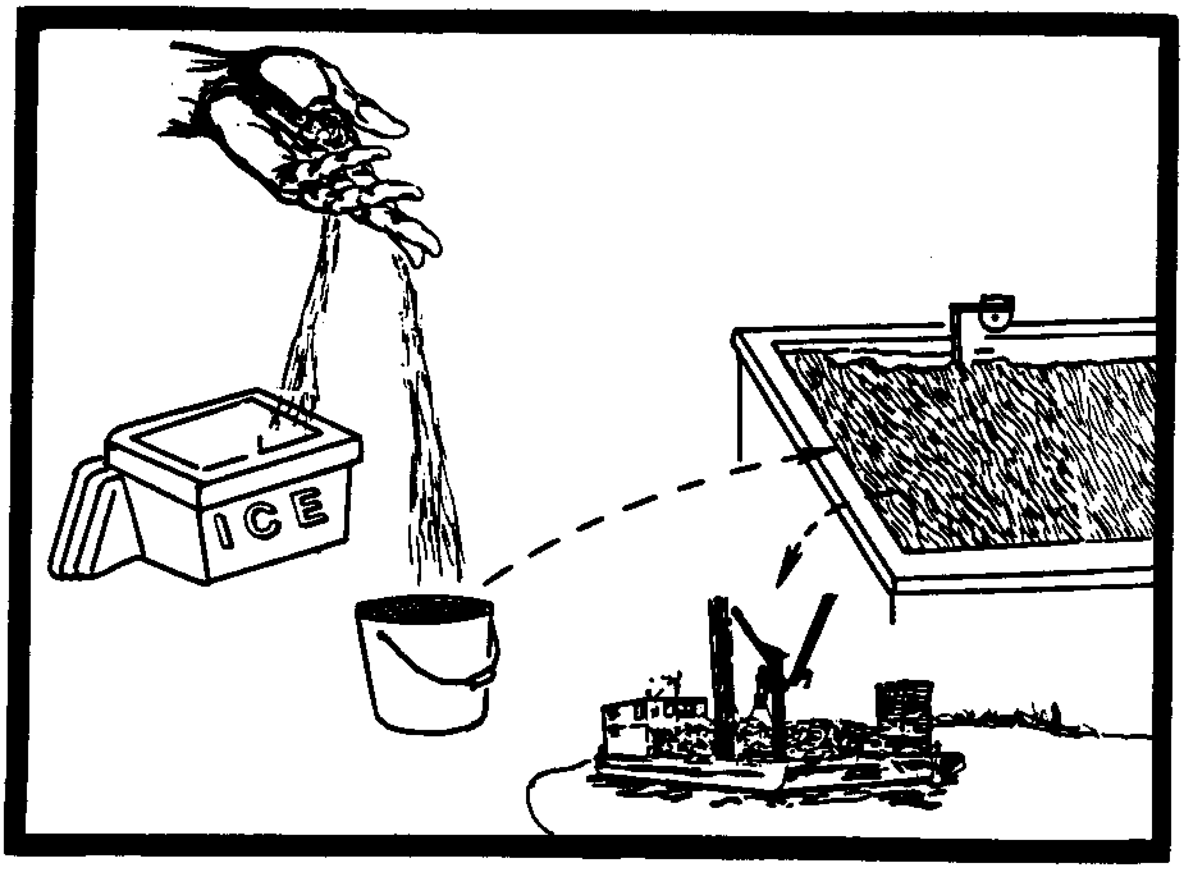
USING REMOTE SETTING TO PRODUCE SEED OYSTERS IN LOUISIANA AND THE GULF COASTAL REGION



John Supan

THE LOUISIANA SEA GRANT COLLEGE PROGRAM

USING REMOTE SETTING TO PRODUCE SEED OYSTERS IN LOUISIANA AND THE GULF COASTAL REGION

by

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SEA GRANT
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The successful larval and algal culture methods used at the Grand Isle hatchery of Gulf Shellfish Farms of Louisiana, Inc., are in part a result of training by Lee Hanson at his Whiskey Creek Oyster Hatchery in Netarts, Oregon. Mr. Hanson is a co-owner of the Grand Isle facility. His knowledge of hatchery management is admired and his assistance, hospitality, and friendship are greatly appreciated.

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Figures 1, 3, 4, 5, 6, 11, 12, and 13 are from *Advances in the Remote Setting of Oyster Larvae*, Jones and Jones, 1988, published by the Aquaculture Association of British Columbia. Thanks are extended to the Aquaculture Association of British Columbia for its kind permission to use these figures. Figures 8, 9, 10, and 14 were drawn by John Brown from slides produced by the author.

Finally, this publication is dedicated to the memory of the late Warren Mermilliod, marine advisory agent with the Louisiana Cooperative Extension Service in St. Bernard Parish, whose assistance as co-investigator during the early phases of the project was just one example of his dedication to the Louisiana seafood industry.

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PREFACE

This manual is the result of an oyster culture demonstration project, sponsored by the Louisiana Sea Grant College Program and the Louisiana Cooperative Extension Service. The project was a response to the lack of consistent supplies of seed oysters from Louisiana's public reefs for bedding on private leases. The manual is an effort to help Louisiana oyster farmers produce their own seed oysters.

The information here was gathered from industry manuals published and distributed in the Pacific Northwest and also generated by research and field demonstrations in Louisiana. Those publications include the following.

Methods for Setting Hatchery Produced Oyster Larvae, by Gordon and Bruce Jones, Innovative Aquaculture Products, Ltd., Lasqueti Island, British Columbia, Canada. Published in 1983 by the Marine Resources Branch, Ministry of the Environment of the Province of British Columbia (Information Report No. 4).

Advances in the Remote Setting of Oyster Larvae, by Gordon and Bruce Jones. Co-published and distributed in 1988 by the Aquaculture Association of British Columbia (5331 Hammond Bay Road, Nanaimo, B. C. V9S 5N7).

A Manual for Producing Oyster Seed by Remote Setting, by William G. Roland and Thomas A. Broadley. Produced in 1990 by the Extension Systems Branch, B. C. Ministry of Agriculture and Fisheries (808 Douglas St. Victoria, B. C. V8W 2Z7).

If you are interested in the tank designs and cultch handling methods used in the Pacific Northwest, you may wish to read these publications. Keep in mind, however, that although the technique of setting oyster larvae is basically the same, the Pacific and Gulf regions have different oyster species, climate, and seawater temperatures. If you need assistance in using this manual, contact your local marine advisory agent in the Louisiana Cooperative Extension Office.

INTRODUCTION

Oyster production in Louisiana has ranged from a low of 4.8 million pounds in 1966 to 14.3 million pounds in 1985, and has averaged 10.4 million pounds annually. Approximately 80 percent of Louisiana's oyster harvest has traditionally been taken from private leases. Although production since 1982 has been well above the long-range average, much of this increase can be traced to increasing effort. Issuance of oyster dredging licenses by the Louisiana Department of Wildlife and Fisheries has increased from 390 in 1981 to more than 1,000 since 1985. Although leased acreage has increased to 312,000 in 1987-88 compared with 193,000 acres in 1975-76 , production from private grounds has shown very little growth, with declining production per acre.

For over 100 years, the Louisiana oyster industry has relied on the state's public oyster reefs for a supply of seed oysters. There are many reasons for the decline in the productivity of these reefs, including saltwater intrusion with its resulting marsh loss, natural oyster predation and disease, and increased harvesting pressure. Lack of a consistent seed supply for oyster farming has been a significant detriment to the economic development of the state's oyster industry.

During the 1970s, the Pacific Northwest also experienced a similar problem with seed supply. However, research and development by university and industry members in the region has given the individual oyster farmer the ability to produce seed oysters using ready-to-set or "eyed" larvae from oyster hatcheries.

Larvae are microscopic, free-swimming oysters that develop from eggs and sperm spawned by adult oysters. Oyster larvae have a velum (similar to a tiny tongue with hairs that beat back and forth), which propels them through the water and gathers food. The larvae begin to grow their shells within the first 24 hours. During a 10- to 15-day period, the larvae swim and feed on algae (microscopic, free-swimming plants). As they grow, the shell changes from a straight hinge to an adult shape. Near the end of their swimming period, the larvae develop an eye spot (black dot) on their shells and grow a "foot" that allows them to crawl. During the last 48 hours, they search for a place to set or cement themselves by crawling on whatever they find suitable. After setting, they then change from a swimming existence to a sedentary one; their velum and foot are absorbed and other internal organs change.

In the wild, larvae swim up and down in the water and are moved by tides and currents, but in the hatchery, they are raised in large tanks. Commercial hatcheries use several tanks that can each hold over 8,000 gallons of seawater for high-volume larval production.

Larvae are small and are measured in microns (there are approximately 25,000 microns to an inch). Larvae begin as fertilized eggs measuring

40-50 microns and grow to 285-320 microns. At that size, the "eyed" larvae can be seen swimming inside a white bucket, looking like fine grains of brown-black sand.

Remote setting methods allow the grower to use a hatchery without the expense, special abilities, and location needed to operate one. In the Pacific Northwest, for example, large commercial, high-volume oyster hatcheries now produce billions of larvae for sale to growers.

Remote setting of the Pacific oyster (*Crassostrea gigas*) was first investigated during 1972 in laboratory studies by D. S. Lund, at Oregon State University (OSU) and commercially by W. W. Budge. Larval handling and remote setting was further refined by west coast oyster growers and B. A. Henderson, also of OSU. Prior to these efforts, oyster hatcheries were not economically feasible because of cultch handling and grow-out problems. Remote setting techniques helped hatcheries become viable by allowing a division of labor between the hatchery operator and the oyster farmer, and enabled the hatchery to concentrate on high-volume larval production. Successful commercial remote setting methods have been well documented. Two publications of the Aquaculture Association of British Columbia document many remote setting activities along the northwest Pacific coast.

The general process is as follows. Hatchery-raised larvae are wrapped in moist nylon cloth and paper toweling, and shipped to the grower in an insulated container at 41°F (5 C). Upon arrival, the larvae are suspended in a covered tank of filtered seawater at about 86°F (30°C), containing washed and aged cultch. Oyster shells are generally used as cultch, held in plastic-mesh bags (shellbags). The larvae are introduced at a rate of 75-100 per shell, anticipating a 20 to 50 percent attachment to the shells during the setting period of two to three days. Setting and spat condition are verified by microscopic examination prior to cultch placement on a leased waterbottom (nursery area). The newly set spat remain protected from predators in the nursery stage until the spat grow to a size for planting. Protecting the young spat while they grow larger improves survival on the bedding grounds. When and where to plant are a very important decisions, since the larvae can be lost to feeding crabs and oyster drills.

Since larvae can close their shells like adult oysters, they can be stored in the refrigerator. Researchers found that they have a shelf life of up to seven days, so long as they are kept moist and at the proper temperature, but long storage times are not recommended. Larvae should be delivered from the hatchery overnight and set as soon as possible.

The remainder of this manual will discuss important points that need to be considered before larvae are set.

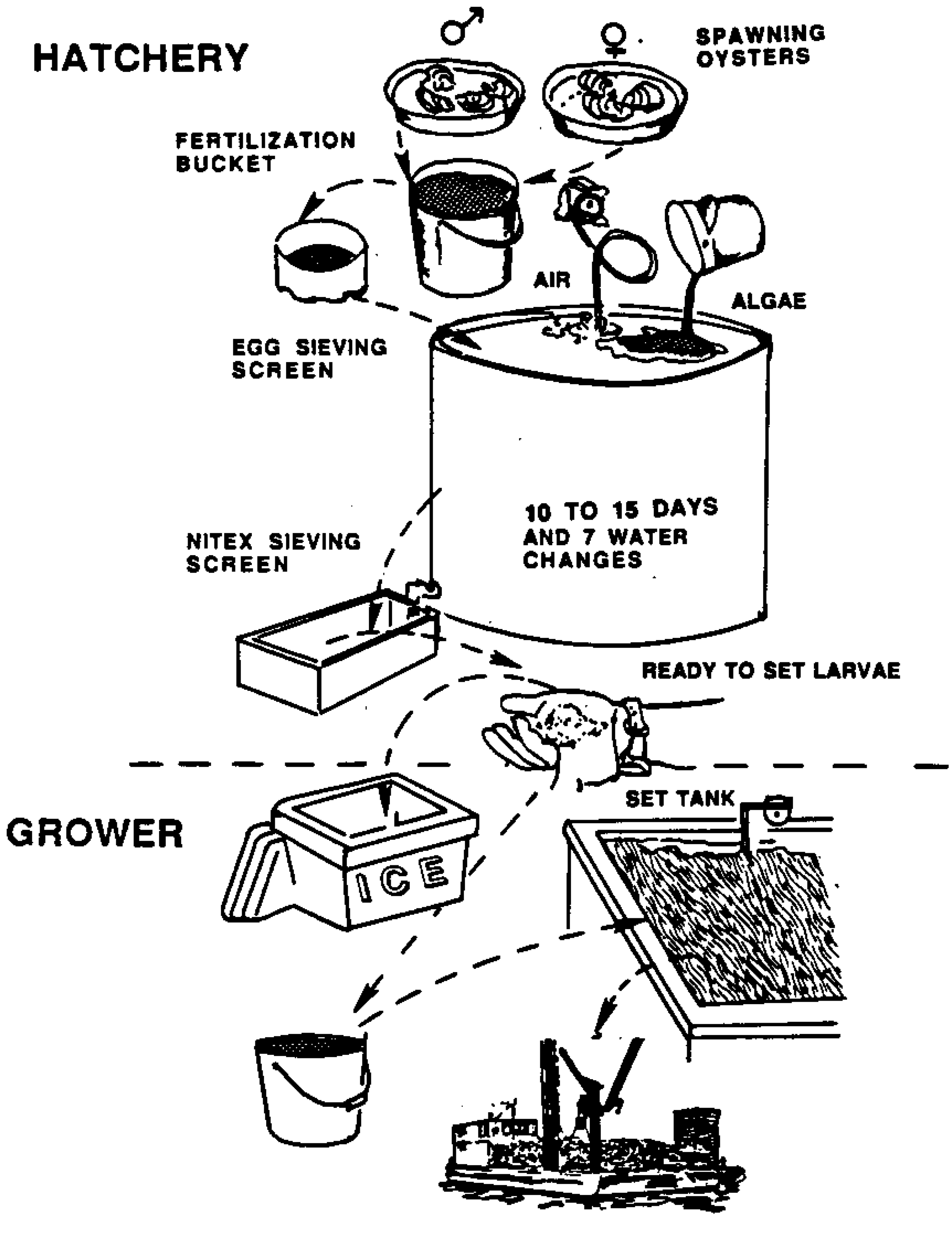


Figure 1. Oyster production from start to finish, using hatchery-raised larvae and remote setting (from Jones and Jones, 1988).

CHAPTER 1

CHOOSING A REMOTE SETTING SITE, NURSERY, AND GROWOUT AREAS

Water quality is the most important factor in choosing a site. **Consistently good water quality can mean the difference between having regular successes or failures.**

Setting Site

A "common sense" way of determining water quality is by looking at the activities in the watershed or drainage area of the bay or bayou under consideration. Herbicides are lethal to larvae at strong doses. Check to see if local road maintenance efforts include the use of herbicides to control ditch weeds. Runoff from boat yards can cause problems for setting operations, especially from antifouling paints. Bilge water, which usually contains oil, fuel, and hydraulic fluids can cause problems if pumped into setting tanks.

Very high tides over the marsh can result in brown-colored "dead water," caused by decaying marsh grass. Failed larval sets are likely when such water is used.

Check the salinity (salt content) of the water you are considering. This can be done with an inexpensive hydrometer (see Appendix 1). Larvae do not set well in water that is too fresh. The salinity should be above 10 parts per thousand.

Other factors to consider include:

- access to electric power
- ease of getting to the site for providing surveillance, monitoring, maintenance, and delivery of larvae from the hatchery
- transport of cultch to the site and seeded cultch to the nursery area
- quick access to the nursery site when freshly set spat are ready for transfer
- ease in pumping water from below the surface to avoid surface pollutants and rainwater and off the bottom to ensure that the water does not contain sediment

Nursery and Growout Sites

Choose your nursery and growout areas the same way you would choose a lease for bedding oysters. Oystermen know that oysters grow faster in areas with swiftly-moving currents because more food is available. This is important in placing stacked containers or shellbags of spat. When placed in slack water, the growth of spat located in the inner areas of containers or shellbags will be less than that of spat in the outside areas. Stunted seed oysters don't grow quickly when bedded.

Bottom type is also important if the cultch is to be placed on the bottom. A bottom firm enough to walk on without sinking is the minimum requirement for placing pallets of containers or shellbags. If containers or shellbags are going to be thrown directly on the bottom, a hard reef is necessary to prevent burial.

Other factors to consider include:

- location close to the setting site, to avoid drying out the freshly set spat and to reduce transportation costs
- use of the site during rough weather
- water deep enough to keep the spat submerged
- water quality
- theft

CHAPTER 2

REMOTE SETTING SYSTEM CONSTRUCTION AND PREPARATION

The system needed for setting larvae includes a tank, air lines, a blower, a cover, and a seawater pump and filter.

Tank Design, Construction, and Preparation

Setting larvae in a tank containing cultch and seawater provides the oyster grower complete control over seed production, as opposed to releasing the "eyed" larvae into the wild over a reef. The tank can be simple and of any shape. The cultch and water should not be more than four feet deep to allow complete penetration by the larvae.

The tank volume depends on the amount of seed you want to produce from each batch. Larger tanks are more efficient and economical for high-volume production per unit of effort and construction costs. Larger tanks require a great deal of structural support because increased water weight creates greater stress. Smaller tanks can be made much more simply and cheaply.

At the Oyster Farms facility, a tank 10 x 8 x 4 cubic feet holds 300 shellbags, which are approximately three feet long and hold about 215 oyster shells. About 1.3 million spat can be produced from each set with a tank this size, if approximately 100 larvae per shell are added, and 20 percent of the larvae set, an acceptable setting success rate. Figures 2, 3 and 4 illustrate examples of tank designs.

Tanks can be made of other materials as well. Cement is acceptable if the surface is smooth. Metal tanks are not usually used because most metals are toxic to the larvae, tend to rust, or are too expensive.

Most setting tank interiors are light in color. Keep in mind that larvae like to set on darkened surfaces.

The tank should have at least a two-inch drain. **Draining and cleaning are easier if the tank drains from the bottom.**

After construction, the tank should be thoroughly soaked to leach out toxic chemicals from the construction materials. This is especially necessary for fiberglass, gelcoat, painted material, and cement. Completely fill the tank with water and allow to soak for a couple of days. After draining, repeat the process twice more. Rinse the tank with water between soakings. Exposing the tank to direct sunlight during leaching will also help. Fiberglass, gelcoat,

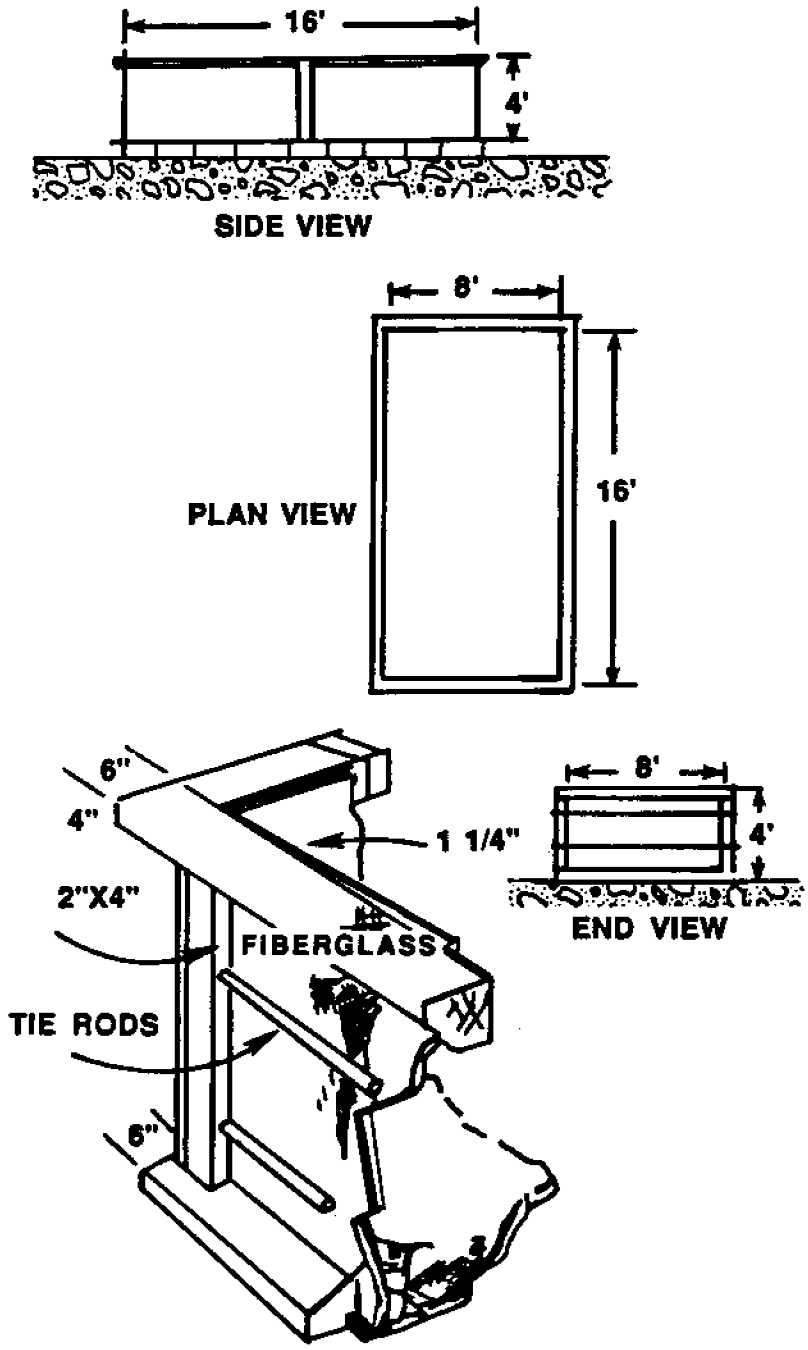


Figure 2. Plywood and fiberglass tank design.

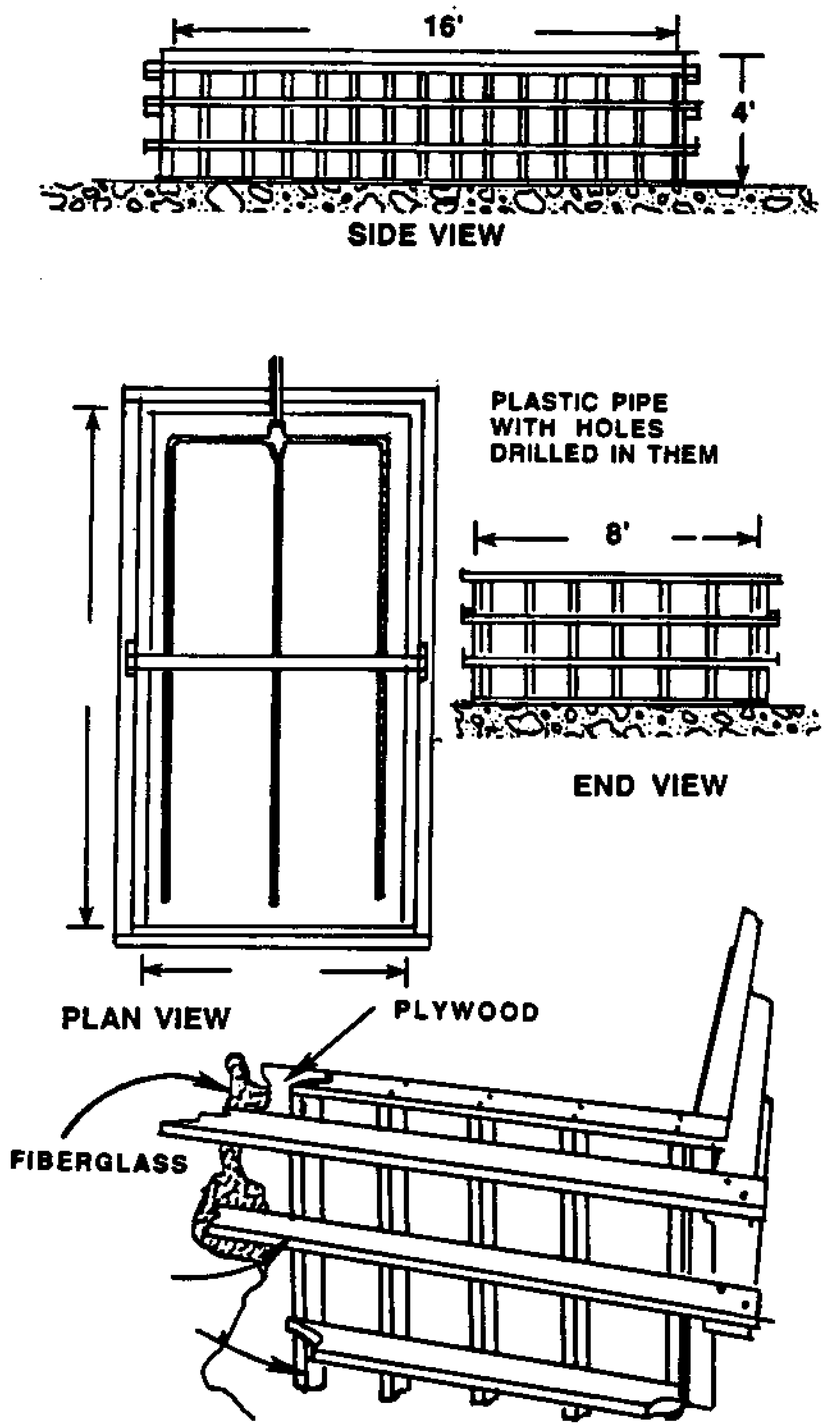


Figure 3. A setting tank design. Note that 2 x 4s and 2 x 6s are used instead of tie rods, as in Figure 2 (from Jones and Jones, 1988).

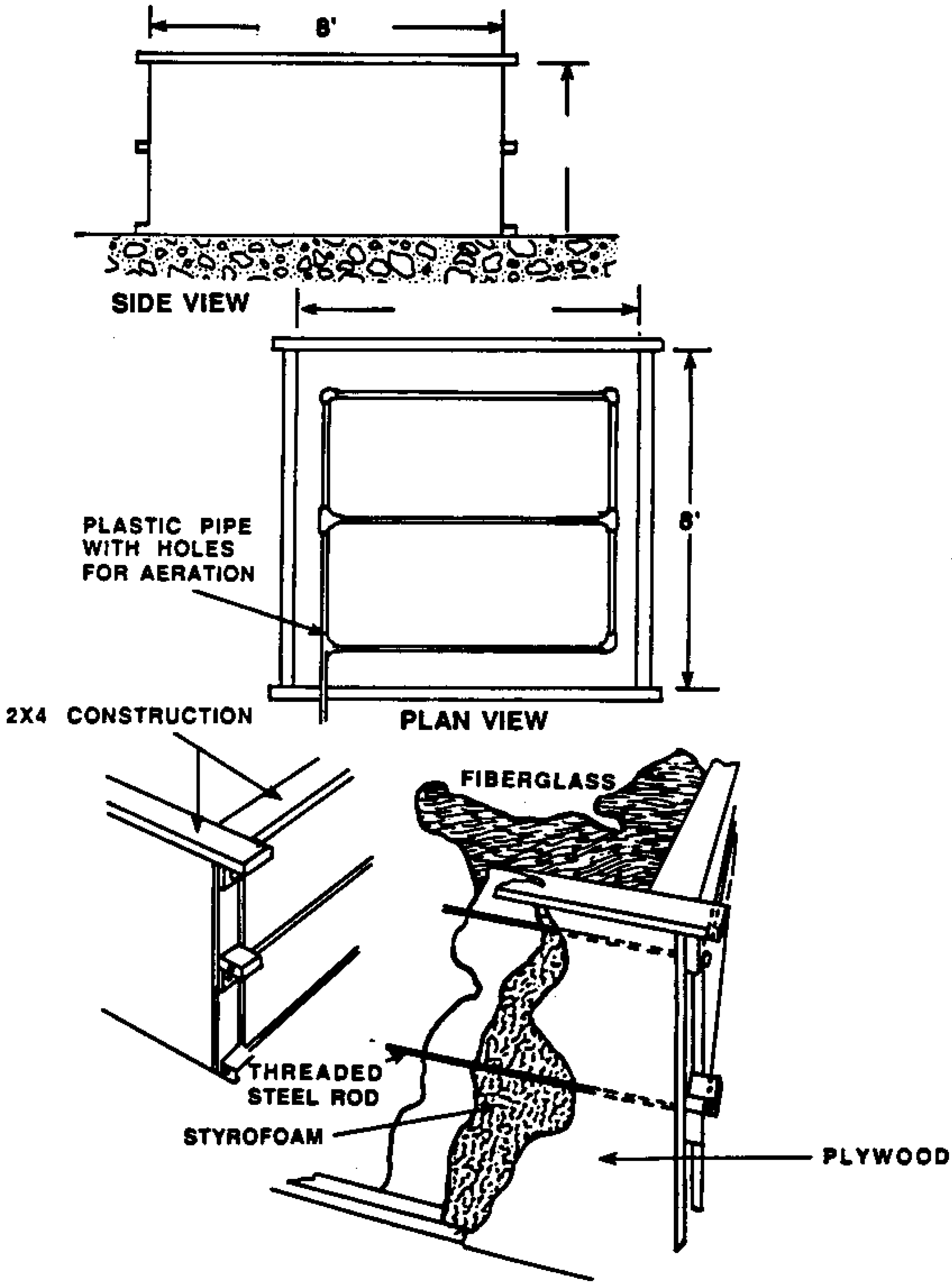


Figure 4. An insulated tank design. Insulation is particularly important if the seawater is heated, to keep heating costs down (from Jones and Jones, 1988).

and paints should leave no odor in an empty tank once leached. Cement tanks are well leached when the pH is neutral.

A steam cleaner can be used to quickly leach fiberglass. The nozzle is fixed toward the center of a covered tank and the tank is steamed for six hours. This method should avoid burning a hole in the fiberglass and make the surface very hot (Jones and Jones, 1988). Afterwards, the tank should be rinsed until there is no remaining fiberglass smell.

A tank cover is necessary to keep rain out and to darken the inside of the tank during setting. Since "eyed" larvae swim away from light, a cover helps in obtaining an even set on the cultch. In Louisiana, a tightly fitted tarp works well.

Aeration

Air is bubbled through the tank during setting to help keep the larvae evenly distributed. Plastic pipes with small holes (1/32-inch to 1/8-inch) drilled about every foot, laid evenly across the tank's bottom, work well. The air lines should be designed to allow easy removal and cleaning (see Figures 3 and 4).

Air can be supplied by any means so long as it is oil-free. Compressors and pumps can be used, but blowers work best (i.e., high volume, low pressure). A cheap blower can be made using a smog pump from a small truck or automobile (part of the vehicle's emission control system) driven by a belt from a 1/3 to 1/2 horsepower electric motor (Figure 5). Connect the blower's outlet to the tank's air pipe system. A valve may be placed between the blower and tank to control the air flow and bleed off excess air. Make sure that any air source is located higher than the water level in the tank, so that the pump will not fill with water when it is turned off or when the power goes off.

Seawater Pumping and Filtration

Ideally, a pump should be chosen to match the total dynamic head of any system, which includes the type and length of the plumbing, number and type of fittings, and the height to which the water is being pumped. Remote setting systems do not have critical pumping requirements. The pump size depends on how fast you want to fill the tank because once the tank is filled, the pump can be turned off. Radial (centrifugal) pumps with plastic, cast iron, or brass impellers are commonly used. Swimming pool pumps with plastic impellers and intake baskets to catch debris work well with seawater. Locate the pump near the water to eliminate impeller cavitation. Keep silt from fouling the cultch inside the tank by locating the pump's intake off the bottom and away from boat wheelwash in shallow water.

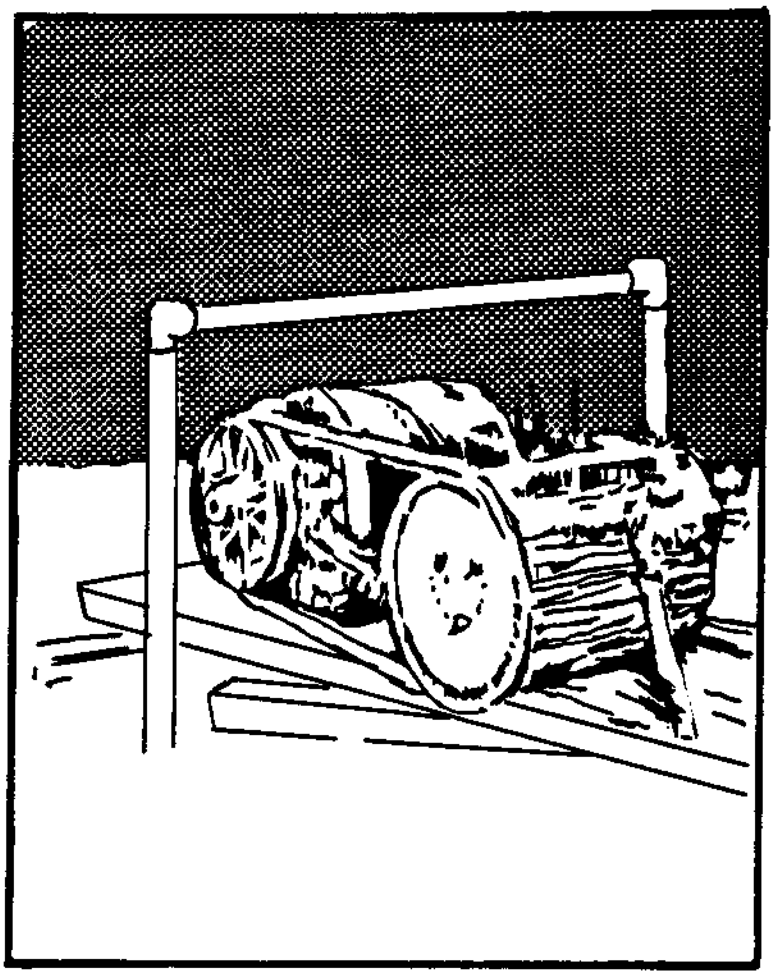


Figure 5. A "smog pump" air delivery system (from Jones and Jones, 1988).

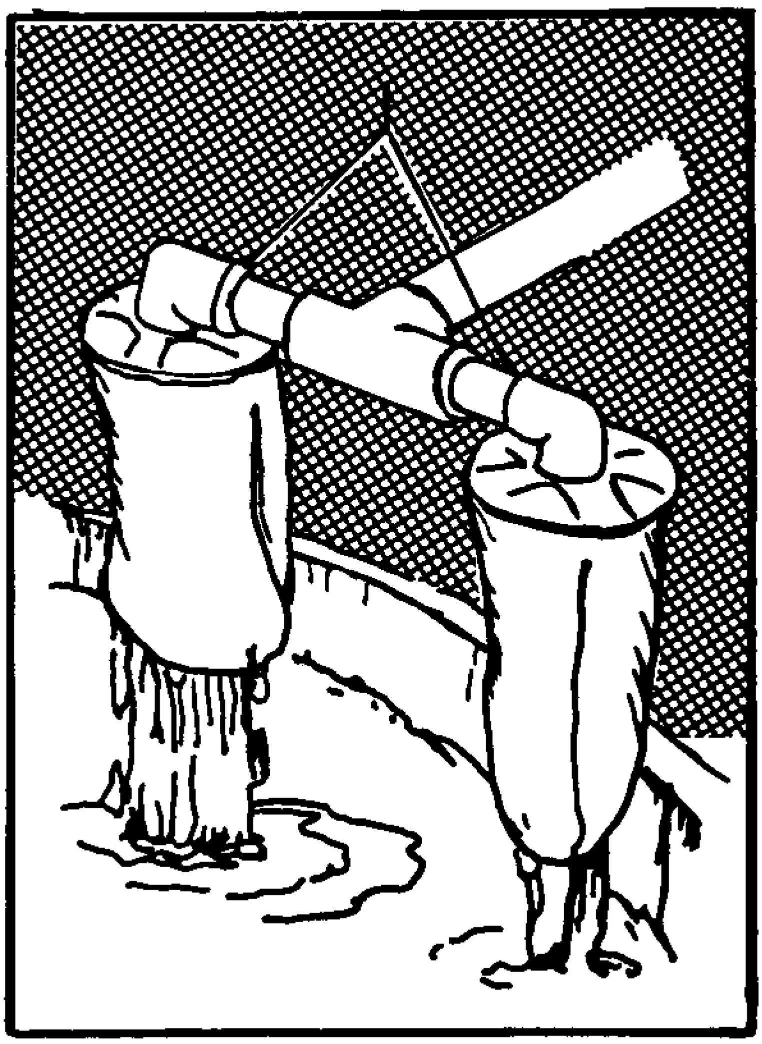


Figure 6. Filter bags suspended over a tank (from Jones and Jones, 1988).

Seawater should be filtered before it enters the tank to remove most of the larger microscopic plankton that eat or compete with the larvae. Filter bags (rated for 50 microns) are effective enough for remote setting, easy to use, and economical (Figure 6). They can be purchased from most aquaculture supply companies. Commercial swimming pool sand filters work well also, but are more expensive.

CHAPTER 3

CULTCH PREPARATION AND HANDLING

The majority of the labor required for seed oyster production using remote setting techniques involves cultch preparation and handling. Cultch must be washed free of grit, chips, and dirt; the tanks must be loaded and unloaded; and the cultch placed in a nursery condition where enough spat growth can take place to deter predation once they are bedded on the lease.

Cultch Preparation

Oystermen know that clean shells (cultch) are important for obtaining a good set on a wild reef, and remote setting is no different. Depending on the cultch type used, preparation may include the following.

Aging: Shucked shells should be aged at least six months to one year before using in a remote setting tank. Meat remaining on fresh-shucked shells will quickly "sour" the water in the setting tank, which will kill larvae and spat. Weathering the shells (i.e., piling them up outside) will help remove the remaining meat and fouling organisms (e.g., barnacles, mussels, "sea grasses," and "jelly").

Grading: Grading shells helps obtain a uniform size by removing smaller shells and fragments. Motorized tumblers and shakers can be used, which can also remove much of the powder and grit from the air-dried shells.

Washing: Washing is very important, because dirt and grit will keep the larvae from setting on the cultch. Washing can be as simple as rinsing the cultch off with water from a hose or it can be part of a mechanized process that grades, washes, and containerizes the cultch.

Leaching: If plastic, rubber, fiberglass, cement, or other artificial cultch materials are used, leaching is important for removing toxic residues that may remain from manufacturing. Soaking the material in water is a common practice, but fouling may be a problem if it is soaked in seawater. A leaching period of four to eight months is recommended for plastic cultches (Roland and Broadley, 1990), however, the warmer climate in the Gulf region will quicken the process. Cement or cement-coated cultch must be soaked to neutralize the pH (i.e., a pH of 7), because cement mix is very alkaline.

Cultch Handling

Oyster shell is the cultch most used and is usually handled in shellbags averaging approximately 40 pounds each. The bag material (a roll of 13-inch lie-flat heavy-duty shellbag material or tubing with 9/16-inch mesh) is available from most aquaculture supply companies. The material is cut at the desired length (usually six feet), knotted at one end, slipped over a three-foot length of eight-inch PVC pipe (thin-walled) and filled with shells. The pipe is then removed and the shellbag is tied shut. Generally, shellbags are stacked on wooden shipping pallets for forklift handling.

Oyster Farms utilizes a front-end loader to dump shells into a machine that grades and washes shells and then sends them into a hopper. Laborers cut and knot the shellbag material, slip the bag onto the loading pipe(s) at the bottom of the hopper, remove the bagged shells, knot the bag again, and stack it on a pallet (Figures 7 and 8).

Smaller operators simply load shellbags using a hand-held hopper next to a shellpile, then wash with a fire hose. Sometimes a table-loader may be used (Figures 9 and 10).

Note: Sunlight will break down plastic over long periods of time, so bagging fresh-shucked shells to be washed a year later may result in "rotten" shellbags.

Tank Loading and Unloading

Shellbags are usually loaded into and out of the tanks by hand, but palleted shellbags are also used in setting tanks. Conveyors, front-end loaders, and various hoists are used for loading and unloading tanks.

Other Cultch Types

Clam shells, limestone, and similar cultch will tightly pack the 13-inch lie-flat bagging and may not allow larvae to penetrate for a good, even set. Research will be conducted by LSU during 1991-92 to try these materials with other bag sizes. Results will be included in future editions of this manual.

Crushed shell, sold in feed stores as chicken scratch, is used to produce single oysters. The cultch can be spread onto the bottom of shallow setting tanks (like soft crab shedding tanks). After setting, the cultch must be handled gently to reduce crushing the freshly set spat.

Artificial cultch, such as "french tubes" and cement-coated materials require special handling as well. Some of these materials are used in other regions with good success. For information on handling these cultch types, consult the west coast setting publications mentioned in the first part of this manual. LSU research results using these cultch types will also be included in future edition of this manual.

Figure 7. Shellbags ready for handling.

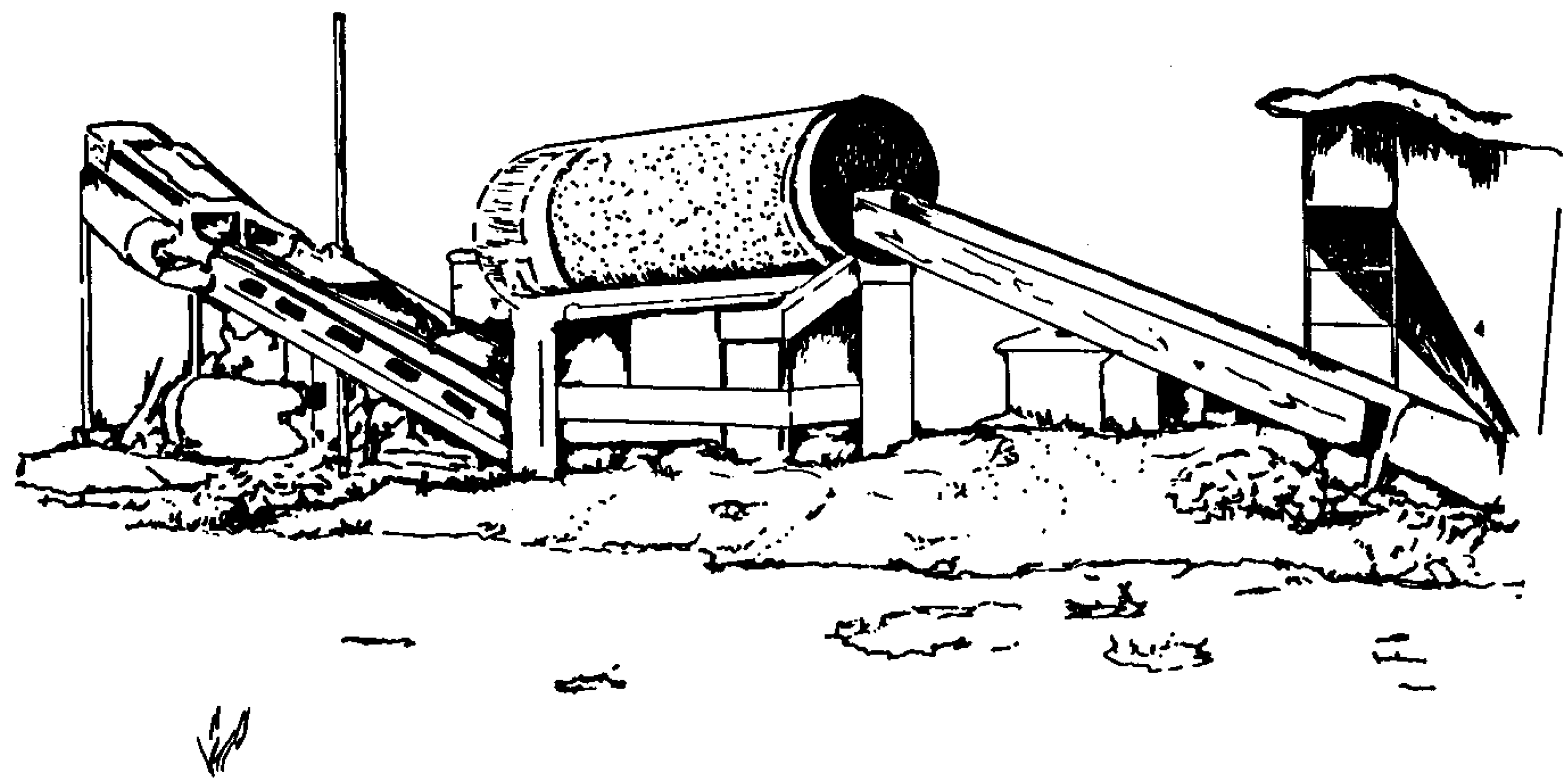


Figure 8. A shell grader/washer.

Figure 9. Shellbags can be made by one person with a hand-held hopper.

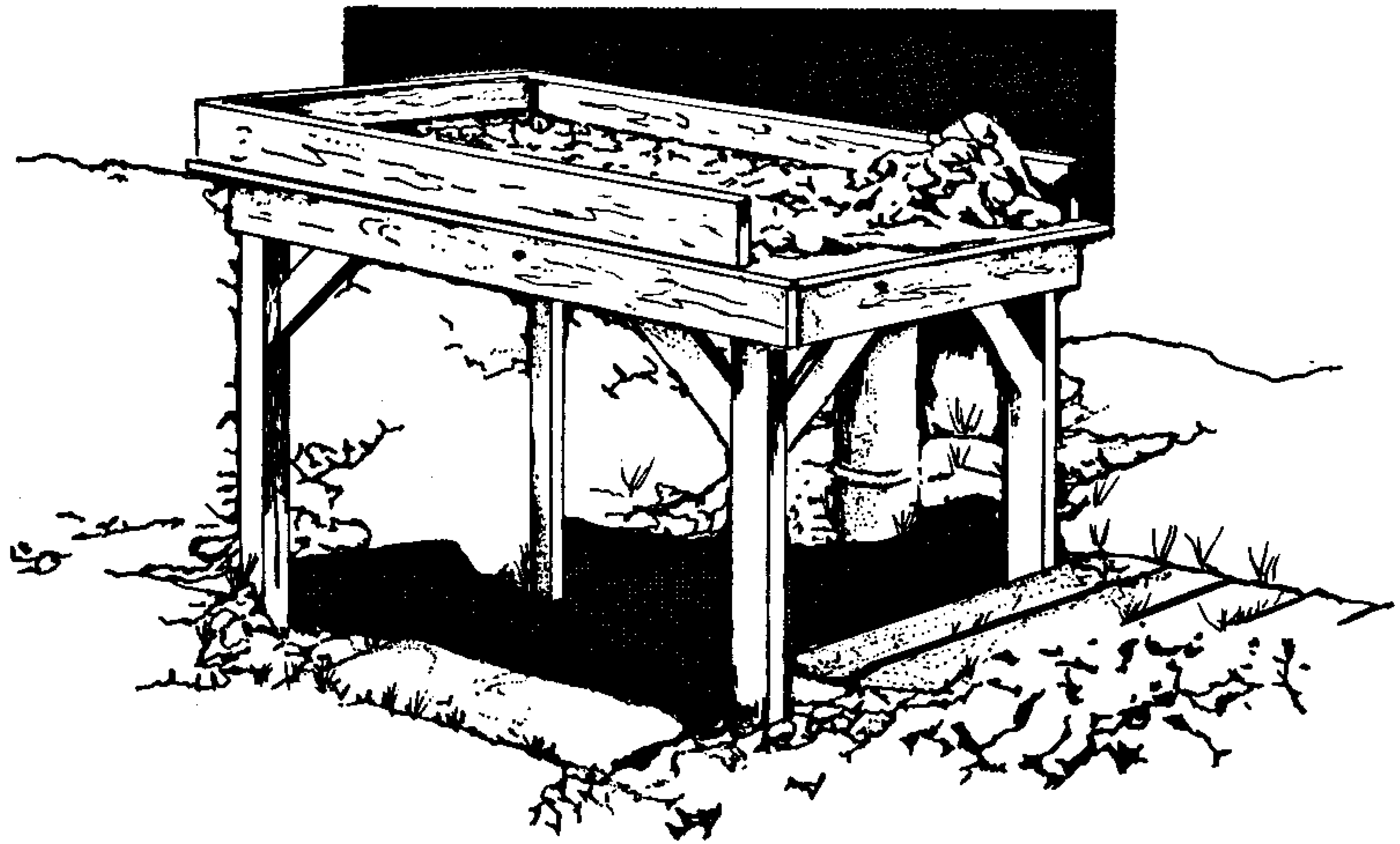


Figure 10. A table-loader used for making shellbags. A sprayer (drilled pipe) may be located across the table to hand-wash shells while bagging.

CHAPTER 4

ORDERING, EVALUATING, AND HANDLING LARVAE

It is important to know how much larvae is needed for each set. Knowing how to tell good larvae from poor larvae (evaluation) and how to handle the larvae are also skills that must be developed.

Ordering Larvae

To know how much larvae is needed, a basic "recipe" can be used to start with. Each grower can improve or change his recipe after evaluating seed production results to decide whether to use more or less larvae during later sets. Oyster hatcheries can customize an order by making individual quantities of larvae within an order, so the order does not have to be split up for each setting tank. Assuming good larval quality and that everything is done correctly, the following calculations are a good start.

Setting Tank. Average setting success is 20 to 30 percent. Adding 100 larvae per oyster shell to the tank may produce on the average approximately 20 to 30 spat per shell. Therefore, a tank that is 10 x 8 x 4 cubic feet containing 300 shellbags averaging 215 shells per bag should receive approximately 6.5 million larvae, resulting in approximately 1.3 to 1.9 million spat.

Nursery Area. Louisiana remote setting experiences have shown a 30 percent mortality rate during the nursery period. This depends on where and how the shellbags or cultch are placed. Initial remote setting results averaged 30 spat per shell from the setting tank and 20 spat per shell after a 30-day nursery period, with the spat averaging 3/4 inch in length.

Growout. Of the 20 3/4-inch spat per shell bedded, three to five market oysters may be achieved, or a 15 to 25 percent bedding survival rate. Most Louisiana oyster farmers have years of experience in bedding seed oysters, so individual results may be better. In general, 3 percent of the larvae added to the setting tank should reach market size.

Evaluating Larvae

Larvae are usually shipped in a styrofoam cooler containing the ball(s) of larvae wrapped in nylon cloth and moist paper toweling with a gel pack built in the lid. The cooler contents should be 40°-50°F (4°-10°C) and the gel pack still partially frozen. There should be no "fishy" odor.

The moist toweling should be removed and the individual nylon-wrapped larval balls placed in a clean bucket containing setting tank water. This will allow the larvae to acclimate or get used to the setting tank water conditions, especially salinity. A 15-30 minute period is recommended to reduce stress on the larvae and help ensure that the larvae swim when added to the setting tank (Roland and Broadley, 1990). After the larvae begin to move in the bucket, don't wait too long, or the larvae will begin setting on the bucket.

The wrapped balls of moist larvae can be weighed to keep track of the order's accuracy. Weigh the nylon cloth wrapping again after the larvae have been removed and subtract the cloth weight from the previous total. A scale sold at local hunting supply stores for weighing gunpowder is suitable.

Buying a microscope to look at larvae and freshly set spat is a good investment (see Appendix 2). During microscopic examination, good-quality larvae can be determined by the following criteria.

Size: Individual larvae should be approximately 285-320 microns from hinge (umbo) to bill (see Figure 11).

Eyespot: This should be darkly colored and 15-17 microns in diameter (see Figure 11).

Movement: Most larvae should be actively swimming with extended velums (swimming organs). Crawling with the extended foot should be noticeable. If no movement is noticed immediately, give the larvae time to acclimate to the temperature and salinity of the water. Cracked shells and fouled velums are a sign of poor handling and raising practices. Some larvae may swim together in strands of mucus, and if this is the case, add more water to the container.

Handling Larvae

It is important that once the larvae arrive from the hatchery they are either refrigerated or used immediately. Heated or dried larvae result in failed sets. *The larvae are fragile.* Don't squeeze or drop the larval ball, and handle it gently. Though the larvae look like sand, they must not be treated as such.

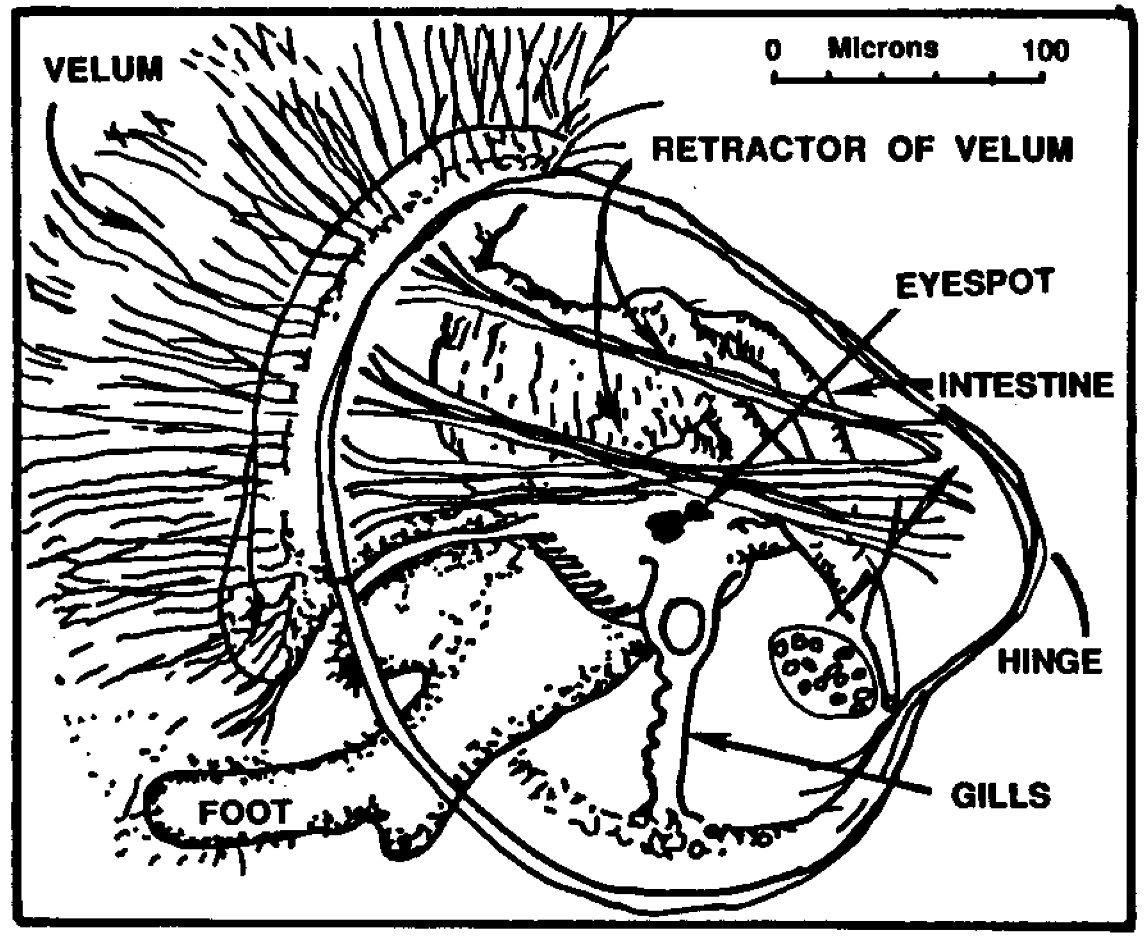


Figure 11. An oyster larvae (from Jones and Jones, 1988).

CHAPTER 5

SETTING METHODS

The actual setting of the larvae is relatively easy, but certain methods should be followed.

Cultch Soaking

A 24-hour cultch soaking period is recommended before the larvae are added. It has been said that soaking the cultch in the tank before adding the larvae "gets the land smell off." Recent research has found that it may put a "sea smell" on the cultch. During soaking, a film that attracts the larvae is formed by naturally occurring bacteria, originally called LST because they were found growing in a larval setting tank. The "scent" or chemical cues that the bacteria expel stimulate the larvae to search, by crawling on their feet, and to cement themselves to the filmed surface (Weiner et al., 1989).

Since faster bacterial growth occurs in our warmer climate, future LSU research will determine the ideal soaking period for our region. Obviously, a setting tank can be used more often if this and other procedures in the setting process can be shortened.

Water change

It is recommended that the water be changed after the cultch is soaked so that fresh food can be provided before the larvae are added. However, successful sets have been obtained without doing so.

Aeration

Constant aeration is generally used, giving the water a light rolling but not boiling action. More research will be conducted concerning aeration. In British Columbia, a fairly high aeration (a good roll but not boiling) for a half hour after the larvae were added produced a more even set than constant aeration. Constant aeration may have produced water circulation patterns that caused the larvae to collect in certain areas. There was no difference in the distribution of spat in the upper, middle, and lower portions of the setting tank with the shorter aeration period (Roland and Broadley, 1990).

Larval Distribution

Even sets start with evenly adding the larvae to the tank. The simplest way is to gently mix the larvae in a plastic bucket of tank water and pour them evenly into the tank.

Some growers ladle the larvae into the tank or use a plastic sprinkling can. Others use a spoon on a pole. Make sure the aerater is on when adding the larvae.

Water Heating

A setting tank water temperature of 77° to 86°F (25° to 30°C) is recommended. Successful remote setting was conducted in Louisiana during 1990, with local seawater temperatures as high as 91°F (33°C).

If setting is going to be attempted during the early spring and fall in the Gulf region, tanks should be insulated and heaters should be used to maintain the water temperature near 86°F. During October, 1990, a cold front passed through southeastern Louisiana, resulting in a setting tank water temperature drop from 82° to 65°F (28° to 18°C) within 36 hours. The remote setting attempts during and after that temperature drop resulted in failed sets. Those sets could have been saved had an electric immersion heater been available. An insulated tank would have helped as well.

Keep in mind that many metals are toxic to larvae. Incoloy 800 stainless steel is recommended for metal heating elements in direct contact with the setting tank water. Twenty-five amp quartz-sheathed electric immersion heaters are used in the Northwest. Simple propane immersion heaters are also used in remote locations (Figures 12 and 13).

Tank Cover

Covering the tank will help obtain an even set, since "eyed" larvae tend to swim away from light. A tarp works well. Heated tanks should have insulated lids.

Setting Time

Allow 48 hours for the larvae to set after they have been added.

Feeding the larvae during setting is not necessary. If the cultch is not going to be moved to the nursery area after the 48-hour setting time (i.e., after the set has been verified using a microscope), raw seawater should be pumped into the tank in a "flow-through" manner to provide fresh food for the new spat. The more water flow the better. Leaving the freshly set spat in the tank without enough food or in a dry condition for too long will cause high mortality. Quickly placing the new spat in a protected nursery condition (i.e., within mesh shellbags along a marsh or reef) will improve survival.

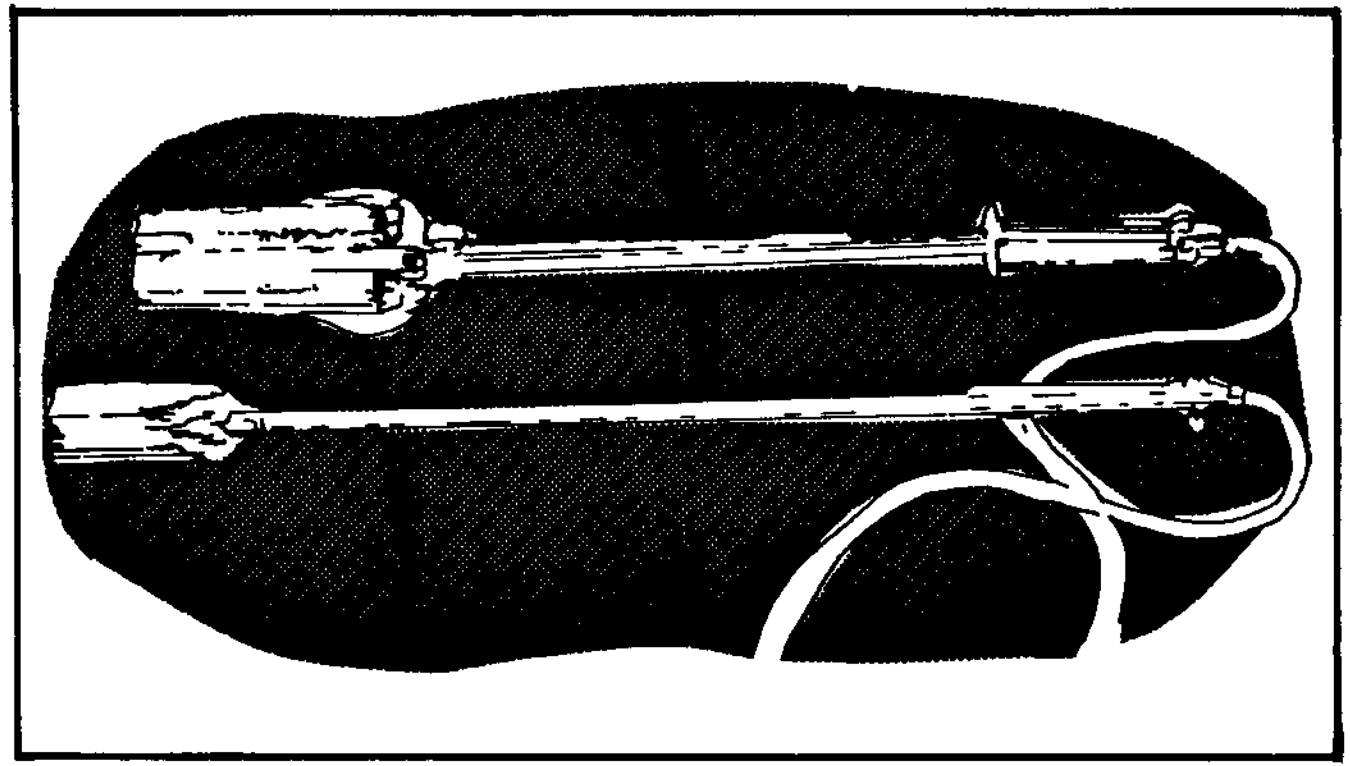


Figure 12. A propane torch is designed for thawing water lines and stump burning (from Jones and Jones, 1988).

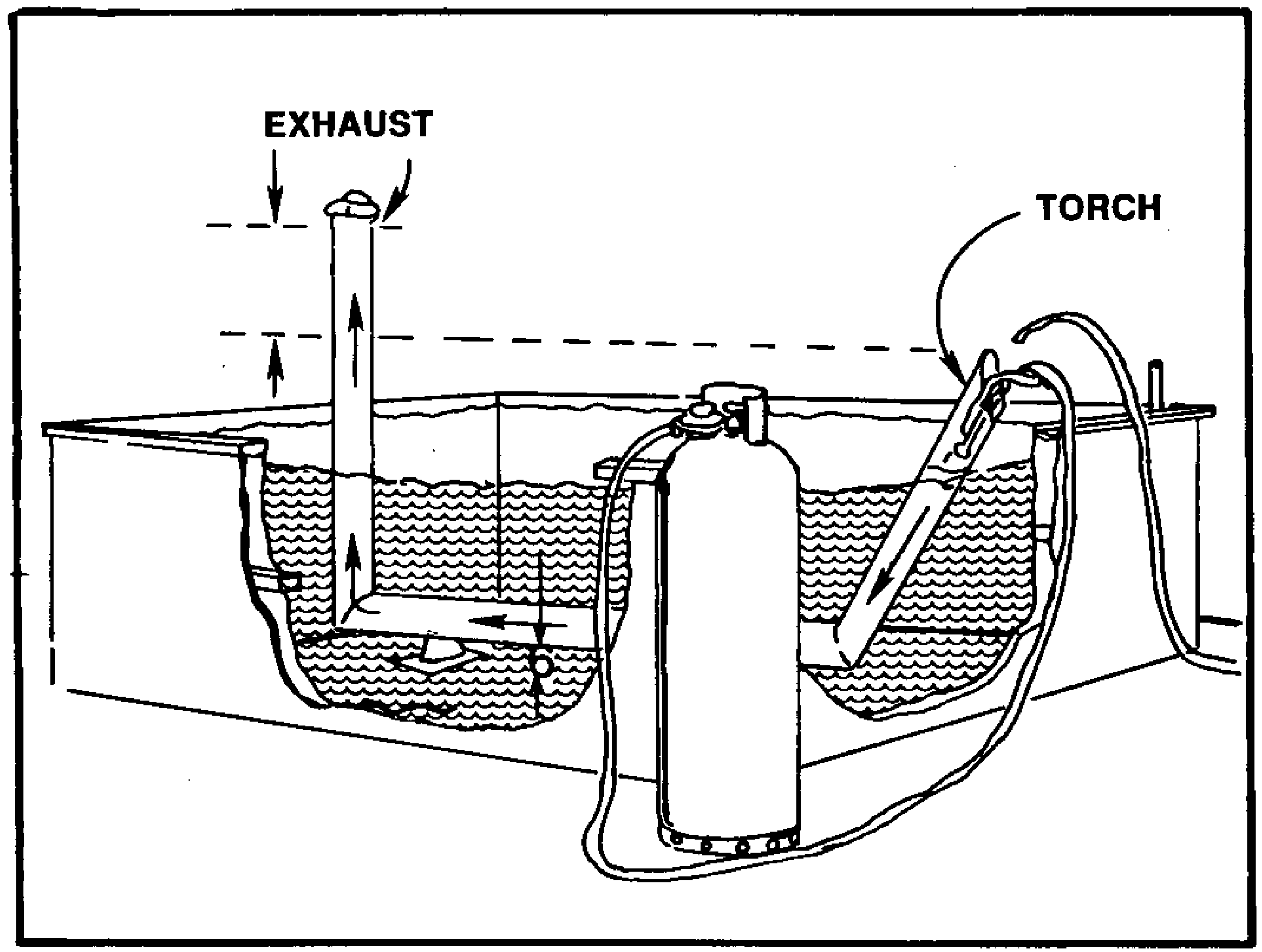


Figure 13. A propane flame-thrower immersion heater. The torch is inserted in one end, exhaust comes out the other. Often it is necessary to blow air from the aeration pump, down the pipe to make it draw (from Jones and Jones, 1988).

Salinity

Salinity in the setting tank should be above 12 parts per thousand, according to previous remote setting attempts in Louisiana. Research is planned in the near future to determine how low a salinity level can be used in remote setting to obtain good results.

If the local seawater at the remote setting site becomes too fresh at times, artificial sea salts, available from aquarium shops and aquaculture supply companies, can be added to increase the salinity and improve remote setting success. How much to add can be determined with a hydrometer (see Appendix 1).

Maintenance Between Sets

After the tank has been drained and unloaded, the tank interior should be cleaned to remove any remaining grit and freshly set spat from the tank walls and bottom. Rubbing the interior with a nylon abrasive pad works well, and these are commercially available with plastic swivel-heads and long handles or poles to save your back. A stiff floor broom should work also. After rinsing the tank, check to see if the spat have been removed by wiping some of the surface with your bare hand. Freshly set spat look and feel like coarse sandpaper. Failure to scrub the tank between sets will result in more troublesome spat removal later on.

The filter bags are made of polypropylene-felt material and need to be cleaned soon after use. Turn them inside out and hose them out thoroughly and allow them to air-dry.

CHAPTER 6

EVALUATING THE SET AND KEEPING RECORDS

It is very important to check the set, especially before the tank is drained and the cultch is removed from the tank and placed in the nursery stage. Much can be learned from failed and successful sets with good evaluation and record keeping.

Checking for Swimming Larvae

Checking the set is done by counting swimming larvae and spat. A one-cup sample of water should be taken from the setting tank at intervals of 1, 24, and 48 hours after the larvae have been added. Pour the sample into a clear glass container and hold it up to or above a light and you should be able to see and count any larvae in the sample. You may also use a microscope or magnifying glass (at least 10-power). Use the one-cup measure each time and take all three samples from the same tank location so that accurate comparisons can be made between samples and sets.

Obviously, there should be fewer swimming larvae over time. A fast decrease in the number of swimming larvae found in the samples means that the larvae were ready to set and the cultch, tank, and water conditions were right. If five or more larvae are still found swimming in the one-cup sample after 48 hours, the larvae were not ready to set, the cultch was not suitable, or the tank conditions were not right and a longer setting time is needed. When the water gets too cold (i.e., as is likely at night in the late spring and early fall in an uninsulated tank), live larvae may stop swimming, though the internal organs can be seen moving under a microscope (Appendix 2).

Checking for Spat Set

Counting spat is very important and simple, once you get an eye for seeing freshly set spat. Air-drying the cultch sample before counting makes it easier to see the tiny spat. When a larva successfully completes metamorphosis (changes) to become a spat, a new edge of shell will have grown onto the cultch from the bill of the larval shell, with the hinge pointing slightly upward. A hand-held tally counter helps to keep track of counts.

A new shell should be hung or placed in the tank when the larvae are added and replaced with another clean, new shell after 24 hours. This will give you a spat count for the first and second 24-hour periods of the setting time. These can be hung overboard for later reference. There should be a decreasing number of spat on these shells over time. The new shells should also be placed in the same section of the tank each time for accurate comparison.

As the setting tank is being unloaded, check some of the cultch from different sections of the tank to determine the evenness of the set. If shells are being used, count at least six shells from each section of the tank, such as the middle, side, and corner. Be sure to take shells from the top, middle, and bottom layers of the cultch. For later reference, try labeling some of cultch from these areas before placing it in the nursery area. A waterproof marker and plastic plant labels are very easy to use on containers. The labels are used by local nurseries for labeling small trees.

Accurate data collection and record keeping can help determine how good and poor seed production occurs. Thorough counting and record keeping will make future setting easier and provide better results. Setting results can vary for many reasons (i.e, different individuals, water sources, setting techniques, nursery and growout locations, seasons, larval sources, cultch types, etc.). Appendix 3 in the back of this manual contains data sheets for remote setting. Copy them and use them regularly.

CHAPTER 7

TRANSFERRING AND PLACING THE CULTCH IN THE NURSERY AREA

The nursery stage is an important step in seed production using remote setting techniques. During this stage, protection from predation (i.e., mud crabs, blue crabs, and sheepshead) improves survival and allows the spat to grow to seed size for later bedding on leased waterbottoms. Best spat survival and growth are obtained by unloading the protected cultch from the setting tank into the nursery area soon after the set occurs, with little time out of the water.

The shellbag's mesh material provides good protection for the spat and allows easy transfer and placement in the nursery area. Shellbags of spat are typically stacked and strapped on wooden pallets and then placed on the lease bottom. Boom-equipped boats are used to lift the palleted shellbags in and out of the water. A small boom-equipped, self-propelled spud barge, commonly used in the oil field, is ideal for transferring and placing palleted shellbags (Figure 14).

The shallow marsh shorelines in the Gulf region are ideal nursery areas for the placement of palletized containers of spat. Placement along shorelines with fast current improves survival and uniform spat growth within stacked containers.

Placing shellbags directly on a hard reef may be another nursery stage method. The shellbags could be used with an onbottom longline or be given individual floatlines, similar to those used with crab traps. Such deployment would be suited for the typical oyster boat used in the Gulf region. Placement on a hard reef is important to prevent container burial. Shellbags will also trap silt and sediment along the bottom if not used in high-current areas as well.

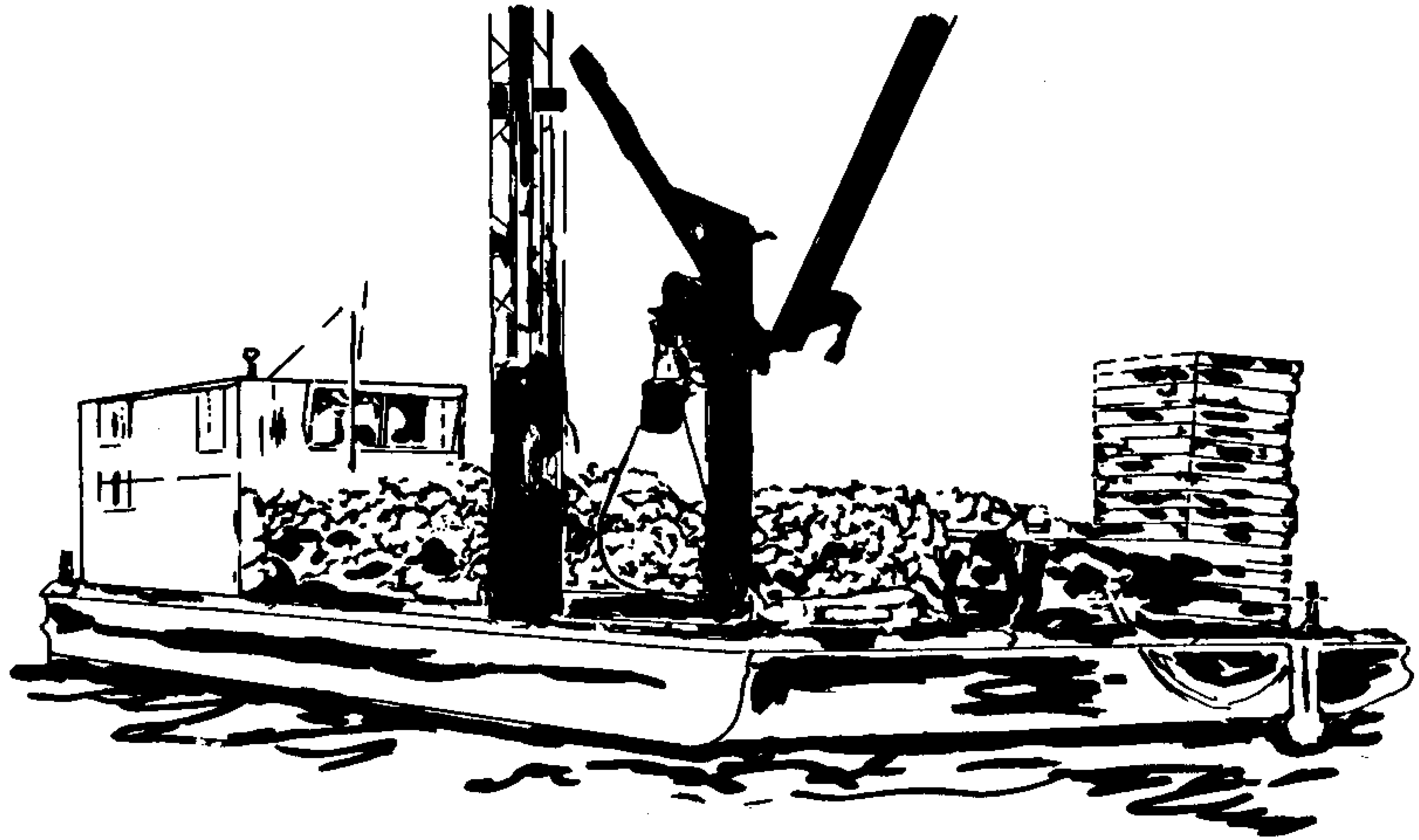


Figure 14. A spud barge loaded with shellbags.

CHAPTER 8

EVALUATING SEED GROWTH AND SURVIVAL, AND DETERMINING WHEN TO PLANT

Spat growth of up to one inch (25 millimeters) within 30 days was common in Louisiana during 1987-90 shellbag-nursery trials in salinities ranging from 11 to 18 ppt.

While the bags are being emptied, it is important to evaluate some of the shells from different shellbags to obtain an accurate average of seed production. Average number of seed per shell, the number dead and alive (percent of survival), and average size are valuable information for evaluating the effectiveness of remote setting efforts and its cost. Such information will help individual oyster farmers improve their techniques and allow them to customize production, depending on the conditions encountered.

Determining when to empty the shellbags for bedding onto the lease bottom is up to the individual oyster farmer. During summer nursery trials in Louisiana, spat began to grow through the mesh material within 40 days. This should be avoided, because high mortality will result from damaging the thin-shelled seed during bedding.

Damaged seed is more likely to attract crabs and other predators to the bedding site. Crab predation can be quite heavy when bedding is done during the summer months; however, the larger the seed size, the fewer predation problems. Crab predation can be reduced by harvesting crabs from the bedding area using baited crab traps. Black drum prefer single oysters and have difficulty feeding on clusters of oysters. Spat smaller than 1/4 inch are especially vulnerable to mud crabs.

Flatworms (i.e., the oyster leach, *Styloccus* sp.) are a minor predator of spat on oyster reefs, since they may be preyed upon by crabs and fish when they crawl from one spat to another. However, during Louisiana shellbag-nursery trials, flatworms caused up to 33 percent spat mortality. The flatworms appear to be protected by the mesh covering as well. Overnight air-drying and concentrated saltwater dips are effective in treating the cultch to reduce flatworm predation. The simplest treatment is timing, which is important if flatworms become a problem. Bedding the seed before too many losses occur exposes the flatworms to their natural predators. Keep in mind, however, that early seed bedding to reduce flatworm predation must be weighed against possible crab predation later.

Planting The Seed

Since most oyster farmers have generations of experience with bedding oysters, little needs to be mentioned here. The characteristics of seed produced by remote setting are different from those of seed dredged from seed reefs. Seed produced by remote setting usually is not as cupped and is more thinly shelled. The advantage of this technology is the large quantity of seed produced. Fewer boat loads of such seed may be needed. How much seed survives obviously depends on whether the seed is mishandled before bedding, the bottom type, salinity of the bedding area, and predators. Smaller seed obviously needs a longer growout period.

CHAPTER 9

THE COST OF REMOTE SETTING

The total cost of seed production using remote setting depends on the individual oyster farmer; the kind of equipment and labor available; the farmer's experience; and bedding ground conditions. Since the costs are likely to be variable, the farmer should take great care in his own estimates. A more detailed cost accounting follows as a guide (Tables 1 and 2).

Estimates for Table 1 are based on standard setting tank designs found in this manual. The tank interior is fiberglassed for waterproofing and for providing a strong surface against wear from repeated loading and unloading of shells. The fiberglass surface is painted with epoxy paint to eliminate a reaction of the water with the styrene in the resin. Using wood glue and good carpentry, three or four coats (two to three gallons) of epoxy paint may be good enough as a tank interior coating.

Two filter bags are used at a time during tank filling (Figure 6). Since the bags may be worn by repeated cleaning, two extra are included in the cost.

Estimates for Table 2 are calculated from remote setting experiences by Oyster Farms, Inc. of Hopedale, Louisiana. The labor costs include bagging the shells, loading and unloading the tank, and placing the shellbags in a nursery area. For removal from the nursery to the growout area, include an extra day's work ($150) for bedding (breaking open the shellbags). Boat fuel is not included. A 1,500-foot roll of bag material costs about $75 (delivered). Generally, a bag of seed averaging 20 spat per shell cost about $6. Note that Table 2 included a depreciation charge for the setting system. The grower should realize that this is not an out-of-pocket expense but is an allowable deduction for income tax purposes.

A 20 percent setting success rate is guaranteed by most commercial hatcheries, including Gulf Shellfish Farms of Louisiana's hatchery located on Grand Isle, Louisiana.

Each set from a tank is bedded on an acre. This is standard procedure for Oyster Farms, Inc. Other growers may do their planting differently. A 3 percent return of market-size oysters from the amount of larvae added to the tank may be attainable. Higher setting rates and returns may be attainable with good setting, nursery and bedding techniques, water quality, evaluation, and record keeping.

TABLE 1. INVESTMENT NEEDS FOR A SINGLE TANK REMOTE SETTING SYSTEM *

Materials and equipment for an 8 x 8 x 4 cubic feet setting tank.

6 sheets of 3/4" exterior-grade plywood	$140.00
6-8' 2x4's (treated)	12.00
16-8' 2x6's (treated)	48.00
1 gal. preservative (for tank exterior)	13.00
fiberglass materials: 16 yds of 1.5 oz. mat @ 3.55/yd. = $57.00 6 gal. resin & hardener = 77.00 1 gal. acetone = 10.00	144.00
1 gal. white epoxy paint (for tank interior)	26.00
1/2" PVC pipe & fittings for air lines	11.00
4-50 micron-rated filter bags & 2 support discs	57.00
1-1/2" PVC plumbing for water pump & bag support discs **	5.00
1-13' 8" thin-walled PVC pipe (for making shellbags) ***	38.00
tank cover (plastic tarp)	15.00
hardware	30.00
air pump ***	290.00
water pump***	135.00
Options:	
microscope (1-100x & 1-30x pocket scopes)	120.00
hand tally counter	12.00
Total	$1,096.00

*Heaters and tank insulation not included

**Plumbing costs depend on how far the tank and/or pump is from the water source

***Can be used with additional tanks

TABLE 2. APPROXIMATE COSTS FOR SETTING 240 SHELLBAGS PER SET

Depreciation of setting system with options (table 1) *		
Electricity for air and water pumps		5.00
Eyed larvae at $100/million x 6 million		600.00
Larval shipping		48.00
Shellbags: $0.95/bag x 240		229.00
9.5 cubic yds. of oyster shell @ $16.50/yd.**= $157.00		
6'mesh material/bag @ $0.05/ft x 240 *** =	75.00	
Labor:****		600.00
3 men each earning $50/day ($6.00/hr) for 4 days		
	Total	$1,482.00
Cost/bag averaging 250 shells/bag and 20 spat/shell		$6.17

*The entire investment was treated as 5-yr property under IRS Modified Accelerated Cost Recovery System (MACRS). Depreciation charges vary year to year under this system. The depreciation charge in the table reflects the setting system in its third year. The yearly depreciation is $219.00.

**Shucked shell prices range from $14-$19.00 (delivered).

***1,500' roll.

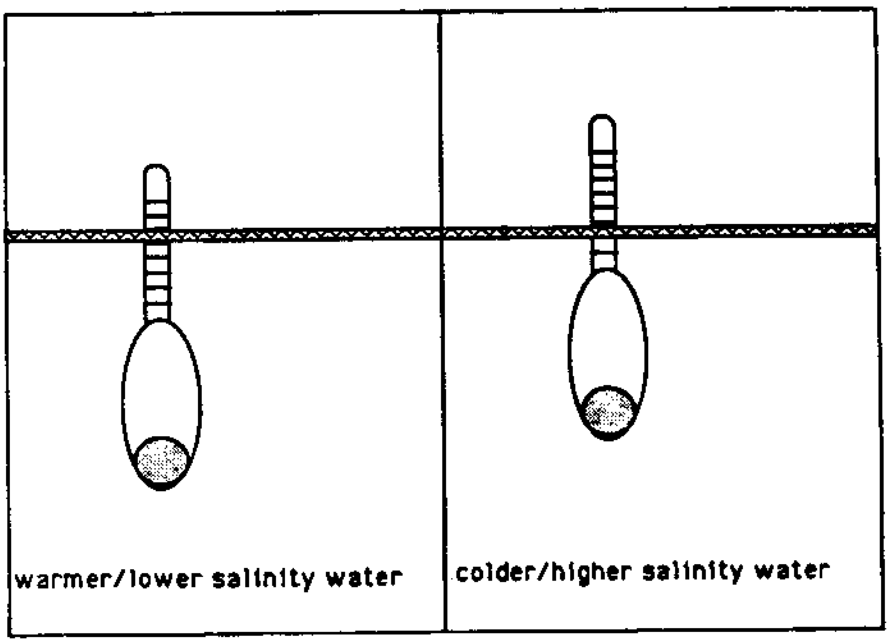
****Labor includes making shellbags, loading and unloading tank, and placing bags of spat in nursery area. Include an extra work day ($150) for removal from the nursery area to growout area. Management and security are not charged here.

APPENDIX 1

HOW TO MEASURE SALINITY WITH A HYDROMETER

Whether you farm oysters, make soft crabs, or own a saltwater aquarium, knowing the salinity of seawater (the amount of salt present in the water) can be valuable information. This can be obtained inexpensively with a hydrometer.

A hydrometer is a precisely weighted, sealed glass tube that measures the density of a liquid by how high or how low it floats. A numbered scale is located inside the stem to obtain a reading of the density, also known as the specific gravity. The density changes with temperature and with differences in the amount of salt in the water.



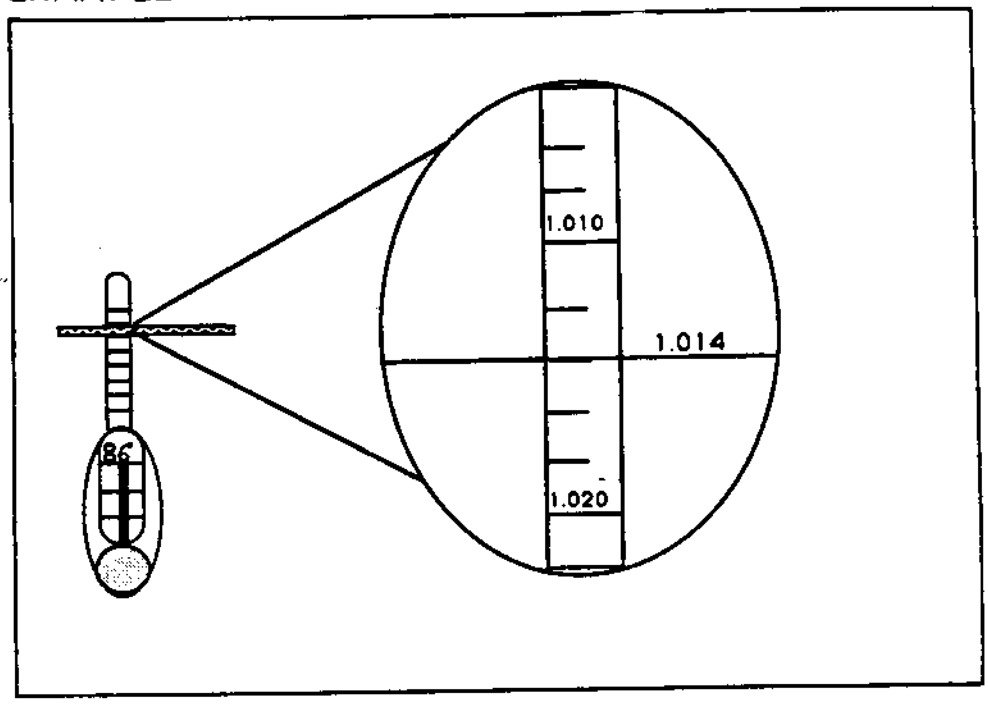
Hydrometers are made specifically for various liquids, such as syrups, alcohol, and battery acid, so make sure that the one you use for measuring salinity is specific for seawater or brine. Hydrometers for seawater can also be purchased with thermometers built inside. They can be purchased at aquarium shops and aquaculture supply companies.

To help in reading the hydrometer, try using it in a bucket of water. You could also use a short length of three-inch PVC pipe, with a cap on one end, filled with sea water.

Most hydrometers are built to be used at a temperature of 59°F (15°C), so when the seawater temperature is different, the observed reading on the scale must be converted to the actual temperature. This can be easily done by using Appendix Table 1.

Using the example below, the hydrometer reading is 1.014 at a temperature of 86°F. By looking at Table 1, the salinity would be about 24 parts per thousand. Without converting for 86°F, the salinity would have been off by 5 ppt (1.014 at 59°F = 19 ppt).

EXAMPLE



APPENDIX TABLE 1. CONVERTING DENSITY TO SALINITY

Density (sp. gravity)	Salinity 59°F	70°F	80°F	90°F
1.000	0	2	4	6
1.002	4	5	7	9
1.004	6	8	9	11
1.006	9	10	12	14
1.008	11	13	15	17
1.010	14	15	17	20
1.012	17	18	20	22
1.014	19	21	23	25
1.016	22	24	25	28
1.018	25	26	28	30
1.020	27	29	31	33
1.022	30	32	33	36
1.024	33	34	36	
1.026	35	36		
1.028	38			

APPENDIX 2

BUYING AND USING A MICROSCOPE

Buying a microscope to look at larvae and freshly set spat is a good idea and investment. A poor larval shipment can be determined beforehand, reducing the possibility of a failed set and the resulting wasted labor. Cultch should also be checked to make sure you have a good set before unloading a tank.

Microscopes generally use a combination of lenses to magnify. Scopes usually have a 10 power (10x) eyepiece and different lenses (objectives) below the eyepiece that can be switched for different magnification. Some cheaper models have interchangable eyepieces and one lens below them. Whichever is used, keep in mind that it is the combination of the two that determines the magnification or power (x). For instance, a 10x eyepiece with a 10x objective will magnify 100 times (100x). With a 3x objective, it magnifies 30x. A knob is turned for focusing.

Buying a microscope to look at larvae and freshly set spat need not be too expensive, but like everything else, you get what you pay for. The more you spend, the better the field of view (i.e., the circle you view may be the size of a jar lid as opposed to a dime). There may be two eyepieces as well. Such options make it easier on your eyes, especially if you are going to look in the scope for long periods of time.

The least expensive are pocket scopes with one or two eyepieces (biscopes) having 100x or 30x magnification (sold as separate scopes). These have a battery-operated light and a vinyl carrying case ($20-$50). Scopes used for students in high school and college have more than one lens and are more expensive ($250-$800). These are sold as compound scopes with magnification in the high range (100x-400x) and stereo (two eyepieces or oculars) dissecting scopes for close handwork with low to midrange magnification (10x-40x). Used scopes are available. If you are going to invest that much money, buy or build a carrying case as well.

To check larvae closely (i.e., to see internal organs moving to verify that nonmoving larvae are dead or alive), 100x is needed. You will be able to see the extended foot as well, meaning that the larvae are ready to set.

If you want to measure the larvae, a scale (micrometer) is needed. The scale is marked from 0 to 100 and is made from clear plastic or glass. With expensive scopes, the scale is placed in the removable eyepiece, so when you are looking in the scope, the 0 to 100 scale is in view over what you are measuring.

Less expensive scopes have eyepieces fixed in place, so if you want to measure larvae, you can place the scale down in the sample that you are observing or lay it on top of the sample as a cover slip. Inexpensive, hand-held pocket scopes can be used to measure larvae by placing the clear scale (sold as a cover slip) onto the bottom of a clear glass ashtray with a little seawater and a few larvae. The larvae can then be evaluated for velum and foot movement and measured as they swim over the scale. If they are moving too fast, some fresh water or a capful of alcohol (gin or vodka) will stop their swimming. Too much liquid in the ashtray will make measuring troublesome. If you need to push the larvae around while looking at them to get them situated over the scale, make a probe with a straight pin inserted diagonally through an eraser on a pencil.

Freshly set spat can be easily seen at 30x. A 10x magnification will allow faster shell examination by covering more area while looking for spat, then changing to 30x to get a closer look. Use the probe to push grit aside. Larvae that have successfully set will have grown a new edge of shell from the bill onto the cultch with the hinge pointing slightly upward. Freshly set larvae are hard to see on wet cultch, because of the glare from the light. Air-drying the cutch first helps.

Appendix 3

SETTING CHECK LIST

PREPARATION

Date and Time
or Comment

__________ Larvae ordered from hatchery and transport arranged.

__________ Setting tank preparation completed (cleaned and washed).

__________ Heating and aeration systems tested.

__________ Cultch preparation completed (aged and cleaned).

__________ Tank loaded and filled with water for conditioning.

__________ Test cultch hung in tank.

Amount and type of cultch in each set tank

__________________ Tank A __________________ Tank B

__________________ Tank C __________________ Tank D

__________ Conditioning water dumped and filled with heated water.

LARVAE INSPECTION

__________ Larvae arrival time and date.

__________ Temperature of larvae in ice chest.

__________ Color and smell.

__________ Moisture of bundle of larvae.

__________ Average size of larvae.

__________ Range of larvae sizes.

__________ Average size of eye spot.

__________ Foot activity.

__________ Loose velums.

LARVAE INSPECTION (in bucket)

_______ Number of larvae per ml in bucket.

_______ Total number of larvae (number per ml x volume).

_______ Mucus production (stringing).

_______ Behavior (drop to bottom, stick to bucket, etc.).

SETTING

_______ Time and date larvae put in tank.

Number of larvae in tanks.

_______ Tank A _______ Tank B

_______ Tank C _______ Tank D

_______ Bay water visibility.

_______ Salinity and temperature.

_______ Aeration and frequency and duration.

_______ Temperature at start of set.

_______ Number of larvae swimming after 1 hour in 1 cup.

DAY 2

_______ Temperature in morning.

_______ Number on test cultch.

_______ New test cultch added.

_______ Number of larvae swimming in 1 cup.

_______ Food added? (amount)

_______ Water change? (amount)

_______ Temperature at end of day.

DAY 3

__________ Temperature in morning.

__________ Number on test cultch.

__________ New test cultch added.

__________ Number of larvae swimming in 1 cup.

__________ Food added? (amount)

__________ Water change? (amount)

POST-SET AND NURSERY

__________ Date and time of removal from tank.

__________ Air temperature and weather conditions.

__________ Length of time out of water.

__________ Location of cultch for first 2 to 3 weeks.

__________ Tide foot level or depth.

__________ Location of cultch for nursery.

__________ Tide foot level or depth.

SPAT COUNTS PER CULTCH PIECE

	TANK A	TANK B	TANK C	TANK D
AT REMOVAL				
AFTER 2 WEEKS				
AFTER 1 MONTH				

APPENDIX 4

REMOTE SETTING SUPPLIERS LIST

The list below is included to help you locate equipment and supplies that you may not normally purchase. There are other sources. This list is not an endorsement of these suppliers. Call or write for their catalogues. Also check local aquarium shops.

Gulf Oyster Larvae

Gulf Shellfish Farms of Louisiana
P.O. Box 100
St. Bernard, LA 70085
504-787-3131

Shellbag Material and Other Aquacultural Netting (Heavy-Duty Shellfish Bagging [Tube])

ADPI Enterprises, Inc.
3621 B Street
Philadelphia, PA 19134
1-800-621-0275

Tenax, Inc.
8291 Patuxent Range Rd.
Jessep, MD 20794
1-800-356-8495

Nalle Plastics, Inc.
203 Colorado
Austin, TX 78701-3998
1-800-531-5112

Internet, Inc.
2730 Nevada Ave. N.
Minneapolis, MN 55427
1-800-328-8456

Filter Bags and Support Rings

A.R.E.A., Inc.
P.O. Box 1303
Homestead, FL 33090
305-248-4205

Aquatic Eco-systems, Inc.
2056 Apopka Blvd.
Apopka, FL 32703
407-886-3939

Pumps and Blowers

Fritz Aquaculture Products, Inc.
P.O. Drawer 17040
Dallas, TX 75217
1-800-527-1323

Argent, Inc.
8702 152nd Ave. N.E.
Redmond, VA 98052
1-800-426-6258

A.R.E.A., Inc.
P.O. Box 1303
Homestead, FL 33090
305-248-4205

Aquatic Eco-systems, Inc.
2056 Apopka Blvd.
Apopka, FL 32703
407-886-3939

Grainger, Inc.
825 Distributor's Row
New Orleans, LA 70123
504-733-9742
(check for Grainger
distributors in your area)

Aquanetics, Inc.
1177 Knoxville St.
San Diego, CA 92110
619-275-0243

Microscopes, Hand Tally Counters, Salinity Measuring Equipment

Argent, Inc.
8702 152nd Ave. N.E.
Redmond, WA 98052
1-800-426-6258

Forestry Suppliers, Inc.
P.O. Box 8397
Jackson, MS 39284-8397
1-800-647-5368

A.R.E.A., Inc.
P.O. Box 1303
Homestead, FL 33090
305-248-4205

Aquatic Eco-systems, Inc.
2056 Apopka Blvd.
Apopka, FL 32703
407-886-3939

Fritz Aquaculture Products, Inc.
P.O. Drawer 17040
Dallas, TX 75217
1-800-527-1323

Electric Immersion Heaters

Glo-Quartz Electric Heater Co., Inc.
7084 Maple St.
Mentor, OH 44060
1-800-321-3574

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