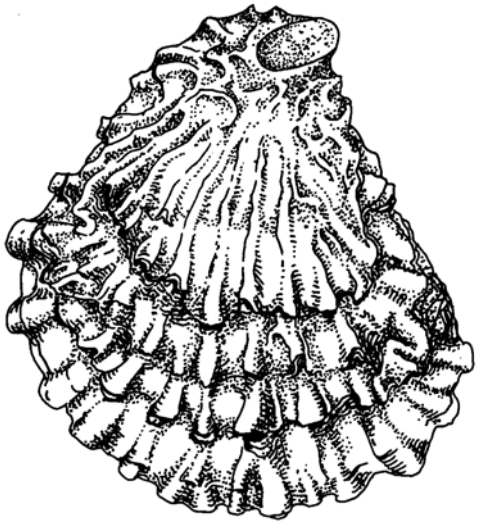
NORTH CAROLINA



UNDER DOCK OYSTER CULTURE

PROGRAM

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What is the UDOC Training Program?

In 2004, the N.C. General Assembly created the Under Dock Oyster Culture Program to allow people the opportunity to grow oysters under their coastal docks or piers. The program allows qualified permit holders to attach up to 90 square feet of oyster cultivation containers to a dock or pier owned by the permit holder. The N.C. Division of Marine Fisheries, in conjunction with N.C. Sea Grant, administers the program.

N.C. Division of Marine Fisheries
3441 Arendell Street
P.O. Box 769
Morehead City, N.C. 28557
252-726-7021/www.ncdmf.net
Contact: Craig Hardy

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North Carolina State University
Box 8605
Raleigh, N.C. 27695-8605
919-515-2454/www.ncseagrant.org
Contact: Steve Rebach

This document is designed to educate potential oyster gardeners on the program's legal requirements, as well as educate the public on how to begin and maintain the oyster culture process. (See Appendix A to review applicable statutes and rules.)

Permit Requirements

Because adverse health consequences may result if oysters are harvested and eaten under certain conditions, prospective oyster gardeners must review, and be tested, on the materials in this publication.

In order to receive an Under Dock Oyster Culture (UDOC) Permit, applicants must first pass a test to ensure they understand the legal requirements and safety precautions that must be taken when harvesting oysters. Test information and directions are attached at the end of this publication.

Other conditions of the permit include:

- The permit holder must own the dock or pier where the oyster containers or cages will be attached.

- The dock or pier cannot be located in an area the state health director has recommended be closed to shellfish harvest due to pollution, or that has been closed to harvest by statute, rule, or proclamation due to suspected pollution.

- Permit holders obtaining oyster seed or spat from an out-of-state source, must first receive an Importation Permit from the N.C. Division of Marine Fisheries to ensure adequate disease testing has been conducted.

- The permit holder may only grow the Eastern oyster, *Crassostrea virginica.* Non-native oysters are not allowed in the UDOC Program.

- Permit holders may attach up to 90 square feet of oyster cultivation containers to a dock or pier owned by the permit holder. *The containers are limited to a 6 inch maximum height allowing a maximum volume of 45 cubic feet.*

- Permit holders shall comply with the biological data sampling and survey programs of the N.C. Marine Fisheries Commission and the N.C. Division of Marine Fisheries.

- Permit holders shall post signs indicating the presence of oyster cultivation containers and that the oyster cultivation containers and their contents are private property. Signs shall include the permittee's name and permit number.

- UDOC permit holders may consume oysters they grow, but they are prohibited from selling their oysters.

- Permit holders must attempt to cultivate oysters on a continuous basis.

- An UDOC Permit is not assignable or transferable.

- If the permit holder fails to comply with the above requirements, the director of the Division of Marine Fisheries shall revoke the permit, and the owner of the dock or pier shall remove the oyster cultivation containers within 15 days of revocation.

- The permit holder shall provide a severe weather response plan (tropical, winter, ice, etc.) and is responsible for implementing the plan when conditions warrant.

- Action by a permit holder to encroach on or usurp the legal rights of the public to access public trust resources in coastal fishing waters shall result in permit revocation.

- The permit holder is responsible for the maintenance, removal, and clean-up of the culture containers.

- No one can take shellfish from the permitted containers unless they are with the permit holder or they have written notarized permission of the permittee.

Problems with theft or vandalism of a permit holder's oysters or containers should be reported to local law enforcement agencies, either the county sheriff or the local police. The N.C. Marine Patrol does not have jurisdiction over theft or vandalism of private property.

Permit Renewal

Permits must be renewed on an annual basis. In order to be eligible for renewal, the permit holder and the dock location must meet the permit requirements listed above and the permittee must document they have attempted to grow oysters on a continuous basis. The permit holder must provide documentation of permit activities for the previous year, including:

1) Number of oysters deployed into the containers, number of oysters removed from the containers.
2) Documentation of the source of the oysters (must have a valid *Permit to Introduce or Transfer Marine and Estuarine Organisms* if the oyster seed or spat is from out-of-state).
3) Document the disposition of oysters grown under this permit.

Getting to Know the Oyster

Understanding basic oyster biology will help you be successful in your efforts to grow them.
The scientific classification of the Eastern oyster is:
Phylum: Mollusca
Class: Bivalvia
Order: Ostreoida
Family: Ostreidae
Genus: *Crassostrea*
species: *virginica*

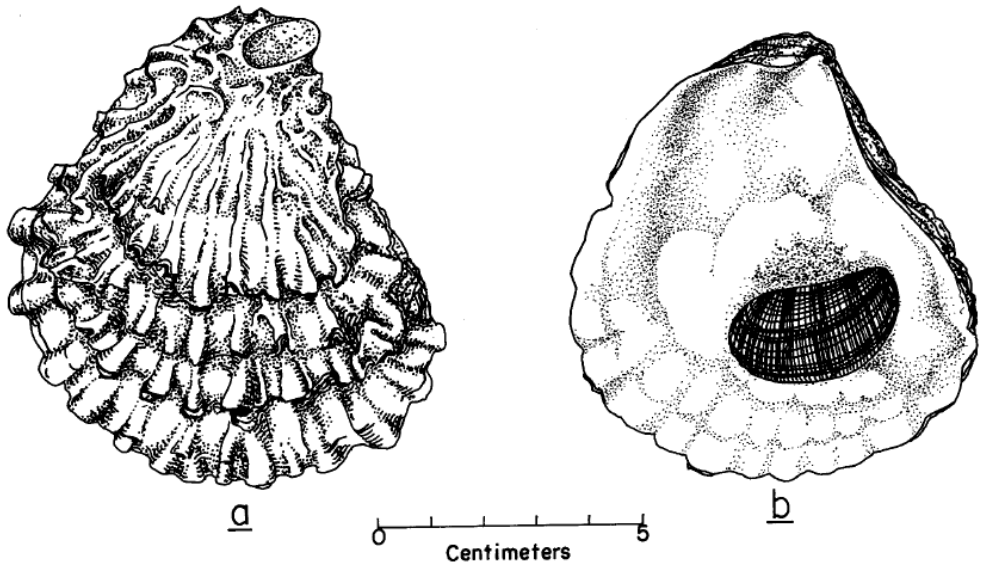

Fig. 1. ***Crassostrea virginica***. (a) lower (left) valve, (b) inside of upper (right) valve. (Galtsoff, 1964).

The oyster, like other typical bivalves, has two shells covering its body. These shells are normally gray in color, often stained with patches of light brown from algae. Shell shape is variable. The two shells fit together tightly but are not identical as they are in clams, mussels and most other bivalves. The left valve is almost always heavier than the right and more deeply cupped. The bottom shell is usually cemented to a rock, shell or other solid object. The top shell and the shell margins grow in irregular bumps and twists so no two oysters look exactly alike. It can grow to a length of about 8 inches. The typical life span of an oyster is between 5 and 10 years, though they are capable of living longer.

Oysters eat by filtering food from the surrounding water through their gills. They are most efficient removing particles that are only one ten-thousandth of an inch in size. It has been estimated that an adult oyster will filter 13 to 50 gallons of water a day.

Reproduction

Under natural conditions, oysters spawn as water temperatures rise in the spring. In North Carolina, spawning occurs at temperatures at or above 68°F (20°C). Typically the major spawning is in June, but spawning can occur throughout the warm months. Sperm and eggs are released at the same time and fertilization occurs in the water column. A female can release between 23 million-86 million eggs per spawn. A fertilized egg develops rapidly into a microscopic swimming trochophore (Fig. 2). After 24 to 48 hours, the trochophore develops into the feeding veliger stage. After two to three weeks from the original spawning, the larvae seek a solid surface, exude a drop of cement to keep them permanently attached and become "spat." Spat are mostly male and grow rapidly. Sexual maturity can occur within 4 months. Oysters start out as male and switch gender back and forth during their life span.

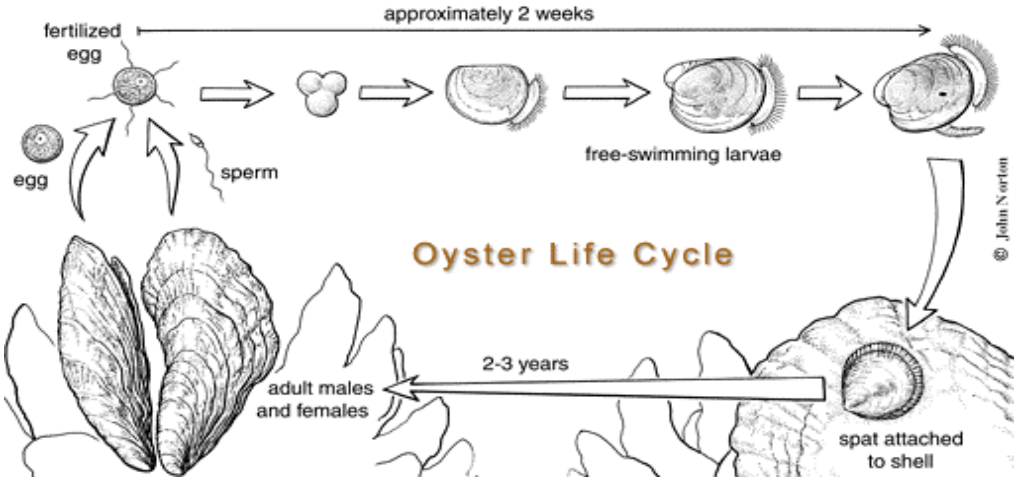

Figure 2. Oyster Life Cycle

Conditions for growth/environmental needs

In North Carolina, the Eastern oyster typically lives in shallow estuaries that have a relatively firm and stable bottom, fluctuating temperatures, low to high salinities, and clear to muddy waters. Growth to harvestable size (3 inches, 75mm) can take 12 to 36 months, depending on temperature, water salinity and food supply. Understanding such variability can help in deciding when and whether or not to grow oysters. Several additional factors may be closely associated, such as salinity, disease and predators. Make sure you assess the characteristics of a particular site before you attempt to grow your oysters.

Following are the optimal conditions for oyster growth:

- **Salinity: Optimal salinity 15 - 18ppt**

Salinity refers to the total amount of salt dissolved in water and is measured in parts per thousand (ppt). The salinity of the ocean is approximately 35 ppt. Oysters are typically found in salinities

ranging from 5 to 32 ppt, but they thrive at salinities above 20 ppt. Salinity is usually greater and more consistent in areas with active tidal flushing and a relatively small watershed. Areas that produce extreme fluctuations in salinity should be avoided. Creeks or rivers draining large watersheds are more likely to produce damaging freshwater influxes. Rainfall runoff leaves large watersheds more slowly and prolongs the exposure of shellfish to low salinities and runoff pollution.

When salinity is above about 20 ppt, marine predators and oyster diseases flourish and destroy large numbers of oysters (see Diseases and Predator sections). Oysters usually live in brackish waters, or in areas of unstable salinity, unsuitable for marine predators.

- **Temperature: Optimal temperature range from about 70 to 85 ^{o} F**

Adults exist within a range of water temperatures from 28 ^{o} F in New England to 97 ^{o} F in the Gulf of Mexico. During low tide, oysters may be exposed to and survive air temperatures below freezing or above 120 ^{o} F. Oysters tolerate freezing of their tissues and can revive after thawing. Optimum water temperatures for growth, reproduction, and survival of oysters range from about 70 to 85 ^{o} F, and the response of oysters to temperature changes and extremes depend on an interaction of environmental conditions. The rate that water is pumped through the oyster's gill system is determined by temperature. A water temperature range of 70 to 80 ^{o} F results in favorable pumping rates for supplying needs for oxygen, food, and waste disposal. Oysters are relatively inactive below 45 ^{o} F and pumping is greatly reduced.

- **Water Flow: Optimal tidal range should be above 12 to 15 inches**

Adequate tidal flushing ensures a mixing of the water, delivers food, removes wastes and stabilizes the salinity. Sufficient water exchange is needed to carry wastes away and to bring in food. Too much flow may wash away cages or floats; too little flow may cause excessive silting. The ideal site would provide plenty of water flow to transport food, for example near a creek or marsh that ebbs and flows with the tides. Ideally the tidal range should be above 12 to 15 inches. Excessive wave action, on the other hand, wears on cage attachments, and can impact oysters. Each dock is more or less exposed to heavy weather. Adjust according to your situation.

- **Oxygen: Optimal condition greater than 5 ppm**

The rate of oxygen consumption by oysters increases as temperature increases and salinity decreases. Oysters are able to survive daily exposure to low oxygen and can even survive anaerobically (without oxygen) for three days after spawning. But they grow best when oxygen concentrations remain greater than 3 to 5 ppm. Although they can tolerate relatively low dissolved oxygen levels in water, their growth will be poor, and they will become more susceptible to disease. At low oxygen levels, oysters expend more energy pumping water through their bodies to get the necessary oxygen; therefore, less energy is available for growth. Usually water will contain adequate dissolved oxygen in the upper portions of a water column or if it is subject to mixing by the tides, current, or winds. Oxygen consumption is zero when the shells are closed. Oysters exposed to prolonged periods of low salinities close their shells and die of anoxia (no oxygen).

- **Sedimentation: Overabundance can kill oysters**

Oysters can tolerate water with large amounts of suspended solids, but the pumping rate decreases with increasing concentrations of suspended solids. In natural environments, oysters apparently develop and grow better in waters with more suspended solids than in waters with less suspended particulates. Storms and hurricanes may destroy oyster reefs by covering them with sediment.

Oyster Diseases

- **Dermo**

A number of diseases can infect and kill oysters. Probably the most common, and the one blamed for the widest spread mortality in North Carolina, is Dermo, (*Perkinsis marinus*). This disease has been an invasive and destructive disease to oysters, including those in aquaculture situations. It is thought by some investigators to have been introduced into East Coast waters in the 1950s with the limited introduction of *C. gigas* oysters from the Pacific Coast. The relationship between Dermo and salinity is well established. Low temperature/low salinity combinations retard Dermo development. Oysters can exist and grow vigorously in salinities slightly lower than the minimum tolerated by Dermo. Dermo is a warm temperature disease with outbreaks and mortalities occurring in the summer months. The disease does not cause serious mortalities below salinities of 12 to 15 ppt, but can persist in over-wintering oysters in salinities below 5 ppt.

Raising oysters off bottom may promote faster growth and better health, which may help them resist the lethal effects of Dermo, during years with normal and above average rainfall. It seems to be one of the few management strategies that work to strengthen oysters against the disease. Drought and high salinity can result in heavy infestations of sea squirts and barnacles, heavy overspatting, infestation of mud worms, and flatworms, weakening the crop and setting the stage for Dermo to attack. The result can be high mortality and a nearly total loss to the crop.

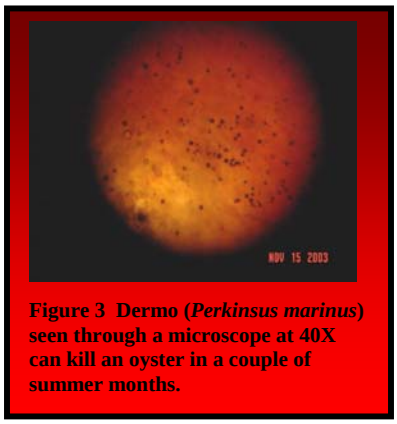

Figure 3 Dermo (*Perkinsus marinus*) seen through a microscope at 40X can kill an oyster in a couple of summer months.

As the oysters contract Dermo, their growth rate is reduced. By the time they are ready for harvest, the oysters are unmarketable due to emaciation, gaping, and pale digestive glands.

From the Pamlico Sound south, Dermo attacks and weakens aged oysters and kills them. Generally, this occurs after the second summer when the water is hottest and saltiest. Perhaps not coincidentally, Dermo occurs during periods of drought when most organisms that attack oysters thrive. During an extended drought, there is little one can do other than try to save what few oysters manage to survive the onslaught. Interestingly, a tropical storm or glancing blow from a hurricane causes a dramatic drop in salinity and for a period of time stems the flow of Dermo and the growth of the organisms that kill oysters. If the storms are not severe enough to destroy the in-water facilities, the oysters grow fast and fat.

- **MSX** (*Haplosporidium nelsoni*) is a disease that has devastated the oyster population in the Chesapeake Bay. It is present in North Carolina waters, but at a much lesser degree. It has been reported as far south as the Florida Keys, but there have been no reported widespread mortalities. Its destructive effect begins at the Virginia border and extends north into Canada.

- **SSO** (*Haplosporidium costale*) was discovered during a search for MSX along the Atlantic coast in Virginia and Maryland. It has caused heavy mortalities in that area, but so far has not been a problem in the Carolinas and to the south.

- **Juvenile Oyster Disease (JOD)** is a relatively new threat affecting oysters smaller than 25 mm. It arises in hatcheries and nurseries where oysters are in high-density situations. Little has been published on this disease, yet its serious nature warrants consideration of all information currently available.

- ***Vibrio vulnificus*** is a freeliving microbe occuring naturally in temperate estuarine areas throughout the world and can affect humans. The numbers of *Vibrio vulnificus* in coastal waters increase during warmer months, with most cases of Vibriosis occuring during late summer and early fall. The disease can be acquired by eating raw, undercooked, or minimally processed seafood, including oysters and other shellfish. It can also be acquired by other means than ingestion. Individuals with compromised health and weakened immune systems are especially vulnerable. It can range in severity from a condition similar to gastroenteritis – with associated nausea, vomiting, and diarrhea – to a life threatening primary septicemia.

All raw foods, including oysters, contain bacteria. Handle oysters as you would any perishable food. Keep oysters cold, handle oyster meats with clean hands on sanitized surfaces, and use older products first. Purchase oysters only from reputable, properly licensed or permitted outlets.

The material in the above section was modified from Perkins (1995) Publication No. 434 - Southern Regional Aquaculture Center.

Click here to learn more about → Handling Oyster Products
(http://srac.tamu.edu/tmppdfs/7419369-434fs.pdf)

Oyster Gardening

Seed Sources

Ideally, obtain your oyster seed directly from in-state commercial and research hatcheries or nurseries. As a participant in the program, you will start with young oysters, called "seed" or "spat," that have been spawned and reared in a hatchery. Contact the N.C. Shellfish Growers Association or the Shellfish Gardeners of N.C. for suggested seed sources, and for information about timing and techniques of successful oyster culture (see Appendices C & D).

A gardener can purchase small, 6 to 8 mm seed and grow them in bags or trays until they are large enough to put into a grow-out system. Because of the oysters' small size, the bags must be fine-meshed enough to hold the oysters until they grow a bit. An easier option would be to purchase ready-to-plant oyster seed at 30 mm or greater, and plant them in 1/2 inch or larger cages, which would serve as the final grow out system.

Whatever the case, young seed will require some sorting to cull out dead oysters and, if necessary, the double and triple clusters. A good salt bath and drying helps control predators and some diseases. Thinning the rapidly growing small seed to control crowding, and thereby improve growth and lessen mortality, is a must. About a quart of seed per cage will allow plenty of room for growth.

Seed or spat obtained from a hatchery should be acclimatized to the salinity of the water they are going to live in. The current sources for seed are higher salinity areas. If you are in a low salinity area this can

affect you. Discuss this with your seed source or other program participants in your area. Oyster seed stock will survive in water of a different salinity, but they will take a couple days to get comfortable with their new surroundings.

Finally, if seed is acquired from any out-of-state source, the importer must apply for and obtain an import permit from the N.C. Division of Marine Fisheries. These permits require the seed or larvae be tested for disease prior to shipment. Importers must apply for the permit at least a month before the expected shipment date and to ensure that the out-of-state supplier understands exactly what is required. (http://www.ncdmf.net/download/UDockPermit.pdf)

The material in the above section was modified from Wallace (2001) Publication No. 432 - Southern Regional Aquaculture Center.

Click here to learn more about → Cultivating the Eastern Oyster

(http://srac.tamu.edu/tmppdfs/6045439-432fs.pdf)

Growing Areas

Shellfish are filter feeders, and pump water through their gills constantly. Through this pumping action, oysters are able to gather food particles, but they also take up any bacteria, viruses, or other pollutants present in the water. These pollutants can quickly build up to dangerous levels within the flesh of the oyster. If oysters containing high concentrations of bacteria or viruses are consumed raw or undercooked, they can cause severe illness in the consumer. The N.C. Shellfish Sanitation Section is the agency charged with monitoring oyster-growing areas, and recommends closing those that have the potential for causing illness.

All oyster-growing areas are closely inspected every three years to document existing or potential pollution sources. In addition, water samples are collected at least six times a year and tested for bacteria. Yearly reviews of bacteriological data and pollution sources are carried out. This information is then used to classify each oyster-growing area as approved, prohibited or conditional. Approved areas are consistently open to shellfishing, while prohibited areas are consistently closed. Conditional areas are generally open to shellfishing, but can be closed after a significant rainfall. The area is closed until water sampling indicates a return to acceptable bacteria levels.

The current classification and management plan for your area can be determined easily by calling or visiting the Shellfish Sanitation Section of the Division of Environmental Health in Morehead City (252-726-6827). Maps are available showing classification lines, and staff can identify the classification of your area – over the phone if necessary. It is important to regularly monitor the status of your area, as the status can change quickly due to temporary closures after rainfall, due to high results during bacteriological sampling, or due to unexpected pollution events. These changes are made by proclamation from the Division of Marine Fisheries, and can be received via email, or viewed on the web at www.ncfisheries.net/procs/index.html.

Although current management for oyster-growing areas has been successful in protecting shellfish consumers from getting sick, it is not designed to take into account areas under piers or docks. Here, water flow is significantly reduced, and bacteria and other pollutants have the potential to build up much more rapidly than in open waters. Significant sources of bacteria, including birds, pets and septic tanks, are typically located near docks, and fecal contamination can quickly reach the water directly or can be

washed in after rainfall. Therefore, it is recommended that great care be taken in monitoring your under dock oyster garden. Pet waste should be removed from any area near the water as quickly as possible, and you should keep a careful eye both on your own and surrounding septic tanks for any signs of a problem. If possible, the presence of birds should be minimized on and around the dock, and any bird waste present should be washed away by a method that does not send it directly into the water around your oysters. If care is taken to minimize the amount of pollution entering the water around your garden, then you can help keep your oysters clean and ready to eat.

Conditions can change water quality in very small areas that normal testing will not detect. Concerns you need to note:

- Run-off from a local ditch that empties near a growing site can bring contaminants for short periods during rains.
- At the latter part of ebb tide (intertidal areas) in coves and creeks, upland contaminants are least diluted by salt water. Therefore shellfish are more likely to be exposed to unsafe higher levels of pathogens.
- If there has been a heavy rainfall, growers can delay harvest for a couple of days after the water clears, to let the oysters flush that potential contamination through their gut – just to add a measure of safety.
- Marine toilet discharges are an obvious source of concern.

Containers and Cages

There are several major advantages to growing oysters in the water column in cages. Because the oysters are contained, they can be brought up on the dock and counted, checked for health, measured and some cleaning can take place if necessary. Another advantage is better water flow, resulting in better food availability and faster growth. Spat can be grown out to adult size in cages. Oyster cages should hang from your dock so the oysters sit about one foot below the water surface at low tide.

There are a variety of different container designs and construction techniques. Below are some of the more popular models:

1) Page Cage

Figure 4. **The Page Cage** was modeled after the square baskets used in the Chesapeake Bay and was designed by Blan Page and Kim Hamilton. It's the best design for use with a dock.

Dimensions = 1.5' x 1.2' x 0.7' (18”x14”x6”)
Carrying Capacity = ~250 adult oysters

Page Cage Building Instructions (PDF)
(http://www.mobilebaynep.com/oystergardening/Documents/Page_Cage_Building.pdf)

This type of cage is recommended for high wave-energy areas. Their location below the water surface helps dampen the effect of surface wave energy. Also, they have no floatation to crack if the cage knocks into the dock pilings. One disadvantage of this type of oyster cage is since its position is fixed, it will not rise and fall with the tide. Oyster cages are usually hung

horizontally to give the oysters plenty of room and to maximize their growth rates. The cage should be tied off so the oysters sit about one foot below the surface of the water at low tide. The top of the cage may be exposed during the lowest tides. The objective is to keep cages as high up in the water column as possible (where the supply of plankton and oxygen is plentiful), without risking exposure to freezing air temperatures. In the wintertime, it is essential that your cages remain under water. This is because oysters exposed to freezing air temperatures may die. (Oysters are fine if they are in water, even if they freeze into a solid block of ice). It is recommended that cages be lowered to just above the bottom late in the fall, and left there until all risk of freezing air temperatures has passed. If winter storms and tides combine to create unusually low water depths in your area, oysters will remain underwater. During the warmer months, you can raise your cages back up closer to the water surface. Oysters will benefit from drying out a bit when exposed to air during the occasional extremely-low tides once all risk of freezing has passed. Just make sure they are not exposed to hot, direct sunlight for longer than three or four hours.

Cages can be secured to the dock in any number of ways. Each cage can be suspended between two pilings or hung by tying a line around a plank on your dock. Some gardeners drill small holes through four dock planks and thread one cage line through each hole. Knots can be tied in the top ends of the lines so they can't fall back down through the holes. Your securing system will depend on your dock site. The important point here is to make sure the cages do not bang against pilings – banging can cause oysters to close up and stop feeding.

2) Mobile Bay Float

Figure 5. The **Mobile Bay Float** was modeled after Eastfields Floats (Mathews, VA).

Dimensions = 3’ x 1.5’ x 0.5’
Carrying Capacity = ~350 adult oysters

Mobile Bay Float Building Instructions (PDF 465k)
http://www.mobilebaynep.com/oystergardening/Documents/Mobile_Bay_Float_Building.pdf

The advantage of this type of oyster garden is the float is at the surface of the water, so your oysters are always at the top of the water column. This positioning allows them maximum exposure to oxygen and plankton. Your float and oysters will not be hurt if the water freezes around them in the wintertime. Oysters will die if they freeze ***in air***, but not if they freeze in water. For this reason it is essential that your float is not exposed to air by extremely low tides or storms. Consider moving your float to a deeper area for the winter if necessary.

3) The Taylor Float

Figure 6. **Taylor Float** Ideal if you have a mechanical lift to handle the weight.

Dimensions = 4' x 2' x 1'
Carrying Capacity = ~1000 adult oysters

A Taylor float is made from a rectangular frame of PVC pipe for floatation, with a wire mesh basket suspended from it. The float pictured here measures about 4 feet x 2 feet x 1 foot deep. The float can be secured under your dock making sure there is enough slack in the lines so it can rise up and down with the tide, but not so much slack that the float bangs against pilings, which may damage the float. This type of oyster garden also floats at the surface of the water, providing favorable exposure to food and oxygen. Another advantage of keeping your oysters very close to the surface is that you can readily observe some of the underwater activity of fish and other organisms that will be drawn to your garden. Still another advantage is that wave action at the surface may help keep the oysters clean.

The major drawback to a Taylor float is its weight. While you might begin with a manageable amount of spat, the weight of oysters will increase considerably in a good growing year. Because you will need to get the float and oysters out of the water periodically, this can present a problem. They work best in low wave-energy areas. In high wave-energy areas, Taylor floats have the potential to bang against pilings and crack. Once cracked, PVC flotation will take on water and sink.

Click here to learn more about → Floats and Cages (http://www.mdsg.umd.edu/oysters/garden/start.html)
and How to secure them to your dock (http://www.mdsg.umd.edu/oysters/garden/location.html)

Costs
The Page Cage can be built for less than $ 10, while the Mobile Bay Float for less than $ 20.
The materials for cage construction should resist UV (sunlight) damage and corrosion in the water. Cages are easy to make, but a mistake can result in the loss of your oysters. Purchase of cages or the materials from a source familiar with the problems might help avoid some of these mistakes. Check with the local Shellfish Gardeners of NC organization for current techniques, sources of cages and help.

For more information about types of cages that can be used for oyster gardening, see Chapter V of Swartzenberg, J. and S. Kemp. 2004. "**Culturing oysters in North Carolina."**

Stocking Densities
Regardless of the size that seed oysters are when purchased, the size of the cage mesh dictates the size of seed that can be planted. As a rule of thumb, use a seed size that is about three times the mesh size. Therefore, a 5/8-inch mesh would require a seed size of about 2 inches. Smaller seed tend to either slip through or grow into the mesh. As a general rule, the larger the seed the better the crop. Larger seed

tend to reach maturity faster and therefore can avoid some of the problems with barnacles, overspatting, and the like.

Seed Size	Cage Size	Oysters per Cage
Up to 15 mm - 0.6”	3/16” mesh	2 Quarts
40mm - 1.5”	3/8” mesh	600
50mm - 2”	5/8” mesh	500
63mm - 2.5”	5/8” mesh	450

Stocking Density for 18”x36”x4” hard cages.

Growth Rates
Although cultched oysters can exhibit rapid growth – sometimes reaching one inch (25 mm) in two to three months after settlement – growth is extremely variable and depends on many interacting factors, especially salinity, temperature, food availability and water quality. Data you collect about your oyster garden will provide valuable insight for oyster restoration projects and for other oyster gardeners.

Care and Maintenance – Fouling Organisms
It is good practice to periodically pull your containers up on the dock and clean fouling organisms from the cages to allow better water flow, which also brings oxygen and food to the oysters. Check cages/bags for condition at the same time. Clean cages mean good water flow. Overcrowding as oysters grow can also affect water flow, growth, and health of the oysters. As oysters grow the transfer of some oysters to other cages may be necessary.

Predators, Pests, Competitors and Fouling Organisms

A wide variety of predators, pests and competitors can attack or starve oysters. With a good understanding of these nuisances, along with effective management strategies implemented during the lifespan of the oysters, an oyster gardener can manage the crop with the best degree of predictability possible, minimize crop loss, and head-off disaster.

Oyster drills number among the most common predators. After clinging to an oyster, they secrete a chemical that little-by-little softens the oyster shell. Then abrasive action erodes the shell, weakens it, and eventually bores a hole through to the oyster. The oyster drill then inserts a proboscis through the hole, feeds on, extracts, and kills the oyster.

Figure 7: This small oyster does not have long to live. It is being attacked by oyster drills.

Salinity is one of the main forces that determine the distribution

of oyster drills. As a general rule, they are limited to salinities greater than 15 ppt, depending on water temperature. They also can tolerate exposure to unfavorable environmental conditions for short periods of time by tightly closing up and insulating themselves from their surroundings. They can tolerate short-term fluctuations in salinity better than long-term exposure to low salinity. At low salinity their activity decreases.

An extreme in temperature limits the activity of drills. Feeding ceases below 50 °F and decreases above 86 °F. Under flood conditions with a sustained salinity below 15 ppt, the drills are eliminated. At low salinity and temperature, they tend to bury themselves in the substrate and leave the oysters alone.

Various methods of controlling drill infestations have been tried with little success. Physically trapping them, using small oysters as bait, has had a limited effect as has other biological introduction of predators such as moon snails. The problem with such treatments is that the moon snails then have to be dealt with. A saltwater brine dip with follow-up air drying will rid seed cages of most of the snails and drills.

Perhaps the only practical way to control drills that have infested a cage is to bring the cage to the surface, dry it, pick out the drills, and move it to a different area of bottom or to an off-bottom situation.

Crabs kill oysters, especially spat and juveniles, by crushing the shell and eating the meat. Blue crabs crush small oysters and chip the lips of larger oysters to extract the meat. Stone crabs crush even large, market size oysters. While stone crabs are intolerant of low salinity water, blue crabs tolerate a much greater range of salinity. Thus, it is likely that some type of crab population will be a predator at any site that supports oyster culture.

Figure 8: Small crabs grow up inside oyster cages and chubs and soon become large enough to destroy small oyster seed.

Crabs are a very mobile species. They can and will enter trays, spat bags, and cages as juveniles, feed off whatever is available, and grow to substantial size, preying on small fishes and oysters, especially small seed.

Trapping can reduce the general crab population, but the best control is to check cages and trays periodically and physically remove the crabs.

Flatworms, also called oyster leech and *Stylochus*, are thin, flat, elliptical, and reproduce extremely rapidly. In one observation, a flatworm laid 39,000 eggs in a 48-hour period. They grow rapidly, mature sexually in about two months, and live for about a year. They flourish in a salinity greater than 15 ppt but can tolerate salinity as low as 6 ppt.

Flatworms enter an oyster through a partially gaping mouth and generally prefer small (less than 1/4 inch) oysters. Though they do not generally attack large oysters, in one lab experiment, three flatworms killed and ate an adult oyster in a week. They prefer barnacles, but can cause extensive mortality in crowded growing conditions.

Control of flatworms is not difficult. Either a freshwater or highly saline water bath will immediately eliminate the flatworms. However, neither will protect against re-infestation when the oysters are returned to their habitat. Cages with large mesh (5/8 inch) will allow small fish to enter the cage and eat the flatworms.

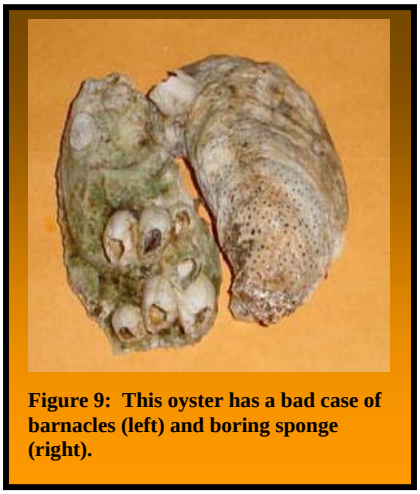

Figure 9: This oyster has a bad case of barnacles (left) and boring sponge (right).

Barnacles are a competitor that can become so invasive they have to be removed from the oyster shell by hand to make the oysters marketable. They tend to reside in the upper portion of the water column and settle on subtidal oysters more than intertidal cages. Barnacles can be controlled to a degree by giving the oysters a heavy salt water bath as described in the section on **salt baths**.

Sponges are among the most common intertidal pests of oysters. They attack the shell by very slowly boring holes using both a mechanical and chemical etching action. In some older oysters, sponges may bore completely through an oyster and kill it. However, most likely the damage to the oysters will be in the outer shell, producing unsightly holes. If the oyster shell is penetrated completely, the oyster will quickly lay down another layer to prevent contact between the oyster and sponge. In severe cases, the oyster will not rebuild its shell quickly enough to protect against the sponge, and the sponge can form adhesions to the oyster tissue, weaken it, reduce its ability to reproduce, and eventually kill the oyster.

Cultured oysters are not immune from a sponge infestation, but they usually grow to maturity before the sponges have the opportunity to significantly deteriorate the shell. Giving mature seed a salt bath and drying will deter most boring sponges.

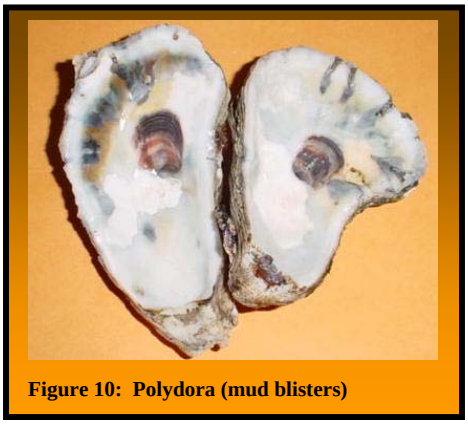

Figure 10: Polydora (mud blisters)

Mud Worms (*Polydora*) lay encapsulated eggs that are attached to the inner surface of a tube on the outside shell of the oyster. The eggs develop in four to eight days depending on the temperature, settle on the outer surface of the shell, make their way to the shell lip of the oyster and immediately bore into the shell using a chemical agent.

Mud worms do not directly attack the tissues of the oyster but force it to rebuild the inner shell over and over. As it does so, the oyster produces an unsightly black and yellow blister on the inner shell. When mud worms attack, the oyster puts its energy into shell maintenance, thereby reducing the energy it puts into growth and reproduction. Poor health and a brittle shell lead to a susceptibility to disease and predator attacks.

An effective control for mud worms is a simple saturation of the juvenile seed (over one inch) in a salt bath (see following section on **salt baths**). This procedure has proven effective for a variety of problems that tend to devalue the oyster crop and should be a regular part of seed maintenance performed during the late fall, winter, or early spring of the first year.

Sea Squirts (*tunicates*) thrive in high salinity waters and can become very destructive during extended periods of drought, especially in waters that are normally high salinity. Sea squirts attach themselves to oysters, oyster trays and oyster cages, and can become so densely packed that they virtually choke out the oysters and rob them of all available food.

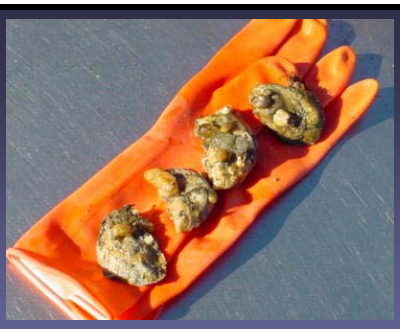

Figure 11: These young oysters are the victim of bio-fouling by tunicates.

Sea squirts can be controlled by physically removing them from cages and through regular maintenance with a freshwater wash and heavy saltwater bath followed by a period of drying. Cages and other intertidal devices that get daily drying should remain relatively free of tunicates.

Overspatting occurs when small spat attach to growing or mature oysters. While the oysters that attach pose a minor problem of competition, their cumulative effect – plus the effect of barnacles, sea squirts and other competitors – can lead to stunted growth, a weakened crop, and susceptibility to disease. Oysters that become heavily overspatted must be cleaned up by nubbing and washing at harvest time, just as those with heavy overgrowths of barnacles. Some control of overspatting can be obtained with a late fall or early winter salt bath and drying. The heavy salt solution will kill most of the small spat.

Salt Baths

The salt bath uses one part salt to three parts water. The salt may not all dissolve right away, but stirring will speed up the process. Bulk salt can be purchased at local supermarkets. Oysters should soak 20 minutes and then dry at least 20 minutes. You should be able to see and taste the salt on the shell when it dries.

The salt bath is as much an art as a science. Oyster gardeners who have used this technique say that the drying process is the critical part; that's when the invading organisms do the dying. Oysters can be lost if left to dry too long and it is possible to undo the effects of the salt bath by not letting the oysters dry long enough. Smaller seed, less than one inch, may not tolerate such a concentrated solution.

When working in the hot sun, 20 minutes is probably plenty of time. On cooler, cloud covered days, you can be a bit more liberal and let them dry for an hour or so. Keep an eye on the oysters. If they are gaping, then it's probably time to get them back into the water. Otherwise, longer drying will produce better results.

Winter is a good time to do this chore. The organisms you are trying to keep off the shells are still young and die easily. If you give them a salt bath too early, the seed may not be able to handle the stress, and the fouling organisms would probably come back soon after the oysters go back into the water. Of course, this is not a permanent solution and fouling organisms will eventually resettle on the oyster.

Appendix A

General Statute 113-210. Under Dock Oyster Culture.

(a) Under Dock Oyster Culture Permit. – An Under Dock Oyster Culture Permit authorizes the holder of the permit to attach up to 90 square feet of oyster cultivation containers to a dock or pier owned by the permit holder.

(b) Application. – The owner of a dock or pier who wishes to obtain an Under Dock Oyster Culture Permit shall apply to the Director of the Division of Marine Fisheries.

(c) Issuance. – The Director of the Division of Marine Fisheries shall issue an Under Dock Oyster Culture Permit only if the Director determines all of the following:

(1) That the dock or pier is not located in an area that the State Health Director has recommended be closed to shellfish harvest due to pollution or that has been closed to harvest by statute, rule, or proclamation due to suspected pollution.

(2) That the owner of the dock or pier has satisfied the training requirements established by the Marine Fisheries Commission pursuant to subsection (j) of this section.

(3) That the attachment of the oyster cultivation containers to the dock or pier will be compatible with all lawful uses by the public of other marine and estuarine resources. Other lawful public uses include, but are not limited to, navigation, fishing, and recreation.

(d) Duration. – An Under Dock Oyster Culture Permit is valid for a one-year period from the date of issuance.

(e) Renewal. – The Director of the Division of Marine Fisheries shall renew an Under Dock Oyster Culture Permit only if the Director determines the requirements of subsection © of this section continue to be satisfied and the holder of the permit is attempting to utilize the permit to cultivate oysters on a continuing basis.

(f) Reporting Requirements. – The holder of an Under Dock Oyster Culture Permit shall comply with the biological data sampling and survey programs of the Marine Fisheries Commission and the Division of Marine Fisheries.

(g) Posting of Signs. – The holder of an Under Dock Oyster Culture Permit shall post signs that indicate the presence of the oyster cultivation containers and that the oyster cultivation containers and their contents are private property.

(h) Sale of Oysters Prohibited. – It is unlawful for the holder of an Under Dock Oyster Culture Permit to sell oysters cultivated pursuant to the permit.

(i) Assignment and Transfer Prohibited. – An Under Dock Oyster Culture Permit is not assignable or transferable.

(j) Oyster Cultivation Training Requirements. – The Marine Fisheries Commission, in consultation with the Sea Grant College Program at The University of North Carolina, shall develop and adopt rules for the training of individuals who cultivate oysters pursuant to this section.

(k) Revocation of Permit. – If the Director of the Division of Marine Fisheries determines that the holder of an Under Dock Oyster Culture Permit has failed to comply with any provision of this section, the Director shall revoke the Permit. The owner of the dock or pier shall remove the oyster cultivation containers that were authorized by the revoked permit within 15 days of revocation.

15A NCAC 03O.0503 PERMIT CONDITIONS; SPECFIC

(h) Under Dock Oyster Culture Permit:

(1) It is unlawful to cultivate oysters in containers under docks for personal consumption without first obtaining an Under Dock Oyster Culture Permit.

(2) An Under Dock Oyster Culture Permit shall only be issued in accordance with provisions set forth in G.S. 113-210 ©.

(3) The applicant shall provide certification of completion of mandated training as required by G.S. 113-210 (j).

(4) Action by an Under Dock Oyster Culture Permit holder to encroach on or usurp the legal rights of the public to access public trust resources in coastal fishing waters shall result in permit revocation.

Consultation with North Carolina Sea Grant has provided this document containing pertinent educational and training information relative to the application, education, issuance and conditions of the Under Dock Oyster Culture Permit. Certification of the satisfactory completion of the mandated training will be a prerequisite for the issuance of the permit. The educational material will be made available electronically through the N.C. DMF web site, in hard copy by mail or obtained at DMF district offices. Training may also be conducted at DMF or Sea Grant sponsored workshops. Testing will be conducted to ensure applicants have an understanding of the educational materials.

Web addresses (URL's) are subject to change by their owners and are not under the control of either the DMF or N.C. Sea Grant. It is possible that links provided in this document may no longer be functional when you attempt to access them. **The Aquaculture Network Information Center** (AquaNIC), http://aquanic.org , is a good starting point to access the world's electronic aquaculture resources.

Appendix B — E-mail Discussion Group

Shellfish_Gardening is a listserv group administered through NC State University for discussion and information dissemination regarding the development of shellfish gardening in North Carolina.

You can subscribe at the following Web site: http://lists.ncsu.edu/ Click on the Subscriber interface button and type shellfish_gardening in the box .

You can also subscribe by sending an email to: mj2@lists.ncsu.edu with the words subscribe shellfish_gardening in the body of the email.

Send email messages to the group at this email address: shellfish_gardening@lists.ncsu.edu
If you have trouble subscribing or sending messages please contact the "list-owner", Sara Mirabilio of N.C. Sea Grant saram@csi.northcarolina.edu

Appendix C — Outside Resources

Network with other gardeners

The **Shellfish Gardeners of North Carolina** promotes the culture of shellfish, and particularly oysters, by individuals using under dock oyster gardens. Their goal is to create conditions conducive to participation, partnerships, and relevant research in shellfish gardening and healthy shellfish. They can be reached at http://www.oysters-cleanwater.info

Appendix D — Web sites with Additional Resources

Citizen's Oyster Gardening Program – Carteret Community College http://www.carteret.edu/aqu/cogp/

Tidewater Oyster Gardeners Association (TOGA) Home Page http://www.oystergardener.org/

Maryland Sea Grant Oyster Gardening http://www.mdsg.umd.edu/oysters/garden/ecology.html

Mobile Bay Oyster Gardening http://www.mobilebaynep.com/oystergardening/Oyster Gardening.htm

Virginia Institute of Marine Science (VIMS) Oyster Gardening http://www.vims.edu/abc/green/ogp.html

N.C. Sea Grant Blueprint – Backyard Shellfish Gardening http://www.ncseagrant.org/files/shellfish.pdf

N.C. Dept of Agriculture and Consumer Services

Aquaculture sites	http://www.agr.state.nc.us/aquacult/links.html
Sources of North Carolina Shellfish	http://www.agr.state.nc.us/aquacult/shellfish.html

N.C. Shellfish Growers Association http://www.agr.state.nc.us/aquacult/NCSG.html

N.C. Sea Grant http://www.ncseagrant.org/

N.C. Division of Marine Fisheries http://www.ncfisheries.net/

Credits

Figure 2 - Illustration on p. 6 reproduced courtesy of the artist, John Norton (johnart@starpower.net). Figs. 3,7,8,9, and 10 used with permission of Jim Swartzenberg.

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