THE HUSBANDRY OF MUSSELS IN A MAINE ESTUARY:

An Approach to A Commercial Enterprise

by
Edward Myers
Abandoned Farm, Inc.

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"I hold every man a debtor to his profession; for the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavour themselves by way of amends to be a help and ornament thereto,"

—*Francis Bacon*

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Edward A. Myers
Abandoned Farm, Inc.
Damariscotta, Maine 04543

Edited by William S. Burtis

To Two Quartets:

First, to the children, who
if only they had started soon
enough, might have brought me
up properly;

Second, to Gerald Brace, Eleanor
Clark, John Hay, and E.B. White,
who, if only their writings had
had a more willing pupil, might
have taught me everything I needed
to know.

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FOREWORD

This document sets out to assess the possibilities for making the husbanded mussel a money crop on the Maine coast.

It also reviews the germane part of how Abandoned Farm set about mussel husbandry in Clarks Cove on the Damariscotta River in Lincoln County, Maine.

This report has no scientific pretensions; there are no scientists, academic or otherwise, at Abandoned Farm; its content and conclusions are solely those of the corporation; approval by the University of New Hampshire has been neither granted nor sought.

There is no bibliography. An extensive literature, scientific and popular (as is customary, some of both sorts should be read warily and some are downright misleading), describes half a dozen centuries of mussel cultivation in dozens of locations on many archipelagoes and on all the continents save Antarctica. There are four basic books:

Bayne, B.L.: Marine Mussels; Cambridge University Press, 1976.

Korrings, P.: Farming Organisms Low in the Food Chain; Elsevier, 1976.

Bardach, John E., Ryther, John H., McLarney, William O.: Aquaculture; Wiley-Interscience, 1972.

Schwind, Phil: Practical Shellfish Farming, International Marine Publishing Company; 1977.

The bibliographies therein may lead to many months of reading.

And a fifth, which is a must: Eleanor Clark's The Oysters of Locmariaquer (Pantheon Books, Random House, 1964); aside from its instruction in the husbandry of molluscs, the book is a pure delight.

Those who disregard the lessons of history are condemned to repeat them. In aquaculture, you are condemned to repeat most of them anyway, in order to confirm their applicability to your site and to your objectives.

SUMMARY

The objective of Abandoned Farm's subcontract with the University of New Hampshire, which spanned 39 months, until March 30, 1978, was, if possible, to create a commercially effective company engaged in the husbandry of mussels. The idea, in other words, was to sell mussels for more than it cost to tend and harvest them.

Abandoned Farm did not accomplish the objective during the period. Stated simply, we lost our shirts. (This may be hereinafter referred to as 'development expenses,' since we're not through yet.)

Luckily, there is no need to apportion a desolate heritage among the taxpayers, via the subcontract (less then one-third of our capital) and the stockholders. The problems, if they can be called such, were simply lack of time to solve problems (assuredly translatable as inadequate management) and lack of capital, working and otherwise.

The idea of husbanding mussels has validity; it becomes more compelling every day. The product is magnificent, the market grows apace, the technology is being worked out; the American eating public is due for a real treat, and some investors are going to make pleasant amounts of money providing it.

At Yerseke, in the Netherlands, it is possible to stand at the head of the quay and be within half a mile of any service a mussel grower may conceivably need (and there are a lot of them): welders, knowledgable blacksmiths, iron-mongers, marine hardware dealers, ship chandlers and ship repairers, berths, moorings, mussel dealers, brokers, exporters, trucking companies, processors, and shuckers. There is even a quality-control syndicate that pays a base price if the mussels spawn in transit and sends them back for replanting. All of this is predictable after centuries of business.

At Vigo, on one of the Galician rias in northwest Spain, the availability is the same along a couple of miles of waterfront in a bustling city with its face toward the sea. And then there is SOMEGA, the Society of Mussel-Growers in Galicia, which, with four or five local phone calls, can set a prospective musseler in business, and in touch with a friendly savings bank accustomed to making crop and equipment loans. Not unpredictable after three decades of becoming the largest mussel-producing area in the world.

Without any of the Dutch or Spanish infrastructure, Abandoned Farm tried to do the whole thing in microcosm, in a fairly isolated by-water with a boreal climate, wherein the local populace thought of mussels as grandfather's trawl-bait or a considerable nuisance and regarded anyone who wanted to raise them as at least suspect and perhaps certifiably insane.

Nevertheless, with the burgeoning interest and with homeopathic doses of American ingenuity and acceleration, Abandoned Farm's estimate is that a husbanded mussel industry in the United States will be operating profitably within another ten years.

If it isn't, it ought to be.

CHAPTER ONE

The Rationale

Feed the World Syndrome

First let's dispose of the feed-the-world syndrome, beloved of freelance feature writers and even of some prospective mussel farmers. It does have a certain fascination because all it takes is some simple arithmetic.

Here are the numbers from a trade book published in 1977. It goes like this:

An acre in a Galician ria has annually produced
clear mussel meat weighing 300,000 lbs.
A New England Bay of less than 300 sq. mi.
could therefore produce 43 billion lbs.
Ergo, concludes the author, each person in
the USA could have annually 2,000 lbs.

Before facing the challenge of delivering five and a half pounds of mussel meat every day to everybody (about 12 times the U.S. consumption of meat grown on land), let's check the figures: 43 billion annual pounds divided by 215 million people = 200 lbs. a piece. Despite the 90% error, it's still impressive.

So: if one could transfer the best producing Spanish acre to somewhere north of Cape Cod; if it could be surrounded with 143,332 equally productive acres; if the top 50 feet of a 224 square-mile area could be heated to the Spanish temperature ranges of 9-20° Celsius (instead of the -2 to +16° C normally observed in the Gulf of Maine); it is certainly arithmetically possible that everyone in the world could have 10 pounds of mussel meat--or thereabouts--annually (unless the United States insists on its full quota of 200 pounds per capita).

There are some constraints in moving from arithmetic to reality, and there may be some delays in stamping out kwashiorkor and marasmus with husbanded mussels.

The anticipated delays do not make it a less worthy goal; but the process is normally from specialty or gourmet food, to staple,

to commodity. The husbanded mussel in the United States is not likely to escape having to follow that path.

Feast to Famine Figures

There is a classic pattern from fishery to fishery along the New England coast--and probably everywhere else in unplanned economies: the process, in modern terms, is the passage of a species from "underutilized" to "endangered."

An 18th-century indentured servant, it is said, could not be forced to eat salmon more than twice a week.

In the first decade of the 17th century, Popham's colony rebelled at being fed lobster at every meal. An early 19th-century lobster-gatherer either used the crustaceans for fertilizer on his garden or tried to conceal his feeding the family with lobsters, lest his neighbors deem him shiftless.

Into the 20th century, town clam laws proliferated as a welfare measure to reserve the clam flats as a resource for people "on the town" or with no other means of support.

It may not be immediate--it is hard to conceive of the complete disappearance of the mussel--but it is within the realm of possibility that the wild mussel might be on the same road of glut followed by exploitation followed by overharvesting followed by crisis.

In 1939, the digger's price for steamer clams was 25 cents per bushel; in 1978 it was 80 times that. Lobsters brought 15 cents a pound at the dock in 1939; for 1978 multiply that by 20, and add predictions of a crash in supply in the 1980s.

Anyone over 40 can remember eight-cent haddock.

In 1951, Maine shrimp could be bought off the tailgate of a pickup on Main Street in Damariscotta for a dollar a bushel (and that included the basket). By 1977, the dockside price was more than 55 cents a pound (and the catch less than 2 percent of the peak).

In 1939, the digger's price was a dime per bushel of wild mussels; in 1977 the price had multiplied by 30. That really isn't saying much, since the price move starts with such a low multiplier and is really only following the minimum wage.

What is needed is a look at the familiar review of available supply in Maine: this is not conclusive, since the mussel was of minor moment post-war, but it does illustrate what could happen.

The interest in food sources to offset meat-rationing and to feed the British led to a 1942-43 survey by Scattergood and Taylor of the U.S. Fish and Wildlife Service. The survey was published in 1949 and suggested there was in 1942 a useable supply of 310,000 bushels of mussels from East Penobscot Bay to Eastport. On the assumption that this was about half the Maine coast, the total availability could be guessed at around 600,000 bushels of mussels.

Dow and Wallace (1954) compiled the production figures from 1942-1948 on behalf of the Maine Department of Marine Resources (DMR), then known as the Department of Sea and Shore Fisheries. They go like this:

Calendar Year	Mussel Harvest (Bushels)
1942	7,600
1943	132,000
1944	175,600
1945	171,700
1946	154,300
1947	2,700
1948	8,300

Dow and Wallace give two reasons for the 98.25 percent drop in 1947: 1) the restored availability of meat; and 2) the suspicion that "canning operations during the war years had cropped almost completely" the ready supply.

Meat rationing ended in the spring of 1945; some contract extensions to provide mussels to the British might be expected for 1946, but not of the magnitude indicated. (The principal canner has disposed of his records, so there is no way to check.) The evidence leans toward the supply shortage for 1947, with a small recovery in 1948.

In a three decade leap forward, Maine Landings reports a production of 141,000 bushels for 1977, an increase of 75 percent from

the 80,200 of 1976; December 1977, alone accounted for more than 53,000 bushels. A 25 percent increase over 1977 would surpass the 1944 peak.

Now it's possible to toss figures around and come up with a number of conclusions, such as:

1. Maine is headed for a wild mussel crash of 1947 proportions: a 98 percent decline, back to about 3,000 bushels;
2. Maine is not headed for a crash because, in the 40s, musseling was all intertidal pitchforking and now most of the mussels are dragged, a lot of them from beds inaccessible to the hip boot;
3. The average wild mussel of market size is 8.2 years old and if the annual harvest is 100,000 bushels and the standing crop is fewer than 600,000 bushels, there will be a crash;
4. The average age of 8.2 years is true, but the first measurements on wild mussels were taken in 1977, and perhaps a recovery in four years is possible;
5. Scattergood and Taylor worked eastern Maine in 1943, when a big source of wartime mussels was Casco Bay, out of their survey area, so the coastwide standing crop is much bigger, even though there are now major polluted areas just east of Portland;
6. The data are thin and wide apart and the whole thing is cyclical and random as to bed-recovery, so there need be no regulation and the fishery should be left to itself;
7. The fishery should be regulated as to minimum size, closed seasons, or closed areas, or any combination thereof in order to preserve the resource.

Whatever conclusions could be drawn, a number of other factors have come to bear in the last decade:

1. The supply of hard clams--surf, deepsea, quahogs--dwindled and contract prices on clam strips for the fried-clam trade have leapt from 60 cents to $1.80;
2. Since OPEC raised its burnoosed head--and the price of petroleum fertilizers--the search for alternative sources of protein has intensified;

3. Per capita consumption of ocean products has risen;
4. Two-thirds of American seafood consumption is in restaurants rather than at home, and the proportion of meals eaten outside the home is increasing;
5. Inflation continues to make the homemaker more alert to good buys in protein and nourishment;
6. Millions of American tourists have been introduced to mussels in Europe.

A combination of these factors has contributed to a situation which can't be proven, but seems to be pivotal: Mussels are no longer an ethnic food, confined to French, Italian, and Spanish restuarants. Consumption of mussels in the United States has been increasing at a 16 percent annual rate (Clifton, 1977) since the late '60s. That curve is now turning upward (see graphs, page 33), as reflected by Maine's production increases, while world production has been growing at only a 5 percent annual rate (FAO, 1975).

For all these upward pressures, economists would still call the nature of the wild mussel market "price inelastic," a phrase that means nobody has to have them.

This seems to be true. A seafood dealer who has no lobsters or littlenecks will go to indecent lengths to latch on to a supply and will blithely drive up the price to get them. But if he has no mussels, he simply offers his customers something else and waits for the mussels to arrive some other day.

The price for a bushel of mussels on the New York wholesale market hovers between $9 and $10. It is a long way from the $1.25 a bushel low of 1951, and it is gratifying to note that Maine wild mussels frequently command a premium of 50 cents or a dollar over New York and Massachusetts mussels. But the price is still "inelastic" in the sense that is stays pretty much the same for months at a time, without regard to weather or demand.

The situation reflects the historical fact that mussels were a species held in low esteem. Two examples: a shipper of whiting who says if he has a couple of feet at the back of the truck after making his load of fish, he throws on fifteen or twenty bags of mussels to

toss into the Fulton market gutter for something to stand on when unloading; a dragger of mussels south of Cape Cod shovelling hosed mussels into bags without regard to cracks or mudders on the expressed ground that at that price (five dollars on the truck) he would "let the pizza parlors pick them over."

Supply

Attitudes are changing, but the market still feels that the supply is unreliable and, through the price structure, tells the shippers so.

The supply of wild mussels is unreliable. If they are to be pitchforked, the tide has to be right. Say you wanted some fresh mussels for your restaurant on a Friday in February. Ideally, you'd like Wednesday's mussels and you tell your dealer so on Tuesday. But the tide is low at 4:30 a.m., an hour and a half before sunrise, and it's low again at 5 p.m., a half hour before sunset. The water temperature is 31° F and the air 10° in the February sun. Nobody goes.

Dragging is more reliable, but as a method it also has some dependence on the tide and a certain amount on the weather. There is the added complication that a mussel may gasp a dollop of mud just as the drag comes by and he may need an extra day to calm down and exchange the mud for some pure salt water.

The Netherlands fishery takes this very seriously. Dragged mussels are taken the length of Holland--from the Waddenzee to the Oosterschelde where they are spread on intertidal sand bottom for cleansing, and are in fact turned over by hand during that time on the sand. It is a labor-intensive step that demands skill and dedication; it is not adaptable to Maine, even if the terrain could be found. And if it could be found, it is doubtful that Maine mussel dealers would take the time and money to rehandle all the mussels brought to them.

At which point, there is still no way of telling which wild mussels contain nuisance pearls, a major deterrent to steady sales. Some areas are heavily pearl-infested; some beds vary widely, though only a few hundred feet apart.

For reliability of supply, freedom from mud and palpable pearls as well, suspended culture is the best method. It is adaptable to

Maine, and the Maine coast, with big tides, many areas of clean water, and depth close to shore, is adaptable to it.

Meat Yield and Protein

Whether or not the mussel is going to feed the world, its meat yield and its nutrient value are significant. By weight, oysters are given a 9 percent meat yield; hardshell lobsters figure at about 20 percent; suspended mussels are reported as 50 percent, and a conservative working rule is 35.

Here is the familiar chart comparison with steak, on the basis of ten pounds of husbanded mussels in the shell versus three pounds, six ounces of clear beef:

	Mussels	Steak
Calories	1,900	7,900
Protein	290 g	294 g
Fat	44 g	742 g
Carbohydrates	66 g	0
Calcium	1.76 g	0.16 g
Phosphorus	4.72 g	2.70 g
Iron	68 mg	44 mg
Thiamin	3.2 mg	1.2 mg
Riboflavin	4.2 mg	2.6 mg

On the basis of the evidence, mussels seem to be a good species to choose for saltwater farming. This rationale has everything but money. The only way to get money for something is to prove the thing worth doing.

CHAPTER TWO

First Considerations

Before proceeding to the mechanics of a mussel farm--the basic mechanics of which have been known for at least 20 centuries--it is essential to understand the necessary fundamentals.

Energy

First above all, a water farm (like many other parallel enterprises on land and sea) is an energy system. The stored and converted energy of the sun, in interaction with the North Atlantic Ocean, is there whether or not there is any human intrusion on it.

This energy system will produce 50 pounds of onions from half an ounce of onion seed and 5,000 petunias from half an ounce of petunia seed on land. It will provide 10 bushels of mussels from half an ounce of mussel spat. It will work these wonders as long as humans will go to some trouble and expense to make sure the energy system is directed primarily to the onions and the petunias and the mussels rather than to weeds and thistles and slugs and insects and starfish and ascidians and everything else competing for the energy.

There is, of course, no energy shortage. There is, in fact, a surplus of unimaginable size, one that will continue as long as the earth receives the rays of the sun. (There is, in fact, a temporary energy crisis only because man placed his bet on the slowest possible method of creating energy, via fossils, and the slowest possible methods of energy-waste disposal, via radioactive isotopes.)

With this enormous energy surplus, there is no point in trying to assess how efficient nature is, measured in human terms for human purposes. A power-generating plant may be only 25 or 30 percent "efficient"--which is to say that a thousand BTUs going in as oil, coal, falling water, or uranium come out as 250 or 300 BTUs of power, with the rest lost as friction or waste heat. But this is so in the natural world, as those who worry about the greenhouse effect know full well; and the human being is only about 1 or 2 percent efficient as a metabolizer of protein. He heats the 2,000 cubic feet of air in a 12 x 20-foot room to sustain the body temperature of six or seven

cubic feet of humanity, the latter occupying 3 percent of the space heated.

Sustainable Yield

So, both in fishing and in land or sea farming, the working basis is the maximum sustainable yield (MSY). That yield is defined very carefully now that we have the capacity to cause zero sustainable yield by sweeping the seas bare, by spilling large quantities of Kepone or oil, by wearing out the land with a single crop, or otherwise insulting nature with an overload.

In fishing, the search for the magic level of MSY is currently being expressed by the quotas set under the Fisheries Conservation and Management Act both for the target species and for the by-catch of other species. On Georges Bank or in the Gulf of Maine, the energy system is so large that the magic can't be seen at work. Correction of the imbalances caused by foreign overfishing is causing anguish and frustration at the moment, a predictable outcome of all federal regulation, however necessary it may be.

In aquaculture so far, the maximum sustainable yield has to be determined by the sea-farmer himself, who must do his own conjecturing as well about the allowance to be made for the by-production of other species. His natural inclination is to crowd his leasehold for maximum yield, but he is dependent upon what may seem to him a whimsical supply of zooplankton and phytoplankton, and nature will correct any imbalances, possibly to the farmer's severe detriment. So his interest in Maximum Sustainable Yield is just as strong as the fisherman's or the land-farmer's.

The second consideration, following from the first, is that the determination of MSY from year to year is a massively large research project. The plankton supply for a Maine estuary, for instance, is a function of the entire Gulf of Maine. It is also affected by the Labrador Current and the Gulf Stream, along with the inshore influences of wetlands and of fresh-watersheds.

Sponsorship of a research project with this scope may be possible only for a federal government. These are fundamental and basic investigations of the deepest import. With lots of good management and

more good luck than we have any right to expect from that quarter, the federal establishment would confine its efforts strictly to the basics. (Attempts at subsidy, loan-guarantee, grant, and social and commercial support have a deserved history of crashing ineptitude; aquaculture is too important not to be spared these attempts. There are more employees of the U.S. Department of Agriculture than there are farmers; the country can ill afford a repeat performance for aquaculture.)

Business for Profit

The third consideration, harking back to the avoidance of the feed-the-world syndrome, is that aquaculture should be entered only on a business footing. The objective is profit. Profits pay taxes, create employment, attract capital, and provide continuity largely unscathed by political upheavals. Crass maybe, but nothing else works.

Spain is a good case in point. Franco came from Galicia and nothing was spared in 1947 to get a raft-culture mussel industry going in that province. Little may have been spared, but nothing much happened either, until along about 1960 when private capital made possible the cleaning and storage plants that enabled steady marketing that changed musseling from a cottage industry to one of major proportion.

Thirty-two years after the initial push, the entrepreneurs are responsible for making a market for the produce from thousands of rafts in the five Galician estuaries. The market is not Mussel Protein Concentrate in flour form for India, but is shellstock at lofty prices for Paris, Geneva, and Milan, along with a market mix of processed canned and frozen mussels, both domestic and export. Three hundred thirty million pounds of mussel meats make an industry. (Galician topography, tidal interchange, and estuarine depths are somewhat similar to Maine's--granted a slightly more benevolent climate; Maine production in a record year, wild and cultivated, totalled 0.6 percent of the Spanish province's.)

Beloved as it may be in the Sunday supplements, the cottage industry for mussels won't work in the United States either. The day Abandoned Farm's telephone log metamorphoses--from requests by

the local Audubon Society or a state college Marine Education class for a field trip, to calls for appointments from the food divisions of Exxon, GE, Ralston-Purina, Union Carbide, United Technologies, and Weyerhaeuser, or any combination thereof--will be a banner day. The expressed fear of being swallowed by one of the Fortune 500 seems groundless (besides, their computers aren't programmed to write checks that small); their expressed interest will be a signal that perhaps Maine aquaculture is on the right track.

So far, FMC, Kraft, Sanders, Congoleum, and Zapata, among others, have bought into Maine at the water's edge and don't seem to have done much harm to the little guy; quite the opposite in fact.

Safety in Numbers

The fourth consideration stems from the third in a way, and that is the function of size. A single mussel-farm in one estuary, whether or not it has acquired the maximum legal lease of two hundred acres, is vulnerable. It risks not being able to accomplish its objective of providing a steady flow of marketable mussels, regardless of weather or of some surprise like a temprary infestation that compels the state to close down its shipping. Not being able to accomplish one's objective on any day of the year is a very grave risk indeed.

While a single mussel-farm is vulnerable, ten of them are not. A massive natural disaster might get to them all, but this is unlikely, especially if they are spread out at 25-mile intervals along 250 face-miles of coast (or 2,500 to 3,000 shore miles). The once-in-a-century storm of January, 1978 (followed by one just as bad on the new moon four weeks later), would have done little, if any, damage to a mussel-farm anchored with proper scope in 90 percent of the Maine estuaries.

Until the number of farms approaches ten--with all of them under one marketing organization (or at least able to buy from one another)--the risk is virtually untenable. The land farmer has the advantage of selling his harvest all at once or of being able to store it in a barn or granary, and he generally harvests in the same year he plants. Not so the Maine mussel farmer, who faces an 18-month production cycle and the need to have his crop "stored" in the water for another seven months while he sells it.

If the farm is vertically integrated from seed mussel to market, as it must be at the outset, this vulnerability must be faced. It is April; the farmer inventories and predicts a 20,000 bushel crop beginning in late September; he plans his marketing campaign to break in October. In round numbers, it says this:

Sales	20,000 bu @ $33 list, less 30+% = net		$458,000
	Production cost 40%	$183,200	
	Advertising cost 10%	45,800	
	Selling expense 15%	68,700	
	General and Administration 15%	68,700	
			366,400
	Operating profit before tax		$ 91,600

He has debt service and a number of other things to think about, plus the cost of setting the crop for the following year. Now the State closes his estuary for Red Tide for four weeks in October. Instead of $15,000 a week, sales are zero. Production cost is largely spent; G & A is the same; the magazine ads closed a month or two ago and the direct-mail campaign went to the Post Office in mid-September.

If there are eight other farms not beset by Red Tide, he can buy from them at $14 a bushel (giving the seller a 20 percent profit since he is free of advertising and selling expense) and stay in business. He can swap 2,500 bushels for return when the ban is lifted from his farm, and have no money change hands. If he has to buy, he may have 2,500 extra bushels in the spring, but he can send those to the cannery or the freezer and at least get his bait expenses back.

But if he has the only farm, he's in trouble.

Safety in Size

The fifth consideration arises from the 20,000 bushel figure used in the example, and that is determining the minimum size of a mussel farm at a single location. It must be small enough to allow human coverage of the premises 24 hours a day, 365 days a year.

The basic reason for this is that the farmer has as his "soil" a part of the North Atlantic Ocean, no matter how far and apparently

securely removed up an estuary. The North Atlantic does not recognize nights, Sundays, or holidays, and must be constantly watched. No exceptions.

There are 168 hours in the week, and that means a minimum of five people, in addition to management. As a practical matter, there are many tasks in mussel farming best done with teamwork rather than solo; in the winter particularly, safety suggests teamwork while handling heavy and slippery weights on and in the water.

The other compelling factors in that 168-hour week are vandalism, poaching, and predation. All three are routine; there are no sensible alarm systems to cover all the possible contingencies; management personnel need sleep and freedom of action when they're awake; the only solution is constant human coverage, around the clock.

This is not to foreclose the American Dream of starting out alone with six mussel ropes and a rowboat, and building up to six thousand mussel ropes and an eighty-foot barge. But before beginning on such a path, the farmer should take a trip to mussel farms in Eire, Wales, Norfolk, Guernsey, the Netherlands, France, Spain, Norway, La Spezia, Venice, Yugoslavia, the Black Sea, South India, China, Korea, the Philippines, Venezuela, Canada and New Zealand (along with Maine, Massachusetts, New York, Berkeley, Oregon, and Puget Sound) and make a list of the one or two-person mollusc operations providing a steady income. The back of the farmer's business card will suffice for that list, leaving room for other notes, too.

Reviewing all the foregoing considerations, the farmer should find that a 20-acre water leasehold (about a thousand feet on a side if square, or any other shape depending on the site) is capable of producing 20,000 bushels and that that figure is capable of supporting the essential 24-hour coverage. In the example, the mussels of the current crop have a street value of $500,000. The yearling crop following on for marketing in the following year must be assessed at the same figure, since most of the costs will have been incurred before marketing and the crop cannot feasibly be replaced if lost by inadvertence somewhere in the 25-month period between placement of the first mussel seed and the selling of the last mussel in that crop.

Seed

The sixth fundamental is the farmer's mussel seed itself. Every country around the planet with an established mussel business has an established mussel-seed business. Of course nature will provide if ropes or nets or any other substrates are hung in the water to wait for the natural settlement of young mussels. But nature's timing is its own and it may not conform to the farmer's schedule. A land farmer who prepared his ground in March or April would be foolish to wait for his corn seed until the end of August, and miss four or five months of growing season. It is no different for mussel farmers.

The fast-growing months for mussels are from April to November. Nature, which is never in such a hurry as human beings, usually schedules mussel-spawning in May and August, timing it into the two plankton-blooms so that there will be plenty of feed for the young. It is an elegantly sensible system, but it does not fit the farmer's necessity for spring planting.

There is no separate mussel-seed business in the United States now. This lack is understandable, but must be corrected, and is an emerging opportunity. In Spain it is possible to make a twenty-peseta phone call to La Coruna, and arrange delivery at a time and date certain--even in Spain--of thousands of kilograms of mussel seed. In the Netherlands, it is possible to line standard mussel-drags with small mesh netting and gather all the seed required from the floor of the Channel. In France it is possible to purchase seed already attached to ropes.

In the United States, the mussel farmer, at the height of his harvesting activities from the middle of March to the middle of May, must gear up for seed-gathering. It is a problem easily solvable with money and time, but the aforementioned 10 farms should set up a separate seed business for themselves and for the farms to follow.

Spawning

The seventh consideration is mussel spawning and its effect on quality. Like most molluscs, the mussel takes sex very seriously indeed:

He and she may lose up to half their meat-weight by spawning; it may take several months to rebuild that weight. Until they do, their quality is not prime; their stamina in shipment is not up to snuff; they can be cooked away to a small nubbin of edible meat.

The Dutch approach this situation with admirable directness: Each shipload must provide a two and a half kilogram sample for inspection; if there is any evidence of spawning in this sample, the entire industry shuts down for four months, until quality is restored. Having been at it for four centuries or so, Holland has a dues-collecting syndicate that pays the shipowner a base price for the load, which he returns to his leasehold.

The Maine approach can be equally direct: Shut down marketing for four months when mussel-spawning is first observed in May and reopen as soon in September as quality permits--usually toward the end of that month.

This is not as drastic as it sounds at first blush. The market is not the million tourists who can snaffle gasoline to get to Maine in their Winnebagos in July and August. It is, for openers, the 60 million people from Portland, Me. to Norfolk, Va., from San Diego to Seattle, who eat from October to May.

Secondly, the mussel farmer needs this time on his leasehold. It is the time of explosive growth (a seed weighing a tenth of a gram when set out in April can grow 35 millimeters by September and multiply its April weight by 45), so that there is steady work on correcting buoyancy, reducing chafe, checking gear, and generally keeping order.

This is also the time to get ready for winter: Resheathing the icebreaking craft with oak, scraping, painting, repairing--getting everything Bristol fashion for the coming winter. This is also the likely time for Red Tide, coinciding with the lowered meat yield.

It is a felicitous calendar; in April and early May, decisions can be made about any of the current crop to go to processing or freezing when the mussels' quality is at its highest, just as the harvesting season is coming to its end. There is also time for all the work there is no time to do during the autumn harvest season,

when the mussels are again at their best. The marketing time should require the least refrigeration and the best holding ability, so that the deserved reputation for superior quality is preserved.

Finding a Place

The eighth consideration is the site of the leasehold, which brings us back to the second consideration--maximum sustainable yield. Since nobody yet knows what that is or how to determine it definitively, reading exhaustively about site-selection criteria--salinity, temperature, tidal interchange, and so on--can be instructive, but there is no proof beyond a history (which doesn't exist) or an inspection of what already grows at a site.

All leaseholds are compromises, and circulation is probably the most important aspect. A bottlenecked cove has wind protection--and thereby liability to ice; an open roadstead may be ice-free but prone to winter gales; and so it goes. Abandoned Farm accepted a 2 1/2-mile fetch to the south, which can produce about four-foot seas dead on in a 60-knot breeze from that quarter; the other three quarters are well protected. South is also the direction of the incoming tide, so the circulation is good, and the feed is apparently excellent. It is good enough anyway, to change 60 pounds of seed on six 20-foot ropes set in April to a total of 1,550 pounds the following October 1st, with about 40 percent of the total weight being market mussels. So Abandoned Farm is contented to bear the risk of that southerly wind.

There is also a law akin to Murphy's that goes something like this: "Aquaculture is an environmentally sound, essential undertaking, providing delicious and nutritious seafood; it should be aggressively pursued--but not in front of my summer place." So the licensing procedure, which comes down to an environmental impact statement, must be very carefully done.

Lewis Thomas is very helpful here: "What we really mean by the word 'environment' comes down to other human beings. We use euphemisms and jargon for this, like 'social forces', cultural influences,' even Skinner's 'verbal community,' but what is meant is the dense crowd of nearby people who talk to, listen to, smile or frown at, give to, with-

hold from, nudge, push, caress or flail out...."* That's a perfect description of those who now turn up at leasehold public hearings, sometimes with legal counsel.

Being a body of new law and procedure, the shape of these hearings has yet to become rigid. A couple of recent ones are on their way through the Maine court system and may soon clarify and simplify how hearings go. In essence, the aquacultural company has to be a truly good neighbor, genuinely compatible with the points of view of commercial fishermen, recreational fishermen and boatmen, and summer people who are convinced, by the taxes they pay, that they are entitled to an untouched water view extending to infinity.

The Wheel

The ninth and final consideration is a determination not to re-invent the wheel or any part thereof. Entry into aquaculture makes the entrant an instant multinational businessperson (or it should). Everything about raising mussels has been tried or is being tried somewhere in the world, and some or all of it is adaptable in some degree to any other leasehold or any other market plan.

This truth brings this essay full circle back to the number one consideration--that there is an awesome and magnificent energy system to which we must accommodate our efforts entirely. It has been done that way with wheat and corn and apples and grapes and stainless steel and surgery and bleach bottles and everything else, and that should include mussels.

* ("The Medusa and the Snail--More Notes of a Biology Watcher", New York, The Viking Press, 1979. Used with permission.)

CHAPTER THREE

How to Operate a Mussel Farm

Abandoned Farm

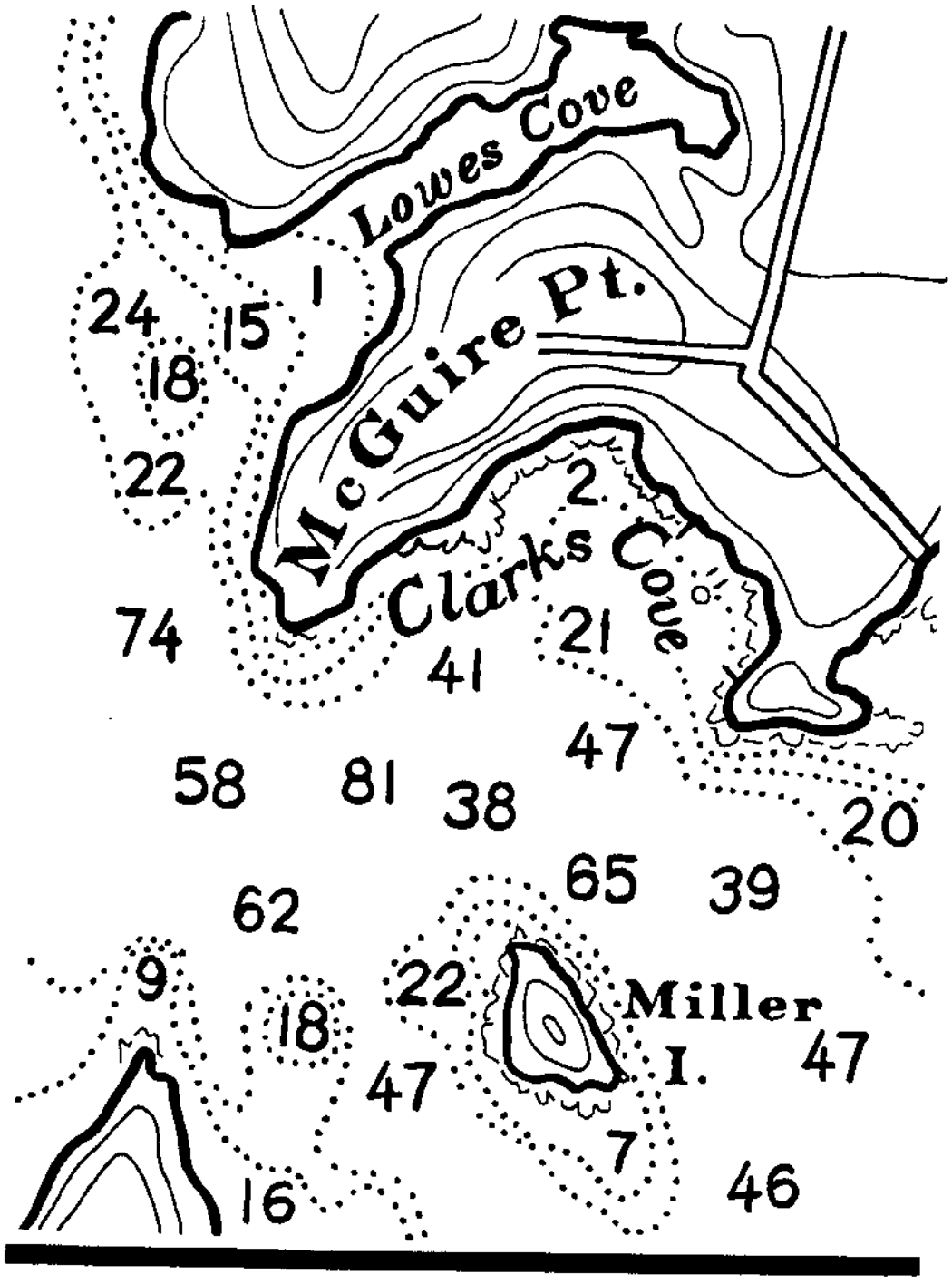
This chapter is an amalgam of historical procedures, occasional common sense, and projections for a business. Even more than venture capital, Abadoned Farm needs competition and those ten other farms.

Abandoned Farm at this point is considered 'pilot commercial': The company has a leasehold from the state of Maine of 20 acres of water; mussels have grown to market size within the leasehold and have been marketed; there have been repeat orders as well as testimonials from satisfied users; our mussels have been consumed in San Diego and Geneva. What Abandoned Farm has not done yet is to scale up in size from the pilot stage to a profit business.

The Abandoned Farm leasehold is in Clarks Cove, a bight on the Damariscotta River estuary in Lincoln County, Maine, at 44° 56' north and 69° 34' west.

Seven nautical miles from the open sea of the Gulf of Maine, Clarks Cove water is classified SA. There are no sources of industrial pollution on the Damariscotta River. Lower water classifications exist at the towns of Damariscotta and Newcastle, seven miles up river, and South Bristol and East Boothbay, three miles down. All four are small towns of 1,000 people or less; their water-quality classifications will be raised as minor sanitary sewage outflows are eliminated under present laws.

The salinity of the water in the cove, which had been checked for the previous 20 years, is generally the same as the inshore waters of the gulf, as recorded by the Maine Deparment of Marine Resources (DMR) Laboratory at Boothbay Harbor. Occasional drops from this salinity of 31 parts per thousand (PPT) are possible, but the lowest recorded in Clarks Cove has been 15 PPT near the surface during the deliberate lowering of Damariscotta Lake by the fish committees of Nobleboro and Newcastle to allow passage of alewives up the fish ladder into the lake. These lowered salinities are brief, usually occur in the spring



Clarks Cove, Damariscotta River
Damariscotta, Me.

when the seawater temperature is four Celsius or below so that mixing is minimal, and are well within the tolerance of the mussel.

The seawater temperature of Clarks Cove, predictably in view of the surrounding land masses, is a degree or two Celsius lower than DMR's Boothbay readings in the winter and sometimes two or three degrees higher in summer. During the past five years, the extremes of water temperature have been -2C, in February of 1977, and 18C during the first week of September, 1976. The temperature range of 6 to 16 Celsius seems fairly predictable for the period from mid-April to the first of December (temperature chart for 1976, 1977, and 1978). The range for the Galician estuaries of northwest Spain is from 9 to 10 Celsius around the year (Ryther, 1975).

The depths of water for Clarks Cove are given on the following chart. It is useful to remember that government soundings are minimum and occupy about a hundred-yard space on a 1:40,000 chart. There is usually 11 feet at mean low water (MLW) at the Abandoned Farm dock and 22 feet at MLW 150 feet seaward from the dock. Soundings for Clarks Cove were made with an ordinary lead line marked in fathoms; four fathoms (24 feet) was considered a minimum sounding for the suspension culture then in contemplation.

Tidal interchange for the section of the Damariscotta River was computed at an average of 44 million cubic meters (McAlice, 1973). To a mean tidal range of 9.6 feet, spring tides will add some 4 feet, 2 or more feet on each side. Special conditions combining both tide and wind--such as the morning tide of January 9, 1978, which the tide table stated was 11.6 feet, but which, with a 60-mile southerly, actually rose over 15 feet--can be troublesome and must be prepared for.

Abandoned Farm leased two and a half acres of land on the shore. This provided the use of approximately 425 feet of shoreline, a dock extending 125 feet, with floats on each side having 5 feet at MLW, a dock pumphouse furnishing a circulating seawater tank system, a 24 x 60 frame building with power and a freshwater supply, and an access road from the town.

As a plus for Abandoned Farm, the landowners were interested in mytiliculture, and therefore leased the premises to the corporation

for five years at a dollar a year. (This generosity is no longer so, as the enterprise changes from pilot project to business).

The geography is rural. On a 225-degree arc from east through south to northwest from Abandoned Farm's dock, just one seasonal dwelling is visible within a mile. Four recreational boaters use two small docks in Clarks Cove during the summer. Other than Abandoned Farm's operations, there is no boating activity in the cove from October to May. There are five year-round dwellings, all more than 700 feet from our dock; the extent of aesthetic interference with their water views is confined to the floating gear.

On extension of the property lines from the shore to the water, our 20-acre water leasehold goes out into Clarks Cove approximately 1,800 feet from the MLW mark. The width is 425 feet at the shoreline; the outer 10 acres form a T that is 800 feet wide.

The cove has a fairly smooth, uninterrupted bottom of soft mud. There was no commercial fishery in the cove from 1952 to 1973, with the exception of three or four lobster traps in the summer near the ledges forming the outside of each point.

The Maine Aquaculture Law is a species law: The lessee has exclusive rights to all the species for which application has been made. This law has the effect of suspending the Colonial Ordinances of 1641-47, which permit anyone to approach high water mark for the purposes of "fishing and fowling," but only to the extent of the species specified in the lease. Therefore, Abandoned Farm has an exclusive right within its leasehold to all the mussels, husbanded and wild, but has no rights whatsoever in the areas of lobstering, crabbing, commercial or sports fishing, or recreational boating, as long as none of these activities molests or damages the aquacultural gear.

The aquacultural rent is $5 per acre per year. This is well above New Jersey's $1.50 per acre and North Carolina's $1, but Maine leaseholds are generally much deeper, so we at least get more for our money.

ABCs of the Farm

The farm animal on a mussel farm is provided by nature with its own food and drink from and in an ocean, which determines its rate of

growth. The functions of the farmer as grower are therefore limited to ABC:

Anchorage--making the mussels stay put
Buoyancy--keeping them from touching bottom
Cultivation substrate--keeping it sound in use.

Obviously, you don't want your mussels wandering all over the ocean, so they must be anchored. You don't want them eaten by crabs and starfish on the bottom, so they must be kept floating. The cultivation substrate--what the mussels grow on, whether it's wood or plastic or rope or metal--must be strong enough to last until harvest, or there won't be any harvest.

Because this is farming, you have to deal with variables: tides and currents, supplies of nutrients, and climate and local weather. For Abandoned Farm, ice is one such variable: One winter, we had to break it out only one day; the following winter, it took 18 full days; the winter after that, three and a half days.

So, with this in mind, assuming a carrying capacity of 40,000 bushels for the leasehold, estimates are based on half that. There will be good years and bad; with any luck, the 20,000-bushel estimate will eventually be considered a bad year.

Growth

Like any other animal, mussels are highly variable in length-weight relationships, but the following chart provides a good working basis.

Growth rates for Clarks Cove for the years 1973-77 are graphed on the next page. The curves show an excellent consistency for the five years. These data are devised from groups of 23-25 mm mussels set out in five-pound plastic hamburger buckets suspended one meter below the surface. Water circulation was enhanced by cutting windows in the buckets and lining them with DuPont Vexar of half-inch mesh. Each bucket contained 25 mussels and was inspected monthly from April to November. Buckets were brushed clean of fouling and the mussels measured at each inspection. Survival was never below 80 percent for the eight-month term. Winter growth was not measured.

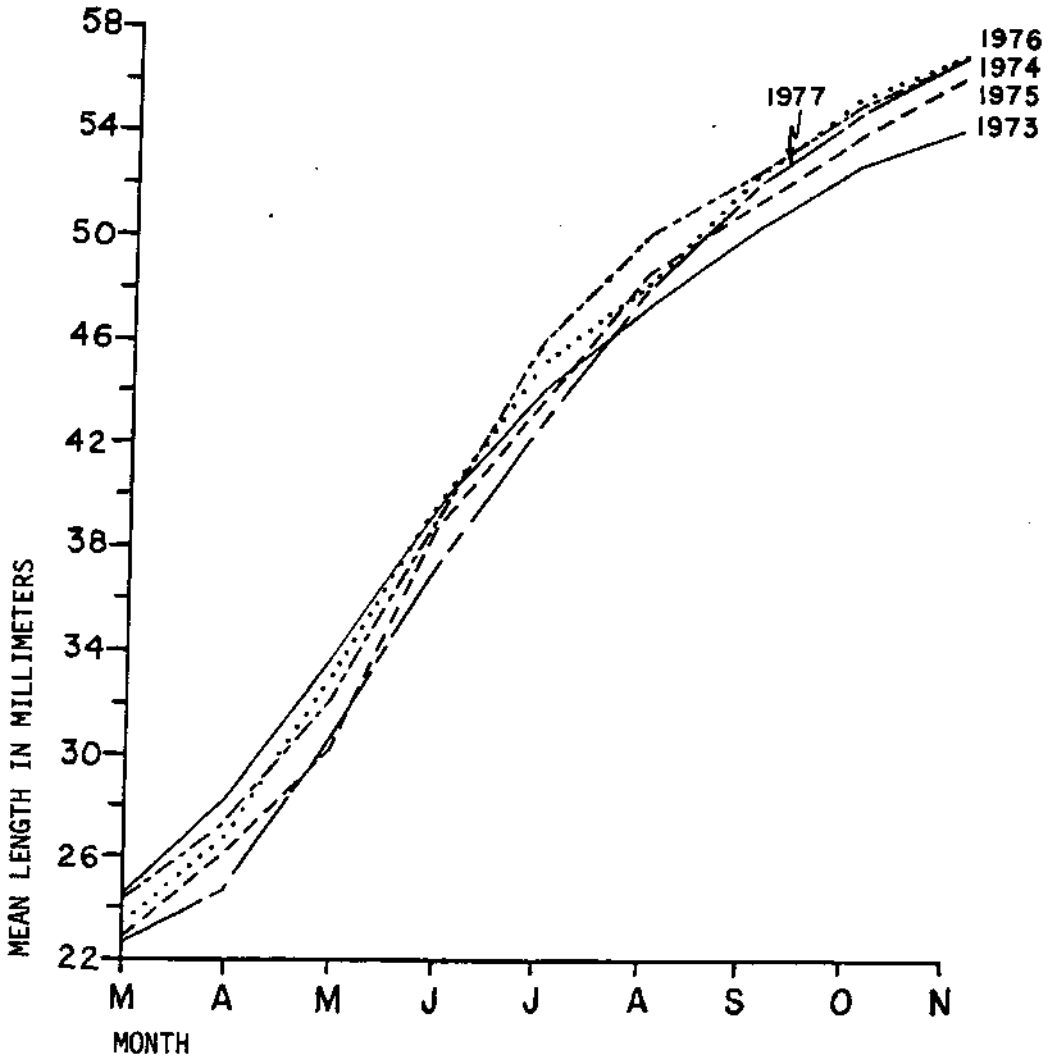
Growth Rates, 1973-77

Millimeters	Inches	Weight	Count/ Kilogram	Count/ Pound	Count/ Bushel	Bushels, if 100% survival
2-8	-	0.1 g	10,000	-	250,000	1
12.7	1/2	0.5 g	2,000	909	50,000	5
25.4	1	1.0 g	1,000	454	25,000	10
38.1	1 1/2	4.5 g	222	109	5,550	45
51.0	2	12.5 g	80	36	2,000	125
57.3	2 1/4	15.1 g	66	30	1,650	151
63.5	2 1/2	20.2 g	50	23	1,250	200
70.0	2 3/4	26.0 g	40	18	1,000	250
76.2	3	33.1 g	30	14	750	333

AVERAGE GROWTH PER MONTH (CUMULATIVE)

This five-year graph shows the consistency of growth from the end of March to November. The curves confirm that the severity of the winter is not a factor.

Rafts were removed from the water in November, and there was no University monitoring of winter growth. Despite scientific literature that suggests there is little or no growth from November through March, Clarks Cove suspended mussels continue to grow, although of course at a slower rate than in the warmer months. A mere five millimeters is nonetheless significant. Going from 56 to 61 mm can mean a 25 percent increase in weight.



This was University of Maine Sea Grant research and should not be confused with the reality of mussel farming, although the results are a good guide for the fair-weather months.

In actual farming, it was found that 2-8 millimeter mussel seed, set out at the same time at the end of March, can draw even with the 23-millimeter mussels used in the research and achieve the 55-millimeter average by the end of November. The difference, of course, is in the percent of survival to this size in the farm situation, where each mussel cannot feasibly be cleared of fouling every month by a graduate student.

Abandoned Farm's working rule is 5 percent survival applied to all sizes in the chart of length-weight relationships. Thus the harvest at two and one half inches should produce 10 bushels--5 percent of the original 250,000 seed--or 12,500 mussels at 1,250 to the bushel.

While wild intertidal mussels grow little if at all during the winter months, suspended mussels exhibit winter growth of a millimeter or two per month (depending upon the severity of the winter) and resume major growth rates in April.

The French market-size has been set at a 40-millimeter minimum, which is very small for American tastes; the Dutch specify that more than 90 percent of any batch be larger than 62 millimeters. Abandoned Farm sets an arbitrary minimum of 54 millimeters (although the eating preference of all its employees, without exception, is for the 48-50 mm size). The "54" makes a good appearance on the plate; the much higher meat yield of cultivated mussels, compared to the wild, makes it possible to market that size and provide good eating and good value.

While this minimum suggests that a marketable mussel can be grown in a single season, sensible planning suggests that the second growing season be allowed. Mussel growth rates do slow down, as they do in any beast including humans, and being sure of a satisfactory harvest above 54 millimeters really requires the second season. So for planning purposes, the April seed is scheduled for market the second succeeding October through the following May.

The Gear

Given these growth considerations, the array of gear in the leasehold is going to provide for two crops in any April. One will consist of last year's seed, now grown enough to be marketable in the proximate October, and the other consisting of this year's seed setting for market the following October.

This is why the land is important. While many coastal towns are mandated to provide town landings and generally do, they are heavily used and can't be occupied by aquacultural gear waiting to go in the water. It is essential to have outside storage and working room for anchors, flotation devices, lumber, and all the other materials required. An order of 2,000 unstackable flotation bottles, for instance, will occupy 6,000 square feet, and they have to be placed somewhere while the attachments and other hardware go on prior to setting out.

A site on class A water on the coast of Maine will run $150 to $200 per shore foot--say $75,000 (for commercial wharf property in a busy harbor, one will pay much more), plus at least $25,000 for the dock and another $25,000 for shore storage and shelter. A lease of such a $150,000 shore facility would be properly $20,000 or $30,000 a year.

The basic item of gear is the scrap automobile tire. One tire filled with foam will support a bushel of mussel seed, which is poured under water pressure into six 20-foot tubes of plastic mesh. These tubes are two and a half inches across when flattened.

The 20-foot tube length is not carved in stone, but is right for Abandoned Farm's situation. First, it allows placement from the 24-foot drain low-water contour outward, with little possibility of touching the bottom, where the mussels would be immediate prey to crabs and starfish. Second, the controlling depth seaward is also 24 feet, so that it would be possible to move the units to the open sea in the unlikely event that were necessary. Third, the tubes are easy to handle with fairly light hoisting gear by one person.

The tires are set out in lines of 46 tires each. The total for each crop is 72 lines, spaced 20 feet apart. Total number of tires

is 3,312. Total number of tubes is 19,872. The length of one tire-line is 150 feet.

Seventy-two lines, 150 feet long, at 20-foot intervals occupy just about five acres. To keep them in one place requires two three-eights inch trawl cables, each anchored with inch chain to a two-ton granite mooring on shore, and run straight out and attached to the end of each line. Their purpose is to help keep the whole array in position during gales (in the southern quadrant; breezes from SE through N to SW are no problem at Abandoned Farm).

In addition, 144 anchors are used to keep the tires in position. The anchors are approximately 70 pounds, and are of Abandoned Farm design (as much as any anchor can be said to be original) and manufacture. They are welded together from seven precut pieces of quarter-inch steel. The anchors are set with triplines, to make them easier to raise and inspect. When the 144 anchors are set, the effect is a cat's cradle, so that each anchor can help the next one in times of extraordinary stress.

The weight of a 46-tire line set out with seed is about 4,200 pounds. Mature units ready for harvest may bring the weight of a tire-line to 83,000 pounds, or about six million pounds for the entire crop array. The weight is not, of course, all mussels, but includes mud, kelp, algae, and all such accumulations over the growth cycle.

The grid for the second crop is precisely the same in design and execution. The space between them leaves room for the anchors without overlap on the bottom and for mooring and maneuvering water-craft on the surface.

As the mussels grow, their weight outruns the buoyancy of the tire supporting them. Sixty-liter peroxide bottles with a lift of 100 pounds each must be added as the tires begin to sink. A heavily loaded unit may require up to five bottles for support. The full array can therefore require 16,000 bottles for flotation.

A mussel farm is a materials-handling business involving millions of pounds. Under the most efficient system, all possible materials handling takes place on the water, with only the finished product coming ashore. While Abandoned Farm reached its current pilot-

commercial stage with the use of open boats, a small prototype barge, and mussel cleaning and grading machinery in an enclosed shed on the dock, the plan for scaling up in size absolutely requires a vessel big enough to allow every function to be performed on the water, so only the final product is conveyed ashore.

There are energy considerations, as well as practical ones: 200 gallons per minute of washwater is needed for grading during harvest, during culling, and during seed placement. Two hundred gallons a minute is approximately 100,000 pounds of water an hour. It makes no sense to lift this water 20 feet to working level on a dock or 50 feet to a shore building and then to have to dispose of it all, if the pumping can be done on a vessel five or six feet above the waterline and the washwater can be disposed of overboard.

Electricity is valuable for lighting and other appropriate functions, but hydraulic power is far superior to electric motors in a saltwater environment. Diesel fuel can be safely used to drive the machinery.

The additional compelling argument for vessel-based farming is that all harvesting involves grading and culling to size, so all mussels not going to market are going back overboard to grow some more. It makes no sense to bring all this weight ashore, only to have to take it out again. All molluscs should be out of water the shortest possible time, and the way to accomplish this is right on the leasehold.

The required work space to harvest 300 bushels per day (two days per week = 600 bushels per week x 33 weeks = 20,000 bushels total) is an enclosed platform 50 by 25 feet. If it is a barge, its total dimensions can be 60 x 30; if it is a seagoing vessel, which is vastly to be preferred because it can proceed under its own power to other farms and to loading docks, its overall length should be about 80 feet, with a beam of 25 feet.

Calendar

A. The Year

Once the two crop arrays are out in the leasehold, the farm

calendar comes clear:

October 1 to May spawning	33 weeks	harvest and ship
June, July	8 weeks	all maintenance; winter preparation
August, September	9 weeks	strip, grade; reset spring seed crop

Each year, a certain sequence of events must occur. Between January and March, prepare tire units and associated gear for the spring seeding. Between April and May, set out the seed tubes. During all the months, the farm chores cannot be ignored--cleaning, checking buoyancy, and making sure everything stays in place.

In the depth of winter, ice-breaking has priority. This must be done immediately; channels from the dock to open water can be opened by small outboard-powered boats sheated in (1 1/4-inch) oak. After the larger pieces have been pushed out to where the tide or wind will carry them away, the spaces between the lines are broken out and cleared.

The ice must not be allowed to build up. Neglect for one or two days can't be permitted because ice chafes the gear at the surface, and might carry away the gear. It also makes regular work difficult.

B. The Harvest

The harvest day is blocked out at six hours, plus half an hour for positioning yourself in the water and one and a half hours for packaging the finished product and getting it ashore.

Only one positioning a day is necessary, because a day's harvest will come from just one 46-tire line--or part of it. With a yield of 10 bushels per tire, 30 tires will fill a day's requirement. More realistic is a yield of 6.5 bushels per tire, which takes a full line of 46 tires for a day's requirement. That estimate is nicely conservative, as it asks for 1.1 bushels per line or about 3.3 pounds of market mussels per linear foot.

With the platform positioned at 7 a.m. (the latest sunrise is at 7:14 a.m. in a Maine December), the scheduled flow is 80 bushels per

hour, through the following steps (steps five through eleven are for market-size mussels):

1. Lower collecting basket, attach unit to hoist, detach unit from line for lifting (2 min.)
2. Strip unit into hopper; pile stripped unit on upper deck for future use (1 1/2 min.)
3. Wash mussels into declumper (capacity 80 bu/hr)
4. Put declumped mussels into washer grader
   a. Seed mussels to bin for retubing
   b. Undersize, 25-53 mm to separate bin for retubing
5. Put market size in debearding machine (capacity 60 bu/hr)
6. Check inspection belt for removal of cracks and breaks and any surviving extraneous material
7. Drop mussels into rotary wet-well hold to rest and recover from machinery trauma
8. Convey mussel from wet hold to boxing line filler
9. Insert refrigerants (as needed) and staple box
10. Move boxes to 12-bushel palletizer and strapping machine
11. Place rollers for pallets to end of conveyor at stern
12. Wash seed mussels into tubes for re-attachment to flotation tires
13. Wash undersize into larger-mesh tubes for re-attachment to tires
14. Reset tires with seed and undersize mussels in the water
15. Steam to shore conveyor while packing is completed
16. Convey packed mussels to truck with packages labelled according to order of delivery
17. Vessel returns to berth.

The person coming on watch for the 3-11 p.m. shift washes down the vessel, checks and lubricates machinery, renews supplies of boxes, strapping, pallets, tubing of required sizes, provisions, and fuel for the following day; tests radar for all-night inspection of lease-hold, night lights, and search lights.

C. The Seed

During the eight weeks from April 1 to May 26, the 11 p.m.-7 a.m. watchperson handles the seed. If it is possible to receive seed already set in tubes, the job is to assemble 92 units each night and slide them overboard at 46 each on a line to the mid-leasehold moorings. The vessel can tow these two lines into their seed crop position first thing the following morning. If it is not a day when the vessel goes to harvest, the lines will keep until ready for positioning.

If the seed is delivered in bushels instead of tubes, these are conveyed to the tubing bins aboard and worked there. This procedure requires an extra person on the night shift. As the mussel "industry" stratifies, the delivery of seed ready-tubed and on schedule is essential. This will go beyond local purveyors, and should include seed sets anywhere from Narragansett Bay to Chincoteague, Va. The usual struggle with fish bureaucrats about interstate shipment is bound to ensue, but since the seed is many months away from human consumption, the red tape ought to fall away in the fulness of time.

The Market

Now that there is a feasible system, there remains the reasonable question as to whether all the mussels that are produced can be sold for more than it costs to produce them.

Abandoned Farm can speak to the fresh market only, since we have done only experimental freezing, pickling, and canning. Meanwhile, the Koreans, with interest-free AID money, can produce individually quick frozen mussels cheaper than their benefactors; the New Zealanders are freeze-drying mussels, putting them in capsules, and peddling them as palliative or cure for rheumatoid arthritis, but the FDA does not encourage this route to riches in America.

Much of Abandoned Farm's marketing effort is proprietary, but some is in the public domain, such as the market test done by the Whittemore School of Business and Economics at the University of New Hampshire ("Test Market Introduction of Bright Seas cultured mussels in Augusta, Nashua, and Portsmouth", 1978). Mussels were supplied

in quart bags--32 to the bushel--for distribution by UNH students to supermarkets in the three test cities. Abandoned Farm's base price was $22.50 per bushel to UNH, which wholesaled at a price designed to give the supermarket a 35 percent per bushel margin at retail, ranging from $38.12 ($1.19 per quart) to $60.80 ($1.89 per quart). This was a remarkable performance in the face of locally available wild mussels at a retail varying from $12.00 to $36.00 per bushel.

Since that test, we have a list price, including packaging throughout the schedule, of $33.00 to restaurants, less 16 2/3 percent to wholesalers (net $27.50), less 16 2/3 percent to distributors (net $22.90). The following is a tabulation of some selling prices.

Gross Profits and Margins

Husbanded Mussels at $33.00 list price per bushel

(All prices are actual examples in commerce)

Net weight of bushel - 55 pounds

Retail

	Per Pound	Per Bushel	Gross Profit	Percent on Selling Price
Highest reported	$1.99	$109.45	$76.45	70
New York City (Upper East Side)	$1.26	$ 69.30	$36.30	54
Discount market	$ .99	$ 54.45	$21.45	40

Restaurant

	Per Serving	Per Bushel	Percent Food Cost
Boston Waterfront	$3.95	$237.00	14
French prix fixe	$3.50	$210.00	16
Maine local	var	$189.00	17
West Coast	$5.00	$300.00	11

Wholesaler 16 2/3 % on $33.00 list Gross Margin $6.60

Distributor 16 2/3 % on $27.50 net Gross Margin $3.96

Abandoned Farm $22.90 net

(Local in-plant retail is metric: $1.25 per liter, $45.00/bu)

As always, the prime consideration is that the customers make money on the product. The price schedule may change; the relationship between the wild mussel (from about $7 per bushel for spawned-out junk to $22 packed for air shipment for a picked wild mussel) and the cultivated one may be a little narrow at the moment, but the latter is a product just being introduced. One measure is that a busboy scrubbing ten a minute can debarnacle and decrud a wild mussel bushel in two hours; the husbanded mussel needs no cleaning; it's ready for the pot and shrinkage is minimal. The busboy's two hours cost the restauranteur close to $10.

Abandoned Farm has not tested the market in volume, and will not until there is a source of top-quality supply other than our own single leasehold on the Damariscotta. A convincing result of the marketing so far is a file full of declined orders, which, at a level rate, would be about half way to the objective. There is quite a difference between a file folder and actuality but a sound promotional campaign backed by steady production and reliable supply could put profits in multiples and still reflect only a tiny segment of the potential market.

None of which makes any difference if there is no profit or profit potential. (Those looking for a sure thing should go to the horse races, where there is always at least one winner.)

The Money

The first thing to do is put out the necessary array of gear to create a crop. On a 20-acre leasehold, these are the costs:

I. For seed placement

Useful Life (yrs)	Item	Rounded Cost
10	152 anchors @ $65	$10,000
10	Outer moorings @ $500	1,000
2	4,000 feet 3/8 cable	1,400
3	20,000 feet 5/8 anchor line	2,500
10	3,600 feet 1/2" chain	12,000

5	600 thimbles, 1,200 shackles	6,000
5	3,500 foamed tires	14,000
2	12,000 feet tripline	600
3	100,000 feet 1/2" line	6,000
5	400 buoys, miscellaneous hardware and fastenings	2,000
10	7,000 flotation bottles	21,000
	Total	$76,500

II. For maturing crop

Cost and materials same as above	$76,500	
13,000 flotation bottles	39,000	
		$115,500

III. Seed and substrate

3,500 bushels seed $17,500 each of two years	$35,000	
500,000 feet of mesh tubing (seed)	25,000	
500,000 feet of large mesh (mature)	20,000	
For each of two years	$45,000	
		$90,000
Total for both arrays, with mussels		$317,000

Stop right there. To pile on the capital cost and expense of an equipped vessel, plus all the accounting, legal, insurance, and all the rest of it for application to a single farm, is an exercise in futility.

Ten leaseholds with central marketing, receiving, and headquarters present a reasonable picture:

10 arrays	$3,170,000
2 vessels	900,000
Site acquisition	400,000

Headquarters	400,000
Working capital	2,000,000
Total	$6,870,000

Other than possible economies of scale that are not considered, the purchasing, warehousing, marketing, and general and administrative categories are consolidated. Sites are simpler, because the shore-duplication is virtually eliminated. For the purpose of the example, expansion and efficiences are not taken into account. The operating pattern is:

Sales	200,000 bushels @ $22.90 net		$4,580,000
	Production cost	$1,832,000	
	Gen. & Admin.	458,000	
	Advertising	458,000	
	Selling expense	687,000	
			3,435,000
	Operating profit		$1,145,000
Percent on sales	25 %		
on equity	16 2/3 % (if all equity; no debt)		

After years studying water temperatures, salinities, growth rates, meat yields, shell weights, currents, tides, plankton, recipes, relative fuel costs, and all the rest of it, it turns out to be quite simple. At a fraction of the cost for a dry hole on Georges Bank or the Baltimore Canyon, adapt a planetary industry of renewable resources to the United States.