AQUACULTURE IN MAINE

Maine Aquaculture Innovation Center
with the
Maine Aquaculture Association &
University of Maine Sea Grant College Program

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INTRODUCTION

How will Maine's seafood industry differ by the year 2000? Perhaps the most startling changes will occur within the aquaculture sector. By the end of the century, farmed fish and shellfish will represent over 50 percent of the value of all seafood products.

Genetic engineering and artificial selection will breed fast-growing, disease-resistant stocks of oysters, salmon, and trout, while halibut and other "wild" species will be domesticated for pen culture. Many current fishermen's cooperatives will also become aquaculture cooperatives. To enhance the wild harvest, lobsters, clams, and oysters will be routinely raised in public-owned hatcheries for release or planting along the coast.

While farm-raised products will never replace wild harvests, by the year 2000 the culture of aquatic species will transform a hunting/gathering approach to fisheries into an investment/management approach using husbandry of marine animals as the basis for predictable landings.

Presently over 15 percent of total fish and shellfish landings in the United States are farm-raised. However, since seafood consumption has risen more than 25 percent in the last five years, supply has continued to lag behind demand. Over half the seafood now eaten in this country is imported. Excluding petroleum products, seafood imports account for 28 percent of our annual trade deficit. As demand for seafood continues to increase and wild stocks level off or decline, aquaculture offers the only alternative to imports.

Looking Back

Numerous estuaries, sheltered coves, and a large tidal flow of plankton-rich water make Maine an ideal place for aquaculture. Commercial aquaculture began here in the early 1970's with a few small oyster, mussel, coho salmon, and rainbow trout farms. When Maine's lease statutes were passed in 1973, individuals and companies were allowed exclusive rights to their crops.

Unfortunately, many of these early pioneers were undercapitalized, could not obtain enough seed stock, selected poor sites, or their efforts proved too labor-intensive. Consequently, the industry grew very slowly during its first decade in Maine.

Looking Ahead

The 1980's have brought promising change. With the adoption of bottom-culture techniques, for example, mussel farming has burgeoned from 1982 to the present. Farm-raised mussels have a current dockside value of over $2 million, but account for less than 25 percent of Maine's total mussel landings. Only an estimated two percent of available mussel culture sites are presently leased, so future harvests could be valued much higher.

The present cultivated salmon harvest is expected to reach one million pounds with a landed value of $4-5 million. With 445 acres of salmon leases both granted and pending, annual harvests could yield up to $180 million at currently attained production rates. In comparison, landed value for lobsters for Maine's entire coastline amounts to $60 million per year.

Current statewide production of cultivated oysters numbers less than one million count annually. Within five years, farm-raised production could grow tenfold with a dockside value of $3 million. For every 1,000 acres planted, approximately $35 million of oysters can be harvested each year.

Public aquaculture, or *stock enhancement*, by release of hatchery-raised animals, is being experimented within Maine as a necessary and appropriate function. If proven feasible as a technique for enhancing wild stocks, it will expand into a large-scale, coast-wide effort. Two public-owned hatcheries, one for lobsters in Cutler and one for clams on Beals Island, were established several years ago and are producing millions of juvenile animals, which are annually transferred into the estuaries for grow-

out and harvest in the wild.

To prevent unauthorized interference or theft of planted crops, aquaculturists require some form of legal exclusivity. The 1973 statutes permit leases for aquaculture where proposed sea farming activities do not interfere unreasonably with navigation, adjacent landowners' access to water, or existing fishing and recreational activities.

In a 1988 revision of the statutes, maximum lease holdings for an individual or company were limited to 150 acres, annual fees increased to $50 per acre per year, and a sizeable application fee was introduced. In addition, a strict environmental survey is now required to avoid destruction of existing valuable marine habitat.

Coincident with the application for an aquaculture lease, the Maine Department of Environmental Protection (DEP), the federal Army Corps of Engineers, and the U.S. Coast Guard must consent to the use of coastal waters and placement of floating structures.

Conflict with Traditional Fisheries

Opposition to aquaculture has centered around conflicts with existing fishing practices, charges of unhealthy environmental effects, and encroachment upon the aesthetics of shorefront landowners. Some fishermen feel that aquaculture threatens their way of life.

Since the ocean and its resources have always been considered public domain, the privatization of use through the exclusivity in the lease statutes is a fundamental philosophical shift. Accompanying this change is the fear that much of Maine's coastal waters will be privately controlled by large corporations limiting the public's commercial and recreational uses. However, only 1,011 acres, or about two square miles, of the more than 2,000 square miles of coastal waters are currently leased or under application.

Charges that aquaculturists drag up wild mussel seed beds and transfer them to leased areas, that dragging itself is harmful to lobsters and their habitat, that salmon in pens pollute the bay bottom by accumulation of feces and unused feed, and that indiscriminate use of fish antibiotics will affect the marine environment are concerns well worth investigating. The state has allocated additional marine research monies to investigate these questions of conflict. In the meantime, it seems prudent to continue the commitment to expansion of aquaculture activities.

Maine Aquaculture Innovation Center

One bright hope for stimulating aquaculture development in Maine is the founding of an industry-controlled Aquaculture Innovation Center jointly sponsored by the Maine Aquaculture Association and the Maine Agricultural Experiment Station at the University of Maine (UM).

Located on the University's Orono campus and receiving a funding commitment from the state's Science and Technology Commission, the Center's mission is to identify scientific and technological constraints to aquaculture in Maine and to link private and public resources together in the research necessary to overcome these constraints.

Most immediate research efforts will tackle production problems such as disease diagnosis and control, genetic improvement of fish and shellfish, increasing harvesting and processing efficiencies, and developing culture methods for promising new species.

A Partnership of Research and Industry

With the increasing complexity of marine issues

facing us in the next decade, aquaculturists have responded by joining a statewide trade association. The Maine Aquaculture Association (MAA) encompasses the finfish, shellfish, and fisheries enhancement sectors.

Association activities include sponsorship of public seminars and conferences, participation in the Maine Fishermen's Forum, lobbying in the state legislature for the interests of the industry, and co-sponsoring the Maine Aquaculture Innovation Center. The MAA is recognized as the collective voice for sea farmers and has represented the industry in both state and federal administrative and regulatory matters.

In compiling this guide, the Association is working with the University of Maine's Sea Grant Marine Advisory Program and the Maine Aquaculture Innovation Center to publish a comprehensive, useful summary of Maine aquaculture. We hope it proves helpful to prospective career aquaculturists, educators, students, legislators, and the general public who wish to know more about aquaculture in Maine.

Dick Clime, President
Maine Aquaculture Association

ALL ABOUT AQUACULTURE

What is Aquaculture?

Aquaculture is the controlled cultivation and harvest of aquatic plants and animals and offers the possibility of expanding domestic supplies, thereby reducing fishery product imports in the United States, which now total over two and a half billion dollars.

Does Aquaculture Make Economic Sense?

Almost any type of fish or shellfish can be raised from its larval stages to a healthy, marketable adult, but it is often more expensive to do so than to go out and catch it. However, the technology to raise fish or farm the waters exists; scientists are continually improving culture methodologies within the confines of economic realities; and research on all aspects of aquaculture is increasing. In addition, the worldwide demand for fish is up, although the supply remains more or less static.

What Is the Most Important Marine Finfish Cultured in the United States?

Salmon. Two types of salmon culture systems exist: *ocean ranching* and *pen-rearing*. The first technique relies on the salmon's homing behavior, while pen-rearing involves the enclosure of young salmon in pens or brackish water ponds.

What Are the Major Cultured Aquatic Species in Maine?

Besides European oysters, mussel, and salmon, which are now being cultured successfully, other species with culture potential include American oysters, sea scallops, surf (or hen) clams, soft-shell clams, quahogs, codfish, trout, halibut, and lobsters.

What Are the Economic Pitfalls of Aquaculture Projects?

Many aquaculture projects, although proven sound technologically, are not always economically feasible. Some of the reasons are: labor and nutrition are expensive; problems associated with production and marketing; difficulty in obtaining financing because of the risk factor; and substantial legal restraints to its development. To be economically feasible, aquaculture must be able to produce a product at a reasonable cost and sell it at a competitive price.

Is the Maine Coast Suitable for Aquaculture?

According to University of Maine marine economist James Wilson, the physical circumstances of the Maine coast (high tides, a heavy nutrient load, and protected embayments) are nearly ideal for culturing seafood, and, with the exception of Alaska, the most extensive resource of this kind in the United States.

How Do You Apply for an Aquaculture Lease in Maine?

Contact the aquaculture leasing program administered by the Maine Department of Marine Resources (DMR) in Augusta at (207) 289-2291. Also see the section on leasing in this guide on page 16.

What Is the Potential for Lobster Aquaculture?

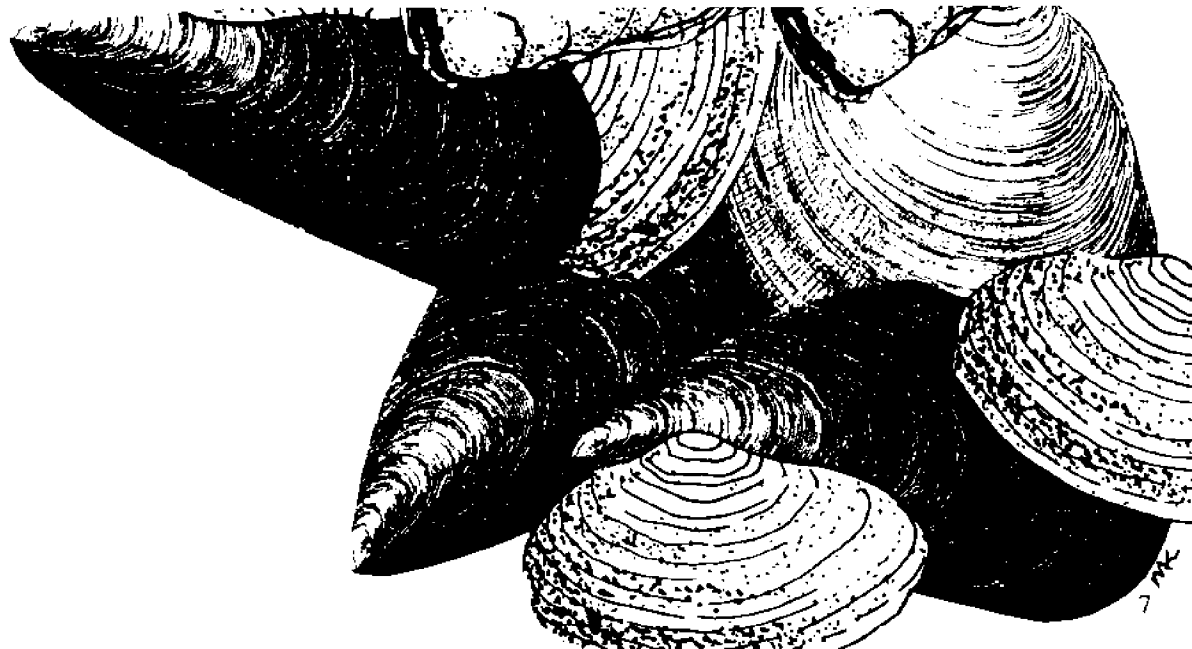
The largest single problem with cultivating this crustacean is the fact that it is cannibalistic. A second problem is its slow growth rate. In 40 F water it may require seven or eight years for a lobster to reach market size. Aquaculturists at the University of Maine's Ira C. Darling Marine Center and the Cutler Marine Hatchery are currently raising larval lobsters for release into coastal waters.

Is There an Organization for Aquaculturists in Maine?

Yes. The Maine Aquaculture Association (MAA) was formed in 1977 and is a cohesive force for the industry.

What Are Some of the Specific Problems Facing Maine's Aquaculture Industry?

Current constraints on the industry include seed availability; hatchery technology; mechanization of cleaning growing and fouling control; site selection for hatchery, nursery, and grow-out operations; overwintering methods and storage; automation in harvest and processing equipment; storage facilities; disease and pollution control; red tide monitoring, prevention, and controls; and improved growth rate and winter-hardy stock development.



MILESTONES IN MAINE AQUACULTURE

1949 European oysters from Holland are stocked in Maine.

1964 First soft-shell clams spawned in lab for research purposes in Boothbay Harbor (Bureau of Commercial Fisheries Biological Laboratory).

1966 Maine Department of Marine Resources (DMR) begins experiments cultivating many forms of marine life, including cultured oysters.

1970 Conference on aquaculture in New England held by TRIGOM (The Research Institute of the Gulf of Maine) in Durham, New Hampshire.

First state finfish grow-out efforts by Maine Salmon Farms, Wiscasset.

1972 Aquaculture hatchery built at the University of Maine's Ira C. Darling Center in Walpole as the foundation for first Sea Grant-funded project on the "Culture of Resources in a Cold Water Marine Environment." First facility to raise soft-shell clams on a large scale and to produce triploid shellfish of four species (American oysters, 1979; soft-shell clams and bay scallops, 1981; hard-shell clams, 1986).

1973 Enactment of the Maine Aquaculture Law.

1974-1977 Transfer of shellfish hatchery technology from university to private sector.

1975 First aquaculture lease granted in Maine to Abandoned Farm, Inc., Clark's Cove, South Bristol.

1977 Formation of Maine Aquaculture Association.

1979 Maine's first mussel bottom-culture lease.

1980 Development of Maine Aquaculture Plan by State Planning Office.

1983 Jonesboro 4-H Marine Project, stepping-stone that spawned Cutler and Beals Island hatcheries.

1985 Establishment of Fisheries & Aquaculture Research Group (FARG) within UM Agricultural Experiment Station.

1986 Founding of Cutler Marine Hatchery, first privately operated, fishermen-sponsored lobster rearing facility in U.S.

1987 Founding of Beals Island Regional Shellfish Hatchery, first-of-its-kind shellfish management program using hatchery-reared soft-shell clams.

1988 Formation of Maine Aquaculture Innovation Center.

1989 Formation of Cobscook Bay Finfish Growers Association.

MAINE'S CULTURED SPECIES

Aquaculture is a rapidly developing industry in the Northeast. As of 1986, there were more than 50 commercial aquaculture operations in Maine, from salmon ranching operations in the Cobscook Bay area Downeast to mussel farms along the Damariscotta estuary in the midcoast region.

In addition, aquaculture of other marine species, including oysters, clams, and lobsters, has also been established. Culture of scallops, halibut, and certain "gourmet" seaweeds have been proposed, but little or no research and development has been conducted. Culture of baitfish is a well-established industry in the state, with an annual market value of over $6 million.

Oysters

Oyster aquaculture in Maine must be viewed in the context of the ecology and history of the two resident species. The **American oyster** is a truly estuarine species that thrives in warm summer waters and survives in the coldest winters. These oysters were once locally abundant in the upper reaches of Maine's estuaries in south-central Maine. Potentially favorable environ-ments are still abundant, although natural populations are now rare. This factor, coupled with severe disease-related loss in the mid-Atlantic region, has made Maine a highly desirable culture environment for this species.

The **European oyster**, "the gourmet's choice of fine oysters in the world," was introduced to Maine in the late 1940's with new, commercially-important natural populations developing in south-central Maine since the early 1980's. The European oyster is oceanic in its evolution, growing in cooler summer temperatures, but not tolerating very cold winter temperatures. Therefore, the best culture sites are in the mid to lower estuary. The market for European oysters has also been spurred in the last several years by the disease loss of nearly the entire western European industry. Thus, the Maine environment today represents a culture area that has not experienced disease loss for either species of oysters.

Aquaculture of oysters in Maine began in the early 1970's, concurrent with the lease law of 1973, and it has evolved to a small, but stable, new industry. The early emphasis, pioneered by the Maine Coast Oyster Company of Blue Hill and furthered by others on the Damariscotta River, was on the raft culture of European oysters. Hatchery-produced "cultchless" seed oysters were reared to market size in two-three growth seasons by various forms of suspension gear, including Japanese lantern nets, stacked trays, and floating trays.

Two problems dampened the industry in the late 1970's: 1) the highly labor-intensive nature of suspension culture and 2) heavy overwinter mortality of European oysters coincident with the hard winters that occur every five to six years in Maine. As a result, in order to assure the oysters' survival, culturists rapidly changed their approach to culture. Although American oysters are now more important, European oysters are still being cultured.

Hatchery-produced seed is reared to a 2" size the first year in floating tray nurseries covering an acre or more. They are then overwintered in cool, damp-air storage to be later deployed to on-bottom leased sites which are protected from heavy weather. The major problem now is control of predators on the on-bottom sites, including crabs, oyster drills, starfish, and eider ducks. Using these techniques, the new industry is able to produce a high quality restaurant half-shell oyster in two to three growth seasons.

Over the past fifteen years, the foundation has been laid for what may become an important expanding industry for Maine. The major constraints to industry expansion are: 1) predator control with on-bottom culture, 2) deteriorating water quality, 3) poaching, and 4) political compatibility of the leasing system with adjacent inshore landowners. The oyster growers take the traditional viewpoint that Maine's rich estuaries should be a food production factory or farm, whereas other property owners see an unobstructed view of Maine waters as adding to their property value. Resolving these problems will require a certain amount of give and take by oyster growers and property owners in the future.

Mussels

Wild mussel harvests along the Maine coast have been recorded since 1887, with a peak of 2.6 million pounds of meat during World War II in 1944. Since 1979, total Maine mussel landings have increased from less than .5 million pounds to over 6 million pounds of meat per year. From 1982 to 1986, there was a five-fold increase in Maine's production of cultivated mussels (predominantly bottom culture) with landings increasing from about 200,000 to one million pounds of meat.

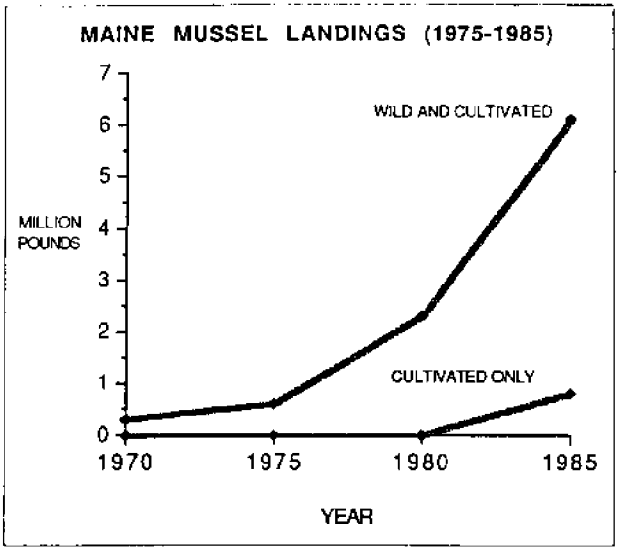
The increase in both cultured and wild landings in the 1980's was partly due to the market opportunities developed by the cultured fisheries, allowing for expansion of the wild fisheries and added stability in the marketplace.

In the early 1970's, the University of Maine's Sea Grant College Program funded work on the development of *rope culturing* techniques and conducted basic research that led to a more thorough understanding of the basic biology of the mussel. The rope culturing technique produced a very high quality product on a reliable basis. However, because of its labor intensive characteristics, it proved to be uneconomical except for the most discriminating markets.

Although rope culturing is not now the preferred method of cultivation, this technique will likely be used in the future as the market for mussels, especially the so-called "white table cloth trade," develops further.

Bottom culture is an economical alternative to rope culturing and is now the dominant method employed. The 1972 passage of legislation allowing aquaculture leases gave a strong impetus to the establishment of mussel bottom-culture leases.

In the wild, mussels tend to grow in dense clumps. The tight packing of the animals slows their growth and leads to a product of poor quality. If mussels are spaced out in less dense clumps, their growth rate and product quality improve markedly. Bottom culturing is



the transplantation of crowded, small mussels, so-called *seed*, from the dense clumps they tend to form naturally to less dense aggregations on other parts of the ocean bottom.

Because transplantation is costly, fishermen do not normally have an incentive to undertake it, unless they can be assured of exclusive rights to the results of their cultivation. Once that right is established, however, the incentives for further cultivation are limited only by the extent of the market for the product. Once lease rights are granted, strong incentives for the development of markets are also created. Therefore, the stronger the market, the more valuable the lease.

The strong demand for quality product that began in the early 1980's appears to be continuing and expectations in the industry are that expansion of the market may extend well into the 1990's. However, competition from other New England states and Canada and discoveries of high-quality wild stocks will require

increased quality and higher yields from Maine farms in order for the mussel bottom-culture industry to remain cost-effective in future years. High quality standards and consumer confidence in the health and safety of mussels will become increasingly important.

A quality control worker proudly displays a fresh catch of mussels in a Gulf of Maine processing plant.

Salmon Farming in Maine

The Maine coast offers the two main ingredients for salmon farming: a plentiful supply of clean, fresh water and nearby saltwater coves with strong tides. In fact, Maine waters in the Cobscook/Pasamaquoddy Bay region, the United States' eastern edge, are among the best suited for cultivation of salmon in the world. Due to the region's extraordinary tidal flows, twenty foot tides provide a continual flushing action that keeps the waters around the pens clear and provides an abundant supply of oxygen to the fish.

Net-pen cultivation of salmon involves rearing salmon in floating pens until they have reached marketable size. In general, a salmon farming operation proceeds as follows: young salmon roughly five inches in length ("smolts"), are purchased from a hatchery or reared by the aquaculture operation itself. These smolts are then placed in net-pens set in marine waters with suitable temperature, salinity, and oxygen levels.

The net pens, joined together in units of sixteen, cover about 2.5 total acres. An operation of this size can produce about 50,000 fish per annum for market. The net pen system is held in place by a line attaching it to a mooring set on submerged land. The smolts are "grown out" for a period of 18 to 24 months by feeding them specially manufactured dry feed pellets and/or wet feed developed from fish waste. To prevent spread of disease among the fish, they are innoculated or antibiotics are placed in the fish feed.

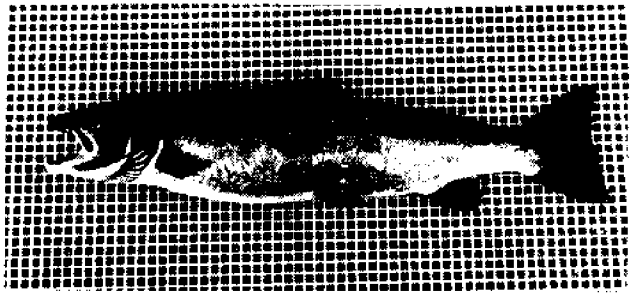
When they reach marketable size, the fish are harvested, cleaned and iced, and delivered to market. Because fish can be harvested on demand, prompt delivery of fresh product is a good selling point for farm-reared fish.

Rearing salmon in net pens results in discharge of a variety of pollutants. Uneaten feed, feces, antibiotics used to treat disease, insecticides used to treat parasites, and antifouling agents to treat the nets may enter the marine environment in varying concentrations and amounts. Proper site selection may be the most effective and least expensive form of pollution control.

Applications to lease Maine's submerged lands for use in growing pen-raised salmon have often met with stiff opposition from area residents. This opposition can be divided into three main areas of concern: 1) impacts on commercial fisheries either through the capture of traditional fisheries' markets or physical displacement of them; 2) impacts on amenities, such as scenic views, valued by littoral landowners; and 3) environmental impacts as potential threats to existing and future marine uses.

Although net-pen cultivation of Atlantic salmon has considerable commercial potential in Downeast Maine, growth in this emerging industry has been limited by local opposition to salmon aquaculture proposals. Opponents have focused arguments on aesthetic and environmental degradation impacts on opportunities in existing commercial fisheries.

Those involved with the industry maintain that appropriate siting of salmon aquacuture net-pen systems will prove the best form of pollution control. Adequate flushing of the lease area, a function of the large tides and currents in the waters of Downeast Maine, will also help prevent build-up of oxygen-demanding sediments, fish feces and feed, and associated water quality problems.



The first 10,000 salmon for an aquaculture project are transferred from a truck aboard the ferry Everett Libby to a net pen in Burnt Coat Harbor off Swan's Island, the first community west of Washington County to embrace commercial salmon aquaculture in its waters. At a Department of Marine Resources (DMR) aquaculture hearing on Swan's Island last April, 1989, Mariculture Products, Ltd., a Maine-based aquaculture venture, outlined plans to lease an 18-acre site in Toothacher Bay on the southwest side of Swan's island in cooperation with the Fishermen's Coop. The Fishermen's Coop was closely involved in the selection of the site, and its members will provide support services for the operation, including the icing and handling of fish and the storage of feed. (Excerpted in part from Island News/Summer 1989*)*

Clams

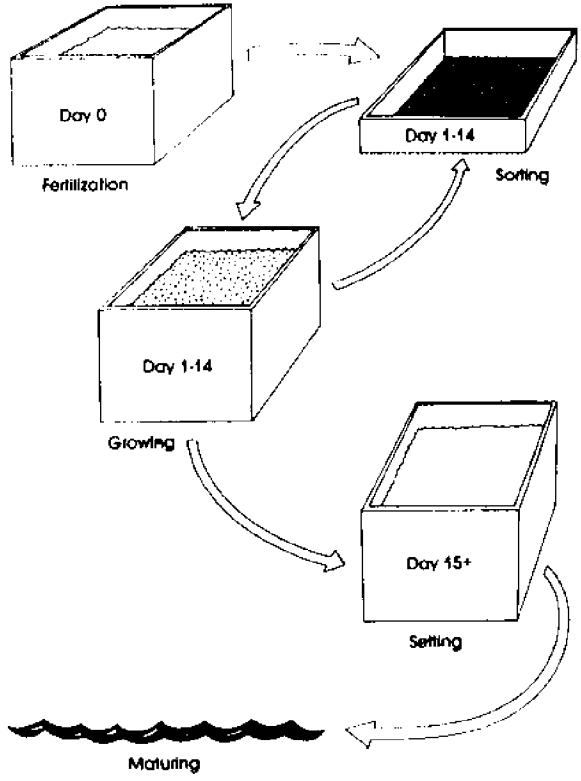
Stock enhancement of wild, commercially-important marine or freshwater species using progeny reared in an aquaculture facility is not uncommon. Both land-locked and ocean-dwelling salmon and trout are released yearly from public hatcheries in Canada, Norway, and the United States. Stock enhancement efforts using hatchery techniques are also underway in the Chesapeake to restore populations of striped bass and on Martha's Vineyard to raise juvenile lobsters, bay scallops, and hard clams.

In Downeast coastal Maine a similar public aquaculture venture began in 1987 with the creation of the Beals Island Regional Shellfish Hatchery management program. It is the first shellfish management program in this country based on stock enhancement using hatchery-reared, soft-shell clam juveniles.

From 1984 to 1987, statewide landings of Maine's second most economically-important marine resource (after lobsters) declined by 53%. In response, six communities in Washington County, where 45% of the state's clam landings are harvested, proposed utilize modern aquacultural techniques to enhance production of their existing, but dwindling, stocks.

In 1988, additional grant support funded construction of a greenhouse adjacent to the remodeled facility, and the towns of Cutler, Whiting, Steuben, and Mount Desert Island joined the program.

The question raised by the Beals Island hatchery, or by any public stock enhancement effort with high visibility, is whether or not the program is biologically and economically worthwhile. To assess the efficacy of this effort, University of Maine Sea Grant funds have been awarded to determine the environmental and biological variables in order to optimize growth and survival of the hatchery-reared juveniles. These parameters include: 1) transplant time, 2) stocking density, 3) clam size, 4) protection mechanisms, and 5) transplant sites.



Hatchery Diagram

Once these questions have been addressed, the soft-shell clam hatchery management program will be closer to reaching its long-range goal of using hatchery techniques for wiser management of natural stocks in the future.

Lobsters

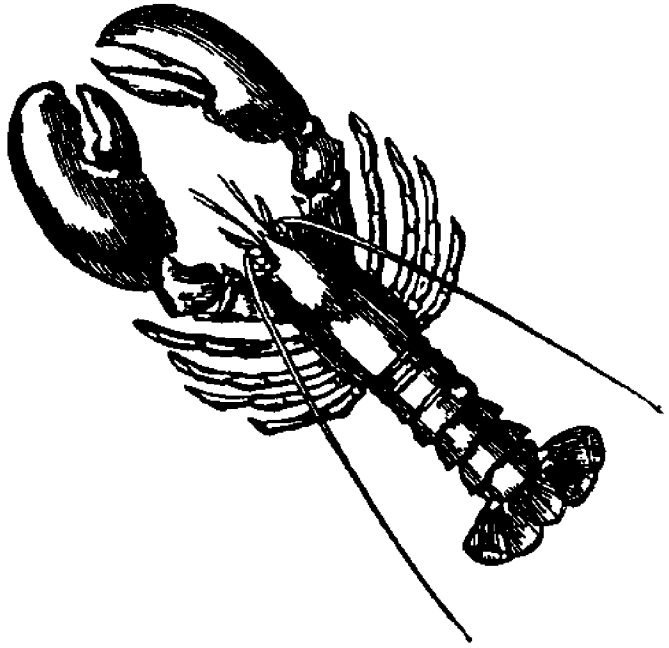
Hatching baby lobsters for release in the wild is not a new concept. At the turn of the century, several facilities in the Northeast were hatching and releasing millions of small lobsters. The large lobsters, known as "canners," were then part of the fishery, and many of them were females ripe with eggs. These eggs were scraped off the tails, incubated in jars, and later released in vast quantities as newly-hatched, first-stage larval lobsters.

In the early 1950s, a ten-gallon plastic bowl was modified to culture several thousand newly-hatched lobster larvae to the stage where they resembled small lobsters and would stay hidden on the bottom when released. This system used flow-through seawater and brine shrimp as a lobster food.

In 1985 lobster larvae were being raised using the above process at the Darling Marine Center in Walpole. An overabundance of lobster larvae led to the adaptation of existing shellfish hatchery equipment and techniques for the culture of larval lobsters. This innovative experiment allowed lobster larvae to be raised in static tubs of warmed seawater and was developed into a culture system that could be utilized effectively over a long hatchery season on the coast of Maine.

There are currently three locations in Maine where lobsters are being raised and released for stock enhancement purposes. Two of these are in Five Islands and Stonington and are funded and operated on a volunteer basis by fishermen themselves. The third is in Cutler and is a community-managed facility, funded by Maine's lobster fishermen and administered by the Department of Marine Resources. The fishermen-operated hatcheries produce 10,000-20,000 lobsters each year. The Cutler hatchery produced 175,000 in its third year of operation.

After nearly 100 years of lobster hatch and release programs, there is still one question that remains unanswered: Do these released lobsters recruit into the commercial fishery in large enough numbers to be worth all the hatchery effort? Although mechanical tagging of small lobsters is not feasible with existing technology, a tagging program to determine if hatchery-produced lobsters survive would be informative.



Raising and releasing lobsters which have been bred for a rare pigmentation is one technique currently being developed. Experimental efforts include collecting, culturing, and breeding blue and red adult lobsters to provide color-tagged baby lobsters for release. The rarity of these colors in the wild will allow easy identification of hatchery lobsters when they are caught in a lobster-sampling program or in a lobsterman's trap.

University of Maine personnel are also organizing an effort to monitor hatchery lobster behavior and survival from release to recruitment into the fishery. Results of these experiments will eventually establish whether to abandon lobster hatcheries or to establish one in every coastal community.

SITE SELECTION

Selecting the proper site is the most important consideration in starting up an aquaculture operation. The best seed source, the most extensive financing, and the best-prepared lease application will mean little, if a poor site is chosen. Site selection is also the most difficult and least specific step in the aquaculture process.

As land animals, humans have little understanding of the underwater nuances of current temperature, feed availability, and other factors which effect marine species. This section describes how site selection should be carried out, but please note that it deals with what has worked in the past rather than with any predictable or infallible methods.

Three factors to consider in choosing an aquaculture site are *convenience*, *biology*, and *politics*, which are each discussed below.

Convenience: Unfortunately, this is often the primary determining factor in most site selections. People like the idea of setting up an aquaculture operation near their house or off their dock so they can "keep an eye on it." The problem is that the spot right off one's dock may not be suitable for growing mussels or salmon.

In addition, the site must be accessible by boat at most tides, not involve long boat trips outside protected waters, and be relatively free of ice in the winter. It should also be protected from prevailing winds. In the case of mussel bottom culture, often two sites are chosen: one with protection from northeast wind and the other with protection from the southwest . This allows easy harvest in diverse weather conditions.

Biology: An aquaculture site must be able to support the species intended for culture. For example, mussel culture sites must have adequate algal levels, while salmon sites must be warm enough in winter. These basic biological facts should be considered in selecting an adequate site.

While areas can be studied for a variety of parameters (temperature, dissolved oxygen, chlorophyll, nutrients, current flow, etc.), current knowledge of the needs of cultured animals is so limited that intensive studies at this stage are usually not cost-effective. A look at what presently lives in the area is a more reliable indicator of good sites.

Test seeding of several areas with a few of the intended culture species is the best way to document a potential site. Growth rates of the test individuals can be measured and compared. The best site can then be chosen by balancing the "convenience" parameters (mentioned above) with the observed growth rates. Although growth observations take time (3-6 months), they are inexpensive and the most reliable means available to indicate true site potential.

Politics: Factors in this category deal not only with the requirements of Maine's aquaculture lease regulations but also with the "facts of life" along the Maine coast. Lease regulations and common sense both dictate that aquaculture sites not interfere with navigation in the area, the comings and goings of the people who own property on the nearby shore, or with traditional fishing activities.

When looking at a potential site, it is important to understand the traditional uses of that area. This is easily done by simply talking to people in the area. Involving the local community at this early stage has consistently resulted in fewer problems later in the process of setting up an aquaculture operation. By letting people know what is going on, sites can be located in less disurpting locations and less negative publicity will be generated when the operation is underway.

Site selection is a balancing act among the three categories discussed above. The site off the end of a private dock may be convenient and not interfere with anyone, but if mussels won't grow there, it is not a good place for a mussel lease. A currently available site that is protected from wind and ice with consistently warm temperature is not a good choice for a salmon site, if you can't get in there with a boat large enough to carry a few thousand adult fish. Finally, a site right in front of one's house with the most amazing oyster growth data is of little use for oyster bottom culture, if it is a lobstering "sweet spot" in the summer and dragged heavily for scallops and sea urchins in the winter. Consequently, any site selection is a compromise decision.

A LOOK AT LEASING

Under Maine law, 12 M.R.S.A. § 6072, the Department of Marine Resources (DMR) may lease areas in, on, and under the coastal waters including the public lands beneath those waters and portions of the intertidal zone for scientific research or for aquaculture of marine organisms.

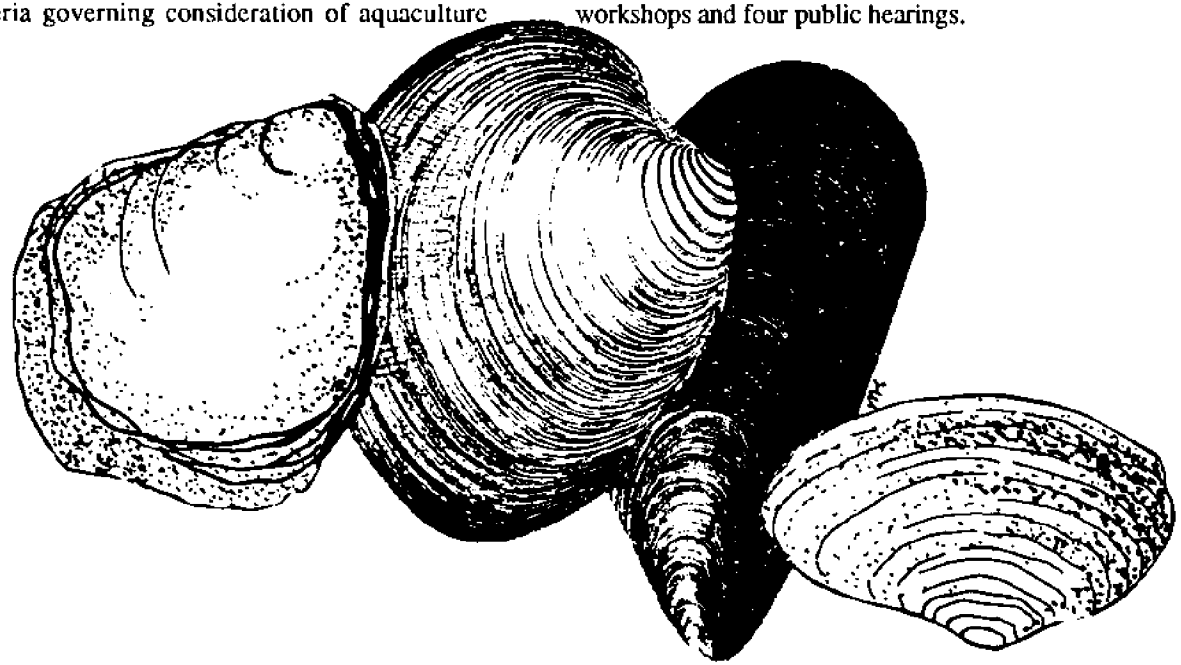
The Department of Marine Resources revised aquaculture regulations prescribe the procedures and substantive criteria governing consideration of aquaculture lease applications submitted to the Commissioner of Marine Resources pursuant to 12 M.R.S.A. § 6072 enacted by the Maine Legislature effective September 29, 1987. These regulations set forth procedural requirements for all aspects of the adjudicatory aquaculture lease application and administration process, consistent with the revised requirements of 12 M.R.S.A. § 6072 (the Aquaculture Statutes) and the Maine Administrative Procedures Act, 5 M.R.S.A. § 9051 *et seq.*

These revised regulations establish procedures and explain criteria governing consideration of aquaculture lease applications submitted to the DMR and prescribe criteria for subsequent annual lease review, lease renewal, lease revocation, and lease transfe

There are major differences between the current aquaculture regulations and the regulations adopted by the DMR in June, 1983.

A nonrefundable application fee is now required for all aquaculture applications, with varying fees depending on the size of the lease requested. The DMR must conduct an environmental review of the proposed lease prior to the public hearings on these applications. Lease applicants must show that they have the technical capabilities and financial capacity to operate and maintain all aspects of their proposed aquaculture activities. In response to a legislative mandate, the lease rental fees have been increased from $15.00 to $50.00 per acre per year for all categories of aquaculture leases.

These new and revised regulations went into effect on December 27, 1988, following several industry workshops and four public hearings.



AQUACULTURE RESOURCE DIRECTORY

Shellfish Specialists

Robert Bayer
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Dept. of Animal & Veterinary Sciences
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(207) 581-2785

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Samuel Chapman
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Aquaculture Specialist
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Newcastle, Maine 04553
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Chris Heinig & Brian Tarbox
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University of Maine
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One Howell Lane
Eliot, Maine 03903
(207) 439-1876

William Mook
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Mook Sea Farms, Inc.
HC 64 Box 041
Damariscotta, Maine 04543
(207) 563-1456

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Abandoned Farm, Inc.
P.O. Box 551
Damariscotta, Maine 04543
(207) 563-3935

Carter Newell
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P.O. Box 141
Tenants Harbor, Maine 04860
(207) 372-6317

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McKown Point
West Boothbay Harbor, Maine 04575
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University of Maine
Orono, Maine 04469
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Orono, Maine 04469
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234 Nutting Hall
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Demonstration & Development Farm
RR 4 Lime Kiln Road
St. George, New Brunswick EOG 2YO
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(207) 581-2735

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Maine Dept. of Inland Fisheries & Wildlife
284 State Street
Augusta, Maine 04333
(207) 289-3651

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(salmonid culture)
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University of Maine
Orono, Maine 04469
(207) 581-2582

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Aquatic Animal Health Laboratory
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(207) 581-2810

Glenn Salvadore
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Fisheries Technology Service
P.O. Box 99
Beals, Maine 04611
(207) 497-5997

Evelyn Sawyer
(finfish hatchery; salmonid vaccines)
Sea Run, Inc.
RR #1, Box 1045
Kennebunkport 04046
(207) 985-7957

AQUATIC ANIMAL HEALTH LABORATORY

The Aquatic Animal Health Laboratory (AAHL) at the University of Maine is designed to provide user groups in Maine and nearby New England states with sophisticated monitoring of the health status of aquatic animals, especially cultivated species.

The health monitoring can include certification for absence of specific diseases and/or determining the cause of disease outbreaks as needed. The laboratory at Orono and its affiliates have the most up-to-date facilities which enable them to supplement, not supplant, other existing services in the state. (See listing under Paul Reno)

Sea Urchins & Seaweed

Benjamin Baxter
Extension Professional/Marine Program
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Ellsworth, Maine 04605
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Bristol, Maine 04539
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216 Deering Hall
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Orono, Maine 04469
(207) 581-2978

Leases & Site Evaluation

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Commissioner, Maine Dept. of Marine Resources
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Augusta, Maine 04333
(207) 289-2291

Penn Estabrook
Deputy Commissioner
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Augusta, Maine 04333
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Ken Honey
Hearings Officer
Maine Dept. of Marine Resources
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Bristol, Maine 04539
(207) 529-5349

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Durwood Gray
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Belfast, Maine 04915
(207) 342-5971

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University of Maine
Orono, Maine 04469
(207) 581-1854

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Damariscotta 04543
(207) 563-1456

Mussels

Abandoned Farm, Inc.
P.O. Box 551
Damariscotta 04543
(207) 563-3935

Isaac Beal
P.O. Box 124
Beals 04611
(207) 497-5632

Blue Hill Mussel Farms
Box 58
Blue Hill 04614
(207) 374-5488

Paul Brayton
Route 175
Brooklin 04616
(207) 359-8877

Bruce Davis
Box 587
Addison 04606
(207) 497-2640

Great Eastern Mussel Farms, Inc.
P.O. Box 141
Tenants Harbor 04860
(207) 372-6317

Elliott Guptill
586 Basin Road
Addison 04606
(207) 497-5962

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States Point Road
St. George 04857
(207) 372-8825

David Hutchinson
P.O. Box 405
Highland Avenue
Stonington 04681
(207) 367-5000

Dennis Johnson
Box 146A
Milbridge 04658
(207) 546-2644

Little River Mariculture Co.
P.O. Box 198
Machias 04654
(207) 255-3931
(also European oysters)

Maine Mariculture
Route 129
So. Bristol 04568
(207) 644-8428

Maine Sea Farms, Inc.
Main Street
Box 521
Blue Hill 04614
(207) 374-2893

Ralph Smith
P.O. Box 267
W. Jonesport 04649
(207) 497-5721

John Stotz
P.O. Box 131
Round Pond 04564
(207) 529-5566

Paul Thompson
P.O. Box 375
Cutler 04626
(207) 259-2053
(Oysters, scallops)

Oysters

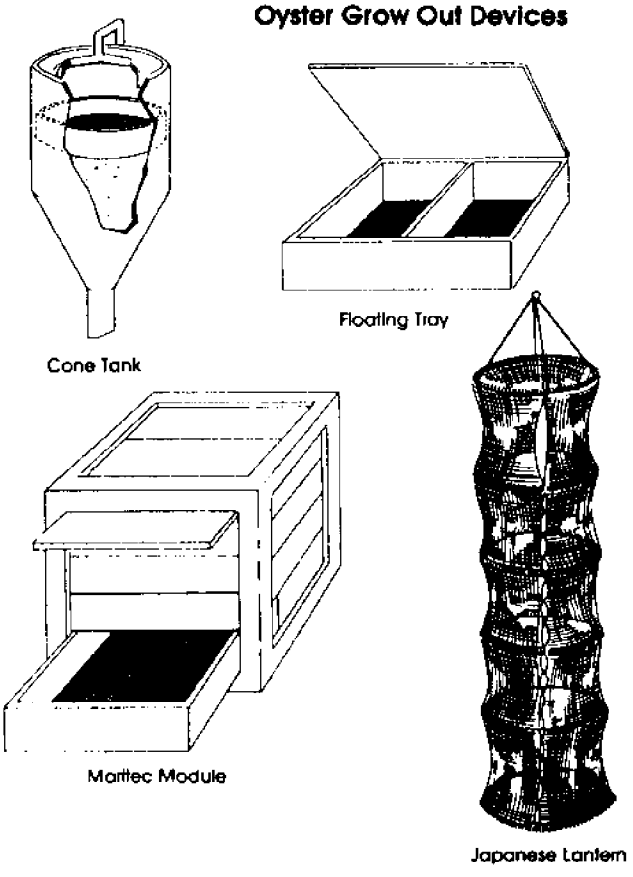
Richard Carver
27 Pacific Street
Rockland 04841
(207) 594-8153

Carver's Shellfish (hatchery)
Beals 04611
(207) 497-2261

Dodge Cove Marine Farms, Inc.
P.O. Box 211
Newcastle 04553
(207) 563-8168

Maine Mariculture
Route 129
So. Bristol 04568
(207) 644-8428

Marine Bioservices Company (hatchery)
High Island
So. Bristol 04568
(207) 644-8537



Mook Sea Farms, Inc. (hatchery)
HC 64, Box 041
Damariscotta 04543
(207) 563-1456

Pemaquid Oyster Company
RFD #1, Box 149
Damariscotta 04543
(207) 563-8440

Kevin Scully
RR #1 Box 2598
North Edgecomb 04556
(207) 633-3599

Sea Farms Associates
3081 Mere Point Road
Brunswick 04011
(207) 725-4557

Spinney Creek Oyster Company
One Howell Lane
Eliot 03903
(207) 439-1876
(also clams)

York Harbor Export, Inc.
P.O. Box 737
York Harbor 03911
(207) 363-7207

Hard Clams, Soft-shell Clams, Surf Clams and Bay Scallops

Beals Island Regional Shellfish Hatchery
P.O. Box 195
Beals 04611
(207) 497-5769

Chance Along Sea Farms, Inc.
Flying Point Road
Box 164
Freeport 04032
(207) 773-0788

Mook Sea Farms (hatchery)
HC 64, Box 041
Damariscotta 04543
(207) 563-1456

Sea Farms Associates
3081 Mere Point Road
Brunswick 04011
(207) 725-4557

Salmon and Trout

Atlantic Salmon, Inc.
32 Quarry Road, Apt. 14
Waterville 04901
(207) 872-0882

Craig Brook National Fish Hatchery
P.O. Box A
East Orland 04431
(207) 469-2803

Ducktrap River Fish Farm
RFD #1
Lincolnville 04841
(207) 763-3960

East Coast Fish Farms
Box 231
Leighton Point Road
Pembroke 04666
(207) 726-3997

Scott Emery
George Harris
Kendall's Head
Eastport 04631
(207) 853-2913

Green Lake National Fish Hatchery
RFD 4, Box 135
Ellsworth 04605
(207) 667-9531

Island Salmon, Inc.
5 Key Street
Eastport 04631
(207) 853-2501

Maine Coast Nordic
104 Maine Street
Bar Harbor 04609
(207) 288-3331

Maine Fishfarm, Inc.
One Memorial Circle
Augusta 04330
(207) 623-5167

Maine Pride
5 Sea Street
Eastport 04631
(207) 853-6088

Maine Salmon
5 Key Street
Eastport 04631
(207) 853-2543

Mariculture Products, Ltd. (hatchery)
P.O. Box 528
Bingham 04920
(207) 667-5422
and
98 Main Street, Suite A
Ellsworth 04605
(207) 667-5422

Nellie B. Fisheries, Inc.
Route 190
Eastport 04631
(207) 853-6066

North Atlantic Aquaculture
8 Prince Street
Eastport 04631
(207) 853-2789

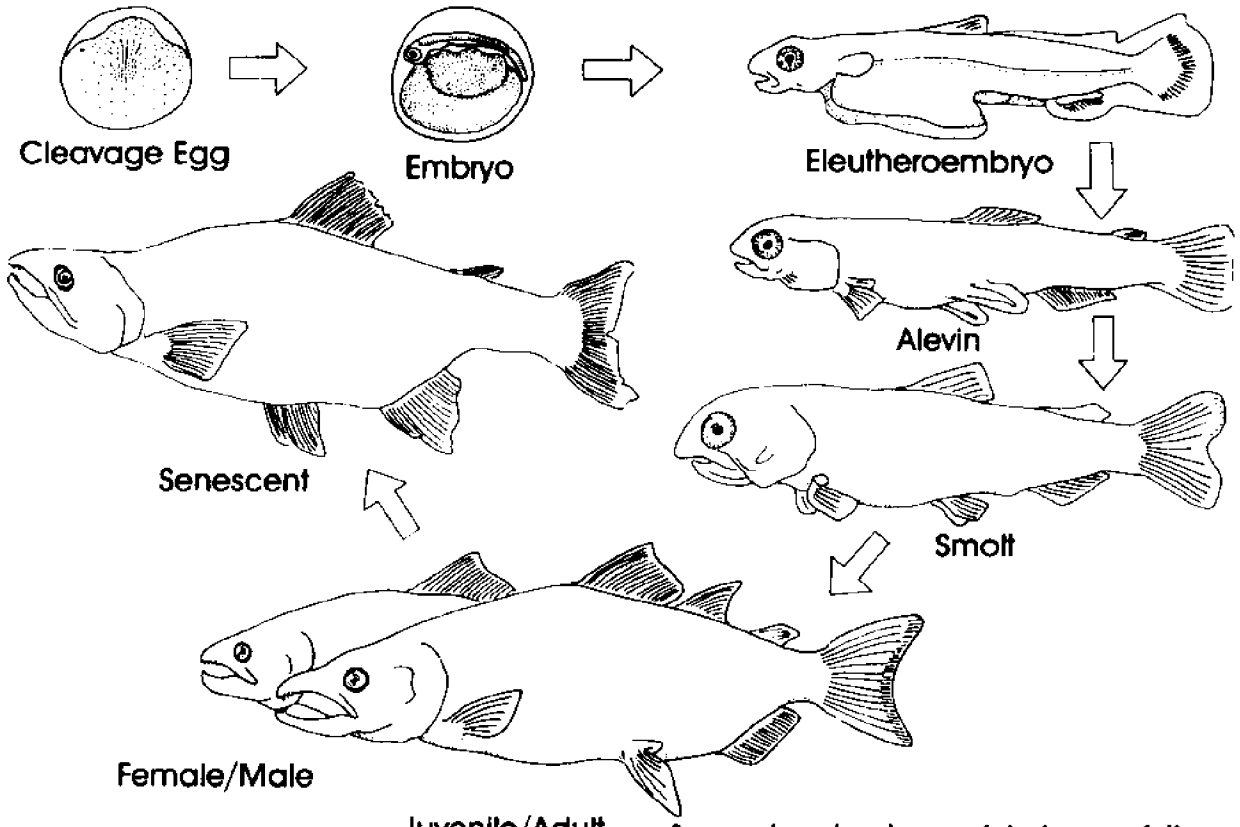
Ocean Products, Inc.
P.O. Box 263, Estes Head
Eastport 04631
(207) 853-6081
and
400 Commercial Street
Portland 04101
(207) 774-5124

Rier Brothers Salmon Company
Diamond Point
Lubec 04652
(207) 733-4477

Sea Farm Lubec, Inc.
P.O. Box 279
Pumping Station Road
Lubec 04652
(207) 733-2458

Sea Run, Inc.
RR #1, Box 1045
Kennebunkport 04046
(207) 985-7957

Senorita Fisheries, Inc.
78 County Road
Eastport 04631
(207) 853-4481



Successive developmental stages of the salmon.

Skybird Unlimited
RFD #2, Box 272
Lubec 04652
(207) 733-4489

Gary Small
Box 70C
Eastport 04631
(207) 853-4248

Jeffrey Stevens
RFD #2, Box 235
Lubec 04652
(207) 733-4683

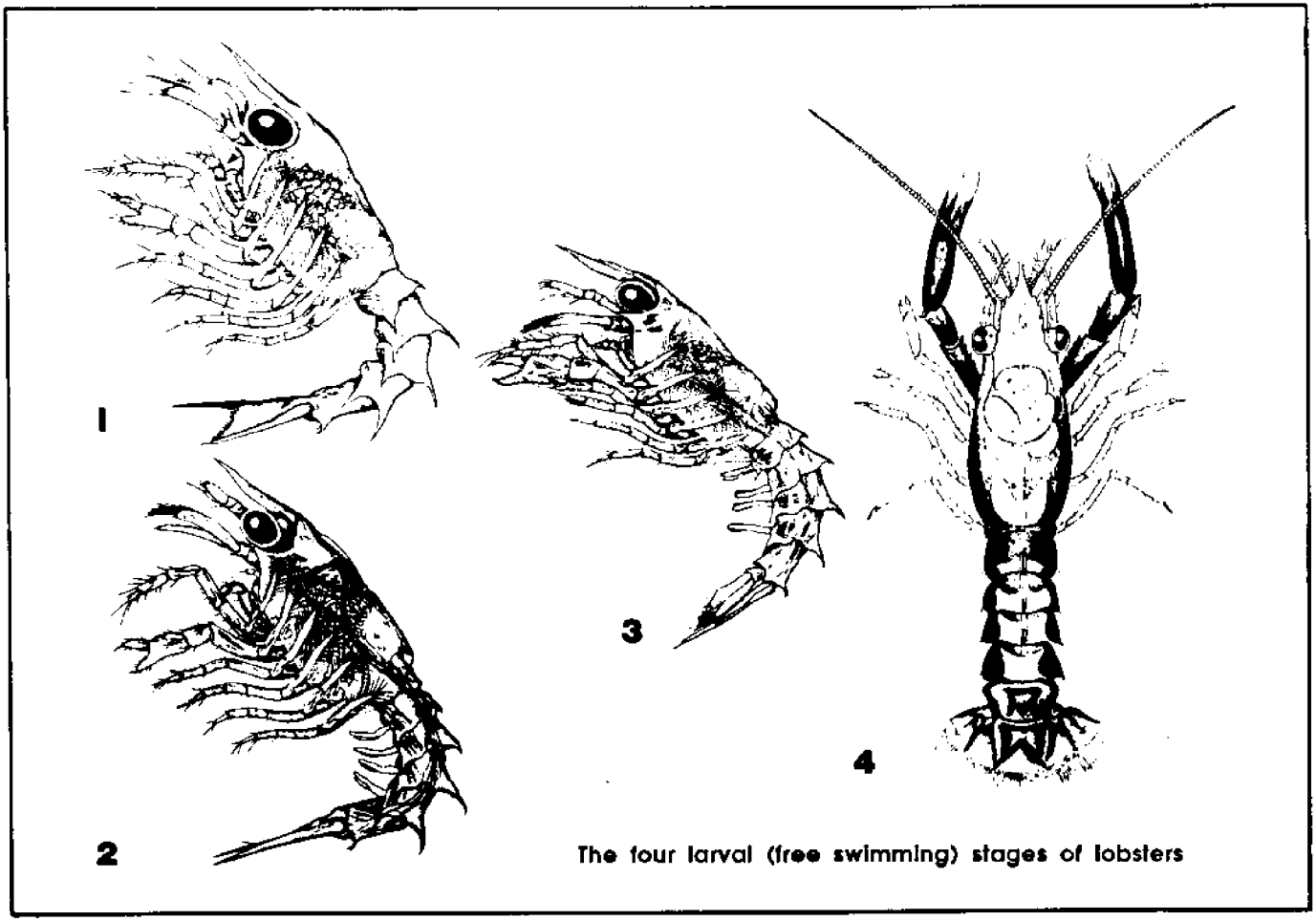
Stonington Packing Company
P.O. Box 528
Rockland 04841
(207) 594-4412

Public/Community Aquaculture

Beals Island Regional Shellfish Hatchery
P.O. Box 195
Beals 04611
(207) 497-5769

Cutler Marine Hatchery
Cutler 04626
(207) 259-3693

Darling Marine Center
Walpole 04573
(207) 563-3146



The four larval (free swimming) stages of lobsters

REGIONAL BUSINESS ASSISTANCE AGENCIES

Small Business Development Centers

Coastal Enterprises, Inc.
(Lincoln, Sagadahoc, and Knox counties)
P.O. Box 268
Wiscasset, Maine 04578
(207) 882-7552
Contact: James Burbank

Eastern Maine Development Corporation
(business counseling and loans)
P.O. Box 2579
One Cumberland Place
Bangor, Maine 04401
(207) 942-6389
Contact: Charles Davis

University of Maine at Machias
(Washington County)
Math and Science Building
9 O'Brien Ave.
Machias, Me. 04654
207/255-3313, ext. 287
Contact: William Little

University of Southern Maine
(York and Cumberland counties)
59 Exeter St.
Portland, Me. 04102
207/780-4949
Contact: Diane Branscomb

Other Agencies

Farm Credit of Southern Maine, ACA
615 Minot Avenue
Auburn, Maine 04210
(207) 784-0193
Contact: Frederick Morton

Quoddy Job Opportunity Zone
Washington County Vocational Technical Institute
River Road
Calais, Maine 04619
(207) 454-2144
Contact: Hugh Porter

SCORE (Service Corps of Retired Executives)
(Small business counseling at no charge)

Augusta	622-8509
Bangor	941-9707
Ellsworth	667-5800
Central/Northern Aroostock	498-6156
Lewiston/Auburn	782-3708
Oxford Hills	743-2425
Portland	772-1147

Statewide Business Assistance Agencies

Finance Authority of Maine
83 Western Ave.
Augusta, Maine 04330
(207) 623-3263
Contact: Karen Lazareth

Maine Department of Economic and Community Development
State House Station 59
193 State St.
Augusta, Maine 04333
(207) 289-2656
Contact: Nancy Seawall or Duane Tuttle

Maine Development Foundation
45 Memorial Circle
Augusta, Maine 04330
(207) 622-6345
Contact: Henry Bourgeois

Small Business Administration
40 Western Ave.
Augusta, Maine 04330
(207) 622-8242 (management assistance)
(207) 622-8378 (finance)
District Director: Roy Perry

United States Department of Agriculture
Farmers Home Administration
USDA Office Building
Orono, Maine 04473
(207) 581-3400
Contact: Raymond S. Roberts III

Technical Assistance

Center for Innovation & Entrepreneurship
16 Godfrey Drive
Maine Tech Center
University of Maine
Orono, Maine 04473
(207) 581-1465
Contact: Ray Noddin

Department of Industrial Cooperation
University of Maine
109 Boardman Hall
Orono, Me. 04469
207/589-2200
Contact: Lois Pineau

Department of Industrial Cooperation
University of Southern Maine
101 Technology Center
Gorham, Me. 04038
207/780-5439
Contact: Ivan Most

Fisheries Technology Service
Maine Department of Marine Resources
State House Station 21
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(207) 289-2291
Contact: Phillip Averill

Maine Agricultural Experiment Station Fisheries & Aquaculture Research Group
University of Maine
Orono, Maine 04469
(207) 581-2709
Contact: John Riley

Sea Grant Marine Advisory Program & Maine Lobster Institute
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Orono, Maine 04469
(207) 581-1422
Contact: David Dow

Innovation Awards

Environmental Protection Agency
Office of Research and Development
Research Grants Staff (RD-675)
401 M Street, S.W.
Washington, D.C. 20460
(202) 382-7445
Contact: Walter Preston, SBIR Program Manager

Maine Aquaculture Innovation Center
University of Maine
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Contact: John Riley, Program Director
(207) 581-2715
Robert Blake, Associate Director
(207) 581-2759

Maine Science & Technology Commission
State House Station 147
Augusta, Maine 04333
(207) 289-3703
Contact: Tish Tanski

National Coastal Resources Research & Development Institute
Hatfield Marine Science Center
2030 South Marine Science Drive
Newport, Oregon 97365
(503) 867-3300
Contact: Earle S. Buckley

National Science Foundation
1800 G Street, N.W., Room 1250
Washington, D.C. 20550
(202) 357-9666
Contact: Roland Tibbetts
or Ritchie Coryell, SBIR Program Managers

Northeast Regional Aquaculture Center
Southeastern Massachusetts University
North Dartmouth, Massachusetts 02747
(508) 999-8157
Contact: Gerald A. Donovan

Sea Grant College Program
14 Coburn Hall
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Orono, Maine 04469
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Small Business Innovation Research
Office of Innovation, Research, and Technology
Small Business Administration
1441 L Street, N.W., Room 500
Washington, D.C. 20416
(202) 653-6458
Maine Contact: (207) 622-8378

U.S. Department of Agriculture
Room 323-J, Aerospace Building
Washington, D.C. 20251-2200
(202) 447-7002
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Business Development and Financing

SBDC Business Information Service
59 Exeter St.
Portland, Me. 04101
207/780-4949
Contact: Janice Tisdale
(marketing research to small businesses at no cost)

Small Business Administration
40 Western Ave.
Federal Building
Augusta, Me. 04330
207/622-8378
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