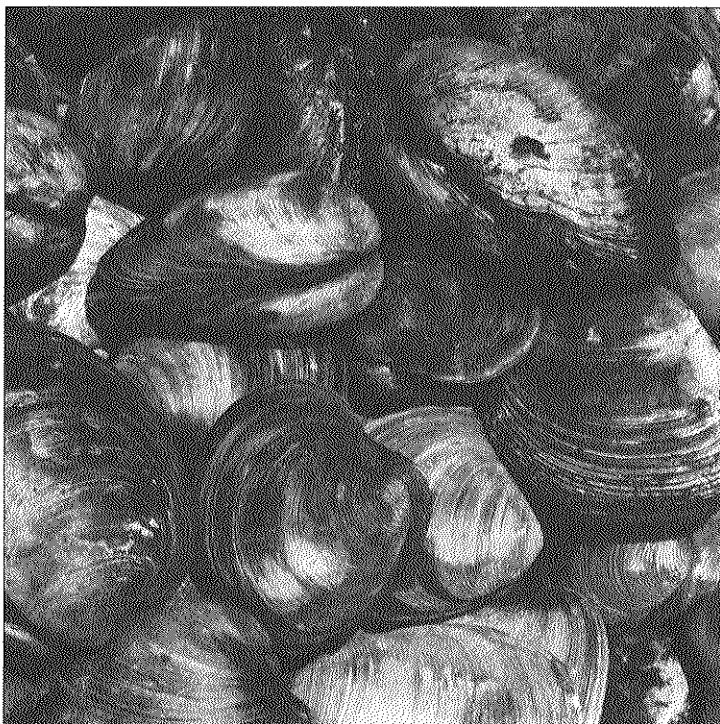




# CLAM GARDENING

A Manual for the  
Small-Scale Clam Operation  
in North Carolina



## FOREWORD

This booklet was produced as a follow-up to a clam grow-out conference held in 1988 at the Duke University Marine Lab in Beaufort, N.C. The one-day conference was sponsored by UNC Sea Grant, the UNC Institute of Marine Sciences, the N.C. Division of Marine Fisheries, the Duke University Marine Laboratory, the Mid-Atlantic Sea Grant Marine Advisory Service Network, the Gulf and South Atlantic Fisheries Development Foundation and the N.C. Biotechnology Center.

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## INTRODUCTION

Hard clams, *Mercenaria mercenaria*, are bringing record prices in seafood markets. But resource managers are concerned that natural populations soon may be overfished. This, combined with an increasing number of areas closed because of pollution, points to clam culture as an economically viable way to produce clams for market.

This booklet addresses the culture of the northern hard clam which inhabits the East Coast of the United States. It also deals with potential problems in obtaining leases and provides basic information needed for a successful clam garden. The term "garden" is used here to differentiate the small-scale farm from larger ones. Shellfish leases traditionally have been called gardens by N.C. watermen. Larger operations would require more detailed planning than is covered in this manual.

There have been many attempts at hard clam culture in North Carolina. Few of those attempts met with economic success. Only recently have research and technology provided the means for the development of an economically viable clam culture industry. Properly applying this technology can help ensure a profitable clam operation.

Clam gardening is a form of aquaculture in which seed, or baby clams, are raised on estuarine bottom leased from the state. The clams feed on naturally occurring food and are protected from predators until they reach a marketable size.

## BRIEF HISTORY OF THE NORTH CAROLINA CLAM FISHERY

Hard clams are a viable income source for thousands of North Carolina's coastal residents. But clams haven't always brought high prices at the seafood market. From 1959 to 1976, the value of clams harvested in North Carolina was less than \$1 million per year. But by 1986 that figure had skyrocketed to about \$7.5 million.

With this financial incentive before them, some fishermen turned from the slower hand harvesting of clams to more efficient mechanical harvesting methods. Mechanically harvesting clams with a hydraulic dredge or a kicker plate is legal in North Carolina. This allows fishermen to bag more clams and to reach beds that are deeper and unreachable by hand harvest.

Kicking and dredging were banned from grass beds or live oyster rock in 1978. Now, regulations allow for a mechanical harvesting season in designated areas only during winter months. Hand harvesting is allowed year-round and since mechanical harvesting was curtailed, hand harvest landings have accounted for

almost two-thirds of the total harvest. Landings peaked in 1983 at almost 2 million pounds and are currently about 1.5 million pounds per year. This comes from about 350 kick boats, 30 hydraulic dredges and up to 15,000 individual hand harvesters.

In 1969, clam fishermen were restrained by only one regulation—a law against harvesting clams from polluted areas. Since then, regulations have been enacted limiting the number of clams harvested per day, limiting minimum size, limiting mechanical harvesting to certain areas and seasons, and prohibiting the taking of clams at night.

## NATURAL HISTORY

Clams are filter-feeding bivalve mollusks that live below the surface of the bottom sediments. They breathe and eat through siphons which pump water and food particles into the clam from the surrounding water. The clam filters food from the water on its gills. In 68-degree Fahrenheit (20-degree Celsius\*) water, an adult clam can pump as much as 1/2 to 1 gallon (2-5 liters) of water per hour.

Clams feed primarily on microscopic single-celled plants, called algae or phytoplankton, suspended in the water. As water passes through the clam's gills, these particles are trapped. Some of the particles are too small and pass through the gills. Most of the retained particles are moved to the mouth and through the gut where they are digested or pass through undigested. Some of the trapped particles bypass the mouth and are returned to the water uneaten.

Clams begin actively feeding when the water temperature rises to 48-50 F (8-10 C) in the spring. Clams stop feeding when temperatures drop below 48 F in the fall. They grow most rapidly at temperatures ranging from 65-85 F (18-30 C).

In addition to feeding on algae, clams may also capture disease-causing organisms and other contaminants from the water. Runoff from agricultural land, discharges from sewage treatment plants, stormwater runoff from cities and leaks from faulty septic systems can contaminate shellfish waters. Such contamination causes certain areas of the state's waters to be temporarily or permanently closed to the harvest of some shellfish.

\*Footnote: The metric system of measurement has not been officially adopted in the United States, although some products are being marketed in metric units (for example, 2-liter soft drinks). Most scientific information is reported in metrics. This manual will use metrics in places where it would be easier for you to begin using it. Many clam gardeners are beginning to use metrics.

Under natural conditions, clams spawn when water temperatures reach 68-88 F (20-30 C). After fertilization, clam larvae spend eight to 10 days swimming. Then the larvae "set", or undergo metamorphosis, and become bottom dwelling animals. They may reach a harvestable size in three to four years from this microscopic size.

Common predators of clams are blue crabs, mud crabs, snapping shrimp, whelks, moon snails and rays. Certain birds, mammals and fish also eat clams. However, crabs are the major concern to clam culturists because of the frequency of occurrence and the number of clams they can eat.

One large blue crab can eat up to 750 seed clams a day, and they can occur in densities of one to three per square yard. Mud crabs can eat up to 150 seed clams a day, and you might find 30 per square yard. A crab can eat a clam that is one-third the width of its shell. For example, a 3-inch blue crab can eat a clam that is 1 inch long.

Blue crabs can grow from 1/4-inch to two inches in two months. At this rate of growth blue crabs can overtake the growth of clams. A technological advancement in clam culture is the use of netting or plastic mesh as covering over clam beds. This prevents all but the smallest crabs from entering the bed.

## HOW TO GET STARTED

Now that you better understand the biology of clams and their importance to the North Carolina fishery, the following information will help you get started in clam gardening. Addresses for the agencies mentioned and references for further information are listed in the Appendix.

## LEASES AND HOW TO OBTAIN THEM

With the exception of some submerged lands that have been recognized as privately owned, all other submerged coastal bottomland in North Carolina is public property. Therefore, you must obtain a lease from the state on which to start your clam garden. A lease establishes your responsibility to manage the planted area.

The N.C. Division of Marine Fisheries issues licenses and enforces fishery regulations regarding hard clams. Leases of submerged bottomland for private shellfish culture are also issued by this agency.

In North Carolina, the Marine Fisheries Commission — the regulatory body for the Division of Marine Fisheries — approves leases and makes regulations regarding leased bottomland.

Leases are not granted on areas containing substantial grass beds or natural oyster or clam beds. New leases can be no less than one acre nor more than 10 acres unless a justified need can be shown for a greater area. They cannot be granted within 100 feet of a developed shoreline unless you are the property owner or you obtain a notarized waiver from the owner.

Before filing an application, you should contact members of the Shellfish Management staff of the Division of Marine Fisheries. They can make a preliminary investigation of your proposed site at no charge. This may save time and money by preventing filing for a lease that cannot be approved for biological reasons. They can also help you determine public utilization and long-range management plans for the proposed area.

Leases are issued for 10 years to residents of North Carolina only. A \$100 filing fee is required to apply for a new lease. The Commission issues public notices, and the area is investigated by state officials to ensure that it meets requirements. The Commission will hold public hearings and may approve or deny the lease at its next quarterly meeting. A standard boundary survey of the approved lease area is required within 90 days of official approval. A management plan is required as well as annual reports of planting and harvesting. Leases can be renewed for additional 10-year periods for a \$50 fee.

The lease must be used for commercial purposes, and you must harvest at least 25 bushels of clams per acre each year (400 clams of any size are considered to be equal to one bushel). Owners of new leases and those purchased from a former leaseholder are given three years to comply with production requirements. Report your production in bushels annually to the Division of Marine Fisheries. Include clams planted and harvested in the report. The leased area must be marked, and the markers must be maintained. Currently, leaseholders are charged \$5 per acre per year for rent. Non-compliance with the requirements may result in termination of the lease.

It takes three to six months or more to obtain a lease. In North Carolina, about 370 leases covering more than 3,000 acres have been issued.

## OTHER PERMITS AND LICENSES

Permits are required for any activities that may degrade the sensitive nature of the coastal environment. Any construction or land alteration in wetlands or areas of environmental concern will require a permit from the U.S. Army Corps of Engineers or the N.C. Division of Coastal Management, respectively. As you will see later, some operations, such as clam nurseries, discharge water into an estuary. Permits may be required for this type

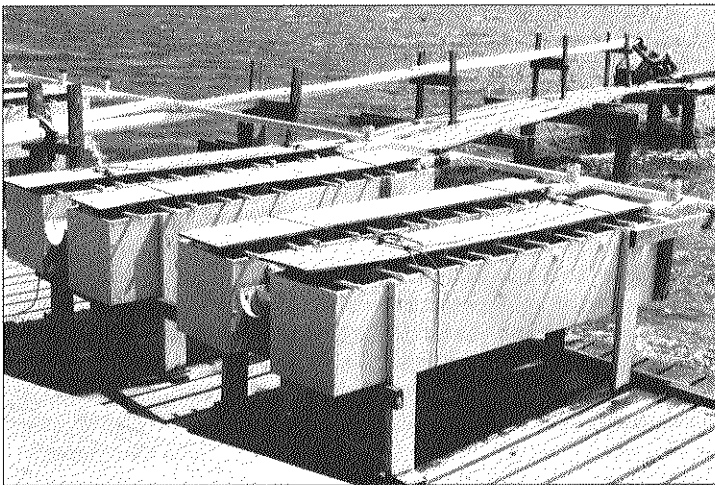
system. The Division of Coastal Management can provide assistance.

Licenses and permits you may need to harvest and sell clams are described later in the appropriate section. The Division of Marine Fisheries also will issue an aquaculture facility permit when you begin operation. This will enable you to handle and sell undersized clams. Keep all your receipts for seed clam purchases as proof of hatchery origin.

## LOCATION

As with any form of aquaculture, the selection of a site for your clam lease is of primary importance. Several factors, including the salinity, temperature and dissolved oxygen of the water, as well as real or potential pollution, currents, bottom type and accessibility determine the suitability of a site. The same criteria should be applied to the location of a nursery if you decide to operate one.

If an area already has clams growing on it, it's probably suitable for clam gardening. But in North Carolina, leases may not be issued in areas where natural clam or oyster beds contain 10 bushels or more of shellfish per acre. You can make your own preliminary survey by raking several areas of your lease. Rake 20-30 areas, each 1 yard square, for every acre in your proposed lease site. Divide the total number of clams and oysters of all sizes you find by the number of sampled areas. If you find an average of one shellfish per square yard, then more than 10 bushels per acre are present. If you find some areas of the proposed lease site seem to contain a greater abundance of



Upwellers



shellfish, you can shift your boundaries to avoid those areas and recheck the new area.

Avoid areas with extreme fluctuations in salinity. Clams require relatively salty water for good survival and growth. Normal clam grow-out requires water which is about two-thirds the salt content of the ocean (18-20 parts per thousand salinity). For help in determining the salinity of your site contact one of the agencies listed in the Appendix.

The salinity is usually greater and more consistent in areas with active tidal flushing and a relatively small watershed. 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 clams to low salinities. Adequate tidal flushing ensures mixing of the water, delivers food, removes wastes and stabilizes the salinity.

Hard clams can withstand full sun and near freezing cold for short periods. Keeping clams submerged will eliminate the stress caused by these extremes. It may also improve growth. Choose an area that is shallow at low tide. This will make planting and harvesting much easier.

Clams can withstand relatively low dissolved oxygen levels in water, but growth will be poor. At low oxygen levels, the animal expends more energy pumping water through its body to get the necessary oxygen. Therefore, less energy is available for growth. Usually, water will contain adequate dissolved oxygen for clams if you choose an area thoroughly mixed by tides, currents or the wind.

There must be sufficient water exchange to carry wastes away and to bring food in. Too much water flow may scour the bottom and wash the clams away; too little flow may result in the accumulation of silt which can smother clams. Avoid areas open to long distances where waves can build up and wash across the lease. Choose a deeper site.

Most soil types are suitable for clam aquaculture. The ideal soil is firm, but loose enough for raking. Avoid locations where loose silt accumulates. Seaweed growth is harmful only when it reduces water circulation or smothers the clams by growing profusely on clam bed covers.

Avoid polluted waters. Never attempt to grow clams in water receiving discharge from industries, marinas or sewage plants. Bacteria, viruses, chemicals or heavy metals may contaminate the site. Water containing chemicals, such as insecticides or herbicides from farm runoff, should also be avoided because these materials can kill clams. The N.C. Division of Environmental Management will provide information about existing discharges in the area in which you propose to grow clams.

The clam culture site should be accessible. Being able to drive to the leased area is an advantage, but many areas can be reached only by boat. Poaching, vandalism and damage to the site can be minimized by adequate surveillance. If the site can be watched from the home, surveillance is much easier. Once clams reach market size, you may even want to have someone stay on a houseboat anchored at your lease site.

## HATCHERY

If clams are to be grown on a leased area where clams already grow, some seed clams will probably set naturally. But for greater production, you'll need hatchery-raised seed. Hatchery techniques are relatively simple, but the biological principles involved are quite complex and are beyond the scope of this manual. Therefore, most growers will probably purchase their seed clams from a commercial hatchery.

Thorough investigation and study and a sizable capital investment are needed before a hatchery begins operation. For more details about these techniques contact your Sea Grant advisory service agent listed in the appendix.

## SEED CLAMS

Seed prices vary considerably according to size (See Appendix for Seed Suppliers). Recently, prices have ranged from \$3 to \$34 per thousand seed clams. Seed clams are sold according to size and are usually measured in millimeters (one millimeter is 1/25-inch or slightly smaller than 1/16-inch). This measurement is used because most hatchery sieve screens are made of material designed to millimeter tolerances.

Smaller seed (2-6 mm or 1/12-1/4-inch) are less expensive, but more vulnerable to predators. Seed this size are suitable for nurseries. If they are planted directly on the lease, they may be eaten by crabs, smothered by sediments or washed away by currents.

Survival of seed clams from crab predation is directly related to size. Seed that are 8-9mm (about 1/3-inch) are a minimum recommended size to plant. Larger clams have better survival rates. You should not plant seed clams that are less than 10-15 mm (3/8-1/2 inch) directly into beds. You may purchase large seed or produce them from small seed in a nursery. In making this decision, consider your access to suitable seawater, the amount of time you have during the nursery season and the funds you have set aside.

## NURSERY

Small seed clams grow to planting size in a nursery. There are two types of nurseries for seed clams: raceways and upwellers. Fine-mesh bags or trays can also be used but the procedures are complicated and are not covered in this manual. The nursery can assure growth of seed clams in high densities while offering a large degree of predator protection. But you'll need a reliable source of salt water and a fair time commitment (one hour per day) to operate a nursery. A nursery can be helpful also if you buy large seed clams but adverse weather doesn't permit immediate planting. Seed can be held alive in the nursery until conditions permit planting.

If you have a waterfront site with high salinity (more than 18-20ppt) a nursery can be economical because you can purchase very small juvenile seed clams at a fraction of the cost of larger seed. You'll save money by producing your own large seed. But there may be a wide range in the final sizes of clam seed produced this way. Most of your seed will reach planting size, but some will lag in growth. This is a normal occurrence in nature. Plant when most of the clams reach planting size.

## RACEWAYS

The raceway is the oldest and simplest nursery method. Shallow troughs 2-4 inches deep by 2 or 4 feet wide and 8-16 feet long are used (See Figure 1). They can be made of concrete, wood or fiberglass. And they can be filled with 1 inch of sand or left without sand. Raceways can also be stacked. Brace them securely if you stack them.

Water pumped into the raceway brings food and oxygen to the clams. A thin layer of water should flow swiftly over clams from one end of the raceway to the other. Mud and sediment can smother small seed clams and accumulates in raceways, requiring frequent cleaning. The size of the clams makes cleaning difficult. For that reason, raceways are best used for seed larger than 5 mm (1/4 inch). Using this size seed, raceways can be operated with minimal labor; however, upwellers are the preferred method for smaller seeds and can be used for all sizes. Raceways may also be used to store planting size seed grown in upwellers as you sort them from smaller seed. This allows for optimum growth of the seed remaining in upwellers.

FIGURE 1  
RACEWAY

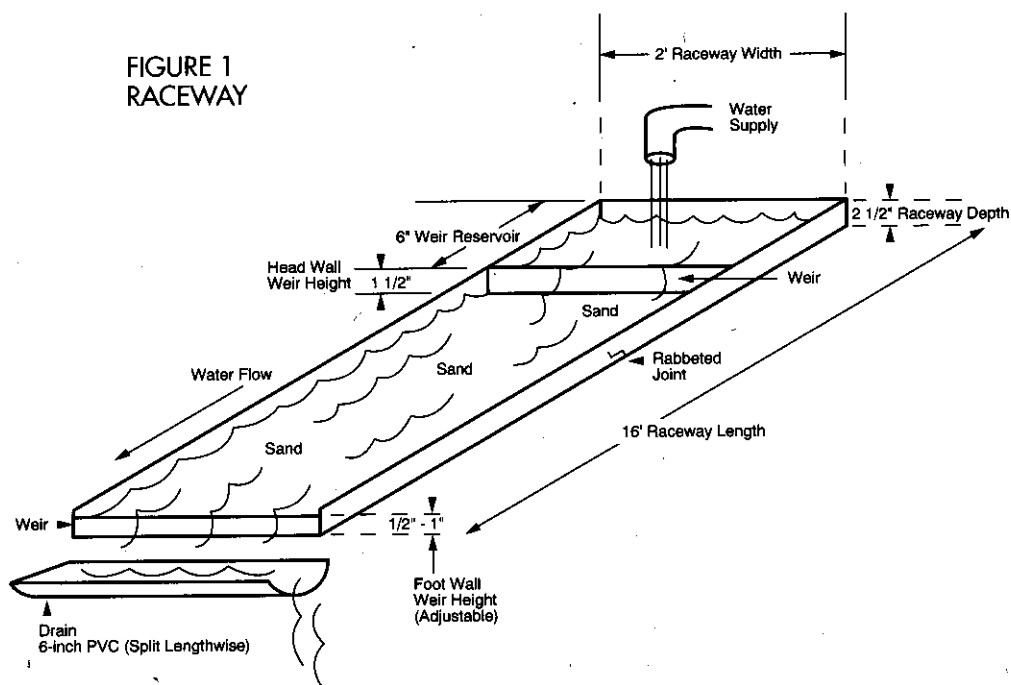


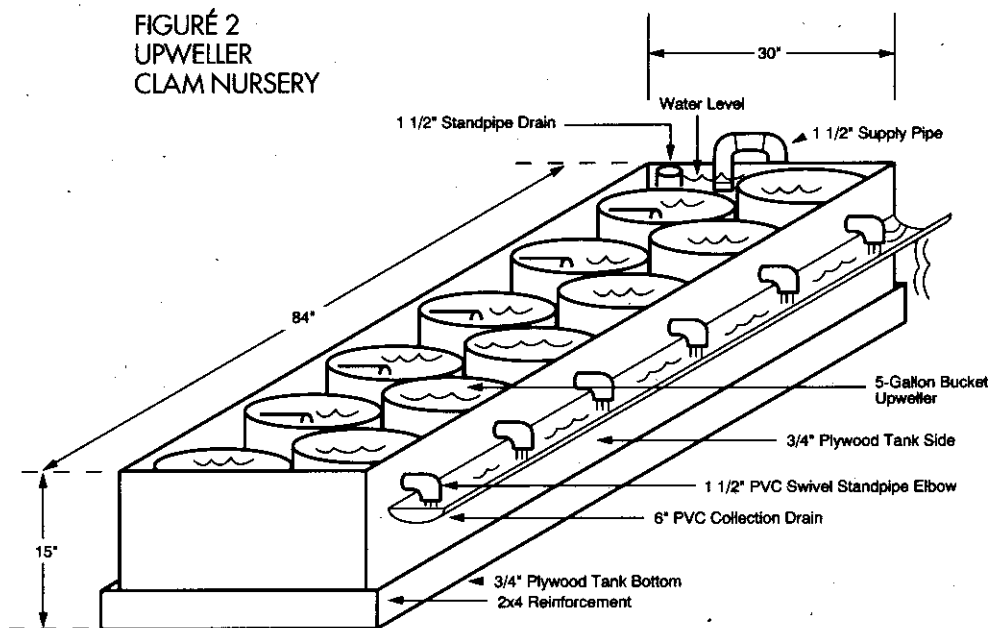
TABLE 1  
Construction Costs for Upweller Clam Nursery System

ITEM	SIZE	AMOUNT	COST
buckets with lids	5-gallon	18	\$36
window screen	1mm	1 roll	4
pipe (PVC)	1 1/2-inch	20 ft.	8
drain pipe (PVC)	6-inch	10 ft.	11
PVC pipe fittings:			
couplings	1 1/2-inch	13	5
elbows	1 1/2-inch	12	5
threaded adapters	1 1/2-inch	4	2
plywood (AC)	3/4-inch	2 sheets	50
2x4 lumber		26 feet	5
2x2 lumber		14 feet	5
miscellaneous (nails, caulk, etc.)			10
pump (1 1/2 hp. centrifugal)		1	220
(1 1/2-inch discharge, pipe not inc.)			
check valve/foot valve	1 1/2 inch	2	34
strainer (scrap materials)		2	5
waterproofing compound		1 gallon	30
<b>TOTAL</b>			<b>\$430</b>

Construction Costs for Raceway

plywood (AC)	1/2-inch	1 sheet	18
1x4 lumber		40 feet	12
drain pipe (PVC)	6-inch PVC	10 feet	11
waterproofing compound		1 gallon	30
miscellaneous (nails, caulk, etc.)			10
<b>TOTAL</b>			<b>\$81</b>

FIGURE 2  
UPWELLER  
CLAM NURSERY



## UPWELLERS

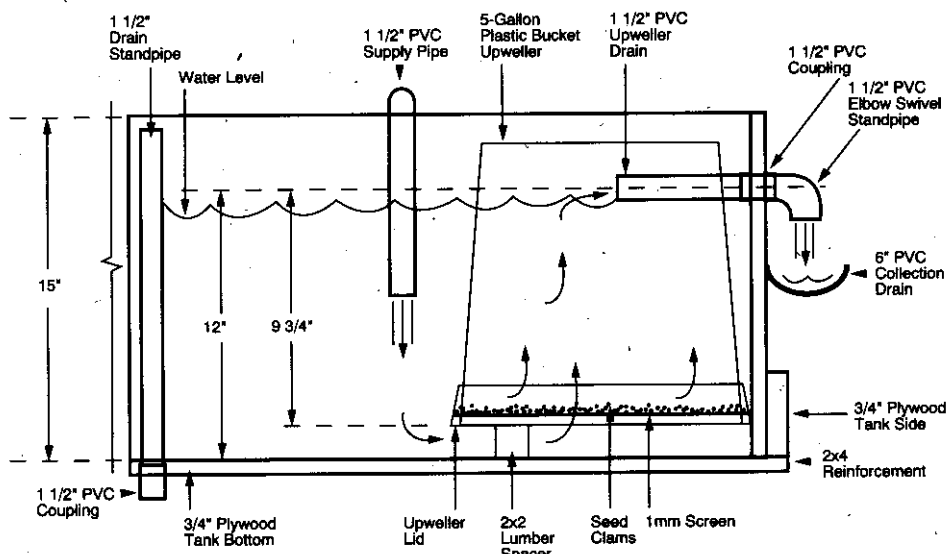
Upwellers are vertical cylinders with screens on the bottom (See Figure 2). They can also be square or rectangular. A layer of seed clams are placed on the upweller screen.

Upwellers are placed in a tank of water and fitted with a drain pipe in the side, which is also fitted into the surrounding tank.

The upweller system consists of a raw water pump, one upwelling tank and twelve upwellers. The pump is a 1 1/2 horsepower centrifugal pump (high volume-low pressure) which delivers water to the upwelling tank at a rate of 50-70 gallons per minute. Each upweller could receive 3-5 gallons of water per minute. The water supply line is 1 1/2-inch PVC pipe. See Table 1 for construction costs.

The upwelling tank measures 7 feet long by 30 inches wide and is 15 inches deep. Build the tank of plywood caulked and reinforced with 2x4 lumber along critical seams (See Figure 2). You'll need to make the tank bottom 4 inches wider and longer to allow room for the 2x4 reinforcement. Seal it with a non-toxic waterproofing material such as fiberglass resin or epoxy paint. Fit 12 PVC couplings glued with polyurethane caulk into 1 7/8-inch holes in the tank's wall. Cut the 12 upweller drain holes evenly

FIGURE 3  
CROSS-SECTION OF UPWELLER  
TANK SHOWING WATER FLOW



spaced and centered 10 1/2 inches above the tank bottom. They will act as drains for the water that flows through the upweller tanks. Use a PVC coupling glued in place flush with the tank bottom. A 14-inch piece of 1 1/2-inch PVC pipe inserted into the coupling acts as a stopper. Fit the upweller tank with a drain in one corner of the bottom. Attach two 2x2 wood strips flat to the tank bottom as spacers for supporting the upweller tanks (See Figure 3).

Upweller tanks are made of 5-gallon plastic buckets with lids. Use a sabre saw to cut out the bottom of the bucket and to saw an 11-inch diameter circle from the center of the lid. Use a hole saw to cut a 1 3/4-inch hole in the side of the bucket centered 10 inches down from the lid.

Make upweller drains by gluing a 9-inch piece of PVC pipe (1 1/2-inch) with polyurethane adhesive caulk through the hole in the side of the bucket so that one end of the pipe is near the center of the inside of the bucket. Support the drain pipes while the caulk cures to assure level. After the caulk has cured, use fiberglass window screen material with a mesh size of about 1 mm. to make upweller screens. Place a section of screen over the top of the bucket. Snap the lid (now a hoop) in place on the bucket so that the screen mesh is held taut. Use silicone caulk to

seal the gap between the screen and the inside of the bucket if there is not a tight seal.

After the silicone has cured, invert the upwellers. The lids rest on the 2x2 wood strips in the bottom of the tank and the upweller drain pipes plug into the couplings in the side of the upweller tank.

A common collection drain for all upweller drains is made by sawing in half lengthwise an 8-foot piece of 6-inch PVC drain pipe (See Figure 3). Nail it horizontally to the outside of the upweller tank below the coupling drains. Slope the common drain from one end of the tank to the other for proper drainage.

Pump water into the tank through the supply line. Make sure the end of the supply line is below the water surface to eliminate the formation of bubbles. Bubbles collect under screens and cause upwellers to malfunction. If you have bubbles in the water, double check the pump suction line for a tight seal. Bubbles may also cause clams to develop a gas-bubble disease at certain times of year.

The water will flow upward through the screens on the bottom of the cylinders, through the layer of seed, then out the drains in the side of the cylinders. This method simplifies regular cleaning of clams. It also results in a more efficient use of the food in the water. Even so, clams will not remove all food from the water in a single pass through the system. The effluent water from one upweller tank can be routed to a second upweller tank.

Keep upweller screens taut. This assures an even layer of seed clams for uniform water flow. Sagging screens will cause clams to bunch up in the center of the upweller. Water will avoid the thickest layer of clams and will flow around the edges seeking an area of less resistance. If this happens, clams cannot grow rapidly and may suffocate.

Raw seawater containing clam food is pumped to the nursery on shore. A 1 1/2-hp. centrifugal pump will provide water for about 100,000 seed clams in 12 upwellers or six raceways (200,000 if water is used twice). You should have access to a back-up pump in case the primary pump breaks down.

Before purchasing small seed clams for your nursery, plan backwards from the desired planting date to determine the size seed to buy for stocking the nursery. You can get reliably good growth of clams most months of the year except December through March. Allow time for your seed to grow to planting size before winter (See Table 2). Add two to three weeks extra growing time to be on the safe side.

Also, when figuring the number to order, consider that you will have dead clams in the nursery and in the grow-out beds. Calculate backwards from the number you want to harvest, increasing this number to account for expected mortality. Use

**TABLE 2**  
**Seed Clam Growth: Time to Planting Size**

INITIAL SEED SIZE	PLANTING SIZE	TIME IN NURSERY
1-2mm	10-15mm	16 weeks
2-4	10-15	14 weeks
4-6	10-15	11 weeks
6-8	10-15	6 weeks

conservative mortality rates when making this calculation because it can vary greatly. A rule-of-thumb is to allow for 50 percent survival in grow-out and 75-percent survival in the nursery.

If you plan to harvest 35,000 clams from a bed, divide 35,000 by .50 (the grow-out survival rate). This calculation gives 70,000 clams as the number to plant. Divide 70,000 by .75 (the nursery survival rate) to get 93,333 clams as the number to buy for the nursery. Round this off to 100,000 for ordering.

Make these decisions well in advance of your need for clam seed and place your order with a hatchery. Some hatcheries operate on a first-come, first-served or advance order basis only.

Before your seed is shipped, start the pump and let the system run for a day or two to make sure everything is in working order. When the seed clams arrive, unpack them and place them in a shaded area. Allow them to warm to the nursery water temperature. After clams have adjusted to local temperatures gently place them in the upwellers. If you have purchased 1-2 mm seed you can divide the seed into four upwellers.

As the clams grow, separate them by size and begin using more upwellers until all 12 are in use. Place screens over the drains for the first two weeks with 1-2mm seed because they may float or wash out with the water flow. When clams grow larger, drain screens are not needed.

A good way to measure seed growth is by volume. Obtain a clear measuring container preferably one that holds one liter and is calibrated in milliliters. Before stocking seed into upwellers, put the seed in the measuring container and record the volume. Do this every two to three weeks and keep records of clam growth. Double check to make sure you received the amount of seed you ordered. Count the number of seed in a portion of your shipment, then divide this into the total.

The clams may double or triple in volume every two weeks. Start with 500 ml (1/2 liter) of 1-2mm clams per upweller. When this volume doubles to 1,000 ml (1 liter) divide them between two upwellers. Continue this process until all upwellers contain clams. Try to maintain an equal volume of seed clams in all upwellers.



## FOULING

In addition to clam food, you will be pumping undesirable organisms and silt into the nursery. Fouling organisms can attach to pipes, tanks and upwellers and silt can clog screens. The system requires regular cleaning.

Fouling is the attachment of unwanted plants or animals to the sides of tanks and upwellers or to the protective screen mesh used to cover clam beds. Barnacles and colonial animals such as bryozoans (wool grass) and tunicates (sea squirts) or marine plants such as red, green and brown algae attach and grow on most underwater objects. Their growth is rapid at times and can cause problems with water exchange through mesh covers and upweller screens. The animals also compete for food.

Reduce fouling by regularly scraping and scrubbing the sides of tanks and upweller screens. Drain the tank once a week, spraying out all sediments. Refill it with fresh water for 30 minutes to one hour; then restart the seawater. A freshwater bath disrupts and reduces the growth of fouling organisms. Build several extra upwellers. Exchange spare upwellers and allow to dry for a day then rotate with other upwellers in the tank. Drying upwellers will also reduce problems with fouling.

Maintain an equal flow of water through upwellers containing equal amounts of clams. Adjust flow rates to individual upwellers by installing swivel standpipes on each drain (See Figure 3). Insert a 3-inch piece of PVC pipe (1 1/2-inch) into one side of twelve 1 1/2-inch PVC elbows. Insert this arrangement into the outside of each upweller drain coupling. Swivel the elbow downward for full flow and upward for reduced flow.

As clams grow in the upwellers, periodically sort them by size. Keep similar-sized seed together by sieving through screens. Do this every two to three weeks. The exact size screen that you use to sieve clams is not as important as keeping different sizes separate. A more uniform flow of water is provided if clams are relatively close in size.

Make sieves of 1/8-inch (3mm), 1/4-inch (6mm) and 3/8-inch (10mm) hardware cloth (galvanized wire) or similar materials. Build a 12-inch square box of 1x4 lumber and nail screens to the bottom using lath strips to make a tight seal. The more sizes of sieves you have, the more time you will spend sorting clams. Two or three sieve sizes are sufficient for small-scale operations.

Sieves work best if submerged. Use a wash tub or bucket larger than your sieves that can be filled with water. Spread a double layer of clams on the sieve and move the sieve up and down under water until the smaller clams have fallen into the bottom of the tub. Use a spray of water from a garden hose to make sieving easier.

Continue this process, starting with the largest seive and ending with the smallest. If you use three sieves, you may have four sizes of clams. This will happen toward the end of the nursery phase. Clams that are retained on the 3/8-inch sieve are ready for planting and do not need further sieving. Keep them together in a separate upweller and wait until you have enough to plant an entire bed rather than planting only a portion at a time.

Another way to keep planting-size seed is to build a raceway (See Figure 1) and position it so the water from the upweller drain flows into the raceway. Put 250-500 large seed clams per square foot into the raceway and allow a layer of silt to accumulate over them or spread a 1-inch layer of sand in the raceway. They will continue to grow and will require less cleaning than if they were being held in an upweller. They will not need further sieving. Place a layer of 1/4-inch mesh down the length of the raceway before adding clams. This will make retrieving them easier.

An innovative nursery developed by Sea Grant and a local seafood producer uses pumped water to grow seed clams in upwellers and to produce soft-shell blue crabs in the water that comes out of the nursery. This method spreads the cost of pumping water over two activities. See Tables 3 and 4 for results of operating this system. Write or call Sea Grant for information on this nursery design and for a booklet on shedding crabs (See Appendix).

TABLE 3  
Growth and Survival of Seed Clams in Upweller Nursery  
System for Three Years (Preliminary Results)

YEAR	INITIAL SIZE	FINAL SIZE	NO. DAYS	SURVIVAL
1985	3.7-4.0mm	7.8-10.2mm	103	89-93%
1986	7.4	9.8	85	99
1987	3-4	8.1-8.4	30	similar to 1986

TABLE 4  
Economics of Upweller Clam Nursery for Three Years

EXPENSE	1985	1986	1987
Small seed clams (100,000)	\$572	\$1100	\$700
Amortized construction cost of upweller system add-on	50	50	50
Set-up cost	50	50	50
TOTAL	\$672	\$1200	\$800
Equivalent cost of large seed clams (adjusted for mortality)	\$946	\$1980	\$1980
Cost savings	\$274	\$780	\$1180

Remember, nurseries require a lot of attention and labor. Some of the tasks include: cleaning tanks and upwellers of fouling and silt deposits, seiving and sorting seed clams by size into separate containers as they grow, and maintaining pumps, pipes and other equipment. Be prepared to spend a lot of time with your clams during this phase of your operation.

## GROW-OUT

Grow-out is the longest phase of clam culture and includes the period between final planting of seed clams and harvest. It can last 24 to 36 months or more.

Grow-out occurs on leased estuarine bottomland. During this phase, much attention must be given to checking grow-out beds for tears or fouling of mesh covers, shifting sediments and survival of clams. It is essential to provide protection from crabs and other predators. As clams reach market size, watch your lease closely to protect it from poachers. You should be able to call authorities quickly if you suspect someone is stealing your clams.

## BED METHOD

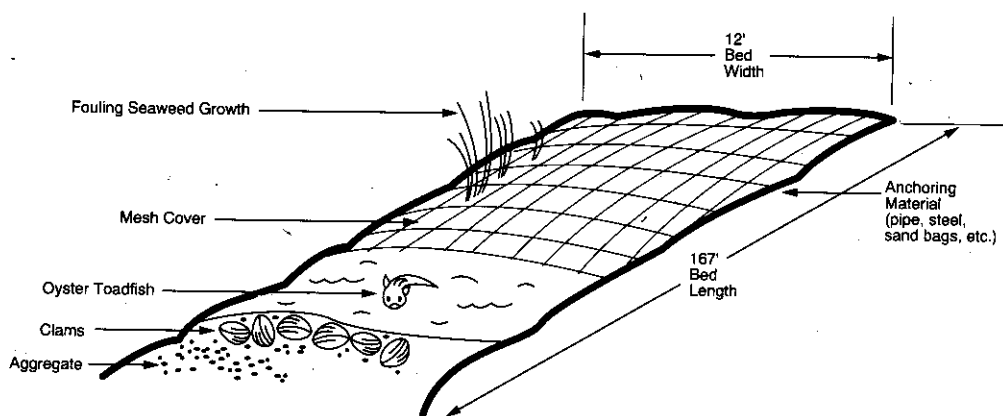
The bed method for clam grow-out is the most widely used and least expensive method for planting large areas (See Figure 4). Beds (also called bottom nets) may fare badly in storms, especially if the mesh covers are fouled extensively.

Before planting, survey your lease site. Walk over it with a rake and compare areas of the lease for depth, bottom type (silt, sand or mud) and amounts of shell material in the sediments. Decide on the best places to plant clams. Consider that shallower areas will facilitate planting, harvesting and bed maintenance activities. A good plan is to start your clam garden in the shallow parts of the lease, then as you learn the procedures plant new beds in deeper water if necessary.

Prepare the area to be planted by staking off the corners and raking the area clean of debris such as large shells or sticks which might rip the mesh cover. This is best done at low tide. Also, remove crabs and conchs which can eat your clams. Smooth out the bottom as much as possible and fill in holes which would make an uneven bed.

Plant clams in spring or fall when water temperatures are below 55 F (10-12 C). At these times crabs are less plentiful and are less likely to get into clam beds. Clams will be able to grow some before crabs return to the area. You can plant at other times of year but survival of clams may be lower. Plant only large seed clams for better survival.

FIGURE 4  
CLAM GROW-OUT BED



There is some evidence that mesh under beds helps improve survival of clams. However, mesh bottoms may interfere with some harvesting methods. If bottoms are desired, put them down at this time. Use a mesh size small enough to hold your seed clams.

Next, add aggregate such as gravel, marl or finely crushed shells. Use aggregate that is 1/2-inch or less. If you use large aggregate you will snag it during harvest. Spread a thin layer of gravel amounting to about one 5-gallon bucketful or 1/2 bushel over a 10-15 square-foot area (5 feet long by 2 or 3 feet wide). Load aggregate onto plywood sheets laid horizontally across one or two small skiffs. Push aggregate off the plywood into the water as you float across your prepared clam beds. A crab will have a more difficult time finding your seed clams if they are dispersed in aggregate. The aggregate also helps to secure clams and reduces the chance of them being moved around by wave action or currents.

After gravel is added use a garden rake to smooth it out filling in any missed areas. Plant your seed clams, spreading them evenly over the bed. Use care to distribute seed evenly and within the boundaries of the bed. Plant 50 clams per square foot. Clams will still grow planted as heavily as 100 or more per square foot but planting at lower densities will spread your investment over a larger area. This reduces your risk somewhat and may even produce marginally faster growth. Determine the

area of your clam bed by multiplying the length of the bed by the width. Next, multiply the square feet of the bed by the desired stocking density to obtain the number of seed clams to plant.

For example, a bed that is 12 feet wide and 167 feet long contains about 2,000 square feet. At a planting density of 50 clams per square foot, 100,000 seed clams will be required for this bed. The width of 12 feet is determined by the size of the mesh used (13 feet wide). An overlap of 6 inches is allowed along the edges to account for anchoring.

You may want to experiment with your first plantings. Plant several beds at a lower rate and several beds at a higher rate. Observe them at intervals to see if there is a marked difference in the average size of clams. Remember, what matters most is the percentage of the crop that reaches market size and how soon they reach that size. Keep track of the growth of individual plantings or seed groups. The fewer clams planted per square foot, the faster and more uniform their growth will be. Also, a thief will probably not be able to steal as many when clams are growing at lower densities.

After you plant your clams, cover the beds with netting. Depending upon the size of clams planted, you can use 1/4 or 1/2-inch mesh covers. Use a cover with a mesh size small enough to retain the size of seed clams you have planted. Most growers use plastic netting and some use woven nylon webbing (See Appendix for mesh suppliers)

Some growers attach 5-inch diameter floats to the underside of mesh covers. This assures that the mesh will not become covered with sand or silt. However, this varies between areas. Areas with much wave action or tidal currents will probably need floatation attached to the covers. Also, seaweed can act the same as floatation and can prevent mesh from silting over.



In areas with fewer tidal currents, a slight amount (1/4-inch) of silt or sand over covers can be advantageous because it will prevent seaweed from growing on the mesh. Clams will be able to extend their siphons upward through the mesh and silt. Deeper layers of silt over covers (more than 1/4-inch) may suffocate clams.

Anchor the edges of the mesh covers. Use steel chain, steel reinforcing bars or long sand filled bags. Place these in a line along the entire margin of the bed. Steel bars are light and easy to handle, but they're rigid and will not conform to the contour of the bottom as easily as chain or sand bags. Some growers attach chain or steel bars to the mesh with stakes or plastic ties or by sewing them into the mesh along its margin. Sand bags seem to be preferred because they are heavier, wider and seal the edge of the cover better than re-bar, leaving fewer gaps for crabs to enter. A disadvantage is that sand bags are bulky and difficult to work with. A compromise may be PVC pipe (2-3 inch diameter) filled with wet sand and capped. You should compare costs of these materials before deciding which to use.

Experiments have shown that you can benefit by stocking oyster toadfish (*Opsanus tau*) under clam bed covers. Toadfish will not eat clams but they will eat crabs. You can probably obtain oyster toadfish from fishermen who catch them while trapping crabs or trawling for shrimp. Make sure the covers of your clam beds have no tears or gaps in their margins through which toadfish could escape.

Once you've planted your clam beds, develop a schedule for maintaining them. Plan to check them at regular intervals (weekly or monthly) for tears in the covers, shifting sediments or fouling. Use a shop-type broom to sweep seaweed growth from covers. You will want to keep several spare covers on hand as replacements for damaged ones.

Double-check beds after storms. Use tide tables to decide on the best time to check your beds. Low tide is best.

Periodically sample your beds to see how the clams are growing and to check for dead clams. Every six months, pull back the covers and take a double handful of clams and sediment from several areas of the bed. Wash out the sediment leaving the clams in your hands. Be sure to get all the clams from the small area you are sampling (not just the largest ones). Record the number of dead clams.

One hundred clams per bed is a good number to measure. You may want to keep records of their growth (See Appendix). You will be especially interested in this if you are trying two or more planting densities. You can measure these with a caliper which can be purchased from a hardware store. If you are only interested in market size you can use a 1-inch wrench or make your own measuring tool. After measuring, if you have 70 clams

out of 100 that are more than one inch thick (26mm) then 70 percent are market size. Find this by dividing the number of market-size clams by the number of clams measured.

It is difficult to predict with certainty the growth rate of all clams for all areas. The growth of your clams will depend on the suitability of your lease site, planting density and amount of the lease planted, extent of fouling on covers and the genetic stock of the seed you purchase. In every batch of clam seed there are some fast growers and some slow growers. Your main concern is the growth rate and survival of the majority of clams in a batch. This determines whether you will make or lose money in clam gardening.

Depending upon the conditions mentioned above, the majority of clams in a particular batch may reach market size after two full years of growing. This means that the income from them will occur during the third year after planting. However, there will still be a group of slow growers left behind. If you have a market that will take them, sell them. If not, replant them on the lease and treat them the same as other groups. Don't be surprised if it takes another full year for the slow growers to reach market size.

## OFF-BOTTOM CULTURE

Off-bottom culture and other water column methods of aquaculture can be permitted for research and experimentation demonstrations and for commercial purposes. Trays, cages and bags are considered water column methods by the N.C. Division of Marine Fisheries. Division officials will tell you if you need to obtain an experimental or commercial water column lease designation for your chosen method. There is a \$500 per acre yearly fee for commercial water column leases and there is no fee for research and demonstration water column designations. The production requirement for water column leases is four times that of standard bottom leases.

## PROTECTING YOUR LEASE

The Division of Marine Fisheries has jurisdiction for enforcing the laws regulating theft of clams from your lease or destruction of your facilities. If you see someone harvesting clams from your garden illegally, quickly find a witness to this. Then call the Division office or the residence of the Marine Fisheries officer in your area and tell them what is happening. You cannot make a citizen's arrest but you can get a warrant for arrest.



## HARVESTING

Before you begin harvesting your crop, you'll need to obtain a shellfish harvest license from DMF. And you'll also need a mechanical harvest permit if you use mechanical methods. Once you obtain the proper permits and your clams are marketable size, you can harvest them. If the market price is low, leave your clams in the beds until the price rises. You may want to harvest ahead of a forecasted rain which might cause temporary closures in your area and prohibit you from harvesting.

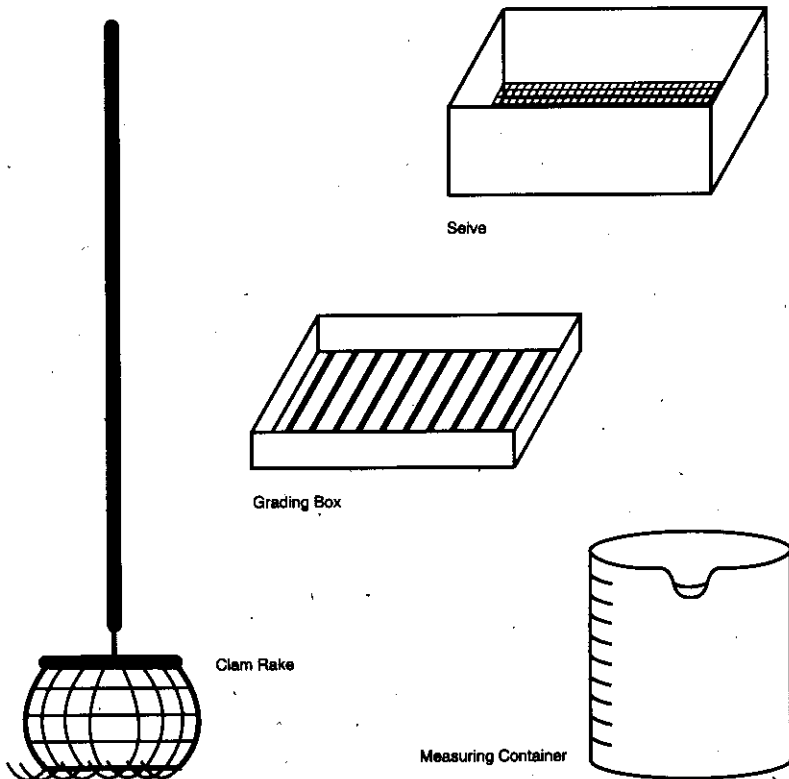
The density at which your clams are growing will have a determination on your harvesting method. You may want to use your hands, rakes, bullrakes or various mechanical devices. You can begin harvesting when your samples show that enough of the clams in your beds have reached a marketable size (about 70 percent).

Some clams will reach market size before others. To avoid replanting undersized clams, wait until most of your clams are at least 1 inch thick. If you've kept the clams together that were growing at the same rate during the nursery and early grow-out phases, you will have a more uniform crop at harvest.

If you have a few beds, dig them with your hands or use a small rake that has been fitted with a basket. When clams are growing close together, it is difficult to dig them with a large rake or bull rake (See Figure 5). The clams become fixed into position because their growth has taken up all the space between



FIGURE 5  
TOOLS FOR CLAM GARDENING

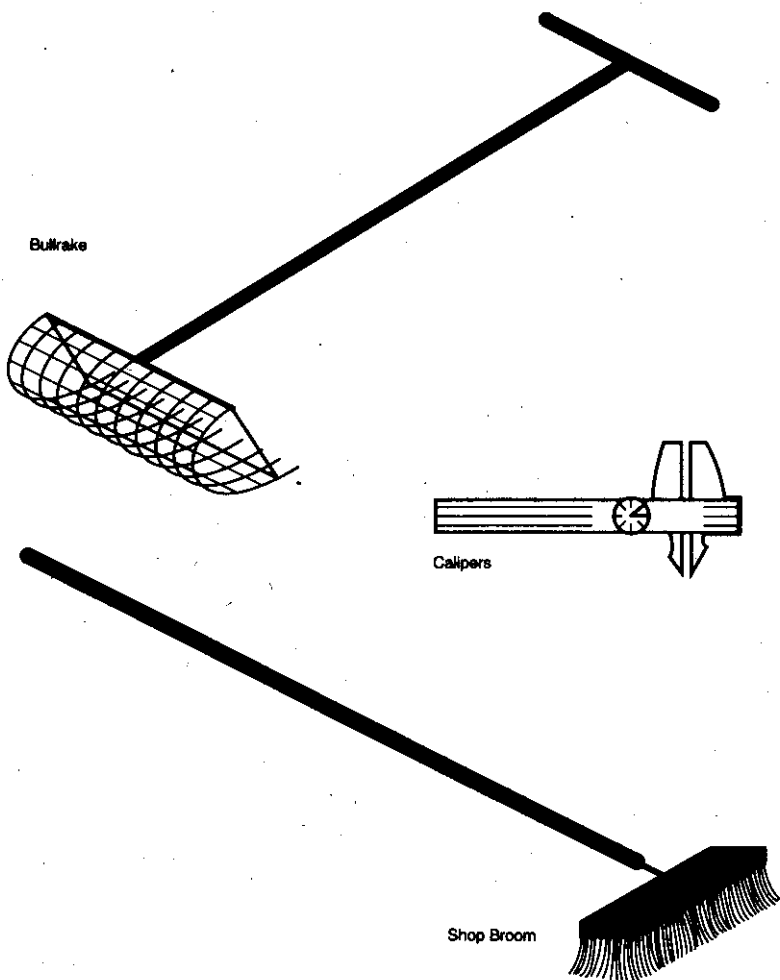


themselves and the gravel. If gravel is larger than 1/2-inch you may spend extra time separating it from clams.

Grade your clams as you harvest them. Measure each clam with a 1-inch wrench or other measuring tool. Because individual measuring is time consuming, you will need to learn to measure only a percentage of the crop. You will be able to gauge the size of the others by looking at them.

A faster way to sort clams is with a grader box. Build a wooden frame of 2x4 lumber. Attach 3/8-inch smooth steel bars to the frame so that they are parallel and 1 inch apart. Put the grader over a bucket and place clams on the grader. Clams that fall through the steel bars are less than 1 inch thick.

If you have a large number of clams to harvest, you may want to hire helpers or invest in a mechanical clam harvester. Mechanical harvesting methods are allowed on private shellfish



leases (except those in primary nursery areas) with a permit from the Division of Marine Fisheries.

One type of mechanical harvester employs a large pump and uses water jets in front of a device that resembles a giant bull rake on skids. The clams are loosened by forcing jets of water between them. The water moves the clams toward the basket of the harvester, which is pulled by hand. The basket acts as a grader and allows gravel and silt to pass through.

Harvesting by hand is easiest at low tide, but mechanical methods need higher water levels to operate. Sea Grant can help you find information on mechanical harvesting and help design a harvester for your own use.



## MARKETING AND HANDLING

Before your clams reach marketable size, you should plan a marketing strategy. You'll need to consider the permits and licenses you'll need and the activities that take place after harvest. A study of market alternatives will also help.

## PERMITS AND LICENSES

When you begin growing clams, get an aquaculture facility permit from the Division of Marine Fisheries. This permit describes your operation as a clam culture facility. You'll need to use this information in your invoicing. To sell clams to the public or to retailers, you will need a clam dealers' license from the Division. You won't need this license if you're selling clams to a licensed dealer. Clams grown from hatchery-reared seed are not subject to a minimum market size restriction. This means that as a clam hatchery or aquaculture operation you can sell your clams at any size you choose as long as you have a willing buyer for them. If you sell clams that are less than 1 inch thick you must indicate on the bill that they were hatchery raised and give your aquaculture facility permit number. A 1-inch thick clam is a minimum marketable size and you should attempt to grow most of your clams to this size.

If you plan to deliver clams in a truck, you'll need an inspection and certification of the truck by the Shellfish Sanitation Division (See Appendix). You will need to get a certification if you plan to hold or grade clams in a building before shipping.

Inspection and certification of your holding facilities is also done by the Shellfish Sanitation Division. They will issue tags for each container of clams that you ship. The tags can be pre-printed with your name and lease location with a blank for date of harvest (See Appendix). Keep transaction records for all your shipments

Other business privilege licenses from state, county or city may be required. Sales tax is generally not required for farm-raised products, including clams. Building permits are issued from the county planning department.

## HOLDING AND HANDLING

Hard clams are classified according to size and packed according to count. Clams are named for their size. Littlenecks are the smallest market size and the most valuable. Their size ranges from 1 inch to about 1 1/4 inch thick. Clams that are larger (1/4 inch to about 1 5/8 inches) are called topnecks and are less valuable. Cherrystones and chowders are and larger less valuable. Since you are producing littlenecks, grade out the under-sized clams. The remainder should be uniform. Graded clams bring a better price.

Clams are usually packed in orange or onion shipping sacks. Bushel baskets are sometimes used for shipping long distances. Pack the number your buyer wants in each container. Littlenecks are packed about 500 per bag. Use tags from Shellfish Sanitation with each container and keep transaction records.

Clams will live about one week to 10 days if they are kept cool (50-55 F), dry and out of the sun. If packed in airtight plastic bags, clams will open up and lose valuable moisture. They will survive cold storage better if harvested just prior to shipping.

When shipping, handle gently to avoid breakage and stress on the clams. Write up an invoice for your buyer listing numbers, sizes and prices of clams in the shipment and line up a trucker. Send the proper documentation with each shipment.

## SELLING CLAMS

The simplest way to market clams is through your local clam dealer or fish house. If you sell your clams to a licensed clam dealer, wait until the price is high. This usually occurs on certain holidays throughout the year and in winter. You can sell to wholesalers/distributors, restaurants, retailers and the public. Marketing your clams takes a lot of time and you must include the cost of this time in the price of your clams.

Learn to be a good salesman. Emphasize the advantages of your cultured product and use their benefits to help sell them. For example, quality control, freshness and low damage rates are benefits of cultured clams.

Reliability and predictable timing of harvests are benefits that are appealing to restaurants. Another good selling point is the uniform size of aquaculture clams.

Read seafood trade magazines to keep up with current market trends (See Appendix). These publications are filled with contacts and buyers' guides. To get the best price, take an active role in marketing your product.

## ECONOMICS

This manual is intended for the small-scale grower who wants to use clam gardening as an income supplement. It is by no means a get-rich-quick scheme because clams require two to four years to reach market size. There are other problems which must be overcome before a profit can be made.

Each clam gardener will have his own set of costs and survival rates for clams. Survival rates are critical and will vary between beds. This is your most important profit factor. Do everything you can to increase clam survival. Tables 5 through 8 provide a general view of the economics of clam culture of one crop. Your labor is not included in the production costs.

Table 5 is a budget showing production costs for 100,000 planted seed clams. As an ongoing clam growing operation you will be planting clams every year. You may even plant two crops a year; one in spring and one in the fall. Fit this production budget to your frequency of planting by making a monthly cash flow chart. Write down the production costs for each crop in the month it occurs and allow an equal amount of time for growth to market size. By doing this you will know what your cash needs are and when they will occur.

Assumptions used in Table 5 are that 100,000 clam seed are purchased at a price of \$25 per thousand. Seed clams are planted in a bed with gravel, covered with mesh and anchored with sandbags. The table also assumes that the lease is new and includes a \$250 surveying charge.

Blanks have been included to the right of budgeted numbers so you can record your costs. You may be able to save money by operating a nursery or by paying lower prices for other inputs. It is very important to keep records of your costs.

TABLE 5  
Clam Budgeting Production Costs

YEAR 1- INITIAL COSTS:	BUDGETED	YOUR COSTS
Seed (100,000 @ \$25/M, 11-12mm size)	\$2500	_____
Protection:		
Mesh	65	_____
Sand and bags	51	_____
Gravel	56	_____
Lease: (One acre lease)		
First year (includes applica- tion fee and survey costs)	350	_____
Labor: (Not included)	0	_____
 TOTAL FIRST YEARS COSTS	 \$3022	 _____
 YEAR 2		
Lease renewal and maintenance	\$60	_____
 YEAR 3		
Lease renewal and maintenance	\$60	_____
 YEAR 4		
Lease renewal and maintenance	\$60	_____
 TOTAL 4 YEARS COSTS	 \$3022	 _____

Use Table 6 to predict the number of clams you will harvest each year at three survival rates (20, 40 and 60 percent). This table assumes that 70 percent of surviving clams will reach market size after 2 full years of growing. They will be harvested during year three. Thirty percent of surviving clams will be harvested during year four.

TABLE 6  
Clam Budgeting Revenue Computations

NUMBER HARVESTED SURVIVAL RATE	60%	40%	20%
Year 1	0	0	0
Year 2	0	0	0
Year 3 (30% of survival)	18,000	12,000	6,000
Year 4 (70% of survival)	42,000	28,000	14,000
 TOTAL	 60,000	 40,000	 20,000

Table 7 shows the gross revenues calculated from the clam harvest figures in Table 6. Gross revenues are shown by year at three prices (12, 15 and 20 cents per clam) for each of the three survival rates in Table 6. Total revenue for the crop is also shown at three prices for three survival rates. From this table you can see the importance that survival has on the success of your operation.

**TABLE 7**  
**Clam Budgeting Gross Revenue**

PRICE PER CLAM		SURVIVAL RATE		
YEAR 3	60%	40%	20%	
\$.12	5040	3360	1680	
.15	6300	4200	2100	
.20	8400	5600	2800	
YEAR 4	60%	40%	20%	
\$.12	2160	1440	720	
.15	2700	1800	900	
.20	3600	2400	1200	
	60%	40%	20%	(Your Rate)
TOTAL REVENUE				
\$.12	7200	4800	2400	_____
.15	9000	6000	3000	_____
.20	12000	7000	4000	_____
Your Price	_____	_____	_____	_____

A cash flow budget compares expenses with revenues as they occur over time. Table 8 shows the flow of cash for one clam crop over a four-year period. Expenses occur each year, but revenues don't come until the third and fourth years. A new operation will have initial costs for several years before revenues are large enough to offset these costs. This emphasizes the necessity for you to start small then grow larger as you gain experience. It also stresses the need for you to keep costs down and to do everything you can to maximize growth and survival of clams.

**TABLE 8**  
**Clam Budgeting Net Revenue\***

YEAR	OUT	IN	CUMMULATIVE
1	-\$3022	\$0	-\$3022
2	-60	0	-3082
3	-60	+4200	+1058
4	-60	+1800	+2798

\*Note: Calculations are based on a survival rate of 40 percent and a price of \$.15. Figures do not account for inflation.

## ACKNOWLEDGMENTS

Much of the information used in this manual was contributed through the following speakers at the Hard Clam Grow-out Conference: Jim Murray, UNC Sea Grant; John Costlow, Duke Marine Lab; B.J. Copeland, UNC Sea Grant; Fentress Munden, N.C. Division of Marine Fisheries; Nancy Hadley, S.C. Wildlife and Marine Resources; Mike Peirson, Cherrystone Aqua Farms; Robert Malouf, N.Y. Sea Grant Institute; Mark Hooper, Hooper Family Seafood; Steve Malinowski, The Clam Farm, Inc.; Ron Hodson, UNC Sea Grant; Bob Hines, UNC Sea Grant; Preston Pate, N.C. Division of Coastal Management; Mike Marshall, N.C. Division of Marine Fisheries; Mike Castagna, Virginia Institute of Marine Science; Charles "Pete" Peterson, UNC Institute of Marine Science; Harold Knudsen, N.C. Division of Marine Fisheries; Jim Easley, North Carolina State University; Skip Kemp, UNC Sea Grant; Joe Huber, County of Carteret; Leslie Lee, Sloop Point Seafood; Maxton Midgett, Duncan Creek Landing; Jerry Monahan, Shellrock Aquaculture.

## APPENDIX

For more information on clam gardening contact:

- UNC Sea Grant, P.O. Box 3146, Atlantic Beach, NC 28512, 919/247-4007. Skip Kemp. Other publications: Shellfish: N.C. Aquaculture Regulations (\$1); Use of Flow-Through Shedding Systems for On-Shore Clam Nursery; A Guide to Soft Shell Crabbing; and a video tape of the Hard Clam Grow-Out Conference of 1988 (one week loan).
- Virginia Institute of Marine Science, Va. Sea Grant, Wachapreague, VA 23480, 804/787-3280. Contact Dr. Michael Castagna. Publication: Manual for Growing the Hard Shell Clam, Mercenaria (\$3).
- South Carolina Marine Resources Research Institute, P.O. Box 12559, Charleston, SC 29412, 803/795-6350. Contact Dr. John Manzi, Nancy Hadley. Publication: Intensive Hard Clam Mariculture, A Primer for South Carolina Watermen.
- Aquaculture Innovation Program, The New York State Urban Development Corporation, 1515 Broadway, New York, NY 10036. Publication: Small-scale Farming of the Hard Clam on Long Island, New York.
- Harbor Branch Oceanographic Institution, Aquaculture Report Series, A Manual for Farming the Hard Shell Clam in Florida. Florida Dept. of Agriculture & Consumer Services, Division of Marketing, Mayo Bldg., Tallahassee, FL 32399-0800.

Other sources of information:

- N.C. Biotechnology Center, Box 13547, Research Triangle Park, NC 27709, 919/541-9366.
- Gulf & South Atlantic Fisheries Development Foundation, Inc., Lincoln Center, Suite 571/5401, West Kennedy Blvd., Tampa, FL 33609, 813/286-8390.



- University of North Carolina Institute of Marine Science, P.O. Box 809, Morehead City, NC 28557, 919/726-6841.
- UNC Sea Grant, 105 1911 Building, Box 8605, NCSU, Raleigh, NC 27695-8605, 919/737-2454.
- Duke University Marine Laboratory, Pivers Island, Beaufort, NC 28516, 919/728-2111.
- N.C. Division of Marine Fisheries, Development Section, Mike Marshall, chief, P.O. Box 769, Morehead City, NC 28557, 919/726-7021.
- N.C. Division of Shellfish Sanitation, Bob Benton, director. P.O. Box 769, Morehead City, NC 28557, 919/726-6827.
- N.C. Division of Coastal Management, Preston Pate, assistant director. P.O. Box 769, Morehead City, NC 28557, 919/726-7021.
- N.C. Division of Environmental Management, P.O. Box 27687, Raleigh, NC 27611, 919/733-7015.

#### Shellfish Seed Suppliers:

- Aquaculture Research Corporation, P.O. Box AC, Chapin Beach Road, Dennis MA, 02638, 617/385-3933.
- Bayfarm, 586 Dock Road, West Creek, NJ 08092, 609/294-0235.
- Biosphere, Inc. 1199 South Green Street, Tuckerton, NJ 08087, 609/296-0945.
- Bluepoints Co., Inc. P.O. Box 8, West Sayville, Long Island, NY 11796, 516/589-0123.
- Cherrystone Aqua-Farms, Cheriton, VA 23316, 804-331-1208
- Harbor Branch Oceanographic Institution, Inc., Route 1, Box 196, Ft. Pierce, FL 33450, 305/465-2400.
- Mercenaria Manufacturing, Route 1, Box 293-B, Millsboro, DE 19966, 302/945-8755.
- Mook Sea Farms, HC 64, Box 041, Damariscotta, ME 04543, 207/563-1456.
- Sloop Point Seafood Co. 207 Pelican Walk, Hampstead, NC 28443, 919/270-2438.

#### Partial List of Aquaculture Plastic Mesh Suppliers:

- ADPI 3621 B. Street, Philadelphia, PA 19134, 800/521-2598 or 215/969-1181.
- Aquaculture Advisory Service P.O. Box 1294 Garner, NC 27529, 919/772-8548.
- B.F. Fence Co. P.O. Box 4121 Harrisburg, PA 17111-0121, 800/255-8397 or 717/564-1972.
- Bruce King and Co., Inc. P.O. Box 2562, Norcross, GA 30091, 404/441-2836.
- Internet, Inc. 2730 Nevada Ave. North Minneapolis, MN 55427, 612/541-9690 or 800/328-8456.

- Tenax Corporation 8291 Patuxent Range Road Jessup, MD 20794, 800/356-8495 or 301/725-5910.

#### Aquaculture Periodicals:

Check with publishers about complimentary copies.

- Aquaculture Magazine, Achill River Corporation, PO Box 2329, Asheville, NC 28802. Bi-monthly- \$15 per year.
- Practical Aquaculture and Lake Management, John Foster, PO Box 1294, Garner NC 27529, 919/772-8548. Monthly- \$12 per year.

#### Seafood Periodicals:

Check with the publisher about a complimentary copy. Some publishers provide free subscriptions for which you may qualify. A list of aquaculture periodicals is on file at the Sea Grant office in Pine Knoll Shores.

- Fish Tails, National Fisheries Institute, 1525 Wilson Blvd., Suite 500, Arlington, VA 22209, 202/524-8881.
- Seafood Business, by Journal Publications, 21 Elm St., Camden, MA 04843, 207/236-4342. Bi-monthly- \$20 per year, Annual Buyers Catalog.
- Seafood Leader, by Waterfront Press Co., 1115 NW 46th St., Seattle, WA 98107, 206/789-6506. Quarterly- \$12 per year, Annual Buyers Guide.

EXAMPLES OF FORMS YOU CAN USE IN YOUR CLAM  
GARDENING OPERATION:

FORM 1  
Clam Gardening Records

DATE	TEMP.	NUMBER PLANTED	NUMBER HARVESTED OR SAMPLED	BED MAINTENANCE

FORM 2  
Seed Clam Growth- When to Buy Seed for the Nursery

Buy 1-2mm	Buy 2-4mm	Buy 4-6mm	Buy 6-8mm	Plant 10-15mm
Aug. 1	Aug. 15	Sept. 1	Oct. 1	Nov.30

**FORM 3**  
**Clam Growth Sampling**  
**Clam Thickness (millimeters)**

SMALLS		(1 INCH)				MARKETS
6-10	11-15	16-20	21-25	26-30	31-35	36-40

Date sampled \_\_\_\_\_

Date planted \_\_\_\_\_

Months growing \_\_\_\_\_

Percents market size \_\_\_\_\_

**EXAMPLE OF SHELLFISH  
 SANITATION TAG**

until empty & thereafter kept in file for 60 days          This tag is required to be kept on container	250 CH Packed by: R. W. Jones Fish Co. Address: Rt. 1, Newport, N. C. Distributed by: Address: _____ Packer's Cert. NO. N. C. 15	Shipper: R. W. Jones Fish Co. Rt. 1 - Newport, N. C. Date _____ Received _____ Consist Of _____ To Be Retained By Receiver For 60 Days Packer's Cert. No. N. C. 15				
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 2px;">           Shipper's Cert. No.         </td> <td style="width: 50%; padding: 2px;">           Dates Reshipped         </td> </tr> <tr> <td style="height: 20px;"></td> <td style="height: 20px;"></td> </tr> </table>	Shipper's Cert. No.	Dates Reshipped			TO: _____  This Package Consist Of 250 CH
	Shipper's Cert. No.	Dates Reshipped				
	SHELLFISH DREDGED FROM Local Area Bogue Sound Bed No.839 DATE _____	SHELLFISH DREDGED FROM Local Area Bogue Sound Bed No.839 DATE _____				

NOTES: