams to the sun's heat for long periods. If tables are not under a roof, tops should remain on the tables during the drying period.

Once clams have reached 1 mm it is more efficient to treat the table with freshwater once a week. Shut off the seawater flow, drain the table and flood the table with cold tap water. It does not matter if the table does not drain completely. This freshwater should remain on the

table for 1/2 hour and then be flushed out by restoring the seawater flow. Freshwater treatment is particularly effective after a table has been cleaned.

3. TOXINS

Toxins dissolved in the seawater can cause serious mortalities of larvae and newly set clams. Careful screening and bioassay of material introduced into the growing system can eliminate some of the problems. For instance, copper ions from metallic copper, brass, copper oxides or chlorides will be lethal in small amounts. Copper pipes should not be used in the hatchery or the post set facility. Certain pigments, paints, coatings and materials can contain toxic elements. As a precaution, a small test batch of larvae should be exposed to new products or materials before they are used.

(a) BIOASSAY

This procedure is used to test new materials or methods. For instance. if a new paint or coating is being considered for the clam tables, the following procedure should be used for bioassay.

(1) Paint a tongue depressor (or equivalent sized piece of wood) with the coating to be tested and allow to dry.

(2) Wash and rinse the coated depressor.

(3) Introduce approximately 1000 clam larvae or fertilized clam eggs and filtered seawater into a clean calibrated container. Stir (using a plunger) and quickly divide the filtered water containing the larvae or eggs equally into two clean containers.

(4) Place the coated depressor into one of the containers and leave the other as a control. After 12 to 24 hours count the live and dead clams in each container to see if the addition of the coated tongue depressor had a harmful effect on the clams as compared with the clams in the other container.

The same method, with modifications, can be used to test food, seawater, new material, etc. A control, i.e. a container without the material being tested, should be included in the test.

Small clams could also be used for a bioassay, but they will not show distress or death as quickly as larvae. Eggs or embryos are even more vulnerable to toxic substances than larvae.

Volatile solvents (like those in glue or cleaning solutions) can be absorbed from the air into the water held in tanks. A good rule is, if you can smell it, don't use it around larval containers.

Pesticides are usually toxic and should not be used around a culture facility. Insect repellents must not be used by anyone who enters the hatchery. Often hatcheries have severe mortalities immediately following aerial insecticide spraying of a nearby area or immediately following a heavy rain and its ensuing runoff. This is because some of the pesticide-laden water eventually finds its way through the intake and into the seawater system of the hatchery.

Herbicides are also quite toxic and will often cause problems following a rain when runoff carries them into the estuary.

Industrial pollutants can cause periods of toxic water. Organic pollution such as sewage has

a high biological oxygen demand and can cause anoxic water (no oxygen). It is best to avoid siting the hatchery or nursery in areas known to be polluted unless an extended period of testing has preceded the decision. Bioassaying the water from an area being considered for a hatchery or nursery site, especially after storms when resuspension of bottom silt might occur or after heavy rains when runoff occurs, might prevent an unfortunate and costly mistake.

IV. EQUIPMENT

Some of the equipment must be constructed, either because suitable equipment often is not available or the cost of manufacture or shipping may be high.

A. SEAWATER SYSTEM

This encompasses the entire dual system for moving seawater through the culture facility, including necessary equipment and operation.

1. PUMPS

Usually, industrial equipment salesmen will be able to recommend a pump that will deliver the

water volume required. The materials in the pump should not be copper, brass or bronze, since these can leach copper ions. A high concentration of such ions can be toxic to larvae. A cast iron pump is usually the least expensive and works very well. Inert materials such as stainless steel or plastics will also work, but are usually more expensive.

2. PIPE

The seawater lines should be PVC schedule 40 or flexible plastic pipe. Follow the manufacturer's instructions for installation. Be sure to allow for expansion and contraction in long sections of pipe. If a large diameter pipe is used, water friction will be decreased, but too large a pipe will act like a trough and more fouling can result. Reducing friction means less dynamic head pressure and greater flow rate for a given sized pump. Pipe size recommendations are usually available from pump suppliers. A dual seawater system is recommended (see IV.A.6.).

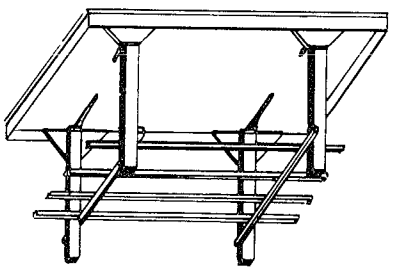
Drains can be plastic or concrete troughs. Points to remember: (1) The fewer the bends and the shorter the run, the easier it will be to clear the drain if it becomes clogged; (2) the

larger the diameter of the drain, the less chance it will become clogged; (3) troughs with removable covers are usually the most trouble-free.

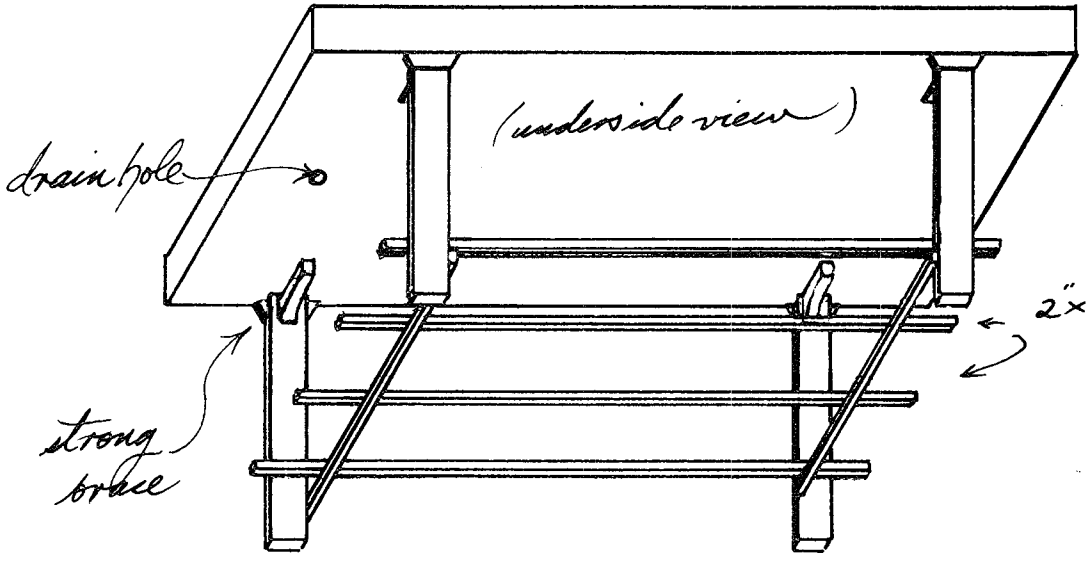
3. VALVES

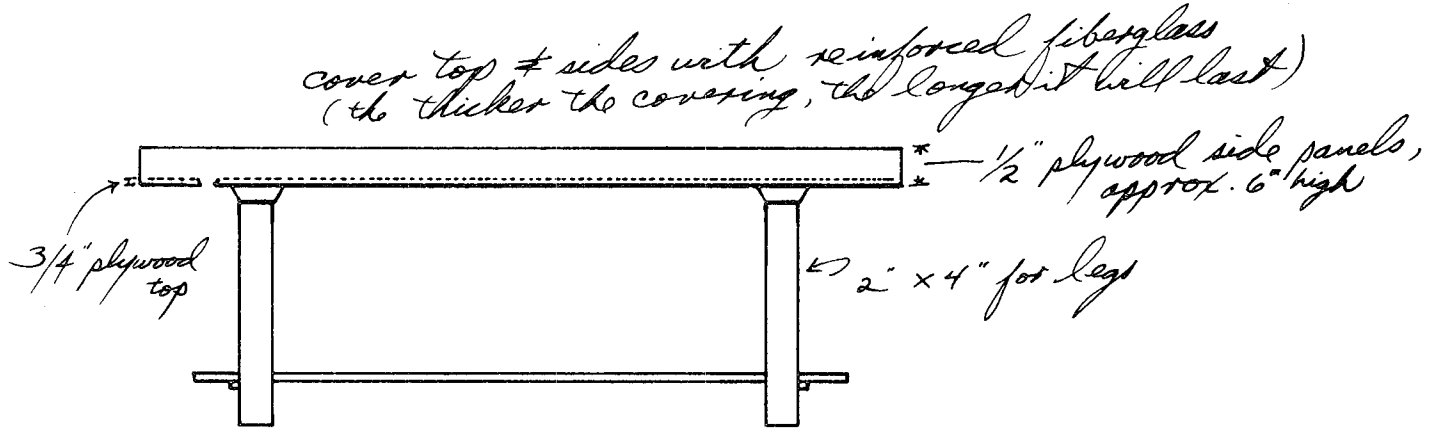
One of the most serviceable types of valves is a plastic ball valve. This type is available from several manufacturers. Some ball valves have removable components and can be repaired easily using replacement parts. This type is recommended.

4. WASH DOWN TABLE



A wash down table is an indispensable item for handling clam larvae or small clams. It consists of a big shallow sink constructed of plywood and covered with a fiberglass matting and resin coating. A good size for the top is 3 ft. x 8 ft., with a depth of 3 or 4 in. The table should have a 1.5 or 2 in. drain hole on one end and should stand about 30 in. tall. It is convenient to have storage racks for sieves underneath. This table can also be used as a water bath for controlling the temperatures of small containers of seawater for individual spawning if hot and cold tap water are available.


Wash down Table
approx. scale ½"/ft
(underside view)
drain hole
2"×2"'s for holding sieves
strong brace


cover top & sides with reinforced fiberglass
(the thicker the covering, the longer it will last)
½" plywood side panels, approx. 6" high
3/4" plywood top
2" × 4" for legs

5. WASHING, SIEVING AND GRADING EQUIPMENT

Two pieces of equipment are necessary when rinsing eggs or larvae from sieves or grading larvae by pouring them through a series of sieves. One is an 8 in. x 24 in. rectangle of 0.5 in. PVC pipe to place the sieves on so they will drain. This is constructed of two 24 in. lengths and two 8 in. lengths of pipe fastened together with four elbows and PVC pipe glue.

The second is a head tank with a hose and valve for rinsing the larvae, etc. Any container that is nontoxic will do for a head tank. It should have a 15 or 20 gallon capacity. A plastic tote box, similar to those used in food handling, works well. A plastic 3/4 in. thru-hull boat fitting is installed through the bottom, and a length of tygon tubing is fastened to this fitting to carry water from the tank to the table. An inexpensive shut off valve comprised of a 12 in. length of 3/4 in. red rubber tubing, and a 3/4 to 1/2 in. plastic insert reducer coupling is installed at the end. A board with an inverted keyhole-shaped hole and a "V" cut is mounted on the side of the table. When the rubber tubing between the two plastic fittings is folded double

and pressed into the V cut to the 1 1/2 in. hole, it shuts off the flow. When pulled out of this shutoff board, the tubing straightens to an open position and the flow starts. This board and tubing act as an inexpensive valve that can be manipulated with one hand. The head tank is positioned about 4 ft. higher than the wash down table to allow gravity flow. A small pump fills the head tank on demand by flowing cultured water from the algal culture tanks to a float valve in the head tank. The float valve is a plastic device used in cattle watering troughs, and can be purchased from a farm supply store.

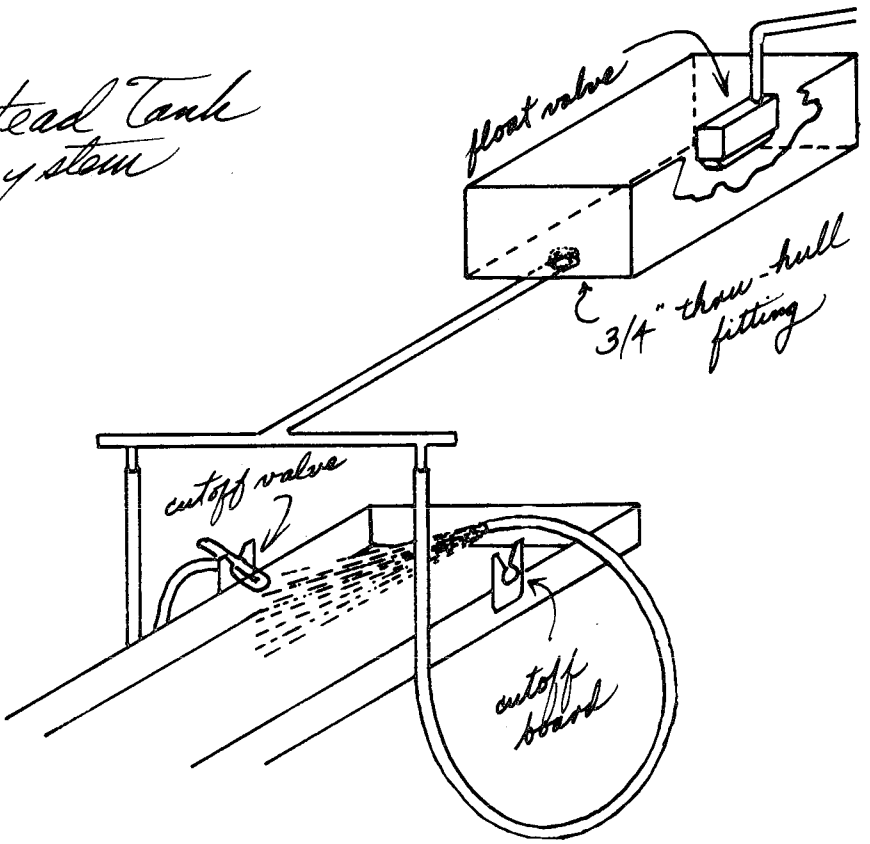
6. OPERATION OF SEAWATER SYSTEM

The entire seawater system should be dual from intake through drains. The problem of fouled pipes is eliminated by operating one half of the dual system on alternate weeks. In addition, the dual system allows for an emergency backup in the event of a breakdown.

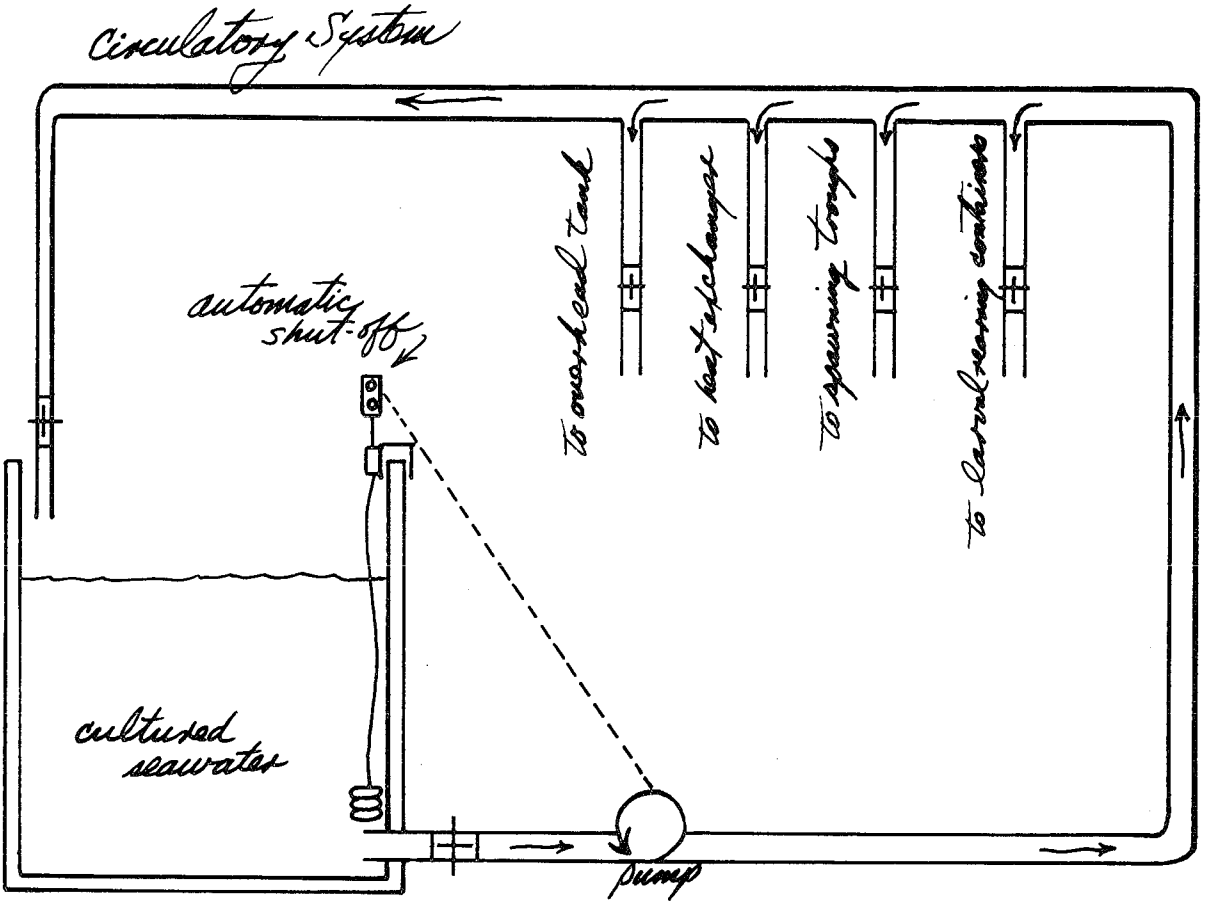
Example:

1st week - start pump 1 line 1
2nd week - start pump 2 line 2
stop pump 1 line 1, rinse
pump but do not drain line
3rd week - start pump 1 flush line 1
stop pump 2 and rinse but
do not drain line 2

Head Tank System



Head tank for washdown table showing location of thru-hull fitting (right) and intake tubing (left). Ref. p. 74.


Circulatory System
automatic shut-off
to overhead tank
to heat exchanger
to spawning trough
to larval rearing container
cultured seawater
pump

4th week - start pump 2 flush line 2
stop pump 1 and rinse but
do not drain line 1

By not draining the line after shutting off the pump, the water remaining in the line becomes anoxic and the fouling organisms that have set in the line during the 7-day use period will die and are easily flushed out. The seawater lines are flushed until the water runs clear.

B. TANKS

Tanks can be made of coated plywood or fiberglass. Be sure that whatever material is used is not toxic to the larvae. If wood or plywood is used in construction, it should be coated with fiberglass matting and resin to seal the wood and to prevent shipworm or other burrowing organisms from penetrating the wood. Uncoated wood can be toxic to larvae and almost always harbors bacteria. Commercially available asphalt coatings of the type used for cattle troughs or polyurethane paints can also be used for coatings. Antifouling paints of any sort must not be used. The toxins that make antifouling paints effective also kill clam larvae, and some are even lethal to small clams.

Seawater weighs 64 pounds per cubic foot at 4°C, so be sure that tanks are strongly constructed. For instance, wooden tanks in the VIMS hatchery are constructed of 3/4 in. plywood. Each 4 ft. x 8 ft. side and bottom of a tank has 2 in. x 3 in. oak reinforcing strips mortised together. These girdle the sides and bottom every 2 feet. Further, two 3/8 in. steel bolt rods cross the open top of the tank. The top edge of the tank is reinforced by a shiplapped 2 in. x 2 in. board bolted at the joint for reinforcement. Be sure the floor that the tanks are installed on is strong enough. Competent contractors can advise on this.

Fiberglass construction of tanks is often the easiest and least expensive method. Tanks for water depths up to 12 in. can be constructed of two alternating layers of 24.5 oz roving and two layers of 2 oz matting with the necessary resin to form the cloth into a tank. The same fiberglass construction can be used for larger tanks (4 ft. depth), but the tank should be further supported by two rectangular girdles of 2 in. x 6 in. lumber, shiplapped and bolted at each corner, and a 2 in. x 2 in. lumber rectangle under the top lip. Properly constructed, circular tanks do not

require such bracing. A circular tank will equalize the pressure on the sides and support itself. There should be ample instructions for fiberglass techniques in your local library.

C. CONTAINERS

Containers of various sizes will be required for the culture facility. Commercially available polyethylene containers are safe. When purchasing, buy seamless containers (if possible) in light, non-metallic colors. Always wash the containers carefully before use, and rinse liberally with filtered seawater. Test the toxicity (see III.S.3.a.) before use.

Glass containers, after a wash and rinse, are always safe to use. Pyrex cake or loaf dishes are very convenient and useful for spawning individuals. Fiberglass containers must be flushed with filtered seawater before use. It is often desirable to soak new fiberglass containers for a few days to eliminate any plasticizer or release agent residue. Metal containers or uncoated wood should be avoided. Ceramic materials work well if they are coated or glazed with nontoxic substances. If in doubt, test!

D. SIEVES

Commercially available geologist sieves can be employed, but the finer mesh size sieves are extremely expensive. Sieves can be constructed using Nitex® nylon mesh or polypropylene mesh fused to the bottom of plexiglass tubing.

Purchase 10 in. or 12 in. diameter 0.125 in. wall thickness clear cast acrylic resin (plexiglass) tubes. Cut the tubes to appropriate length (height of sieve desired) with a masonry abrasive blade on a table saw. Sand the edges to eliminate rough spots and uneven areas with a belt sander or sanding block. The night before gluing Nitex® to the tubing, mix some small scrap pieces of plexiglass (chips from the tube) into a small amount of 1,2 Dichloroethane in a jar with a screw cap. Close the jar securely. Allow the plastic to dissolve until a solution slightly thicker than 40 weight motor oil is achieved. When the glue is prepared, place newspapers on a flat surface (a floor works well), cover with wax paper to prevent sticking and place the Nitex® cloth on the wax paper. Place a bead of the glue solution on the sanded edge of the cut tube with an eye dropper and place this sticky-side-down on top of the

Nitex®. Place about 2 to 5 lbs of weight on the tube (3 or 4 large books) and allow the glue to dry for 24 hours. Cut the Nitex® on the outside of the tube with a razor blade and sand the edge of the Nitex® toward the tube top to remove rough edges. Be sure to inscribe the sieve size on the side of the new sieve with some type of permanent marker.

E. PLUNGER

Plungers can be constructed by cutting a 6 or 8 in. diameter disk from a 1/4 in. thick sheet of plexiglass with a jig or coping saw. Drill a series of 3/4 in. holes inside the periphery. Cut a center hole in the disk. Place a short length of plastic pipe (for example, 1/2 in. CPVA) with a cap on one end through the hole. The pipe can then be cut so that a coupling will secure the pipe and cap section to the disk once the parts have been glued together. Add about an 18 in. or longer section of pipe to the coupling for the handle. Cap this section to keep water out.

F. COUNTING CELLS

Counting cells can be made by forming a dike around the edge of a microscope slide with an RTV

type silicone rubber bead, but the purchase of a Sedgwick-Rafter counting cell is recommended.

G. PIPETTES

Graduated pipettes can be purchased from a scientific equipment supplier. It is easier to use an automatic pipette such as an Eppendorf® with disposable tips, but it is more costly. Disposable tips can be rinsed and reused. Use hot rinse water to prevent cross contamination.

H. MICROSCOPE

A microscope is necessary to inspect clam eggs, embryos, larvae and post set stages until the clams exceed 0.5 mm in size. There is no substitute for a good, easy to use, modern compound microscope. Toy microscopes, ancient microscopes or microscopes that are difficult to use should be avoided. Many problems in clam culture can be corrected if observed early enough. A convenient, easy to use microscope will help insure frequent observations.

It is recommended that a microscope have the following features:

(1) 10X oculars (eyepieces)

(2) 4X, 10X and 40X objectives

(3) lenses should be coated and corrected for color and astigmation

(4) binocular body

(5) focusable nosepiece with low-positioned coaxial course and fine adjustment on each side of stand

(6) mechanical stage

(7) focusable Abbe condenser with iris diaphram

(8) built-in base illuminator and transformer.

A microscope is a precision instrument and should be handled accordingly. If seawater is spilled on the stage or condenser (or anywhere else), carefully sponge it off, wipe with distilled water and dry. When the microscope is not in use, store it in a good, tight, dustproof cabinet containing a light. The heat from the light bulb will prevent moisture from damaging the lenses.

I. TROUGHS OR TABLES FOR GROW OUT

Troughs or tables can be constructed just as the tanks are. There should be a drain hole at one end in which a standpipe can be fitted. The drain hole should have a downspout to direct the

draining water into a sieve. This will prevent loss of clams during drain downs.

J. FIELD EQUIPMENT

Field equipment needs vary with local conditions. Generally these are simple predator exclusion devices.

1. BAFFLES

Construct the baffles by bending a 14 ft. length of 5/8 in. reinforcing rod into a 2 ft. x 5 ft. rectangle. Construction of a jig of the appropriate size will facilitate this operation. Use a "C" clamp to hold the starting point of the rod on the frame and heat the rod to help bend the corners. When the two ends meet, tack weld these together. Weld two 3 ft. legs on each 2 ft. side of the completed rectangle so that they extend 2 ft. below the frame. Lace some 3/8 in. coarse mesh Vexar® or Conwed® netting over the 2 ft. x 5 ft. rectangle using polypropylene rope. Do not use nylon or dacron rope for this purpose. Nylon or dacron will deteriorate in a matter of weeks when exposed to the anaerobic conditions in the mud.

2. PLASTIC MESH FOR PREDATOR PROTECTION - PENS, TENTS AND COVERS

Plastic nettings of various mesh sizes are used for the pens, tents or covers. Smaller sized meshes offer more protection against smaller predators, but require more care to prevent fouling or silting problems

(a) A pen usually is constructed from 3 in. x 3 1/2 in. or 1/2 in. mesh plastic about 11 ft. tall. It is held erect by fastening the top edge to posts imbedded into the bottom, or to a series of net floats. A 3/8 in. chain is encased, and sewn with polypropylene twine, in a fold along the bottom edge and the mesh. Shipworms are found throughout most of the range of clams; therefore, posts should be creosote treated (or other appropriate treatment) to prevent shipworm damage.

(b) Tents and covers are constructed from 1/2 in. or 1/4 in. plastic mesh. The length and width depend on the bed being covered, but should be large enough to allow some slack. The sides and ends are anchored with 3/8 in. steel reinforcing rod laid on top of the edges and further anchored with steel stakes (of the same

material) with the tops bent at about 45° over the reinforcing rod.

Net floats are fastened down the center of the tents at about 4 ft. intervals to cause the center line of the tents to float free of the bottom. This allows the clams to extend their siphons without interference from the plastic mesh. Net floats are not used on the covers.

V. HANDY HINTS

1. Use different color hoses for hot and cold water to avoid the mistake of cooking the animals by using the wrong hose.

2. Wrap the nozzle of your hot water hose with rubber insulating tape to prevent burning your hand. This also helps identify the hot water hose.

3. Stack clean containers upside down. This means they are clean and dust free. As soon as a container is right side up, it is either in use or it needs washing. This system will prevent reusing soiled containers and the ensuing problem of cross contamination.

4. Be sure that tables, tanks, etc. have a downspout on the drain. This prevents the vortex from spraying the contents uncontrollably over a wide area.

5. Don't allow insect sprays anywhere near your clam larvae. Technicians must not use insect repellents.

6. Label everything!

7. Hatcheries are chronically short of technicians' time and containers. Discard batches that are growing slowly or are not robust and healthy. If in doubt, discard and start over.

8. Don't use old food.

9. Keep everything clean and dry.

10. Avoid copper and zinc metals in the hatchery.

11. Before introducing a new material, chemical, paint or container into a hatchery, expose some larvae or small post set to it to see if it is toxic.

12. Be sure to condition any new containers by running seawater into them or immerse them (place overboard) in seawater for about 24 hrs.

13. Don't use anything from the hatchery for any other purpose. Cut off (shorten) handles on mops so they cannot be used for anything else.

14. Use a microscope often! Inspect larvae and small clams frequently.

VI. CLASSIFICATION[1]

Phylum Mollusca Cuvier, 1794

Class Pelecypoda ["hatchet-footed"] =Bivalvia ["two-shelled"]; Lamellibranchia, Lamellibranchiata ["sheet-filled"]

Order Veneroida (=Teleodonta ["perfect-teeth"])

Superfamily Veneracea

Family Veneridae

Sub-family Chioninae

Genus *Mercenaria* Schumacher, 1817

Species *mercenaria* (Linne, 1758)

Common name Northern Quahog

[1] Classification taken from Keen and Coan, etc.

VII. SUPPLIERS

This list is supplied merely as an aid to the beginning operator. It is not a complete list of the suppliers for various products, nor do the authors endorse the products or suppliers listed below. Other products and other suppliers who might be more convenient or competitive may be substituted.

Automatic pipettes, pipettes and pipette tips	- Arthur H. Thomas Co. P.O. Box 779 Philadelphia, PA 19105
Cast acrylic resin tubes, 10 or 12 inch	- Cadillac Plastic & Chemical Co. 15111 Second Ave. Detroit, MI 48203
	Branch - 80 Carnation Street Richmond, VA 23225
Clarifier, Sharples	- Sharples Equipment Division Pennwalt Corp. 300 E. Lancaster Ave., Room 109 Wynnewood, PA 19096
Conicals and fiberglass tanks	- Roger Moorman, Inc. Gloucester, VA 23061
1-2 Dichloroethane, E-175	- Fisher Scientific Co. 7722 Fenton Street Silver Spring, MD 20910
Drum faucet, 6078	- Cole-Parmer Instrument Co. 7425 North Oak Park Ave. Chicago, IL 60648
Filters, bag	- GAF Corporation Industrial Products Division Glenville Station Greenwich, CT 06830
	Call 704-523-8582 - Engineering Sales Charlotte, NC
Filters, core 15 micron W17R10A 10 micron W19R10A 1 micron W39R10A	- Larco Corporation 49 Winchester Street Newton Highlands, MA 02161

Greenhouse and greenhouse suppliers	- H. F. Michell Co. Church Road King of Prussia, PA 19406 or E. C. Geiger Box 285 Harleysville, PA 19438
Heater, immersion, 2000 watts, 33890-140	- VWR Scientific 6601 Amberton Drive Baltimore, MD 21227
Netting - Nitex	- TETKO Inc. 420 Saw Mill Road Elmsford, NY 10523
-	- Sterling Marine Products 18 Label Street Montclair, NJ 07042
- Vexar	- E. I. DuPont de Nemours & Co. Vexar Sales River Road Buffalo, NY 14207
Netting, green, NL5001, for baffles 40 in. wide, low density polyethylene 170 lb. per thousand sq. ft., 2.5 x 3 strands per sq. in.	- Conwed Corp. 770 29th Ave. SE Minneapolis, MN 55414
Netting, black, OV1580 2.5 lb. per thousand sq. ft. 1.5 x 1.2 strands per in.	Salesman - Clifford W. Berry Conwed Corp. 12 Chadwick Ave Marlton, NJ 08503 Phone: 609-983-6136
Plastic containers, 20 and 24 qts. 3 gal.	- Cole-Parmer Instrument Co.
Pumps - Gorman-Rupp, model 11 1/2, A3-B self-priming, centrifugal, base mounted	- Tidewater Supply Co., Inc. P.O. Box 839 Norfolk, VA 23501
- Little Giant pumps	- Cole-Parmer Instrument Co.
- March magnetic coupled seal-less pump, model DP-6T-MD, size 3/4 in. x 1 in., 1/2 hp 1/60/115-230 open drip-proof motor	- Tidewater Supply Co., Inc.

- Barnes pump, model 5 cu, w/3 hp 3500 rpm motor	- Wood Equipment Co. P.O. Box 4964 Richmond, VA 23229
PVC pipe and fittings	- Cadillac Plastic & Chemical Co.
Refractometer, model No. 10419, American Optical Corp.	- Scientific Products 8855 McGaw Road Columbia, MD 21045
Sedgwick-Rafter counting cell	- Arthur H. Thomas Co.
Thermometer, -1 to +50°C, 9294-L16	- Arthur H. Thomas Co.
48 to 102°C, T2352-39C	- Scientific Products
Tubing - rubber, tygon, polypropylene	- Arthur H. Thomas Co.
- Micro-Por	- International Plastics Inc. 10 Innovation Lane, Box 278 Colwich, KS 67030
Twine	- Sterling Marine Products or Nichols Net and Twine Co. Rural Route 3, Bend Road East St. Louis, IL 62201

VIII. INDEX

The College of William & Mary