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Oyster Gardening in Virginia: An Overview of Techniques

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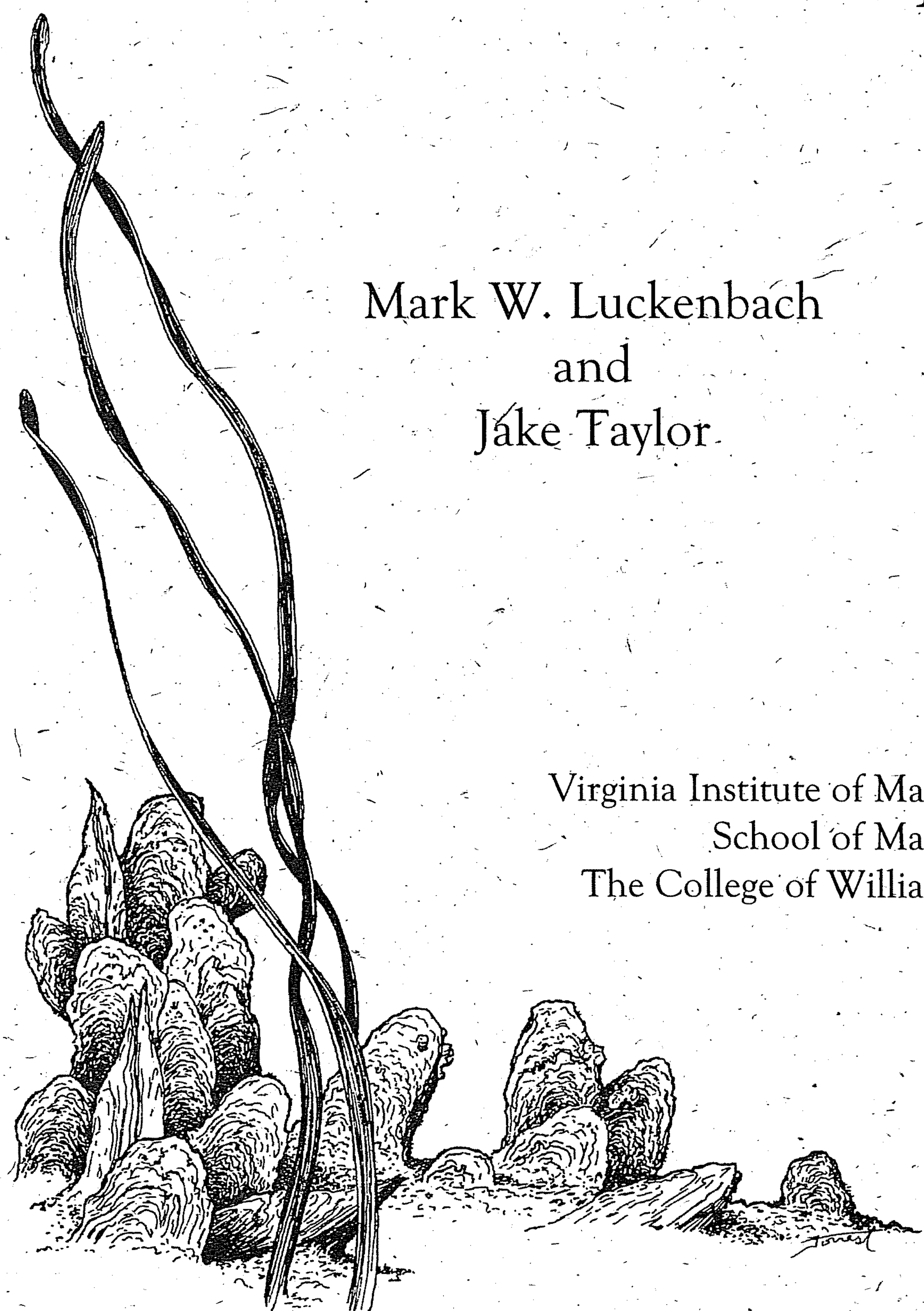

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Preface

This document is intended to respond to a growing demand for information on intensive, off-bottom aquaculture of the eastern oyster, ***Crassostrea virginica****, in Virginia and neighboring coastal states. During the early 1990's, as the epithet of the wild oyster fishery in the region was being written, interest in alternative approaches to culture oysters grew considerably. At the time of this writing, we estimate that over 200 separate off-bottom oyster culture operations are underway within Virginia. Many of the individuals involved are gardeners, growing just enough for personal consumption or marketing through cooperatives. Others have backgrounds as traditional watermen. Still others are more broadly involved in shellfish aquaculture.*

This publication represents an attempt to partially fulfill the requests from oyster gardeners for information on approaches towards culturing oysters.

The approach described here reflects a strategy which we have been developing and refining over the past 8 years. It is neither complete nor exclusive. It is directed towards the culture of ***C. virginica*** *in areas where the oyster diseases Dermo and MSX (caused by the pathogens* ***Perkinsus marinus*** *and* ***Haplosporidium nelsoni****, respectively) are endemic. Our experiences are drawn largely from work in Virginia, but the general strategy should be applicable in many locations from southern New Jersey south along the U.S. Atlantic coast.*

It is never quite the right time for a publication of this type. Refinements in techniques and new lessons learned from failures are ongoing. Regulations in Virginia relating to shellfish aquaculture are currently under review and likely to change. Nevertheless, we offer this in the hope that it will provide an outline of the major components of culturing oysters in the region.

Historical Perspective

The demise of Virginia's oyster fishery has been over 100 years in the making. The initiation of this decline had as much to do with the development of the steam canning process in the 1870's as it did with the presently fashionable excuses of pollution and disease. This process made possible the wholesale over exploitation which ultimately led to reduction of populations below that capable of coping with natural threats or sustaining a fishery.

During the past few decades, oyster populations in Virginia have been particularly hard hit by the sustained presence of two parasite-induced diseases (MSX [caused by *Haplosporidium nelsoni*] and Dermo [caused by *Perkinsus marinus*]). These protozoan parasites have been found at record high levels in recent years; Dermo has now spread to all public oyster beds in Virginia and accounts for 70 to 90% mortality in most (Burreson and Ragone Calvo, 1996). Recovery of the traditional fishery would appear to depend upon a significant abatement of the disease problem coupled with improved water quality and alterations of management practices. There is little evidence that all of these will occur in the near future.

Diseases

Contrary to popular accounts these diseases are not caused by viruses, but rather by single-celled protozoa. The causitive agent of MSX is *Haplosporidium nelsoni*; Dermo results from infections by *Perkinsus marinus*. Neither parasite is harmful to humans and no threat is posed by consuming shellfish infected with either parasite. *P. marinus* is endemic to the area and Dermo disease has likely afflicted oyster populations for a long time. Recent molecular evidence suggests, however, that *H. nelsoni* may have been introduced to the region within the past half century.

Both parasites thrive in salinities above 15‰ and exhibit lowered virulence at lower salinities. Below about 10‰ *H. nelsoni* is eliminated from its host, while *P. marinus* persists at lower salinities but does not reach pathogenic intensities.

New infections of both *H. nelsoni* and *P. marinus* generally occur during warmer months with the peak period for new Dermo infections generally occurring in August and early September in Virginia (Burreson and Ragone Calvo, 1996). MSX infections can arise from May through September, yet the life cycle of *H. nelsoni* and the mode of infection remain unknown.

Overview of the Strategy

Growing oysters in the presence of these diseases requires an integrated strategy which emphasizes (1) brood stock selection, (2) management around disease and (3) rapid growth to harvest size. All too often attempts to culture oysters have focused on just one of these components to the exclusion of others; for instance, the development of a "super" disease resistant oyster or a particular containment system for holding oysters off the bottom.

Brood stock selection - The development of oyster stocks with dual resistance to both Dermo and MSX has been the focus of research programs at VIMS and Rutgers University. While recent progress has been made toward this goal, it is unlikely that a fully resistant oyster will ever be developed. A more realistic scenario is that continuing small improvements in the disease tolerance of oyster stocks will improve the success of integrated approaches to oyster culture.

The most important point for the oyster gardener with respect to brood stock selection is to ensure seed is purchased from a hatchery which has used Dermo-tolerant animals as spawning stock. By this we mean oysters which come from high salinity, disease endemic areas. We generally find that offspring from such oysters can survive one summer of exposure to Dermo. In contrast, oysters produced from stocks which have had little historical exposure to *Perkinsus marinus* (e.g., those from low salinity regions of Virginia and north of Delaware Bay) generally are very susceptible to the disease and seldom tolerate even light exposures.

Selected lines of oysters with a high degree of resistance to MSX have been developed over the past 35 years at Rutgers University; unfortunately, these stocks initially proved to be highly susceptible to Dermo and slow growing. Current selective breeding efforts at VIMS and Rutgers are further developing these stocks to be more Dermo tolerant and faster growing. Within the next few years we expect that brood stocks from these programs will be available to commercial hatcheries for the production of seed.

Managing around disease - The second component of our strategy for culturing oysters is to manage around the diseases. One approach to doing this is spatial. Below 10‰ salinity *Haplosporidium nelsoni* does not persist and, while *Perkinsus marinus* can survive at these salinities, it does not cause mortality. Raising oysters throughout the entire growing cycle in low salinity can be an effective means of avoiding disease, but it results in a very watery tasting oyster which is generally regarded as less desirable.

Highlights of the strategy:

- Purchase disease-free seed produced from the best available brood stock;
- Select a good growing site;
- Protect oysters from predators with appropriate meshes;
- Keep meshes clean and unobstructed;
- Harvest oysters as soon as they are large enough.

A temporal approach to managing around diseases, particularly Dermo, can be effective. In Virginia, late July through early September is the period during which new infections of *P. marinus* generally occur and existing infections intensify. By avoiding exposure to the pathogen during the early stage of seed production, it is possible to limit oysters to a single exposure during the culture cycle. As noted above, this level of exposure is generally not sufficient to cause mortality in hardy oyster stocks. The two means by which a seed producer may avoid disease exposure is to spawn oysters in late June or early July (so that the seed do not go into overboard nurseries until the major disease threat has passed) or to move earlier spawned seed into disease-free (usually low salinity) nursery areas.

For the oyster gardener, it is important to **ensure that the seed you purchase is disease free** at the time of the purchase and that they were produced from the best available brood stocks. A final aspect of temporal disease management is to harvest oysters before they enter their second summer when *P. marinus* infections are likely to intensify and the oysters succumb to Dermo. It is better to eat a 2½ inch oyster in April than to wait a few months for it to grow larger and lose it to disease.

Grow them fast! - The third component of the strategy is rapid growth to harvest size. This has generally been achieved in off-bottom culture, in which oysters are suspended above the bottom in bags or floats. The principal behind this approach is that both the quantity and quality of the food available to the oyster is improved when suspended in the water column. Unfortunately, there are no strict guidelines with respect to the best position in the water column to place the oysters. Often raising the oysters as little as 6 inches above the bottom is sufficient to reduce the amount of suspended sediments which they must filter and improve their growth rates, but performance is very site specific and depends in large measure on the bottom type.

Oyster growth rates are also dependent upon salinity. Below 10‰ oyster growth rates are generally reduced compared to higher salinities; some stocks show intermediate growth rates at salinities between 10 - 20‰ and highest growth rates at high salinities, but that may be a function of heritage.

The quantity and quality of food available to oysters can vary considerably between locations and is a function both of the hydrodynamics at a site and the abundance of phytoplankton in the water. At present the best approach for an oyster gardener is experiment with different areas to determine the site which affords the best growth.

Containment Systems

A wide range of options are available for maintaining oysters off the bottom, each combining advantages and disadvantages. Published methods include the use of fixed racks, floats and suspended bags–e.g. the flexible belt (Creswell et al., 1990) and the chubb ladder system (Skip Kemp, North Carolina Sea Grant College Program). No single method will work for everyone and no single method guarantees success. Each grower must consider characteristics of the growing site and his or her handling capabilities. We have outlined a few containment systems below, but do not mean to imply that they are the most desirable for everyone. Recently a number of different modifications of these systems have become commercially available.

The important features of any system for maintaining oysters in off-bottom culture are (1) adequate predator protection, (2) minimal flow obstruction, (3) ease of maintenance and handling, and (4) low cost. Additionally, it may be necessary, depending upon location, to consider the impediments of navigation or aesthetics associated with the structures.

Mesh Types and Measures

The descriptions of containment systems which follow and subsequent sections on handling generally refer to mesh size based upon a linear measure of the opening. Depending upon the construction of the mesh, the shape of this opening may be square, hexagon or octagonal. Thus, it is important to know which linear dimension is being measured. For instance, the 1-inch, 16-gauge galvanized wire mesh referred to below measures 1 inch on a side from center wire to center wire, with a wire thickness of 1/16 inch (Fig. 1a). The maximum dimension of the opening is, therefore, 1.4 inches. Another mesh, marketed as KET-6 ½ mesh oyster bags by Tenax®, is oval in shape with dimensions as shown in Fig. 1b.

Taylor Float

The Taylor float, so called because much of the design and original testing was done by Jake Taylor at VIMS, is constructed of 4 inch diameter PVC pipe and galvanized wire (Fig. 2). The float is approximately 2 ft x 8 ft x 1 ft deep and is of sufficient size to grow 1,500 to 2,000 oysters to market size. Lightweight, schedule 20 PVC drain pipe works as well as the more expensive schedule 40 pipe. Sizes of the pipe and the number of fittings are shown in Fig. 2. The mesh cage of the float is generally constructed of 1-inch square, double-dipped, 16-gauge galvanized hardware cloth, cut and folded as shown in the figure. Recently we have begun to use a plastic-coated form of this wire, but cannot yet confirm that it has sufficient longevity to justify the added costs. The wire cage is then attached to the PVC float using cable ties or crab pot line.

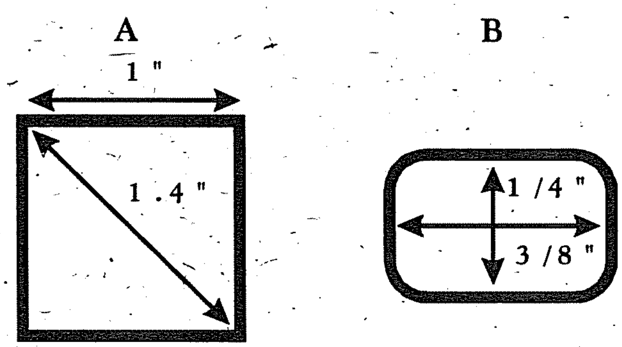


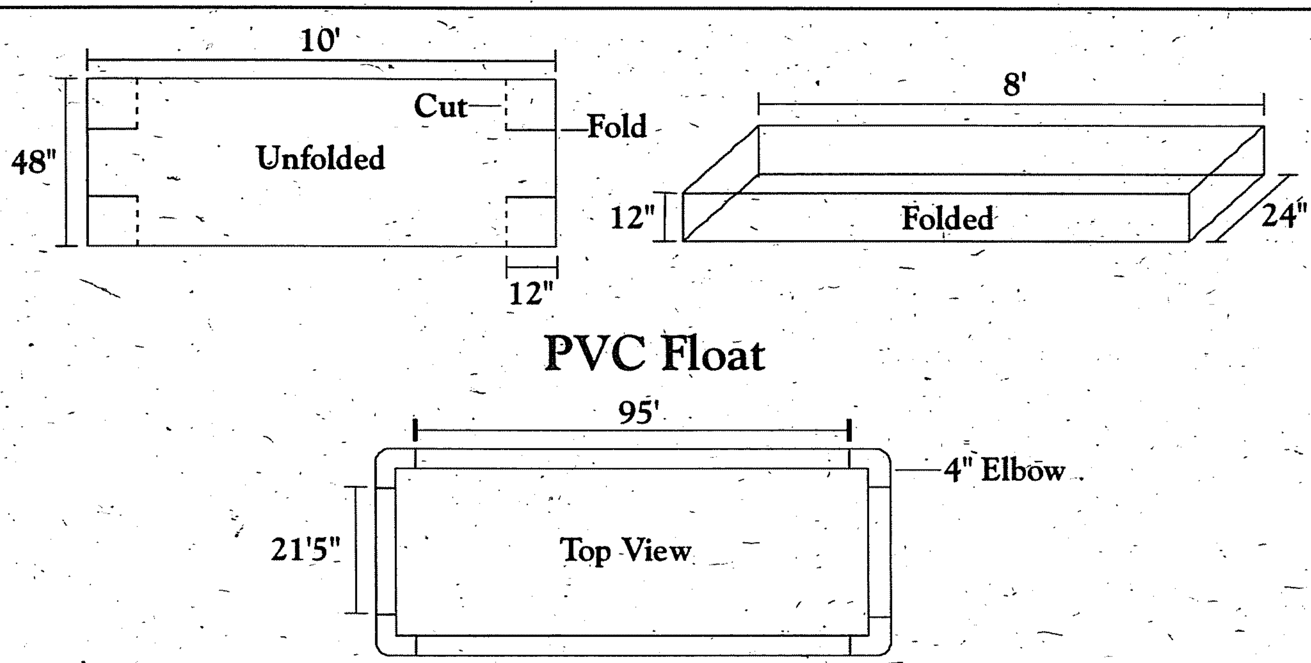
Figure 1. Mesh measurements for (A) 16-guage galvanized wire and (B) Tenax 1/2" mesh bags.

It is important to attach zinc bars as sacrificial anodes to this mesh to reduce corrosion and extend the life of the float.

Oyster seed, which are too small to be retained within the 1-inch mesh, may be placed inside mesh bags (described below) which are then placed within the float. Also, a ½-inch mesh liner made of thin plastic (sold as bird netting to protect fruit trees) may be placed within the float and attached with cable ties. This liner is inexpensive, adding only approximately $1.00 to the cost of a float.

We have investigated several lid options for this float including ¼ inch thick plywood lids,

Figure 2. Taylor float design and approximate materials cost.



Materials for 1 Taylor float:

10' x 4' double-dipped 16 gauge vinyl coated wire, 1" x 1" squares	$ 15.90
2 10' lengths of 4" schedule 20 gauge PVC pipe.	6.70
4 4" schedule 20 gauge PVC 90° elbows	5.00
20 14 ¼" black plastic cable ties	2.70
1"x 3"x 8' wood strip for lid	1.85
3' x 8' filter cloth for lid	1.00
Gray PVC glue & PVC cleaner	1.00
24' #8 crab pot line	0.60
½" stainless steel hog rings	0.50
Miscellaneous	2.00
Total	$ 37.25

Some tips for making floats The wire is generally purchased in 100 ft rolls which may actually vary in length by several inches. Roll out your wire first and measure the total length before cutting. That way if the roll is a little short, you can spread those missing inches among the cuts and still get 10 floats per roll.

wire mesh, shade cloth and no lids. Performance of different lid options vary with location and opinions about the best type of lid vary between culturists. Lids have been found to be useful in restricting the growth of macroalgae in the floats and reducing predation by otters and seagulls. However, barnacle and oyster settlement may be greater under lids and seagulls roosting (with the associated problem of elevated fecal coliform bacteria levels) may be greater on floats with lids. Individual culturists will need to experiment with the use of lids at their site to determine their value.

Several modifications to this basic design have been used by growers in Virginia. One involves using plastic mesh instead of galvanized. Plastic has the advantage of not corroding, but is more expensive, provides less rigidity and offers more surface area for fouling. The PVC pipe may, of course, be cut to any size to fit the needs of individual culturists and some have chosen to work with larger or smaller floats.

Advantages of this containment system include low materials cost and sturdy design. The open mesh of the wire float provides limited surface area for fouling and permits good water flow. Disadvantages include the cumbersome size and need for a hoist to retrieve the floats when they are full of oysters. Further, in some locations the use of these floats may be restricted by navigational or aesthetical concerns.

Wilde Float

This float was designed by Frank Wilde and modified by Andrew Teeling, East Point Oyster Co. It consists of a red cedar wooden frame, polyethylene mesh and a styrofoam lid for flotation. The mesh is fastened to the wooden frame using battens (nailing strips) and two thin strips of pressure treated wood are fastened with plastic cable ties to the bottom of the tray to maintain rigidity. The lid is made of ¾" thick closed cell foam and held in place by a removable cross brace. A lifting bridle or lines for securing this tray to a dock can be attached through the plastic mesh. Recommended stocking density is 300 oysters per float, with culling occurring as oysters reach harvest size.

This float has the advantage of being lightweight and easy for one person to handle. They are durable with an expected useful life of 5 or more years. The shallow draft of these floats makes oysters in them particularly susceptible to wave action and winter freezes.

Universal Oyster Tray

This tray was designed through a collaborative effort by Virginia's Center for Innovative Technology, Old Dominion University, VIMS and East Point Oyster Company. It was intended to serve as a tray which could be floated or fixed above the bottom, either singly or in stacks. The tray is designed to be built entirely out of extruded plastic. At present only milled prototypes are available and the costs are quite high. If sufficient demand for these trays develops to warrant manufacturing them in bulk, the price should come down to the point that they are quite competitive.

Oyster Chub Ladder

Developed by Skip Kemp (North Carolina Sea Grant Program) the chub ladder system uses small mesh bags attached to floats as a means of suspending and protecting oysters. Though designed for use in open water, this system may be modified for use from a dock. Long lines may be strung between dock pilings or attached to floats which are tethered to the pilings. It is important in any modification that the mesh bag remain horizontal in the water. Stocking densities in each bag should range from 25 - 50 oysters.

This system should be very amenable to modifications for small-scale culture operations. The small size of individual units makes it possible to develop manageable arrays of bags to fit the needs of the grower.

Procedures

We recognize that there can be more than a single approach to culturing oysters in this region, but offer this basic sequence of steps as a starting point. The steps and the oyster densities are given for oyster culture using the Taylor float, because we are most familiar with this system, but the basic approach can be followed using other systems. Modifications based upon using smaller seed are outlined below. We recommend that the beginning gardener start with the larger seed.

1. Securely moor floats in the water.
2. Place 15 - 20 mm seed oysters in 3/8" mesh bags at a density not exceeding 2500 oysters/bag and place no more than 2 bags/Taylor float. [Numbers will vary in other floats]. The best time to initiate this step is in late September after the greatest threat of *P. marinus* infection has passed. **Remember to start with disease-free seed from good brood stock.**
3. After 2 - 6 weeks, depending upon growth rates, remove oysters from the bags and place into a float with ½" mesh lining. Densities within the float should not exceed 2000 animals.
4. Over the next 6 - 18 months maintain the oysters and floats in good condition (see below) and **harvest oysters as soon as they are large enough to eat!** The oysters will grow at varying rates and leaving large oysters within the float will slow the growth of the remaining ones.

The box below provides a summary of the steps involved, including those for starting with smaller seed.

Number and size of mesh bags and oysters used in a Taylor float:

- 2500 2-3 mm oysters/ 1/16" mesh bag; 2 bags/float for approximately 2-4 weeks
- 2500 6-12 mm oysters/ 1/8" mesh bag; 2 bags/float for approximately 2-4 weeks
- 2500 15-20 mm oysters/ 3/8" mesh bag; 1 bag/float for approximately 2-4 weeks
- 1500 -2000 20-50 mm oysters/float with ½" mesh liner for approximately 5-8 mo.

Constructing the mesh bags and liner:

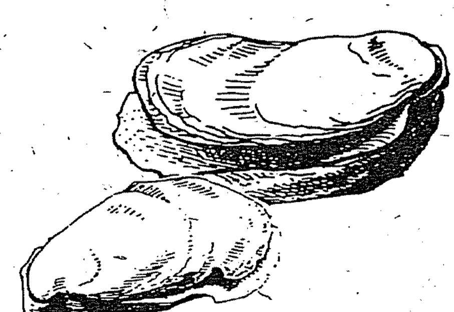
- **1/16" mesh bags**- Fiberglass window screen can be purchased in 4-ft x 100-ft rolls. Cut 18-inch x 24-inch sections and sew two panels together with monofilament line, double stitching along three sides. After placing oysters in the bag seal by stapling two ¾-inch x 18-inch wood strips together on the open side; adding 2 additional wood strips along the bottom of the bag provides additional strength to the bag.
- **1/8" mesh bags**- Plastic mesh may be ordered from several aquaculture supply vendors in flat and tubular forms. The latter are much better for constructing bags. The standard dimensions of a roll of 1/8-inch tubular mesh are 36 inches x 200 ft. Each roll makes about 100 24-inch x 18-inch bags. One end of the bag should be closed with ½" stainless steel hog rings, and the other end with cable ties.
  3/8" mesh bags- These bags can be purchased individually from aquaculture supply companies or rolls of tubular mesh can be purchased. Each bag measures 40 inches by 20 inches. The one open end can be closed with cable ties.
- **½" liner**- Liners are constructed from very thin mesh which is sold as bird netting to protect fruit trees. It generally comes in 3000-ft x 14-ft rolls, but may be purchased in small quantities from some vendors. Cut 9-ft X 3-ft sections and secure it to the inside of the float using cable ties. The liner should extend 6 inches up the sides of the float and be secured at the top with cable ties.

Maintenance and Care

Maintaining an oyster garden is a little like caring for a vegetable garden. **It is a lot easier if you stay on top of a few relatively simple tasks!** Analogous to weeding a tomato patch, the bags and floats that are holding oysters must be cleaned periodically. The frequency with which this cleaning must be done will vary between sites and between seasons and years at individual sites. Regular inspection of the floats and bags is required to judge when cleaning is needed.

The principal cause of fouling is marine organisms which settle from the plankton and attach to the floats, bags and oysters. Most of these organisms can be removed by washing with water (fresh or salt) and scrubbing with a stiff brush. High pressure washing is sometimes required to remove firmly attached organisms, but care must be taken when using high pressure washers not to damage small oysters.

In some locations the settlement of barnacles, mussels and even oysters onto the floats can be a particular problem, since these organisms are not easily washed off. If detected early enough, these animals can be cleaned off using a brine dip (described below in the section about flatworms). It is especially important that a brine dip only be used with **oysters greater than 5 mm**, since smaller oysters will suffer mortality from the procedure (DeBrosse and Allen 1993).



Predators and other associated organisms

Predators ranging from flatworms to river otters may be found associated with off-bottom cultured oysters, but not all animals pose a threat to the oysters. Distinguishing between those organisms which eat or otherwise harm oysters and those which do not is important. A complete accounting of the organisms associated with cultured oysters is beyond the scope of this document, but a few common examples are given below.

- *Flatworms* - The oyster leech or oyster flatworm, *Stylocus ellipticus* (formerly *Eustylochus ellipticus*) can be a very significant predator on small oysters. In Virginia, *S. ellipticus* generally invades oysters in late spring or early summer, though occassionally late summer infestations will occur. This animal is usually no larger than 25 mm, flat and thin with irregular margins and it lacks the "centipede looking" appendages seen on the common clam worm. It can be green, yellowish brown, or salmon in color with a whitish branching intestine that can be seen through the skin. Flatworms prey on barnacles and small oysters and can be devastating to a crop of cultured oysters if left untreated.

  The preferred treatment for flatworm infestation is a brine dip. The bags with oysters should be left out of water for about one hour before the dipping to make sure all oysters are closed. A brine solution is made by dissolving 25 pounds of salt in 10 gallons of estuarine water in a plastic trash can. Each bag is dipped into the brine solution for five minutes with agitation. The bags are then left out of water another hour before being placed back in the float.

  Another treatment is to raise the bags above the low water mark so they are exposed to the sun at low tide. This method should kill the flatworms but not the oysters, but is subject to variation in success depending upon weather conditions.

- *Clam worm* - This polychaete worm (*Nereis succinea*) is usually the most common worm associated with cultured oysters in the region. It is generally 1 - 3 cm in length, segmented and has numerous small appendages running the length of the body on each side. Usually light pink to reddish brown in color, this worm is easily spotted crawling across the shells of oysters. Fortunately, this animal does not pose a threat to oysters and the oyster culturist need not be concerned with them.

- *Crabs* - There are a variety of crabs which may be associated with oyster cultivation and most should be viewed as predators. The blue crab (*Callinectes sapidus*) is a voracious predator on oysters and care should be take to exclude them from the bags and floats. Several species of mud crabs (*Panopeous* and related genera) also feed on small oysters. During mid-to late summer in this region, several of these crabs, especially the blue crab, settle out of the plankton and into bottom habitats. At this time the small crabs may pass through meshes as small as ½ inch and grow rapidly to a size capable of consuming oysters. It is important, therefore, to regularly inspect floats and bags and remove any crabs.

In high salinity environments, hermit crabs (genus *Pagurus*) are common. Though some of these crabs can grow to a size capable of eating small oysters, they generally do not pose a threat to cultured oysters and can in fact be put to beneficial use. Small hermit crabs, those found in shells 1 - 2 cm in length, can be added to the inside of 3/8 inch mesh bags to help control the fouling. They will graze on small animals and plants which settle onto the bag and obstruct water flow. **Do not add hermit crabs to bags with smaller seed (1/16 - 1/8 inch mesh) as they may consume small oysters.**

- ***Grass shrimp*** - The most common organisms associated with oyster floats are small grass shrimp (*Paleomonetes pugio* and *P. vulgaris*). These animals do not pose a threat to the oysters and may be ignored.

- ***Snails*** - In high salinity areas oyster drills (*Urosalpinx cinerea* and *Eupleura caudata*) are major predators on oysters. Fortunately, they are seldom found in off-bottom floats or trays and the few which do manage to invade a float are easily removed by hand. The common periwinkle (*Littorina littorea*), which is usually observed on the stems of salt marsh cord grass, feeds on small fouling organisms. Adding a dozen or so periwinkles to the inside of the bags containing oysters will reduce the fouling and help keep meshes cleaner.

- ***Mammals*** - The principal mammalian threats to cultured oysters are river otter, raccoons and humans. The first two are generally excluded with securely fastened lids, fending off the latter often requires greater vigilance.

Harvesting

Following the procedures outlined ~~above~~ some oysters should be ready for harvest within approximately 12 months (fall of the second year). Oysters should be harvested as soon as they are large enough to consume. For the gardener this is largely a matter of personal preference since regulations limiting harvest for wild stocks do not pertain to cultured oysters in Virginia. Rapidly grown oysters tend to have thin shells with a high meat content. We recommend harvesting cultured oysters at relatively small sizes 2 ¾ - 3 inches in shell length. This reduces crowding in the floats and allows the remaining oysters to grow faster.

Health Concerns

Oysters filter large volumes of water and thus have the capacity to concentrate both toxins and human pathogens. Tidal waters in Virginia are classified open, seasonally restricted or closed to shellfish harvest by the Virginia Department of Health. It is important to know the designation of your growing waters and to take care in consuming shellfish (especially raw) from waters of unknown designation. Contact the local office of the Shellfish Sanitation Program within the VA Department of Health for more information about status of water quality in your growing area.

Regulations

Most states have regulations on the placement of structures in the water for aquaculture and on the importation of seed from other states. Restrictions have been placed on the importation of hatchery-reared oyster seed into Virginia and Maryland. In Virginia, Marine Resource Commission regulation #450-01-0102 requires that the hatchery-reared oyster seed (shell height less than 25 mm) be accompanied by certification from a shellfish pathologist that the seed are disease free. All importation of oyster seed into Maryland from northern hatcheries is forbidden due to concerns over juvenile oyster mortality syndrome. Because these regulations are subject to change and new ones may be promulgated, it is wise to check with the Virginia Marine Resources Commission before making plans to import oyster seed. The Virginia MRC is currently liberally interpreting statutes regarding the placement of oyster floats near existing docks, but potential gardeners should check with the Habitat Division of the Virginia Marine Resources Commission before placing structures in the water for culturing oysters. A general permit which would formally authorize such structure is currently being developed.

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