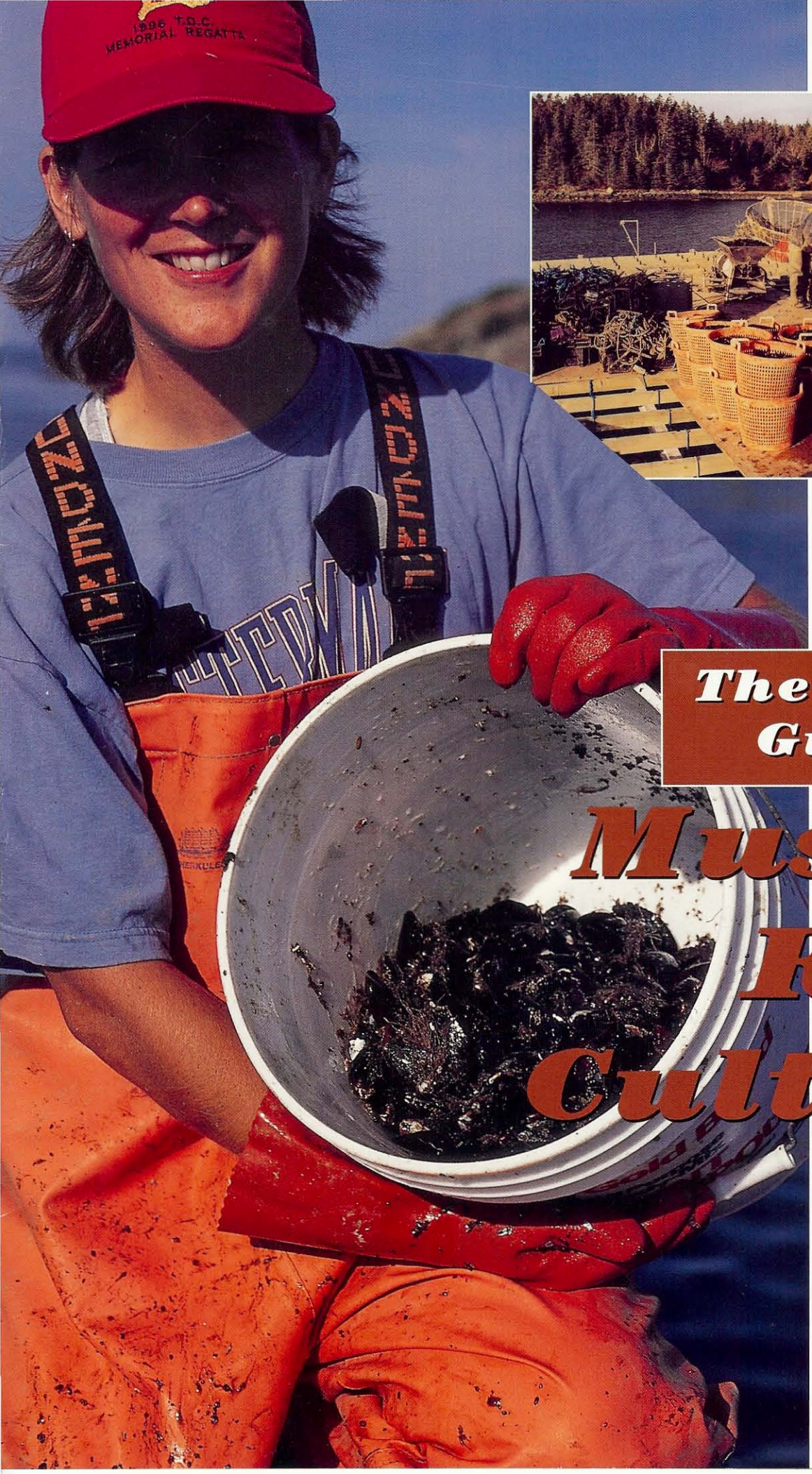

The Maine Guide to Mussel Raft Culture

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September 1999

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ISLAND INSTITUTE

Island Institute
410 Main Street, Rockland, Maine 04841
(207) 594-9209 • Fax: (207) 594-9314
www.islandinstitute.org

Contents

Foreword

By Ed Myers

If you're thinking about farming mussels, either as a sideline or the main chance, this booklet is designed to help you make decisions.

If you're a harvester — of groundfish, lobsters, urchins or any other species — you probably have a leg up on getting into mussel farming:

- You know the water.
- You've got at least one vessel, and a dory or punt, useful for mussel farming.
- You've undoubtedly got the tools to assemble a raft, to keep equipment in good repair, and solve the problems.
- If you've got a pot-hauler, you've got six or eight hundred pounds of lifting capacity for hauling product, setting moorings and anchors, handling chain. A mature, heavily loaded mussel drop 20 feet long might go over 400 pounds in the air, but in the water that would amount to about 160 pounds, so that five feet in the air won't be too hard on you.
- Totes full of mussels are not much more of a nuisance than totes full of lobsters.
- You value your independence, and there's no challenge the North Atlantic Ocean has handed you so far that you can't handle with confidence.

But there's one major difference between harvesting and farming:

You're accustomed to being paid daily when you bring in today's stock — or at least weekly, with a tab for your bait and fuel — and with the startup of a mussel farm, you're looking at two years without any mussel income (and maybe three if the DMR permits get complicated or their timing means you have to miss a season).

So it's a different world, one that calls for a lot of patience. And keeping expense records in careful fashion. The early stages will reduce your income taxes. The later stages can be exciting, as you build a farming business that could become more than a sideline and be nicely salable when the time comes for you to get out of it.

We'd like to help in any way we can.

The Maine Guide to Mussel Raft Culture

In any type of aquaculture, a grower needs to have the right species, the right environment and the right culture technique. The mussel culture process includes numerous steps (seed collection, seed grading, re-tubing or socking, harvesting). If all of the steps succeed, the results can be good crops and a continuing business. This handbook attempts to describe "best management practices" for the mussel raft culture industry in Maine. While this industry is currently only a few years old, its practitioners have learned what works and what doesn't in a range of ocean environments. This guide recommends certain types of mussel culture techniques, but they need to be adapted to particular environments in order to be successful.

The mussel raft project

In May of 1996, the Island Institute, Pemaquid Oyster Company, and Great Eastern Mussel Farms placed experimental mussel rafts at several sites along the coast of Maine: Georges Harbor (Allen Island) in Muscongus Bay, Lunt Harbor (Long Island), and Great Spruce Head Island in Penobscot Bay. Other rafts placed at Hardwood Island, in Blue Hill Bay, were managed by Great Eastern and Pemaquid Oyster.

This mussel project has operated under a United States Army Corps of Engineers Special Permit since it began in 1996. The State of Maine Department of Marine Resources did not have any regulations to govern small-scale experimental lease sites at the time. Today, these sites require permission from the US Army Corps of Engineers as well as an approved standard lease or experimental lease issued from the Maine Department of Marine Resources. (*See lease section of this handbook, page 28*).

Allen Island

Georges Harbor is a small gut located between Allen and Benner islands, four miles outside Port Clyde. The raft site is 25 feet deep at mean low water. It lies in high-energy and

Continued on page 7

In the United States, mussels were first farmed in Maine in 1973 by Edward Myers, who recognized the commercial potential of this "poor man's seafood." His original five-acre Abandoned Farm on the Damariscotta River was partially funded through the Sea Grant Program of the National Oceanic and Atmospheric Administration, which provided money for research related to experimental culture of mussels. The program spurred research and business opportunity on both coasts. Myers's farm grew to nearly 20 acres.

Until Myers turned over his operation to a neighboring aquaculturist in 1993, he was still using the rope culture method he had devised 20 years earlier, producing at the scale of a small cottage industry. Myers's office was in a converted chicken coop, he used a 1924 Maytag washer to de-clump the mussels, and he dispensed philosophy and wit freely. His rafts, initially made from power poles, were upgraded to old tires filled with chemically inert urethane foam, and are now wooden poles floated by plastic barrels that once contained Coca-Cola syrup. Each 22-foot pole, spaced on 18-inch centers, supports 14 ropes. Each 24-foot rope, in turn, produces about 120 pounds of mussels, or five pounds per foot of rope. At Myers's location seven miles up the Damariscotta River from the Boothbay area, the waters have a salinity content which equals that of the inshore waters in the Gulf of Maine.

Maine aquaculture pioneer Ed Myers. (PHYLLIS GRABER JENSEN PHOTO)

■ ■ ■ ■

Each spring, the mussels along the coast of Maine spawn. In some places there is so much seed that a drinking glass could be dipped in the ocean and there would be microscopic seed in every scoop. By early July, the seed "sets" or settles on boat hulls, lobster traps, rocks, and on the ocean bottom. Rope aquaculturists transfer the seed, spawned in the spring, to their rafts during the fall and place the seed on suspended ropes that prevent the mussels from touching the ocean bottom.

The seed reaches two and one-quarter to three inches in length — ready for harvest — 12 to 18 months after being placed on the aquaculture ropes. Total growing time from spawn to

harvest is 15 to 24 months, depending on stocking densities on the ropes. The Island Institute method (described in more detail elsewhere in this booklet) utilizes a stocking density of 100 to 150 seed mussels per foot of rope, harvests mature mussels 15 to 18 months after spawning, or 12 months after placement on the raft ropes. The Aguin (Spanish raft) method, also explained in more detail later, has a total growing time of 24 months with a stocking density of approximately 300 seed mussels per foot of rope. Wild mussels may take seven to eight years to reach harvest size. Mussels grown on ropes also have a higher meat to shell ratio and fetch a higher market price.

Mussel rafts must be placed at locations officially approved as aquaculture lease sites by the State of Maine. Maine has two lease programs. The standard lease is issued for an initial maximum term of 10 years with a maximum size of 150 acres. An experimental lease is issued for a maximum of three years with a maximum of two acres. An individual or company is limited to a maximum of 250 leased acres in Maine state waters.

Applications for lease sites are scrutinized to determine that the site is not a critical habitat for, or adjacent to, a site critical to endangered species such as bald eagles, terns or marine mammals, or is critical to some stage in the life cycle of other species (e.g. lobster shedder holes). The state also wants to be sure that the new lease does not displace an existing fishery or interfere with navigation. The application process also includes a mandatory public hearing for a standard lease and may include, depending on preliminary public response, a public hearing for an experimental lease.

While only the leaseholder may use the area for aquaculture, activities such as recreational boating and fishing that do not conflict with the permitted aquaculture activities are allowed. No chemicals, antibiotics or artificial foods are ever introduced into mussel lease areas in Maine.

Sustainability of the wild resource has been an highly productive waters, but is well protected by high land cradling the harbor to the east and west. Even when the southern head of Allen Island bears the brunt of 20-foot seas, Georges Harbor may see three- to five-footers.

In terms of mussel culture, growth rates on Allen in 1995-96 were as high as any cited in the literature — about 5 millimeters a month — and are a sure indication that there is an abundance food.

The Allen site is not without its problems: fouling by setting starfish and hydroids (sessile, flower-like animals which feed much like a barnacle). Starfish can be managed by dipping the seed collectors in a saturated lime and sea water solution. The lime forces the stars to retract their tube feet and fall off the lines. The mussels are closed during dipping and remain unharmed. Hydroids can be avoided by using a seed collector which mussels will settle on but hydroids won't. A seed collector called "New Zealand Christmas Tree" rope was successfully tested in the 1997 setting season.

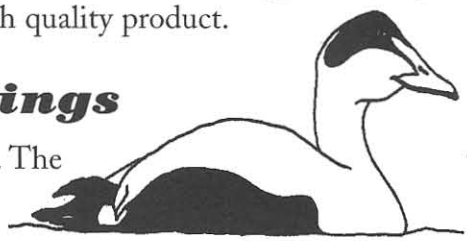
Frenchboro (Long Island)

Lunt Harbor, Long Island, is 11 miles out from Bass Harbor, off Mt. Desert Island. The raft site has 20 feet of water

issue since the late 1970s. Consultants and scientists even then feared overfishing. "In 1978, I thought we'd run out of mussels in two years," reflects Chip Davison of Great Eastern Mussel Farms in Tenants Harbor. "The market grew at a horrific pace."

Today, mussels are marvelously abundant, but quality beds are getting harder to find, and "ugly" gritty wild mussels are no longer acceptable to the consumer. This trend supports a bright future for aquaculture — farming produces a consistently high quality product.

Predators, storms and moorings



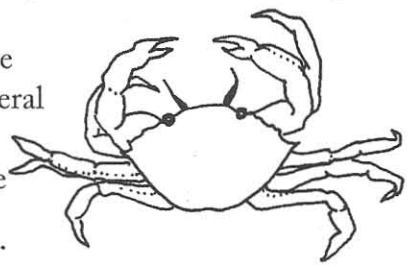
Sea ducks were the Maine cultured mussel's first enemy. The Maine coast harbors the world's largest population of eiders and other sea ducks, which can form rafts covering an acre or more. From December through April, large concentrations of ducks converge inshore in the Gulf of Maine to avoid the harsh conditions of the north. Each mature duck consumes its body weight per day in mussels. Ten thousand pounds of market-sized mussels (worth $4,000 to a grower) can be consumed in a week.

The ducks dive to 35 feet and crush the mussels in their gizzards, sometimes getting so full that they can't fly. One mussel raft farmer spent $3,000 "seeding" a mussel raft with 12,000 feet of drop lines (to which tiny mussels attach themselves at their earliest stages), only to have 60 percent of his mussels eaten by ducks in two days. A leased mussel bottom area in Stonington had 60,000 pounds of seed mussels eaten by ducks in one month. Needless to say, for mussel suspension culture to succeed, the "duck problem" needs to be addressed.

Mussel raft with predator nets hung around its perimeter.

Mussel rafts with predator nets hung around their perimeters can produce high quality mussels for the food service market without the problems of duck predation. Rafts take up much less area than bottom culture, and can yield about five times as many mussels per square foot. (Mussel lines must be suspended at least five feet off the bottom at low drain tide, so crabs and stars are not able to climb onto them for a free lunch.)

Weather can also wreak havoc, as it did in 1992 when a strong northeaster churned up the sea bottom for over a week on Nantucket Shoals and Monomoy Shoals in Massachusetts and Rhode Island. Mussel beds that were the backbone of the Rhode Island industry were buried under several feet of sand. That fishery now relies on beds that are sometimes infested with pea crabs, tiny edible crustaceans that live inside the mussel's shell and steal its food.

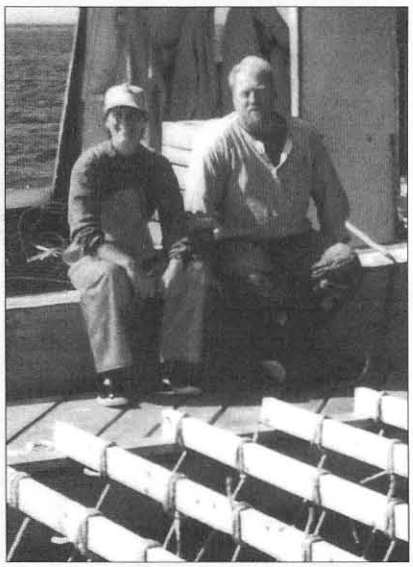


Proper mooring systems are important for successful raft culturing. The grower must have confidence in his system, especially in a good blow. Mussel rafts can be moored in many different ways. Site depth, currents, wind and surf exposure are the major considerations in raft placement. Generally, a 40-by-40 foot raft with 35-foot drops requires, at a minimum, a pair of two-ton blocks, one on the upstream side and one on the downstream side. The bottom third of the mooring chain, beginning at the mooring block, should be at least one inch chain and the upper two-thirds, at least five-eighths. The length of chain in relation to the vertical height from the ocean bottom to surface — the scope — should have a ratio of at least two to one. If the raft is moored in 50 feet of water at high tide, for example, the grower would need about 33 feet of one-inch chain and 67 feet of five-eighths chain to make up 100 feet — for each mooring. A smaller 22-by-22 foot raft with 15-foot drops requires a one-ton block on each end, and has the same chain requirements.

Mussel biology

Mussels feed by pumping seawater (at approximately one gallon per hour per two-inch mussel) through their gills, filtering out suspended particles larger than three micrometers in diameter. Their food includes marine phytoplankton (single-celled plants of which there are about 800 species recorded in Maine), dead organic material, silt and clay.

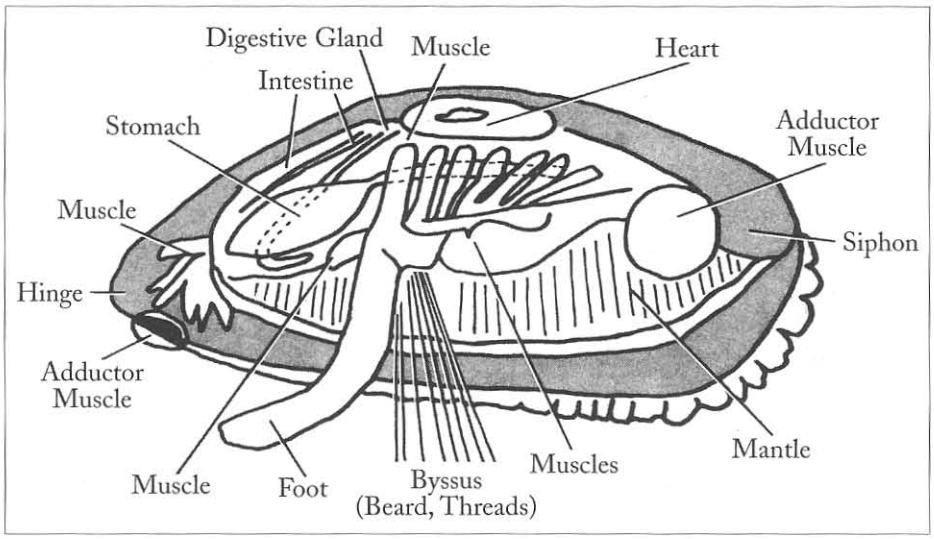
Sexes are separate, and often mussel populations undergo a mass spawning stimulated by increasing food and water temperature in the late spring, and initiated by the release of sperm from male mussels. The fertilized eggs become swimming larvae until they reach about one-quarter of a millimeter (one one-hundredth of an inch) in length. During the swimming larval stage, the mussels first live in surface waters. As they develop a shell and foot and a pigmented area called the eyespot, they settle to the bottom, unless re-suspended by tides



Island Institute's Corrie Roberts and Frenchboro fisherman Danny Lunt.

at mean low water, and is only exposed to a northeast wind. Raft production consistently is higher in Lunt Harbor than at the other sites. The water temperature range is 32-55 degrees Fahrenheit, ideal for mussel growth. In August 1997, the mussels on the Lunt Harbor grow-out raft added 6 millimeters to their shell length. Lunt Harbor proved to be an excellent grow-out site.

Lunt Harbor also differs from Allen in terms of the timing of mussel spat sets. The primary mussel spat set in Lunt Harbor occurs in early May. The primary set around Allen Island appears in early July, nearly two months behind Lunt Harbor. Mussels generally spawn after the water temperature reaches 10



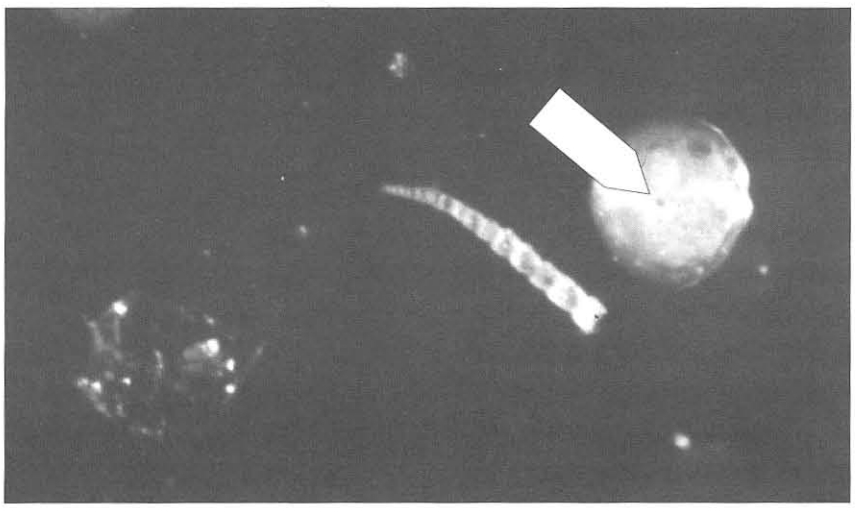
Interior anatomy of a mussel.

or waves. The mussels then attach to substrates (eelgrass, barnacles, rocks and mussel shells) during their primary settlement with a sticky thread called the "byssus." The post-larvae then metamorphose into juvenile mussels.

From the period of primary settlement until a size of about two millimeters, the mussels can redistribute themselves through a very long thread, called the drifting byssal thread. Mussels cast out this thread on the flood tide in waters of moderate current. The thread provides juvenile mussels a free ride inhore to mature mussel beds for final attachment during an optional period of secondary settlement.

The growth of mussels is a function of density (for example, number per square foot of area on the bottom or number of mussels per foot of rope), biomass (how big the meats and shells are in a given area), the concentration of phytoplankton and other food in the water, and the speed of the current that delivers the food to the mussels.

Water temperature is an important factor for mussel growth. Temperatures between 40 degrees Fahrenheit (F) and 70 degrees F are required, and temperatures between 40 and 50 degrees F appear to be ideal. At Abandoned Farm, Ed Myers found that mussels began to lose byssal strength at 65 degrees F. The Island Institute site with the best growth rates has average summer/fall temperatures around 50-52 degrees F and winter temperatures near 32 degrees F. Mussels lose byssal strength and begin to suffer mortality at temperatures above 70 degrees F (65 in Myers's experience). If temperatures are within the required or, preferably, the ideal range, mussel growth rates are primarily a function of food abundance at the site. Mussel meat size (cooked



Pre-setting mussel at the "eyespot" stage.

meat weight) or percentage of meat yield (cooked meat weight divided by total live weight including shell) may vary over an annual cycle, with highest meat yields in the spring prior to spawning. Processed and iced live, mussels have a shelf life of 10-14 days in a 35 degree F cooler (during spawning, shelf life can drop to as low as two days). Mussels can survive in fresh water for short periods by closing the shell and increasing the amount of amino acids in the mantle cavity.

The common blue mussel, *Mytilus edulis*, is a dominant species of the shallow water along Maine's coast, down to over 100 feet. The Baltic mussel, *Mytilus trossolus*, occurs in increasing frequency from Hancock County eastward to Washington County, where the water temperatures are often colder. This latter species represents about half of the mussels in Cobscook Bay, at the eastern edge of Washington County. *Mytilus edulis* comprises the vast majority of the mussels along the Maine coast.

Selecting a site

Picking a successful site requires local knowledge of an area and existing uses, and an assessment of the area's production potential. What constitutes the right site will also depend on the species and phase of cultivation. The following factors relate to whether shellfish will grow fast and survive:

- Speed of the current
- Phytoplankton and other food abundance
- Water temperature
- Water salinity
- Exposure to wave action
- Sediment type
- Water depth
- Predators
- Occurrence of ice

Other factors that influence the potential success of a site and the most suitable method of culture are access, security, water classification (approved/restricted degrees Celsius, 50 degrees Fahrenheit. This is crucial information — seed collectors must be deployed at the proper time. Starfish and hydroids are not an issue in Lunt Harbor.

Hardwood Island

Hardwood Island is closer geographically to Lunt Harbor than Allen Island, but its site characteristics are similar to Allen Island's. The primary mussel set at Hardwood was in early July in both 1996 and 1997. Hydroids are not a problem. There is normally a starfish set in August, but, to date, low densities have prevented a major problem. Hardwood has proven to be an excellent site for seed production. Mussel sets are extremely high, suggesting that this site could be an excellent seed source for many mussel farms.

Great Spruce Head Island

Great Spruce Head Island, one mile north of North Haven in Penobscot Bay, was added to the project in the spring of 1997. Mussel settlement was very high at this site, but, unfortunately, the site experienced large starfish sets. The primary mussel set of 1997 was almost completely destroyed by

ed/ prohibited), leasing issues such as navigation, the presence or absence of existing fisheries, and the need for access.

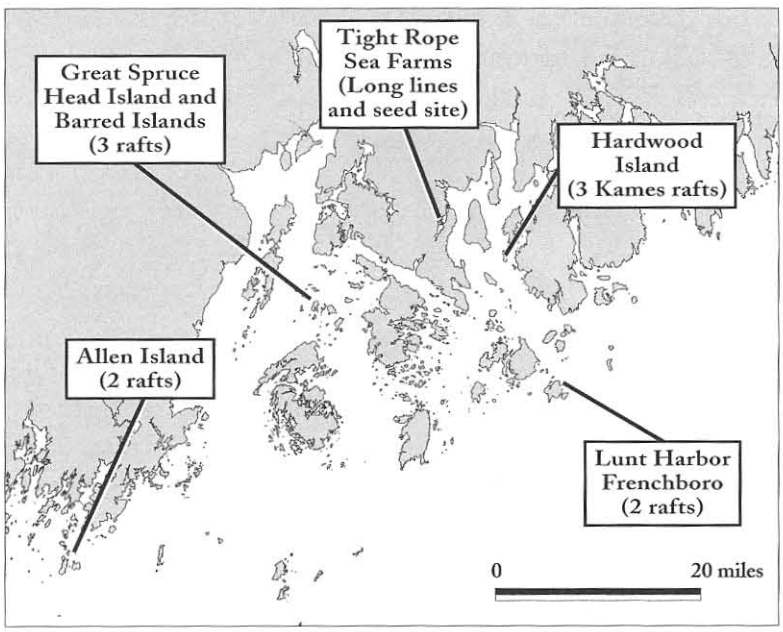
Small-scale pilot studies at multiple sites, although requiring regular visits to monitor the site, maintain predator nets and measure temperatures and food, are helpful because they provide information on growth rates. A detailed analysis of a potential site can provide benefits later on. The information will assist with establishing good seed densities for maximum growth and yield at the area chosen for development.

For shellfish which feed on suspended particles, there is also an important connection between the density of shellfish at a site and the supply of food. For example, if a mussel filters one gallon of seawater per hour, and the food concentration is 40 milligrams of food per gallon, each mussel will obtain 40 milligrams of food per hour. If the tidal currents only supply the mussels with one-half gallon of seawater per hour, the mussels will grow about half as fast due to the low current. As the mussels increase in size, they either need higher food densities, increased currents or reduced mussel densities to maintain growth rates.

At 10–20 mussels per square foot of bottom, evenly spread out, the following conditions would result in the same growth:

- 10 mm per liter, 30 centimeter-per-second (1 ft./sec.) average current
- 20 mm per liter, 15 centimeter-per-second (6 in./sec.) average current
- 30 mm per liter, 10 centimeter-per-second (4 in./sec.) average current

Food for shellfish is measured in many different ways, but consists mainly of live marine phytoplankton (of which there are about 800 species in Maine) and detritus, or dead organic material including some bacteria. The inorganic sand, mud and clay also suspended in seawater aid in the digestion of the food by shellfish, but they also may dilute the more nutritious particles resulting in slower growth. This may happen in shallow, muddy areas on windy days. Particle size can be checked using a blood cell counter (Coulter Multi-Sizer) and an underwater video (see list of suppliers).



Existing mussel culture sites in the midcoast area of Maine.

Food concentration in Maine's shallow waters often changes with the tidal stage and through annual cycles. Weekly samples are needed to accurately characterize the food in an area. Samples should be taken one

meter below the surface of the water around high tide. Since light penetration (visibility) decreases with more particles in the water, a simple and cheap way to test for food is by measuring visibility with a Secchi disk. The distance that light penetrates and illuminates the Secchi disk roughly translates to phytoplankton and other suspended solids concentrations.

Current may be measured with a current meter or from a computer model using the bottom depth from a chart (or your own detailed map of depth.) Tidal height elevations and some field data on currents are also required. Usually, a grid size of about 150 feet will provide enough detail for a good picture of the current patterns within a bay or cove. Wind-driven currents and wave height can also be modeled, using one year of local wind data.

A simple way to measure current is with a stopwatch, a drogue, a measuring tape and a boat. Anchor the boat and release the drogue. If the drogue travels 1,000 centimeters over 20 seconds, the speed at that moment is 50 centimeters per second (20 inches equals 7,200 feet per hour, or 1.2 mph).

Temperature can be measured using a data logger or with a thermometer every time you visit the site. Salinity can be measured using a water sample and an inexpensive salinity test kit or a hydrometer (available from any auto-parts store).

Keep an ongoing log of your observations. They will come in handy as you develop your site and monitor shellfish growth rates.

Steps in culturing mussels

Seed Collection

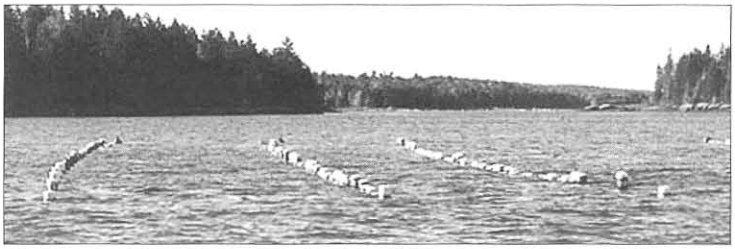
The best way to collect mussel seed is on ropes in suspension culture. This provides young, fast-growing mussels with thin shells, suitably adapted to attachment off the bottom on suspended ropes. Various aquaculturists have tried dredging seed starfish in a matter of weeks. Starfish were so dense that lime treatment was ineffective. Fortunately, a secondary mussel set occurred in late August and repopulated the collectors. At this site, seed is bought from Tight Rope Sea Farms and used only for grow-out.

Raft construction

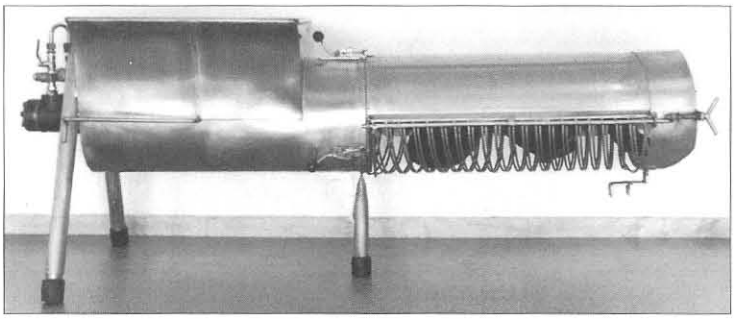
In April 1996, Pemaquid Oyster company and the Island Institute, working in partnership, designed the first mussel rafts for the Sea Station Mussel Raft Project. They proposed a 22-by-22 foot, 144-drop portable raft made of wood frames and decking, with galvanized corners and pre-manufactured plastic flotation billets. It was to be:

- light enough so four people could easily lift one section at a time as it was being bolted together. The design included four 3-by-19 foot pontoons, bolted together in a square
- built with standard galvanized dock hardware
- not more than 625 square feet (25-by-25 feet) overall, so a small boat could easily push or tow it.

In addition, the construction must be able to withstand harsh oceanic conditions, and capable of floating 15,000 pounds.



Series of long lines for seed collection at Tight Rope Sea Farms, Blue Hill, Maine.



De-clumping/grading machine from Spanish manufacturer Aguin.

mussels, but the mussels grow more slowly, the shell appearance is not good, and they have difficulty holding onto ropes or migrating through re-tubing socks.

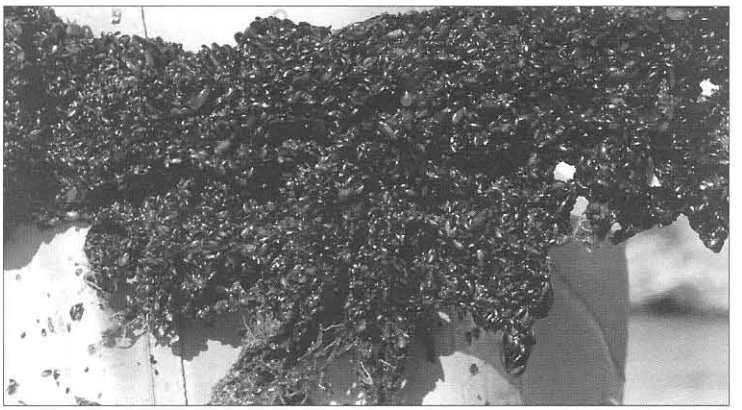
Any rope will catch mussel seed if it is hung in the ocean at the right time. Normally, the industry employs used lobster trap rope (potwarp), hollow-braided polypropylene of one-half inch diameter, or used mussel socking material. Ropes are weighted with cement weights, with bait bags full of rocks or, in the case of hollow-braided poly, with a large spike (20 p by 8 inches) inserted into the bottom of the rope.

Eight- to ten-foot ropes are set in a longline, spaced about one and one-half feet apart. As the mussels grow, the raft may require additional buoyancy. Further details are included in this booklet's account of experimental mussel operations at Maine island sites. The practice at Abandoned Farm was to set "terminal" buoyancy at the outset, to prevent surprises and avoid extra steps later, usually in foul weather. Lines are set out after monitoring for a peak in mussel larvae, or according to the aquaculturist's experience, and seed is harvested by stripping manually into fish totes.

Seed lines should be harvested in early October for grading and thinning, and moved onto grow-out ropes before the water gets too cold to ensure proper reattachment to the grow-out lines. If seed is too small in the fall (less than one-quarter inch in length) for thinning, it can be overwintered and thinned in the late spring, when it is larger.

Once the mussels are stripped off the lines, they need to be graded so the they will grow to market size at an even rate. Shellfish of the same size also grow more evenly than mixed-size distribution. Seed which is not attached too tightly can be graded in small hydraulic grading drums. Tightly clumped seed needs a stronger de-clumper/grader. Growers will find that certain seasons (spring and fall) may be more successful in seed attachment than other times of year. Mussels can be kept cool in the summer by soaking with seawater, covering them with a wet cloth. If they will be out of the water for a few hours, they may be iced.

Harvesting seed mussels at Tight Rope Sea Farms.



Heavy mussel set from Allen Island site.

Attaching seed to ropes

Seed can be attached to short culture socks (less than 15 feet long) using a manual socking table. The graded seed is "re-tubed" like making sausage: it is dumped onto an inclined table with water; a foot valve opens a chute into pre-cut plastic socks. The mussels will grow through the sock and attach to the outside. The sock mesh has to be the correct size (*see table below*) or the mussels may fall out, or not be able to

Guide to mussel sock size and retail prices

from Bridport Maritime Industries Ltd., Bedford, Nova Scotia

Size	Diameter	Mussel size	Price	
			>10,000 MR	<10,000 MR
TMS	1.75"	0 – .75"	$114.85	$122.00
TMS	2"		$131.25	$139.45
TMM	1.75"	0.5" – 1.0"	$97.00	$103.15
TMM	2.0"		$111.00	$117.80
TMM	2.5"		$138.65	$147.35
TML	2.0"	1.0" – 2.0"	$106.00	$112.70
TML	2.5"		$132.50	$141.00
TML	3.0"		$159.00	$169.00
TML	4.0"		$212.00	$225.35
			>5,000 EA.	<5,000 EA.
Bags	43 x 61	Per 1,000	$375.00	$412.00

In June 1996, three rafts were built to these specifications and moored at the first three locations. Each raft was moored at both ends to reduce swing and allow each end to be facing the current generated by the ebbing or flooding tide.

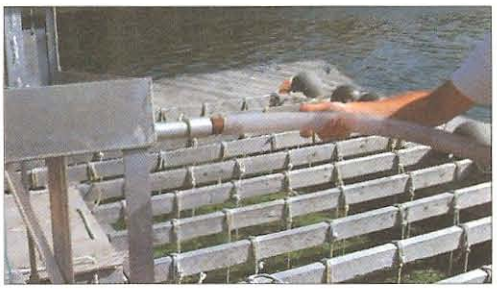
In June 1997, two more rafts were built. One raft went to the Great Spruce Head Island site, and the other was added to the Allen site to become the seed collector. Recently, two more rafts have gone in east of Great Spruce Head Island in the Barred Islands.

Spat collection

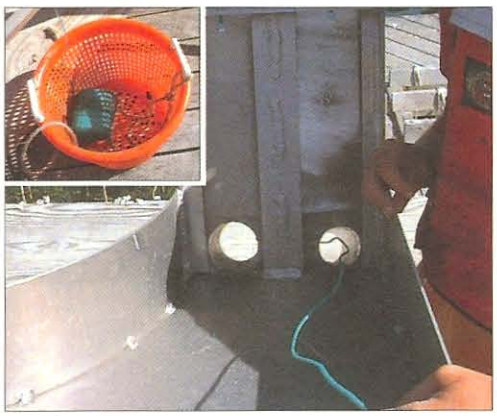
In order to optimize mussel settlement on the spat collectors it is necessary to monitor the water and track the growth of pre-setting mussels at least three days per week from April to August. An easy and low-cost technique for quantifying larval mussel in the water column is as follows:

1. At high tide, pour 10 five gallon buckets (200 liters) of sea water obtained from just below the surface through a 90-micron sieve.
2. Decant the captured plankton into a sample bottle and dilute to 100 milliliters with sea water.
3. Fix the sample with 2 milliliters of 10 percent formalin

1. Island Institute 22'x 22' raft awaiting deployment.



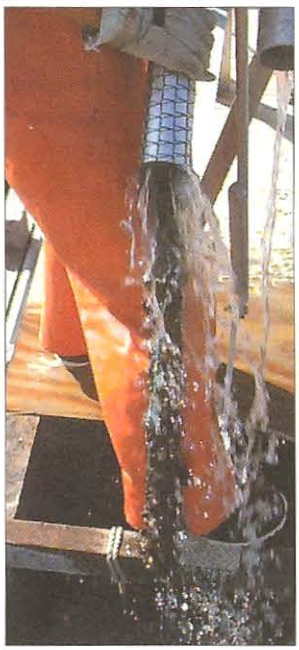
2. Attaching deck hose to socking table.



3. Running twine through the tube in order to reinforce sock.

4. Tying overhand knot in bottom of sock.

5. Raising gate to sluice seed.



6. Sluicing seed into 15-foot sock.

7. Running sock into water to tie onto raft.

8. Hoisting 15-foot sock

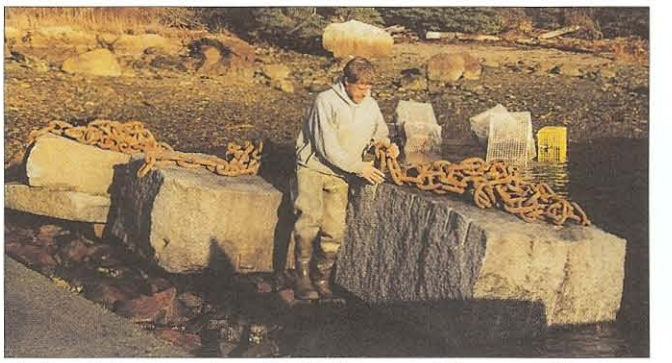
9. Six 15-foot socks piled

10. Shoveling stripped m

and for final harvesting.

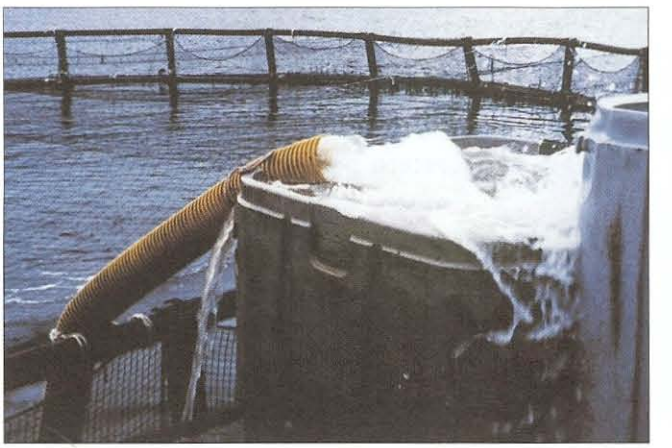
deck, ready to be stripped.

s into totes for delivery.



1. Readying moorings for deployment (Kames raft).

2. Kames raft being towed to Hardwood Island site.



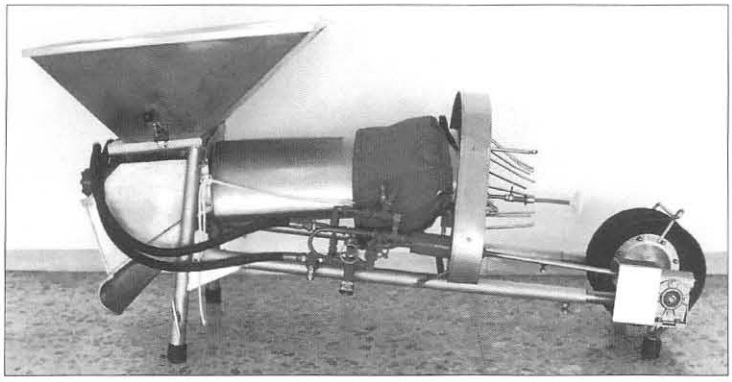
3. Airlifting seed harvested off Treats Island salmon pen.

4. Binding mussels onto rope, using an Aguin roping machine.

5. Hydraulic crane lifting a Spanish harvesting basket into position.

The photo layout on the left side of this 2-page spread depicts a small-scale mussel raft culture operation — specifically, the one currently run by the Island Institute.

The right side of the spread shows a larger-scale, more mechanized operation, being conducted by growers who are associated with Great Eastern Mussel Farms.



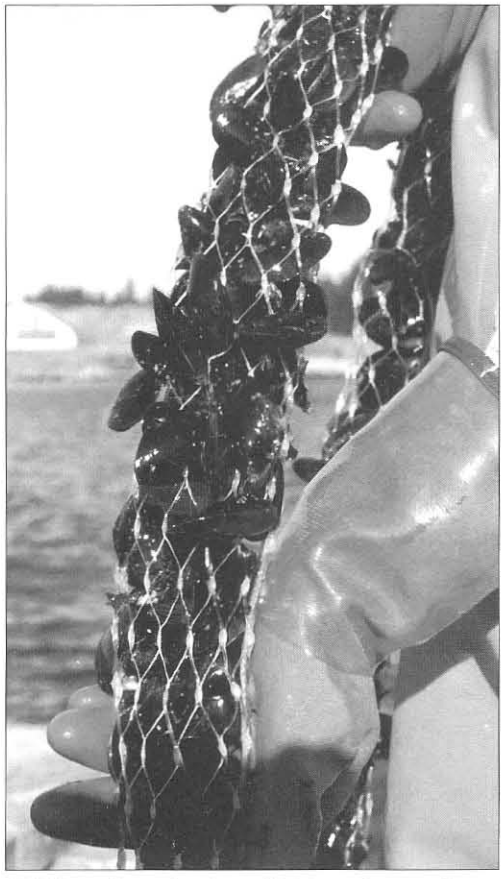
Rope-making machine from Spanish manufacturer Aguin.

crawl out if they are too small.

At sites where water depth is less than 30 feet but more than 18, the manual socking table method may be practical. This method involves 15-foot socks of 2.5 TML (the largest mesh size Irish mesh socking material) and one-inch mussel seed at a density of 150 mussels per running foot.

Two people can sock 150 15-foot drops in eight hours. In 12 months these socks might yield approximately eight pounds of market-size mussels per foot.

If the site allows, mechanization is possible. Seed can be attached to long ropes (30-50 feet long) using an Aguin roping machine. Half-inch polysteel rope which has been shredded to make it fuzzy for easier attachment is a convenient source of rope. In Spain, ropes are made from recycled nylon fishing nets twisted into one-inch, three-strand ropes containing pegs every half meter. Soaking in seawater softens these ropes, so they run better through machinery.



P.E.I. sock at density of 100 seed mussels per foot.

The rafts currently in use in association with Great Eastern Mussel have 35-foot ropes with two-pound dropper weights. The ropes are fed through the machine and a biodegradable cotton mesh (Cotton Plus from J.J. Chicolino, La Coruna, Spain). A cotton binder is wrapped around the mussels, using a hydraulic motor. This machine allows the one-half-inch to one-inch ropes with six-inch long plastic pegs every two feet in the lay of the rope to pass through the machine with a two to four-inch-diameter tube of mussels coming out the other end. The machine can be adjusted to a larger diameter.

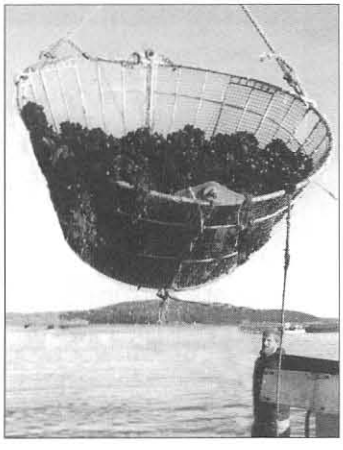
Mussels are usually seeded at densities of 100 to 300 per foot, and yields from lines with pegs could be as high as 17 pounds of market-size mussels per foot. Densities on the plastic socks without pegs should be kept to between 100 and 150, because high densities can cause the mussels to slide off the shorter plastic socks. On the ropes, the pegs keep the mussels from sliding off and provide more surface area for attachment. In 1999, some 35-foot lines had over 600 pounds of mussels after 18 months of grow-out.

Preparing 35' down ropes for seeding with Aguin roping machine.

Harvest

Short socks with moderate densities can be lifted by hand onto a raft. Heavier ropes can be harvested underwater before lifting to prevent the mussels from dropping off the ropes. The mussels weigh three times as much out of water as in water.

In Spain, the system of choice involves an eight-foot diameter basket which holds about 2,000 pounds. The basket is dropped down to about 45 feet, the mussel lines are centered above the basket, and the basket is lifted to the surface. The basket then opens from a hinge in the middle, and the mussels and ropes fall out on deck. They can then be stripped manually or with a mechanical stripper, and run through a de-clumper/grader which separates the market-sized mussels from seed, mud and fouling organisms. Experience has shown that a good crane operator and crew of three can harvest and strip 200 bushels (12,000 lb.) of mussels in about three hours.



Spanish harvesting basket.

buffered in sea water.

4. To quantify, first shake sample jar to re-suspend plankton then draw 1 milliliter and place on a concave slide.
5. Using a dissecting microscope, count all the larval mussels and note the stage of development of each mussel.
6. Repeat steps 4 and 5 four more times (perform 5 counts per sample) and average the results.
7. Graph results over time. When the average eye spot larvae is up to 2 milliliters per sample, seed collectors should be deployed.

Filtering seawater through a 90-micron sieve.

Once seed collectors are in the water, monitoring should continue in order to detect a secondary set. Water monitoring such as this is also helpful in early detection of starfish and hydroid sets.

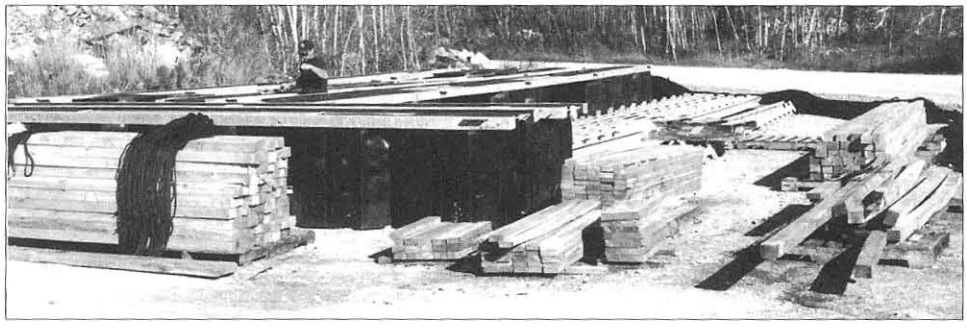
Mussels may be shipped in fish totes, insulated X-actic boxes, or in large canvas bags which fit on a pallet. Bulk shipping to a processor requires 10,000-pound shipments to reduce trucking costs per bushel.

Outreach, applied research

The Maine Aquaculture Innovation Center (MAIC) has been supporting the development of aquaculture in Maine for about 10 years. MAIC formed a mussel suspension culture working group in 1996, with the purpose of advancing the growth of the industry in Maine. Major players have included representatives of Great Eastern Mussel Farms, the Island Institute, Tight Rope Seafarms in Blue Hill and others. The working group obtained funding to enable Dr. Andre Mallet of Nova Scotia to give a seminar on mussel seed collection, mussel larval monitoring and identification, and the basics of longline culture. Other seminars have focused on Spanish rope and machinery suppliers, and the group has watched videos from Prince Edward Island, New Zealand, and Spain.

Using a $2,000 grant from MAIC, the group investigated mussel seed collection along the Maine coast. A few areas were identified as good areas for collecting mussel seed, which settles in late June and grows to about one-inch by early fall if the densities are low enough and if there is a lack of starfish settlement.

Subsequently, the working group received a $15,000 grant from the Up East Foundation to purchase mussel grading and socking equipment from Spain, where there are over 4,000 65-by-65-foot mussel rafts, and a hydraulic power pack for use in commercialization efforts. Members of the industry invested $75,000 in three large raft kits imported from Kames Fish Farming of Scotland, and the Island Institute spent $25,000 for six small rafts for use at sites near coastal islands. See the accompanying account for details.



Kames rafts, in unassembled kit form.

Chip Davison of Great Eastern Mussel Farms, Inc., developed business plans for start-up operations and helped to form a financing company and a mussel raft construction company, Maine Aquaculture Equipment, LLC, to build rafts using Maine materials. All of the projects have been successful (the first large raft yielded 30 tons after 18 months), and there is currently a need to develop a reliable supply of suspension-culture mussels in Maine to meet market demand. By 2000, some market analysts believe, there will be a need for a minimum of 300 tons of mussels per year, and market demand will be about 12,000 tons — 40 times that amount.

Sales and marketing

The purpose of this handbook is to provide current information on techniques for growing mussels on ropes suspended from rafts. As stated in the introduction, mussel aquaculture was first attempted in Maine in 1973. Since then, there have been several efforts. Development of the industry has been slow but production and net yields from current projects have been high, spurring interest from fisherman and manufacturers. There are opportunities on every level from raft and equipment manufacturers to mussel growers, wholesalers and processors. The mussel market is very strong and still growing, creating opportunities for both growers and processors/shippers. Mussel grower cooperatives (Co-ops) could form where growers could each own a share of a harvesting barge or perhaps become a collective wholesaler or processor. Seed production could also become an industry in itself, as it is in Spain.

Getting into business

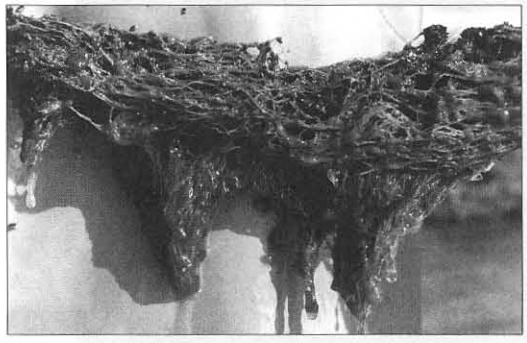
According to the Food & Agriculture Organization (FAO) at the United Nations, worldwide wild-harvest fish landings are not keeping up with the growth rate in the world demand for seafood, and will be unlikely to contribute to any future expansion in supply. The FAO predicts that this supply gap will be supplemented with aquaculture products. In 1996-1997, wild harvest grew less than one percent. Aquaculture production has grown 39 percent in the last three years.

Production is only one part of the equation. Analysts have detected a slight decline in consumption — per capita seafood consumption dropped by 0.2 pounds to 14.6 pounds per capita in 1997. Overall volume of seafood consumed last year decreased as well.

Why? The answer may be low supply and the fact that seafood prices are higher than prices of com-

Seed collectors

Seed collectors have traditionally been old rope of any sort hung down into the water column to catch setting mussels. In 1996, during the first year of the Sea Station Project, 240 seed collectors were made out of 12-foot pieces of old and new pot warp weighted with half a brick.



Heavy hydroid set choking out mussel set.

During peak settlement the collectors were tied onto the rafts at Allen Island and Long Island. After settlement in 1996, it became clear that pot warp tends to attract hydroids. Hydroid densities were so thick that the mussels were completely suffocated at the Allen site, and Long Island did not receive very high settlement densities.

During the winter of 1996-1997 a small group of potential mussel raft growers formed a mussel working group. This group (including the Island Institute) received funding to

petitive proteins like beef and poultry. Supermarket consolidation may also be a contributing factor. To cut costs, many large retailers are converting their full-service seafood counters to self-service. The result is fewer seafood selections and lower sales volume. Suppliers in the future will have to accommodate the growing store demand for case-ready, packaged products and the expanding consumer demand for easy-to-prepare seafood meals.

These general trends, however, do not capture the specific dynamics in the world mussel market. Overall, mussel production has risen sharply over the last ten years, mostly in response to an increase in demand for high quality mussels. Historically the "blue-collar" of bivalves, raked up wild along beaches and sold for a few bucks a bushel, blue mussels have become one of the nation's trendier and more highly demanded foods.

To start a mussel business, you will need a plan to provide proof that you can create income by the sale of a product, in this case market-size mussels. Mussels can be sold on many different levels — wholesale, roadside, retail or "value added" (cooked or processed further).

It cannot be stated often enough, however, that becoming a mussel grower does not in any way mean one is a mussel processor or marketer. This handbook assumes that the market-size mussels produced will be sold to a wholesale processor and shipper. A grower may also be a processor and shipper, but the investment in processing equipment, refrigerated trucks, an inventory of packaging supplies, government certification for trucks and facility, state shipper and re-shipper licenses, personnel and fiscal management can be staggering and too often underestimated. Ill-planned marketing may lead to the quick demise of a mussel farm. At least in the beginning, it is advisable to focus on producing mussels with good yields and selling to a local processor or cooperative.

As of September 1999, there are very few mussel processors in Maine. Tight Rope Seafarms is located in Blue Hill, Maine. Great Eastern Mussel Farms is located in Tenants Harbor, Maine. Great Eastern offers $20 per bushel to growers. This is a yield price. For instance, if a grower brings in 100 bushels of unwashed, un-graded mussels to the plant, the plant will run the mussels through the cleaning, de-byssing, chilling and packing line. If at the end of that run 75 bushels are packed, that lot attained a 75 percent yield and the grower will be paid for 75 bushels.

The business plans outlined in this handbook are based on a $20 per bushel net price to the grower, which was the price paid by Great Eastern Mussel Farms in 1996, 1997 and 1998.

Writing a Business Plan

A self-employed person typically expresses certain personality characteristics that are usually important to success. Some of these characteristics are:

- A need to set goals and be well organized
- A sincere dedication toward achieving goals
- Confidence and positive attitude
- The ability to think fast and creatively

Going into business for yourself means:

- Being disciplined and patient: you can expect little or no income from the business for two or three years
- Being willing to update customer lists, reconcile accounts receivable, settle the accounts payable, update the inventory and all other critical business records every night before you go home
- Keeping a positive attitude
- Being realistic
- Being willing to admit when you're wrong
- Having confidence
- Making sacrifices
- Solving problems
- Taking risks

In short, the small business owner who is in the supply business must make reasonable, market-based assumptions for identifying and targeting the most lucrative markets, and develop a secure network with buyers, suppliers, and potential future partners. He or she must set achievable business and lifestyle goals with a reasonable time line for accomplishing them. It is important to remember that all business activities should be planned toward the ultimate goal of producing enough cash to maintain or help the business to grow and supplying a comfortable life for the owner and those who depend on the owner.

A business plan is a tool and an operations manual for an enterprise. The plan must allow the reader to understand the business and products, identify potential customers, and predict potential pitfalls. The business plan must include a contingency plan, should the business run into trouble. Owners and other participants must be identified. The plan should state what experience and skills they bring to the business. The total tangible assets needed must be identified, as well as where they will come from, and

perform a small experiment to test different types of mussel seed collection ropes obtained from Japan and New Zealand. The Institute trained the group members to monitor spat and quantify the mussel larvae, using microscopes it provided.

At six locations along the coast, including Isle au Haut and Lubec, mussel group members monitored for spat. At peak settlement a variety of collector ropes were deployed at each site, including New Zealand Christmas Tree rope, Japanese Artificial Seaweed rope and poly pro pot warp. At the end of the summer in 1997, the group met and members compared settlement densities on the various types of ropes. Yield per meter of collector material was determined for each site and it was found that the New Zealand Christmas Tree was superior to

Grading seed with Aguin portable grader at Great Spruce Head Island site.

what they will cost. Other questions the business plan should answer include:

- The number of potential customers
- How to communicate the benefits and quality of our product to potential customers
- How much space will be needed
- Staffing needs

The business plan is based on an entrepreneur's idea. It may be used to start and operate the business; it will be a tool to convince lenders to support the business. One can find copies of business plan outlines at banks, at economic development agencies, on the Internet, and from Small Business Development Centers or Small Business Administration offices. No one plan works better than any other. What follows is a suggested outline for a business plan.

- **The cover letter** — typically directed to investors or lenders.
- **Executive summary** (often in place of the cover letter) including a very brief history of the company performance (if already in business), a summary of the projected cash flow, some critical market information, and a paragraph on the experience and skills of the prospective owners. It is basically a summary of the entire business plan in two or three pages.
- **Introductory page** (contains business plan author's name, title, address and phone number).
- **Table of contents**
- **Mission statement** and/or company objectives.
- **Description** of the company including proposed management, location and product or services
- **Marketing plan** including competitive analysis and strategy for positioning and servicing products or services. Here, the author must focus on the business customer's needs rather than on what the owner "thinks" the market is.
- **Production plan** including layout of facility, material sources, and inventory needs
- **Sales and production forecasting**
- **Financials** including projected cash flow and balance sheets, year to date data (for existing businesses), three years of historical data (if applicable), business tax returns (if applicable), and personal financial statement.
- **Exit strategy** — important if the company is funded by investors. In other words, if the company is not doing well, what plan is in place to minimize losses?
- **Contingency plans** for recovering from that which can and will certainly go wrong, including abandonment plan.
- **Summary**
- **Appendix**

Generating a persuasive plan means completing a lot of research: an analysis of the industry, the competition, suppliers, customer profiles, sources of materials. A competitor might find a plan to be a real advantage to its business, so confidentiality is important. Most prospective business owners need assistance with preparing a plan. A local Small Business Development

Center (usually located at an economic development agency such as Coastal Enterprises, Inc., in Wiscasset, Maine, or a Council of Governments such as Eastern Maine Development Corpor-ation, located in Bangor, Maine) offer free advice and guidance for such a task.

Planning a mussel business

Having the ability to anticipate and project costs, income and the cash flow of a mussel raft farm will ease the nerves of the aquaculturist, his or her family and, of course, the lender. Below are a mussel farm work timeline and examples of cost and income spreadsheets for both a small and larger mussel farm. Production of the smaller farm is based on a net yield of four pounds per foot in an 18-month turnaround from seed to harvest. The larger farm is estimated to have a net yield of eight pounds per foot in a 24-month period resulting from higher stocking densities. The smaller farm is less mechanized and uses 10- to 15-foot, hand-socked drops. The larger farm seeds 35-foot ropes using the Aguin roping machine, and harvests with a crane and an 8-foot diameter basket hoisting up to 2,000 pounds a lift.

Timeline

March: Prime harvest. Order materials and begin building mussel rafts.

April: Prime harvest. Investigate possible sites.

May: Begin plankton monitoring and deploy rafts.

June: Monitor mussel spat for optimum settlement on collectors. Deploy collectors.

July: Monitor seed settlement at all sites.

August: Continue to monitor seed settlement and note and correct fouling. Monitor starfish settlement.

September: Prime harvest. Organize supplies for seed socking.

all the other types of gear. At the Allen site, this type of collector rope also had negligible fouling, which was in contrast to the pot warp which was completely covered in hydroids.

Seed grading and roping

Once the seed mussels reach a shell length of one-half inch on the collectors, the mussels must be stripped and thinned in order to continue growing at optimum rates. Seed is graded either manually through sized grates, or through grading drums made from metal rods. Sized seed is then re-sleeved into the proper sized plastic mesh tubing at densities of 500 mussels per meter. Sleeves are usually placed into sea water baths for up to 12 hours to allow the mussels to begin their migration to the outside of the sleeve.

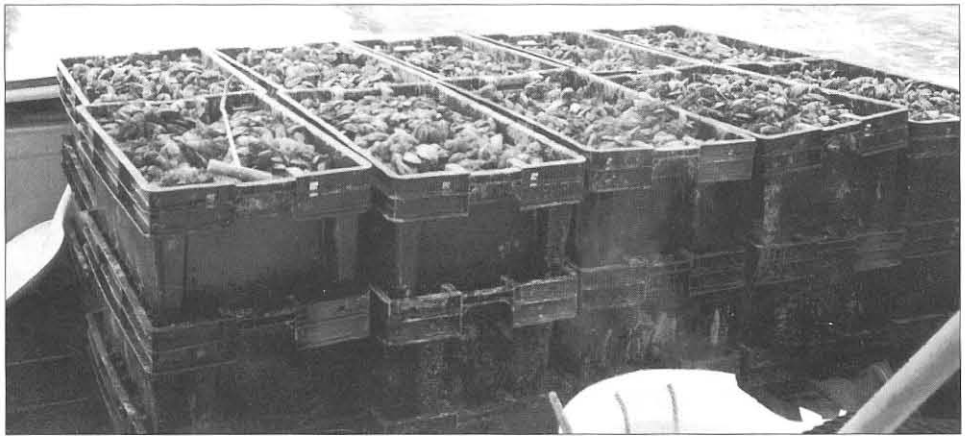
The mussels, ideally, will move to the outside and the mesh will become compressed, becoming the main drop rope, but in some cases, the mussels become caught inside — making harvest difficult and time consuming. A problem associated with this method is that the plastic mesh is not reusable, creating piles of non-biodegradable waste.

In December 1996, 10,000 pounds of 38-millimeter seed mussels were graded, sleeved,

October: Prime harvest. Harvest for good meat yields. Sock or rope seed and re-stock rafts for year two.

November: Prime harvest, good meat yields. Continue harvesting socking or roping.

December–February: Prime harvest, good meat yields. Monitor rafts and seed mussels.



Boat loaded with totes, bound for Great Eastern Mussel Farms for processing.

Direct capital expenses and income

(Boats and boat expenses are not included in the following breakdowns.)

Island Institute • 22' x 22' raft (144 drops) • Based on seven year life of raft and nets
(Based on actual; 18-month turnaround)

1. Start-up expenses

Raft complete	$3,000.00
Moorings (2 rafts)	$1,500.00
(Two 50-foot 1 1/8 twisted nylon bridles, two 1-ton granite blocks, 50 feet one-inch chain, and 100 feet 5/8 chain to make up a two-point mooring system, assuming 37 feet depth at high water)	
Predator net/raft	$545.00
Seed from Tight Rope	
Sea Farms @ $5.00/bu (30 bu/raft)	$150.00
Irish sock .04 cents/ft @2196 ft	$86.00
Labor to build, stock and harvest raft 100 man hours at $10.00/hr	$1,000.00
Total	$5,381.00

2. Income (18 months from start-up) $2,584.00

Production from one raft should yield 130 bushels of 55-60 millimeter mussels at $20.00/bu (sold

unwashed in totes). Raft production goal is to achieve a net yield of at least 4 lb. of market size mussels per foot of drop line.

Maine Aquaculture Kames Raft • 40' x 40' (500 drops) • Based on seven year life of raft, net and droppers
(Based on estimates; 24 month turnaround; five-year, 27-percent return on investment)

1. Start-up Expenses

Raft kit	$15,500.00
Moorings (4 rafts)	$4,500.00
(2-50 foot 1 1/8 twisted nylon bridles, 4-2 ton granite blocks, 200 feet 1 inch chain, and 400 feet 5/8 chain to make up a 4 point mooring system)	
Predator net/raft	$1,000.00
Seed (300 bu/raft)	$1,500.00
500 35-foot ropes with pegs (pre-made @ $10.00 each)	$5,000.00
Aguin roping machine, grader and cotton supplies	$10,000.00
Labor (build, rope, and harvest) 700 hours at $10.00/hr	$7,000.00
Total (40' x 40' raft)	$44,000.00
2. Income (24 months)	$42,000.00

Production from one raft should yield 2,100 bushels of 55-60 millimeter mussels at $20.00/bu (sold unwashed in totes). Raft production goals are to achieve a net yield of at least 8 lb. of market size mussels per foot of drop line. The 24-month turnaround is necessary to reach production goals because original stocking densities are much higher with the Spanish roping machine than the hand socking method, meaning a slower growth rate for the larger raft.

and deployed onto the three rafts on Allen, Hardwood, and Long Islands. At all three sites, many of the mussels did not migrate out through the sleeves creating problems for future harvesting. Other methods for re-seeding needed to be investigated.

The Spanish method of grading and re-seeding, for example, utilizes a heavy main down rope cut to appropriate length for each site with plastic pegs inserted at every one 1.5 meters. The graded seed is then wrapped onto the main rope at densities of 500 per square meter with a biodegradable acetate mesh, much as one would wrap an arm with an ace bandage. The mesh disintegrates slowly in the water and the mussels will then attach themselves to the main down ropes. This process eliminates the problem of mussels becoming lodged in plastic mesh. Once the seed is re-socked, the mussels should reach market size (55-60 millimeters) within 18 months. After harvest, the Spanish down ropes can be reused.

Growout

Once seed collectors are stripped and the mussels are graded, thinned, re-socked, and placed back onto the rafts, the mussels should reach a market size of 55-60 millimeters in 12-18 months. Because of the grading and thinning process,

Training and information

Island Institute
410 Main St.
Rockland, ME 04841
Contact: Corrie Roberts (207) 594-9209
<croberts@islandinstitute.org>

Maine Aquaculture Innovation Center
5717 Corbett Hall, Rm. 438
Orono, ME 04469-5717
Contact: Mike Hastings (207) 581-2263

Great Eastern Mussel Farms
Long Cove Road
Tenants Harbor, ME 04860
Contact: Chip Davison (207) 372-6317

CED/Fishing Industry Retraining Project
116 Tillson Avenue
Rockland, ME 04841
Contact: Scott Tilton (207) 594-2267

Leases and Permits

In order to practice suspension culture of mussels, either for seed collection or grow-out on rafts, you need an aquaculture permit, called a lease. This gives you ownership of the shellfish you have grown on the lease site and protection against unauthorized activities such as poaching. The leasing process usually takes about a year for site evaluation work, filling out an application, site review by the Department of Marine Resources (DMR), public hearings and notification, if the application is for a standard lease. An experimental lease application may take less time. Detailed GPS coordinates, current measurements, diver video observations, and a fair amount of legwork are required for a full lease. For aquaculture lease information, contact the Aquaculture Administrator at the Maine Department of Marine Resources, P.O. Box 8, Boothbay Harbor, Maine, 045538, or call (207) 633-9500.

A good way to start in aquaculture is to get an experimental lease. The application is shorter, the fee is smaller, and the review may be quicker. An experimental lease allows a maximum of three years to try growing approved species on a site two acres or smaller. An experimental lease may be upgraded to a standard lease for a longer lease period. With typical water depths of 55-70 feet at low tide, a two-acre lease could support up to three 40-by-40-foot mussel rafts and produce 60 to 90 tons of mussels per year in full production. An experimental lease will often prevent wasted time if there are problems with ice, ducks or starfish.

There is little substitute for local knowledge about a site for determining its suitability for mussel raft culture. Spend time with local fishermen to discuss potential benefits or problems that the project may create. Talk to riparian (adjacent) and local landowners to make sure they understand the project. Investing your time in communicating about your project with landowners and fishermen will pay big dividends in gaining their cooperation during your start-up and for any future expansion. Minimize visual impacts as much as possible, take a common-sense and comprehensive approach to safety precautions, and use best management practices.

In addition to a lease, the mussel grower must only harvest from a certified growing area and also obtain a commercial shellfish mussel hand harvester's license from the state. This license will allow the grower to transport his mussels by truck on short runs and sell his mussels

to a wholesaler. If the grower processes on site and stores the cleaned mussels in bags hanging off the rafts, for instance, he will also need a wet storage permit. If the grower chooses to sell as a wholesaler or retailer, a state wholesale seafood license is required. Each vehicle the wholesaler uses to transport mussels must have an impervious floor, insulation and cooling capabilities, etc., and also be inspected by a state shellfish inspector. The wholesaler must also have an inspected facility with hot and cold potable water, waterproof flooring and walls, adequate drainage and septic system and a cooler. The wholesaler must also be certified under the federal HAACP program (*see Glossary, page 33*). Certificate holders must submit monthly reports to the state, listing the shellfish bought and sold, their sources and destinations and dates of transactions. A label or marketing tag must accompany each box or bag of shellfish that is transported. The tag must include the name, address and certificate number of the grower, the place of origin, the date of shipment, and the destination. Tags are the grower's responsibility. In order to transport seed over the road from site to site, a mussel grower must also obtain a special permit issued by the state Aquaculture Coordinator.

Shellfish regulations are a work in progress. The above list is incomplete. Growers should consult with the Maine Department of Marine Resources for the latest changes. Regulations are posted on the World Wide Web at <www.state.me.us/legis/homepage.htm>

— By Corrie Roberts, Carter Newell, and several others at the Island Institute, with assistance from Ed Myers. Design by Charles Oldham.

Sections of this text are adapted from *The Great Eastern Mussel Cookbook* by Cindy McIntyre and Terence Callery (Eriksson, 1995).

Business plan incorporates material provided by Coastal Enterprises, Inc.

Hauling out 15-foot down lines — each weighing approximately 150 lbs. — by hand for final harvest.

harvest yields will be close to 100 percent, which makes production estimates per raft easy to calculate. Close records should be kept during each process in order to track production.

Harvest

Twelve to eighteen months after socking, mussels should reach market size of 55-60 millimeters. They may be harvested at any time after the mussels are of adequate size, but it is advisable not to harvest during the warmer months — summer spawnings will reduce meat yields and shelf-life significantly.

Harvesting entails stripping of mussels off the grout ropes, washing, de-clumping, debyssing (removing the threads), and packaging. Great Eastern Mussel is in the process of building a specialized production line containing machines designed specifically to clean and de-byss rope-grown mussels, and is now

Suppliers

Mussel Seed:
Tight Rope Sea Farms, HC 64, Box 397, Brooklin, Maine 04616. Paul Brayton (207) 359-9802

Mussel rafts:
Maine Aquaculture Equipment (MAE), P.O. Box D, Newport, Maine, 04953, (207) 368-4344 (fax 5552). Also suppliers of Spanish hydraulic equipment, pegs and dropper cases. (Approximately $16,000 for a 30-ton mussel raft, 40 x 46 feet with 24 250-gallon floats with closed cell foam, galvanized U-channel and I-beams, and 3-x-4-inch dropper beams, capable of supporting 500 mussel rope drops, each 35-feet in length)

Galvanized dock hardware:
Dock Hardware and Float Dist. PO box 686 Geneva NY 14456 800-826-3433

Hydraulic power packs:
Billings and Cole, Damariscotta, Maine (207) 563-1010

Half inch polysteel fuzzy mussel rope:
Crowe Rope, P.O. Box 600, Waterville, Me. 04901. 800-848-4495, Wayne Weir, sales manager: (207) 832-0394.

Spanish mussel grader, tables and socking machines:
Available from MAE (above), also direct from Spain:
T. Aguin, Ardia, 178, Ponte-verda, 36989, O Grove, Spain, 011-34-989731091

Spanish rope with pegs, cotton binder for socking machine:
J. J. Chicolino, Cordeleria, Vilarino, N/N, 15930, Boiro, La Coruna, Spain 011-34-981-845909.

Plastic dropper weight cases, mussel raft kits:
Kames Fish Farming, Ltd., Peter Richardson, Kilmelford-by-Oban, Argyll, Scotland PA344XA 011-44-1852-200286

Fuzzy rope, graders and continuous longline systems:
Sam Bower, Atkinson and Bower, Shelburne, NS Canada BOT 1WO (902) 875-3281

Mussel socking table:
Steel-Pro, Rockland, Maine (207) 596-0061

Mussel sock (plastic):
IMP Group, 40 Shurman St., Charlottetown, PEI Canada C1E 2A9

Mussel sock (Irish Mesh):
BMI Bridport Maritime Industries Ltd., 205 Blue-water Road, Bedford, Nova Scotia, Canada B4B 1H1 (902) 468-0300

Fukui North America, PO Box 119, 523 Islandview Drive, Golden Lake, ON KOJ 1X0, Canada (613) 625-2688

Net hanging hooks:
Plante's Lobster Escape Vents, 3628 Turner Ridge Road, Somerville, Maine 04348. Contact person: Eric DeDoes
(207) 549-7204.

Predator nets, mooring systems, buoys and X-actics boxes:
Cards Aquaculture Products Ltd., RR 2, Mealy Road, EOG 2RO, Canada. Contact person: Roger Waycot
(506) 465-3382

Scientific equipment:
VWR Scientific Products
(800) 932-5000

Aquatic Ecosystems, Inc.
(877) FISH STUFF

Further reading

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Lutz, R.A. 1980. Editor. "Mussel Culture and Harvest: A North American Perspective." Developments in Aquaculture and Fisheries Science, 7. Elsevier, New York. 350 pp.

Lutz, R.A., K. Chalermwat, A.J. Figueras, R.G. Gustafson and C.R. Newell. 1991. "Mussel aquaculture in marine and estuarine environments around the world." Estuarine and Marine Bivalve Culture, W. Menzel, Editor. CRC Press, Boca Raton, 57-98.

offering to pay up to $20 per bushel for rope-grown mussels. Great Eastern currently pays $6 per bushel for wild mussels, which usually have much lower yields than rope-grown mussels.

The future

The first two years of the mussel raft project were productive. Various seed collectors were tested, resulting in the discovery of an excellent and economical collection material. A small portable mussel raft was designed, built and tested. It proved able to withstand testing ocean conditions. The Mussel Working Group was able to expand the project five-fold, adding more sites and bringing the number of individual participants to thirty-nine.

The mussel raft project offers an economic development opportunity to fishermen and others looking to supplement their income by becoming rope culture growers. Growth in this industry would also impact rope manufacturers and machine fabricators who provide seed collector ropes, metal floats, pre-fabricated metal rafts, metal declumpers and other gear.

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Glossary

Binder: a spool of biodegradable netting used with the AGUIN mussel roping machine to attach seed mussels to a main rope

Biomass: amount of tissue weight per area or foot of rope

Bushel: a volume of mussels weighing approximately 60 pounds

Byssus: threadlike strands mussels use to adhere to a substrate

Byssal thread: (same as byssus)

De-clumping: to break up clumps of mussels held together by their own byssal threads

Dropper weights: weights attached to the bottom of downropes or mussel socks to help sink and stabilize the lines

Eyespot: a microscopic black spot formed in the later stages of mussel larval development

Grading: the act of cleaning and sizing mussels

HACCP: Hazard Analysis Critical Control Point. The U.S. Food and Drug Administration has a mandatory HACCP program for all shellfish wholesalers

Lease: a privilege granted by the State of Maine for a set term allowing specified marine species to be cultured on the surface, in the water column, or on the ocean floor of a subtidal area of State waters. A lease is required by the Maine Department of Marine Resources for culturing any marine organism

Longline: a surface or subsurface line anchored at both ends, supporting downlines or droppers

Longline culture: the method used to grow certain shellfish by attaching nets or lines to a main topline anchored at both ends

Mantle cavity: the area between the layer in contact with the shell (mantle) and the remainder of the bivalve body

Meat: the entire flesh of a bivalve

Omega-3 fatty acids: the "good kind" of fat

Potwarp: rope used in lobster fishing

Phytoplankton: microscopic plants drifting with the currents in the ocean

Purging: cleaning mussels by placing them in clean circulating seawater not necessary in rope cultivation

Raft: a rectangular floating structure used as a work platform and/or to support gear and lines in the water

Re-tubing: to insert seed mussels into a sock mesh material

Rope culture: method of suspended mussel culture

Secchi disk: a circular plate painted with alternating black and white pie shaped wedges used to measure the clarity of the water

Seed: juvenile mussels

Seed collection: to capture larval and settling mussels in the water column

Seed grading: to separate different sizes of juvenile mussels

Set: the local occurrence of larval mussels settling on a surface

Socking: (*see* re-tubing)

Stripping: to remove mussels from their downlines or sock mesh.

Substrates: types of bottom or mussel attachment surfaces

Suspension culture: to grow shellfish by suspending them in the water column

Thinning: to grade/size and sock or rope mussels at a lesser density then what occurs in the wild to accelerate growth rates

TML: the largest mesh size Irish mesh socking material

Tote: a nesting or stacking container, typically used to hold groundfish and shellfish for transport

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410 Main Street • Rockland, Maine 04841 • (207) 594-9209 • www.islandinstitute.org