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Feasibility of the Development of Aquaculture in the State of New Hampshire: A Case Study of the Sea Scallop, *Placopecten magellanicus*

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GOMAR

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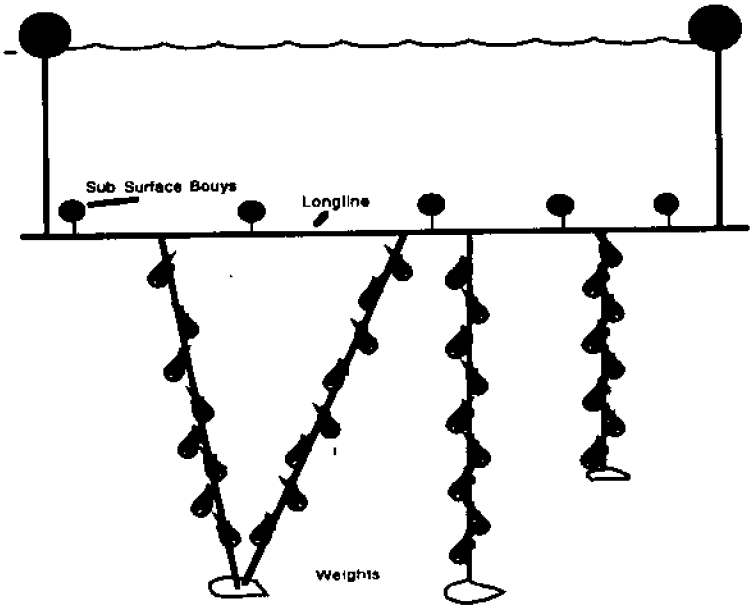

TECH 797; Oceans Projects Course

University of New Hampshire

May 1997

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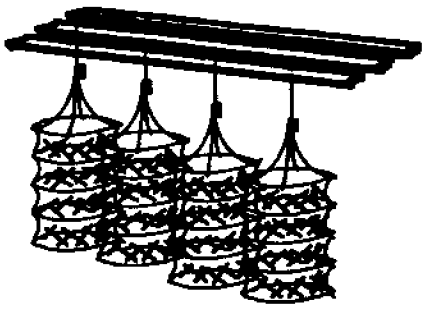
Can be up to 10 levels

Pearl Nets

Optimal in strings of 10



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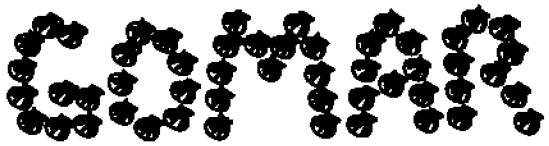

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Table of Contents

List of Tables. iv

List of Figures. iv

Abstract. v

Statement of Purpose. 1

Introduction. 2

Methods. 8

Results. 11

Discussion. 42

Recommendations. 46

Appendix A:

Application for Marine Aquaculture License. . . . 55

Appendix B:

NH State and Federal Marine Aquaculture Agencies. . . 56

Appendix C:

Map of New Hampshire Coastal Zone. 58

References. 59

List of Tables

Table 1. Landed pounds and market values of the four most frequently fished species in New Hampshire waters in 1995 (NH Dept. of Fish & Game.). 4

List of Figures

Figure 1. Suspension culture of spat bags. . . . 16

Figure 2. Spat bags hung from cages. 17

Figure 3. Chinese lantern nets. 18

Figure 4. Pearl nets. 18

Figure 5. Ear hanging technique. 19

Figure 6. Scallops glued to strip. 19

Figure 7. Cages set on ocean bottom. 20

Figure 8. Example of hanging Chinese lantern nets below a float. 52

Abstract

Due to the declining conditions of traditional marine fisheries in New Hampshire, the feasibility of aquaculture development in this state was studied. A model organism, the sea scallop, *Placopecten magellanicus*, was selected, and stake holders representing various facets of the New Hampshire Seacoast community were interviewed, including representatives of fishermen, state planning agencies, regional planning agencies, academia, and cooperative extension agencies. In addition, the regulation of aquaculture in New Hampshire, surrounding coastal states, and Canadian provinces was researched. Operating scallop farms in Nova Scotia were visited. This data was synthesized to evaluate the potential for aquaculture of *Placopecten magellanicus* in the of State New Hampshire. It is our conclusion that aquaculture is not only feasible in the NH coastal zone, but that it offers many benefits to coastal communities and the state. These results clearly illustrate the regulating factors which need to be considered, methods available to operate an aquaculture farm, the high amount of community support, and, finally, the feasibility of *P. magellanicus* aquaculture in both the Portsmouth Harbor and the New Hampshire coastal waters between New Hampshire and the Isle of Shoals. Furthermore, the benefits from an aquaculture operation are discussed, which incorporate the economic stability that aquaculture can offer to the community. Recommendations were also made to feasibly facilitate the development of aquaculture in New Hampshire.

Statement of Purpose

The purpose of this document is to explore the feasibility of the development of an aquaculture industry in New Hampshire, particularly that of the sea scallop, *Placopecten magellanicus*.

For the past several years, there has been an increasing interest in the development of aquaculture in the New Hampshire Seacoast region within public, private, and academic sectors. With declining landings and increasing demand, it has become obvious that a reasonable alternative or supplement to conventional fishing practices should be considered. Through this document, we have 1.) described the potential benefits of a scallop aquaculture industry to the State of New Hampshire, 2.) documented that this organism is viable for culture in New Hampshire coastal waters, 3.) summarized the possible methods of aquaculture of the sea scallop, 4.) outlined the regulatory obstacles to the development of this industry, 5.) discussed the attitudes, concerns, and perceptions of the various stakeholders in such an industry, and 6.) proposed possible recommendations for aquaculture in New Hampshire. This document was intended to promote further discussion of this issue among State of New Hampshire coastal planners and resource management agencies, local fishermen, governments of coastal municipalities, and academia at the University of New Hampshire and its Cooperative Extension program. In addition, we have illustrated that, with foresight and cooperation, aquaculture can reap many benefits for this region.

Introduction

The global rate of decline of fish and shellfish harvests in the past two decades has been alarming, and it has become increasingly evident that this dilemma will only worsen. The March 1996 draft of the National Aquaculture Development of Plan of 1996, proposed by the Joint Subcommittee on Aquaculture (JSA) of the National Science and Technology Council states that worldwide harvests of these products peaked in 1989 at 100.2 million metric tons and have remain unchanged since then. It continues by citing the Aquaculture Production Statistics, 1984-1993, of the Food and Agriculture Organization (FAO) of the United Nations (1995), in which it is noted that 70% of the world's conventional commercial species are now fully exploited, overexploited, depleted, or recovering from depletion. FAO scientists are quoted in the JSA's draft as saying that, "in some cases, some heavily fished species are approaching not only commercial, but biological extinction."

In addition, seafood is becoming more relied upon worldwide as a source of protein. However, our oceans will soon no longer be able to meet this increased demand. The JSA also mentions in the 1996 draft that there will be a 25% increase (from 72.3 to 91 million metric tons) in the worldwide demand for seafood products between 1993 and 2010. The over exploitation of these waters, however, is beginning to have drastic repercussions on a national scale as well. The U.S. Department of Commerce predicts that U.S. demand for seafood will increase by 1.4 million metric tons by the year 2000 due solely to population growth. Howell, et al. (1995), cite National Marine Fisheries Service data from 1993 showing that landings from the North Atlantic trawl industry have dropped 50% from 1983-1992, while the U.S. rate of consumption of seafood has increased by 25% over the same time period.

The federal government has acknowledged the importance of aquaculture and is becoming more supportive of aquaculture initiatives. The 1980 National Aquaculture Act (P.L. 96-362) formulated a national policy toward the development of aquaculture. This act emphasized that the primary responsibility for the development of aquaculture lies in the hands of the private sector, but also discussed the importance of the role of federal government policies and programs that could enhance research, development, education, and interdepartmental cooperation in its development. Additionally, a 1993 amendment to the Magnuson Act recognized aquaculture as one component of the overall effort in the Northwest Atlantic Ocean Fisheries Investment Program. Nearby states, including Maine, Massachusetts, and Connecticut, have developed strategic plans for the development of aquaculture. These governments have included aquaculture in their coastal zone management plans and have begun to provide funding for incentive programs.

As landings have decreased, fishermen all along the Eastern Seaboard are finding it harder and harder to make a living. In an attempt to restore groundfish stocks at Georges Bank in the eastern Gulf of Maine, the New England Fishery Management Council closed this once-abundant fishing grounds in 1994. Although this action will hopefully reap long-term benefits, it has been extremely detrimental to the lives of those who rely on the ocean for their livelihood, leading to high unemployment rates and idle fishing vessels. New Hampshire fishermen have not been spared. In 1997, the waters off of Cape Cod, which is a major migratory route for the right whale, were closed to fishing by fixed equipment because these animals can be trapped in this equipment. The Portsmouth Fisherman's Cooperative has recently filed for a tax break from the City of Portsmouth because their revenue has decreased by $1 million from the previous year.

In 1995, the most recent statistics to date produced by the New Hampshire Department of Fish & Game, the total number of landed pounds of commercial fish species was 11,727,864 with a total value of $14, 925,877 (Table 1)

Table 1: Landed pounds and market value of four most frequently fished species in New Hampshire waters in 1995 (NH Dept. of Fish & Game.)

Species	Landed Pounds	Market Value
Cod	2,362,707	$2,469,878
Spiny Dogfish	2,106,255	$397,812
Lobster	1,834,794	$6,655,660
Shrimp	1,658,588	$1,420,581

Shellfish harvests have, in the past, been successful in New Hampshire, including the soft-shell clam (*Mya arenaria*) in Hampton-Seabrook Estuary, and the American and European oysters (*Crassostrea virginica* and *Ostrea edulis*, respectively) of Great Bay. In 1989, however, shellfish beds were closed by the Food & Drug Administration due to insufficient water quality data, and the state's non-compliance with National Shellfish Sanitation Program (NSSP) guidelines prohibits the commercial sale of shellfish products from New Hampshire waters. These closures will remain until the state implements water classification guidelines recognized by the NSSP and receives an FDA review of recent sanitation surveys, but it is anticipated that a water classification system will be implemented in the near future. Until then, only off-shore recreational fishing from November to April is allowed for the sea scallop (*Placopecten magellanicus*). Sea scallops exist in New Hampshire coastal waters in significant numbers from Portsmouth Harbor to the Isles of Shoals. Development of a commercial shellfish industry could allow New Hampshire to enter into markets for new products, creating new jobs and boosting revenue for the state in additional fishing license fees.

With landings and broodstocks in decline and consumer demand on the rise, there is no question that New Hampshire must turn to innovative methods of adapting to this dynamic and changing market as its fishing industry collapses. Aquaculture could be a feasible solution to this crisis by providing for the maintenance of a harvestable population of fished organisms.

The FAO defines aquaculture as "the farming of aquatic organisms, including fish, mollusks, crustaceans, and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated..." (National Aquaculture Development Plan, 1996.)

The Maine Aquaculture Innovation Center at the Darling Marine Center on the Damariscotta River has created the following definition of aquaculture: "Aquaculture is the controlled cultivation and harvest of aquatic animals and plants. Mariculture is the raising of such crops in the sea. Aquaculture includes both: a) the production of aquatic organisms (animals and plants) that are harvested by an individual or corporate body which has owned them throughout their rearing period , and b.) the controlled rearing of aquatic organisms (during a least one part of their life cycle), such organisms being exploitable by the public as a common property resource (e.g. ocean ranching, commercial and recreational stocking, and fattening of captured stock.)" (Information above obtained from the Maine Aquaculture Innovation Center website: www.mstf.org/~meaqua/index.html.)

Both of these definitions include a provision describing that the farmed organisms are owned and state that the cultivation of the farmed organism is controlled at some point in its life cycle. Through this manipulation, aquaculture can be used in two ways to enhance or supplement the harvesting of natural

populations. By cultivating and protecting early life history stages of desired organisms, natural stocks can be restored through the process of enhancement. If natural or anthropogenic disasters lead to fluctuations in population densities, or if the taking of wild stock has been banned, more intensive aquaculture techniques can be employed in which the organisms remain in captivity from settlement to harvestable size.

Aquaculture could have a potentially significant impact on the state's economy and the fiscal health of the seafood industry. Development of previously non-commercial species may increase revenue by allowing expansion into new markets. Aquaculture could allow for year-round harvesting of this organism through intensive culture or for enhancement of the natural stocks. The industry could become more efficient through polyculture techniques, in which more than one organism is farmed in the same space. New jobs could undoubtedly be created in maintaining an aquaculture facility, marketing the new products, and carrying out value-added processing. Value-added processing augments the marketable qualities of the organism so that they sell for a higher unit price. Aquaculture facilities could serve a dual role as educational centers for the public, attracting tourists to take advantage of site tours, and also enticing them to eat seafood farmed fresh in the state of New Hampshire.

The opportunity to develop aquaculture is clearly presenting itself now. From 1984-1992, aquaculture's contribution to world food fish supply increased from 12% to 17%, and its contribution to animal protein supply increased from 1.8% to 2.7%. On a global scale, many countries, especially Japan, Norway, New Zealand, and Canada, realize the vital importance of aquaculture to help sustain their fishing industries. In contrast, U.S. domestic aquaculture currently supplies only 5.9% of the nation's seafood needs, and the United States is ninth in the

world in terms of value of its aquaculture products (National Aquaculture Development Plan, 1996).

The FAO projects that, to meet global seafood needs by 2010, aquaculture production will have to double over the next decade and a half. Many coastal states, including Maine, Massachusetts, and Connecticut, have developed strategic plans for aquaculture development. It is clear that New Hampshire must evaluate the needs of its coastal resources and begin to seriously consider the feasibility and viability of aquaculture as an option to supplement its fishing industry.

Methods

To investigate the feasibility of aquaculture in New Hampshire, this study focused on the development of the sea scallop, *Placopecten magellanicus*. This species was chosen for several reasons.

1.) A stable market and consumer recognition already exists for the adductor muscle of this organism, and new venues for the half-shell market are currently being explored (Dadswell and Cooper).

2.) *P. magellanicus* can be grown to market size within a year-and-a-half to two years. (Dadswell).

3.) It is naturally abundant in New Hampshire coastal waters and throughout the Gulf of Maine in shallow water less than 20m deep.

4.) Successful scallop farms are currently operational in New Zealand, Japan, and the provinces of Atlantic Canada, including New Brunswick, Nova Scotia, and Prince Edward Island, and Quebec.

5.) The commercial fishery for sea scallops operates year-round, and aquaculture of this organism could be used as a supplement to other *seasonal* fisheries.

Furthermore, although nominal landings of sea scallops in the Gulf of Maine increased by 10%, or 800 metric tons, from 1991 to 1993, the U.S. total decreased by 48% from 1992 to 1993. In addition, USA landings on Georges Bank, which make up only 37% of the total landings there, dropped 56% in 1993, and larval abundance indicates that the number of landings will continue to decline. Fishing effort is double the overfishing level set by the New England Fishery Management Council, so any episode of high recruitment rates would not be beneficial in the long-term.

Over 80% of the landings in the Gulf of Maine was from state waters (within 3 nautical miles from shore). This shows that the Gulf of Maine sea scallop shellfishery relies on inshore scallop beds. Despite recent increases in landings in the Gulf of Maine, a low recruit year and increased effort could easily lead to overexploitation of this shellfishery. Should this commercial fishery be pursued by the state of New Hampshire, the authors of this document believe that a strategic plan involving aquaculture should be explored, and we have made recommendations (See Discussion) on what bureaucratic changes need to be made to allow further development of aquaculture and how it can succeed, using *Placopecten magellanicus* as a model. (Data above obtained from the NOAA-NMFS website: www.wh.whoi.edu/library/sos94/spsyn/iv/scallop.html.)

In order to assess the current opinions, attitudes, and concerns regarding the development of aquaculture in the State of New Hampshire, we interviewed several people, representing academia, fishermen, current aquaculturists, state regulating agencies, and local, state, and regional community planners. Literature was obtained through the UNH/UME Sea Grant Program, the National Sea Grant Depository, M. Dadswell of the Mahone Bay Scallop Co., and the Canadian Division of Fisheries & Oceans. Additional information on the state and regional status of aquaculture was obtained through participation in the Long-line Shellfishing Workshop in Cambridge, MA on Nov. 18, 1996 (sponsored by The Aquaculture Coalition and MIT) and in the "Aquaculture Initiatives for New Hampshire" conference at the NH Farm & Forest Expo on Feb. 8, 1997 (sponsored by UNH Cooperative Extension, NH Dept. of Agriculture, Markets & Food, and the NH Aquaculture Association.) We also investigated current aquaculture regulations in the surrounding coastal states of Massachusetts and Maine and in the Atlantic Provinces of Canada through the Canadian Division of Fisheries and Oceans (DFO). Scallop aquaculture sites at

Chester and at Digby, Nova Scotia were also visited to gain an understanding of the different techniques used in this industry.

Results

Within the U.S., a consensus is developing that aquaculture needs to dramatically increase to support the demand for seafood in this country (National Aquaculture Development Plan, 1996). New Hampshire may be able to contribute to this need by developing aquaculture products that are safe, nutritious, of high quality, and of uniform shape and size. Also, this type of production needs to yield a competitively priced product for market, while minimizing labor intensity and surface water.

In this section, we outline our findings of how *Placopecten magellanicus* is grown in aquaculture systems and the many social, economic, and physical factors that need to be considered during the development of a scallop farm. Although some of the following information specifically relates to the sea scallop, many of these considerations can apply to other organisms that may be chosen for aquaculture in New Hampshire.

Scallop Production and Method

The process of developing an aquaculture farm involves a series of steps. After a site has been chosen, one would need to take the natural factors into consideration. The application will then need to be processed and the permit obtained, then harvesting can begin. Harvesting involves, the collection of scallop spat (larvae), the initial growth of juveniles, and the final grow out.

Scallop Spat

Spat collection is the preliminary step to scallop farming. Scallop spat can be obtained in two different ways, either naturally or from a hatchery. Spat collected naturally are larval collected on spat bags, which is cheap, but the

quality of the larval may vary. Hatchery raised spat is more expensive, but is more reliable and controlled. An average spat size of 5 millimeters is considered necessary for survival to occur beyond this initial step throughout the cultivation processes (Hardy, 1991).

Collection of Natural Spat

To collect spat naturally, an optimal site should be chosen based on physical and biological conditions. A site with good tide flow will have spat dispersed throughout the water column. The area should be highly productive to provide an adequate food source for newly-settled larvae.

Japan and New Zealand have commercial operations that utilize natural spat collection under economically viable conditions. Shumway (1991), lists the four main points that the Japanese follow when collecting spat as follows: (1) the timing of spawning is estimated by changes in the gonad index, of adults (weight ratio of gonad to somatic tissue); (2) the time and location of deploying the spat collectors by larval monitoring; (3) collectors are set where larval concentration is highest; (4) the number and size of settled seed is measured to determine the intermediate culture planning and its timing. Experienced farmers in Japan have a general rule that, when 50% of the trial collectors are covered with spat of over 200 microns in size, they proceed to set their spat bags (Hardy, 1991).

Other points to consider are the current velocity and direction where the spat collectors are placed. The current needs to be strong enough to carry larvae, and the direction should be known before the spat collectors are set. Water temperatures must also be measured because *Placopecten magellanicus* usually cannot survive in temperatures over 23°C.

A spat bag is made up of a nylon mesh that can differ in diameter and have variable mesh size. When choosing the mesh size, it is important to

consider the amount of fouling by marine organisms in the area. If heavy fouling is a problem, a larger mesh size may be required to compensate for this problem. Inside the bag, there is a monofilament netting, which the larvae settle on, that can be bought or obtained free from fisherman, which is very cost effective. The fishermen use the netting, and then usually discard of it.

The most efficient and cost-effective way to collect spat is to know the specific times during the year when there are productive spat falls. These would occur after spawning takes place as discussed earlier.

The technique used for placement of the spat bags in the water column depends on how strong the current flow is. If the current is strong, bags can be suspended from a heavy structure securely anchored to the bottom; such as a metal-frame cage. This will secure the bags and be more efficient for a high rate of return. Otherwise suspension lines can be placed within the water column vertically or horizontally (Figures 1 and 2).

Once the spat has been collected and the whole shell is set on the netting inside the spat bags, the spat is ready for the intermediate juvenile grow out phase. This can be done through lantern and pearl nets, or the use of cages.

Spat Hatchery

The preliminary step in raising spat in a land based hatchery is to obtain the actual larvae. This can be done by obtaining adult scallops and inducing spawning in an artificial environment. This is a cost effective and reliable technique. Larvae can also be purchased, and grown in the hatchery until it reaches the grow out size. This may be costly, but decreases the amount of effort.

Methods of raising larvae within a hatchery can vary. Algae and phytoplankton can be bought as a food source for the spat, which once again is

costly, but less effort is employed. Otherwise, the hatchery can also produce both algae, and spat. The actual systems used to grow the spat, in one hatchery, was the use of fish totes. The fish totes were hooked up to a circulating sea water system, and wooden planks were laid on top from which the spat bags were suspended. Under the bags, there was extra monofilament netting to catch the spat that did not settle in the spat bags. In a hatchery, the farmer needs to consider the future of his or her spat, as to where they will grow until they reach marketable size (Cooper, B. Hillsburn Basin Scallop Co., Personal communication, 1996).

The location of the hatchery is also an important issue to consider. The actual hatchery should potentially be in proximity of high-quality sea water. This is suggested for a couple of reasons. Fresh sea water will need to be flushed through the system where the larvae are raised. The proximity to sea water is also a factor when the juveniles are ready to be transferred into another system in the ocean. The survival rate for the juveniles during the transport will be much greater if the traveling time is short.

An over abundance of seed would be beneficial during the process of collection or grow-out in the hatchery.. At the end of the production, if the yield is high, selling spat to other aquaculture operations would be beneficial. This process itself could become the primary production for a farmer, if it generated enough revenue (Brownell, B, U.N.H., Personal communication, 1996-97.

Grow Out Stage / Intermediate Culture (Juveniles.)

Natural Spat

Once the juvenile scallops, which were collected, reach 5-10 mm in diameter, which usually takes about a year, the intermediate growout stage is the next step of cultivation. The juveniles can be placed in pearl or lantern nets,

Once the juvenile scallops, which were collected, reach 5-10 mm in diameter, which usually takes about a year, the intermediate growout stage is the next step of cultivation. The juveniles can be placed in pearl or lantern nets, which are suspended within the water column on long lines (Scarratt, 1995). The scallops usually remain in this grow out phase until they reach 40-60 mm in size, which normally occurs when they are between one and a half to two years old (Boghen, 1996).

Pearl net aquaculture equipment was developed by the Japanese, and has been used by marine farmers ever since. The pearl nets are sometimes used to collect spat, but are primarily used for the grow out phase. (Figure 3 shows the general design of pearl net system and the ability of water to pass trough the sides and underneath.) If fouling occurs on the netting, the pearl nets can be washed easily with a portable high pressure water system (Hardy, 1991).

Hatchery Spat

This type of procedure is similar to spat collection in the natural environment, but it has an additional step requiring more labor. Once the larvae are produced in the hatchery and have settled on the netting, the metamorphosis grow-out phase is the next step. When the shelled animal is set on the netting, the bags can be placed in the natural environment in a variety of ways (Figure 1 and 2). Within the spat bags, the whole animal will grow to 15 millimeters in size, and are then ready for the cultivation process (Langan, R., Director of Jackson Estuarine Laboratory, U.N.H. , Personal communication, 1996-97).

FIGURE 1:

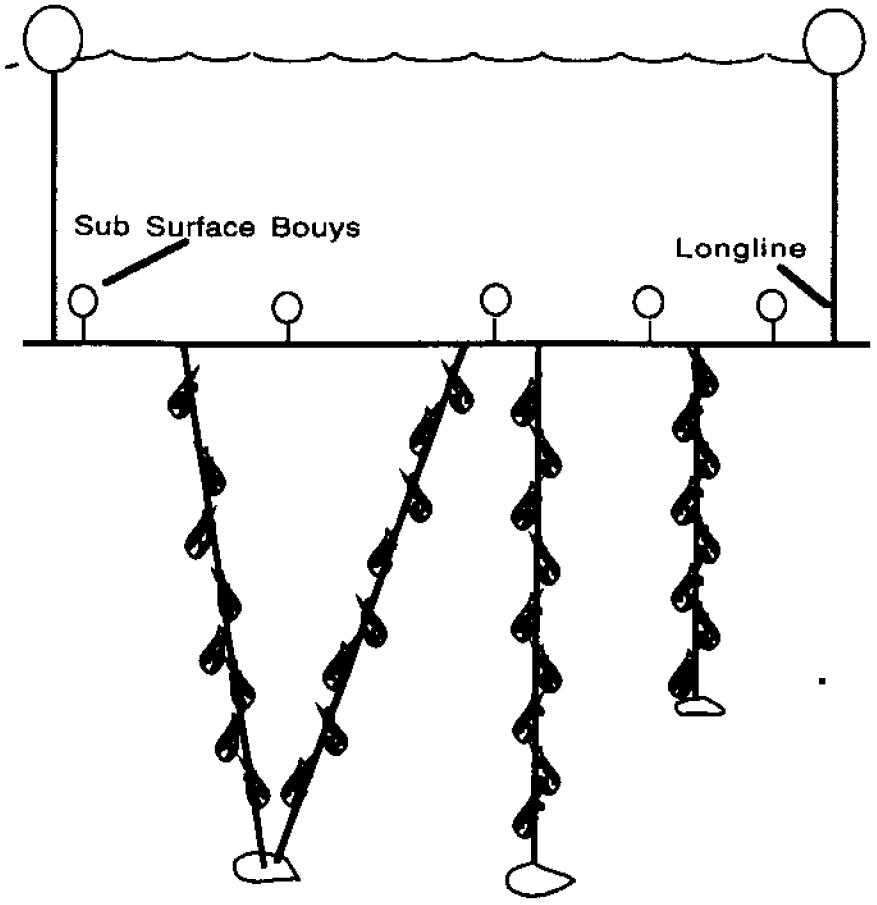
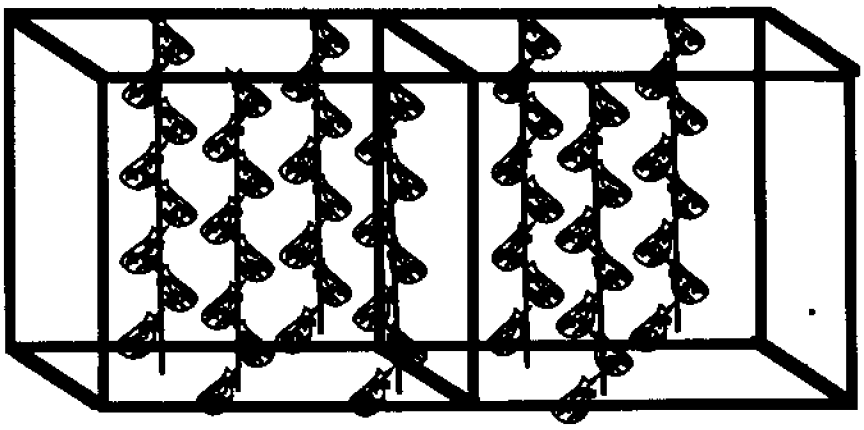


FIGURE 2:



Spat Bags Hung From Cages

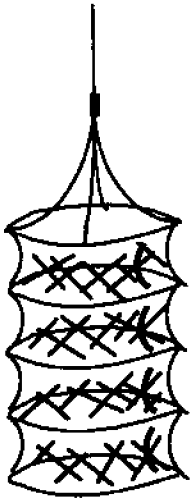
Methods of Cultivation (Techniques)

Suspension Culture

This type of cultivation is also referred to as off-bottom culture. This is because it consists of techniques that are submerged and suspended within the water column. This type of cultivation is more effective in areas that do not have high, strong currents that would disrupt the cultures (Dadswell, M., Mahone Bay Scallop Co., Personal communication, 1996-97). Suspension culture also can produce a scallop of uniform shape and size (Langan, R., Director of Jackson Lab, U.N.H., Personal communication, 1996-97). Pearl nets can be used for the final grow out stage, but most fishermen prefer to use Chinese lantern nets for this stage (Figure 4). Scallops are distributed within the nets which are also suspended within the water column. As the scallops continue to grow some fishermen prefer to thin them out into larger mesh nets. The increase in mesh size is done to allow the maximum amount of water exchange, but they have to be small enough to prevent the scallops from escaping .This is also an

advantage because, each time they are thinned, the shell can be graded so harvesting of uniformly sized and shaped animals is easier to obtain. Larger mesh size also allows the scallops to swim about, keeping the shells fairly clean. Unfortunately, the disadvantage is that this system is very labor and capital intensive (Fisheries and Oceans, Canada, 1995).

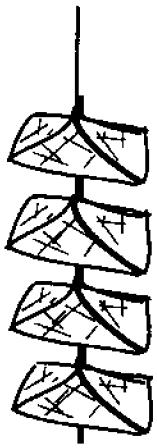
FIGURE 3:



Chinese Lantern Nets

Can be up to 10 levels

FIGURE 4:



Pearl Nets

Optimal in strings of 10

Ear hanging consists of drilling a hole in the back square part of the scallop shell, then putting a plastic tie between the two shells with a rope in between them. This would continue down the rope, and then the ropes would be suspended in the water column (Figure 5). This operation can be very delicate but fortunately can be done when the scallops reach 30 mm in size (Fisheries and Oceans, Canada, 1995). Once the scallops reach 80-100 mm in size they can be retrieved and harvested (Dadswell, and Parsons).

Scallop strips can be implemented in this type of culture. This basically consists of gluing the whole shell of the animal to strips, and suspending through the water column (Figure 6). This method requires hand labor and is

very intensive. It also is considered to take up to much space because the strips need to be placed at a distance from one another to reduce entanglement of the strips in currents of storm surge.

FIGURE 5:

Ear Hanging Technique

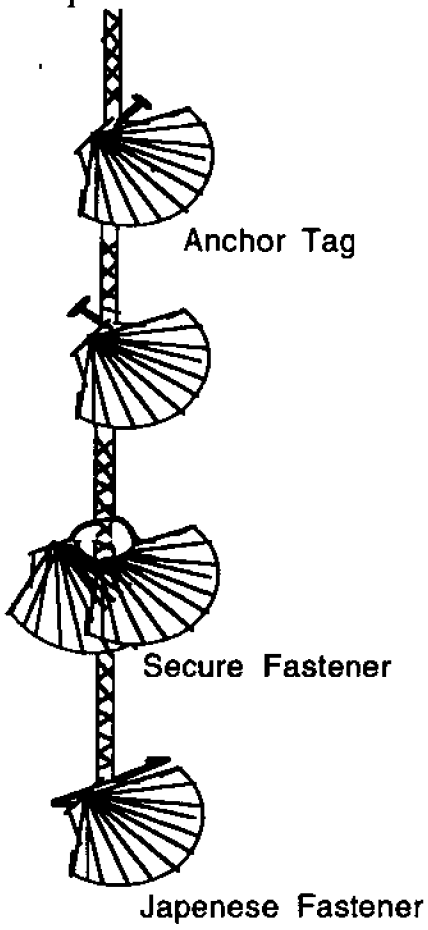
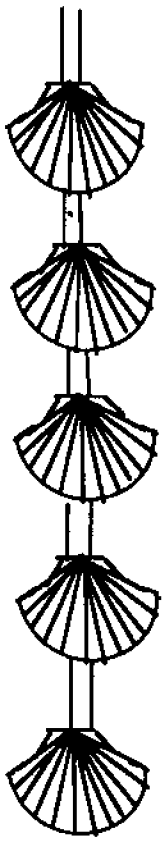


FIGURE 6:

Scallops Glued to Strip

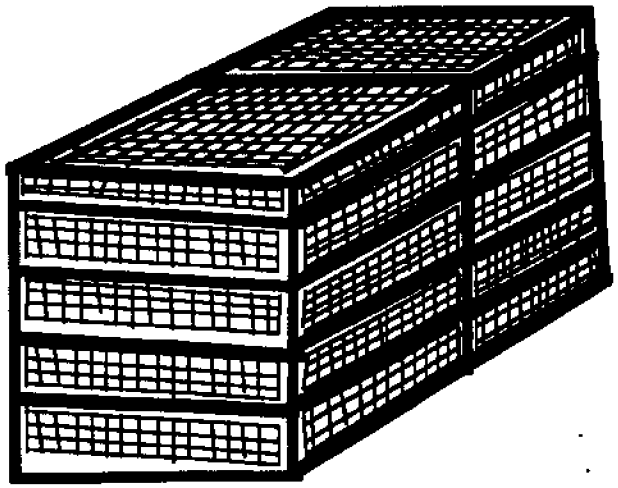


Bottom Culture

In this case this type of cultivation is not actually on the bottom of the sea bed, but near bottom. This type of culture is more efficient than suspension culture if the site is subjected to strong currents.

In Digby, Nova Scotia cages are stacked and fit into a frame (Figure 7), each cage containing juvenile scallops and then set on the bottom, using the appropriate equipment on the boat, until marketable size. Periodic dives are done here to check the equipment, and to analyze the growth of the scallops (Cooper, B., Hillsburn Scallop Co., Personal communication, 1996,).

FIGURE 7:



Cages Set On Ocean Bottom

Enhancement

This type of cultivation consists of the distribution of spat on appropriate bottom types in designated areas. This can also be done to enhance the overall existence of an animal. This can also be done to enhance the environment, and to build up the natural stocks of scallops.

For aquaculture, the site will have spat dispersed by scattering the spat over board and letting them set naturally on the sea bed. The scallops then continue to grow to maturity, or to the size at which they are marketable. The products from enhancement are not as uniform in shape as products from intensive cultivation systems (Langan, R., Director of Jackson Lab, U.N.H., Personal communication, 1996-97). The adult scallops can be collected by divers or draggers.

Using divers to obtain the adults will be very costly due to high costs of scuba diving equipment, and will be very labor intensive. Although this way ensures that all of the scallops that have survived will be collected, and that the scallops that are not marketable size will be left for further growing. This is also the safest way when considering the environment. Using divers ensures that the bottom will not be stirred, nor other species disturbed.

The use of draggers is cost-effective and less labor-intensive. This method disrupts the environment by scraping over benthic communities, and stirring up the bottom and its inhabitants. If the site was placed in a barren area were marine wildlife and desirable habitat is not abundant, the environmental degradation would be less intensive, but the growing conditions for scallops may be less favorable.

Unfortunately, this type of cultivation can have a low rate of return because of significant mortalities (Langan, R., Director of Jackson Lab, U.N.H., Personal communication, 1996-97). In the natural habitat, scallops are

susceptible to predators, which is a direct depletion of the stock. Once the scallops reach a large enough size to escape predators, the problem of natural depletion will decrease. Death can also be caused using the heavy equipment to drag and the initial impact on the bottom, and further movement could endanger the health of the scallop.

Analysis of Techniques

The level of fouling on the equipment will be dependent on such factors as location, season, and depth compared to when the equipment was initially set, and if there is a large amount present, steps to decrease this should be considered. Also, a high level of fouling could be very costly in terms of labor.

The rate of mortality should be analyzed which is a good indicator for a variety of topics. If the mortality rate is low, this usually implies that the cultivation technique is feasible, the habitat is suitable for the scallops to grow in, and the environmental conditions are stable and the present techniques should continue to be implemented. On the other hand, if the mortality rates are high, this can indicate many other problems. There could be a variety of reasons as to why the death rate would be high such as: the cultivation technique was not the proper choice for that particular site, or the biological and physical factors of the habitat may not be suitable for the scallops to survive. Also, this may indicate that a disease is present in the water column such as PSP blooms (Paralytic Shellfish Poisoning) that is caused by the presence of dinoflagellates or that pollution or sewage is present. For example, in 1996 in the Great Bay area there was an outbreak of MSX caused by the presence of *Minchinea nelsoni* which induces mortalities in oysters. Many tests will have to be implemented to research the problem and to solve it.

The meat yield obtained can be useful information as to how well your culture is doing. Studies have shown that scallops grown in a suspended culture will have a larger mass of tissues (including muscle), while having a thinner shell compared to animals that develop in the wild. These animals in culture are compared to animals in the wild that have comparative shell height or age (Dadswell, M., Mahone Bay Scallop Co., Personal communication, 1996). The shell difference is probably due to the allocation of energy the animal supplies to itself. In a culture the scallop does not have to be stressed about predation, and can allocate more energy towards its body size. The difference in this growth rate for a suspension culture can also be the result of a more favorable environment, with optimal conditions of temperature and food supply.

Within the different techniques for cultivation, predation may be a problem. The equipment such as nets or cages could wear and tear, and develop a hole, and predators may get in or a predator larvae could settle.

Harvesting

Once the scallops have been cultivated, and have reached a marketable size harvesting them is relatively simple. For most of the suspension, and near bottom cultures the scallops can be gathered, sorted, sold fresh or packaged, or further processed. All of this can either take place on the water, or on land. The enhancement cultivation of scallops in general, are retrieved by fishing gear, and then further processed (Boghen, 1996). As of now, in the State of New Hampshire, dredging equipment is banned without special permits (NH Fish and Game).

Regulating Factors

Natural factors

Before dealing with administrative problems and bureaucracy, it is important to consider the natural factors that are required and those which should be avoided for an aquaculture farm. Within the State of New Hampshire, these environmental factors need to be considered in detail while selecting a site for aquaculture to take place. During this process, the would-be marine farmer should consider if the farm will be a success at a certain site under optimal conditions. Of course, no one site is going to have perfect conditions, though a few main factors should be considered. When choosing a site, familiarity with sites that are highly productive may be beneficial and help decide how to prioritize the natural factors.

Accessibility to site

When determining where the site will be located, it is important to consider the access that farmers will have to the site. The optimal site would be a short boat ride away, but, at the same time distant enough so that the visual aspect of the aquaculture lines does not obstruct the view of the shorefront property owners. Close proximity would benefit the production because a site located too far away will be more labor intensive and increase costs, such as fuel, reducing the operator's profitability (Hardy, 1991). The site must also be accessible or close to processing plants and distributors (Boghen, 1996).

Exposure

For the site to be successful, the location and the equipment must be selected to reduce wave exposure or current and limit stress on the organism. Wave action, ground swells, and strong currents generated by storms are

limiting factors in the growth of cultured organisms (Boghen, 1996). If foul weather conditions are common, the equipment must be sturdy, reliable, and well anchored. Scallops prefer to live in a stable environment and, when shifted and tossed around, their growth rate can decrease and may lead to mortality (Hardy, 1991). To avoid such problems, the suspension culture should be submerged, but should remain at least two meters from the bottom to avoid the strong surge moving through the culture that would compromise the health of the scallop and the safety of the equipment, and to keep predators out of the equipment. If cages are being used for the cultivation process they will already be on the bottom away from the strong surge, and the mesh of the cage is small enough to keep the predators out.

Food availability

Sea scallops are filter feeders, so a steady current with an abundance of phytoplankton is needed. Samples from a potential site can be taken and studied, but one can also study growth of scallops previously in this area. If scallops are not found within the site, data on other filter feeding organisms will be sufficient information (Hardy, 1991).

Tide flow

Tidal flow is a major contributor to the availability of food. Without constant movement within the water column, phytoplankton will not be distributed evenly throughout the culture. Although, if the tide is too strong, suspension cultures cannot be used because the scallops will pile up in the nets, so cages would be necessary under this condition. Research has also shown that a strong tide will actually decrease the feeding rate of the scallop. An optimal tide is also needed if a site is located near an entry of freshwater to keep the

salinity at an acceptable level (Hardy, 1991). Scallops grow best at a salinity between 30-32 ppt., but can tolerate salinity levels of 25 ppt. or lower for short periods of time. A minimum salinity tolerance has not yet been determined (Boghen, 1996).

Temperatures

Temperature can also influence the scallop's growth. Many factors influence temperature, such as the bottom type, depth, exposure, and tidal height. All of these factors must be monitored for a period of time during the winter and summer to obtain adequate data on the local water temperature fluctuations (Hardy, 1991). Studies have shown that a temperature range from 0° C to 15° C is optimal for scallop production. Temperatures approaching 23° C will cause mortality (Boghen, 1991). In general, if scallops are naturally found in this area, then the temperature should be at least adequate.

Depth

For an aquaculture site that has different types of suspension culture, the depth can vary between 5 and 30 meters. If longlines are the only technique being used, a 15 meter depth is sufficient, as long as the equipment is 2 meters from the bottom (Hardy, 1991). Other considerations need to be studied such as ice, freshwater run-off, and extreme wave action when choosing an optimal depth. If such hazards occur on the site, the equipment needs to be lowered deep enough so the scallops are not affected. A minimum of 10 to 20 meters at low tide for the depth of the equipment is recommended. A rule of thumb is that the equipment should be at least 2 meters under the surface of the water, and 2 meters off of the bottom (Boghen, 1996).

Bottom substrate

An area that is primarily a muddy bottom and has much activity taking place, such as boating and fishing, or a mass of boulders should be avoided because these could lead to potential problems during harvesting. If enhancement or bottom culture are the cultivation techniques being employed, coarse- sand to rocky substrates with a primarily flat bottom is recommended (Boghen, 1996).

Spat levels

To know if natural spat can be collected at a site, trial collectors should be set. Otherwise, previous data collected by local fishery agencies can be obtained, and should be sufficient. (This data may not be up-to-date, so testing the area would be the safest route). If no spat is available in the area, farming should not be ruled out as spat can be collected from another site or a hatchery (Hardy, 1991).

Predation

The main predators of scallops are sea stars (*Asterias* spp.), crabs (*Cancer irroratus*), and lobsters (*Homarus americanus*). During the process of spat collection, it should be noted when spawning of potential predators takes place to avoid settlement of these species in the spat collectors. If the predators grew in the collectors, they would consume the larval scallops (Parsons and Dadswell, 1993). If the technique being used is enhancement and the scallop is large enough to swim and escape, then predation may not be a problem. There are two strategies that may be used to minimize predation. The juveniles may be released at a size at which they are capable of avoiding predation. Second, juveniles can be dispersed at a time when predation is minimal (Boghen, 1996).

Natural and Human Disaster

Factors often over looked when planning aquaculture are the natural and human disasters that have a tendency to affect one's site. Some situations may be detrimental to the survival of the stock. Oil spills, flash floods, a storm, or even another fisherman dragging through an aquaculture site will undoubtedly set back the harvest.

Oils spills may lead to mass mortality and contamination. Oil tanker traffic and its shipping lanes are common in Portsmouth Harbor. In July, 1996, there was an oil spill in the mouth of the Portsmouth Harbor that caused a considerable amount of damage.

Flash flooding causes a decrease in the salinity which would cause severe stress on the sea scallops, possibly causing mortalities or slowed growth. In October 1996, the New Hampshire coastal region was hit with 15 inches of rain in 48 hours, which dropped the salinity of Portsmouth Harbor to 11 ppt. at the mouth of the harbor on the outgoing tide.

Large storms can disrupt the entire area of the site by stirring up the bottom, displacing the gear hundreds of meters from the site, and causing ground swells. On the other hand, storms could bring in a fresh supply of nutrients from out at sea to benefit the production of the scallops.

Application for site

The Marine Fisheries Division of the New Hampshire Fish and Game Department, is the organization where lease applications for an aquaculture site are obtained and where permits are approved. The State of New Hampshire has laws and rules governing aquaculture and application procedures for a marine aquaculture license. The Marine Fisheries Division has produced a draft

document for a New Hampshire Marine Aquaculture Strategic Plan, but this plan has not yet been submitted for state approval. In the appendix of this document is an example of the application for a marine aquaculture license which includes criteria such as descriptions of the proposed project, the source of organisms to be used for the project, and the laws for aquaculture (NH Fish and Game).

If the proposed project involves bottom culture as the aquaculture technique, permits are required from both state and federal agencies. The New Hampshire Department of Environmental Services (NHDES) Water Division, Wetlands Section is the agency to contact within the state, and the Army Corps of Engineers (ACOE) will need to be contacted on the federal level. Names and addresses are provided in Appendix B.

Conflicting Uses

The aquaculture sites should be located in water where there is going to be a minimum amount of conflict. Possible conflicting uses of the NH coastal waters are:

Natural Marine Reserves
Commercial Fishing
Shipping Lanes
Recreational Boating
Public Beaches
Shorefront Property Owners.

Working with these conflicts during the process of site selection will allow for greater community cooperation with and acceptance of the proposed aquaculture site.

Environmental Aspect

Habitat Influence

Aquaculture sites are believed to enhance the natural surrounding area. It has been shown that suspension culture has enhanced the productivity of surrounding benthic and pelagic communities(Dadswell, M., Mahone Bay Scallop Co., Personal communication, 1997). The structures can form artificial reefs that provide the surrounding marine life with shelter and food supply. This artificial reef phenomenon especially attracts lobsters. This proves to be especially beneficial to the lobster fishermen who can set their traps around these sites. In addition, the cultivated species could spawn which would increase the larval concentration and enhance the natural stock, which commercial fishermen could then exploit.

Economic Considerations

Fixed costs are usually categorized as costs in which the farmer cannot change or affect, such as, rent for office and storage space, site leases, equipment purchases and insurance. These type of costs should be researched so the least excessive ones are chosen since they are non- productive (Hardy, 1991).

Variable costs will fluctuate with the amount of production and output,. Examples of such costs are labor (which is the principal cost), repairs, fuel and electricity, telephone, transport, etc. According to Hardy (1991), these costs are good indicators of the overall efficiency of the aquaculture farm because in an efficient farm, these costs will be minimized.

Opportunity costs are the benefits gained from choosing one aquaculture technique over another in operating a scallop farm. Each technique has variable income and expenses because the supply, demand, and inflation on which they are based are subject to change (Hardy, 1991). These items should be considered

proportionally when doing a cost-benefit analysis of each technique. Hardy's (1991) example of a working model for aquaculture describes the economic advantages and disadvantages for different techniques of cultivation. This covers four different methods as follows:

Lanterns on Longlines. When compared with wild stocks this is a better yield and has less mortalities. Although the capital costs, variable costs, and labor costs are high and fouling on the shells is abundant.

Lanterns on rafts. This also has a better yield when compared to the wild stocks and the mortalities are low along with less labor and variables costs, but still high capital costs. The level of fouling on the shells tends to increase if the nets are placed too close to the surface.

Ear hanging from longlines. Compared to lantern cultures this method has increased growth and mortalities that are manageable, but the live market product is unattractive because of excessive fouling. However, the capital costs are reduced, but the labor and variable costs are fairly high.

Bottom culture. This produces a high yield and a very attractive animal for the live market, but accessing the stock levels tends to be difficult and mortalities are usually high. The capital, labor, and variable costs tend to be low while the harvest costs are high (Hardy, 1991).

It is important for marine farmers to consider economies of scale while developing their operation. A farmer needs to evaluate the demand for the product in the area and then determine the scale of the size of the operation. It would not be wise to invest in a large-scale operation that results in a high output of product if the farmer could not break even or make a profit. According to D. Bishop, Vice-president of Operations for Fukui North America (Personal communication, 1996), a company that sells aquaculture equipment,

there are three important guidelines to follow in order to make a profit in aquaculture:

1.) Quality of equipment is more important than its cost. Low-cost items may be low-quality. A slightly larger initial investment may prevent repair or replacement costs in the future.

2.) Labor costs must remain constant or decrease.

3.) Product yield must remain constant or increase.

In the end, it is important to remember that biologists and fishermen are not economists. It may be wise to enlist the help of a marketing specialist in determining economies of scale.

Processing

Processing of the cultivated scallops is generally done by selling them fresh, or with minimal processing. Processing companies need to registered at a federal level to be able to process the scallops (Boghen, 1996).

Distribution centers

To ensure the best product scallops should be transferred to the distributor quickly so they remain fresh, and to prevent deterioration from occurring (Hardy, 1991.) In the State of New Hampshire the main product from scallops would probably be the abductor muscle, while the whole animal could be sold to raw bars. A frozen scallop is treated differently during distribution. During the freezing process no fluctuation of heat can occur at the time. During the transportation of the frozen product refrigeration is needed to ensure this fluctuation does not occur to prevent deterioration (Hardy, 1991).

The Regulation of Aquaculture in The Coastal New England States

Northeast Regional Aquaculture Center

In general, aquaculture in this area is overseen by the Northeastern Regional Aquaculture Center (NRAC). This is one of five Regional Aquaculture Centers , created by the U.S. Congress in Title XIV of the Agriculture and Food Act of 1981 and funded by the U.S. Department of Agriculture. Its mission is to "support, aquaculture research, development, demonstration, and extension education to enhance viable and profitable U.S. aquaculture which will benefit consumers, producers, service industries, and the American economy." NRAC has its headquarters at the University of Massachusetts Dartmouth, Research 201, 285 Old Westport Rd., North Dartmouth, MA 02747-2300. It represents the twelve northeastern states and the District of Columbia through the development and funding of cooperative research and extension projects that support the aquaculture industry in the region. It also assists its constituent states with needs assessment and establishment of priorities. NRAC does not have any regulating power, but it does serve as a resource and information center for aquaculture in the Northeast. (Information obtained from the NRAC website: www.umassd.edu/specialprograms/nrac.)

Consideration of Competing Uses

There are several conflicting uses of marine resources that coastal states must consider in the regulation of aquaculture. Outlined below are some of the more prominent conflicts with proposed marine aquaculture farms.

1.) Riparian Property Owners

The shoreline residents in general are opposed to aquaculture for the concern that their oceanfront view will be obstructed by large raft systems or salmon pens, which are normally associated with aquaculture, therefore reducing their property value. In reality their view is most likely already obstructed by either a cluster of lobster buoys or by the water lane buoys. What is not realized, is that aquaculture can be done without having obstructive surface gear. The majority of the aquaculture gear used is suspended fifteen to thirty feet below the surface, leaving plenty of depth for boat traffic to proceed over the tops of the sites.

2.) Recreational Boaters

Recreational boaters currently have unlimited use of the harbor channel. The only obstacles are the lobster buoys and lane markers. Most recreational boating takes place during the summer months, from May to October, and scallop harvesting takes place during the winter. The recreational boaters would not want any additional obstacles which may hinder their freedom of travel in the channel.

3.) Commercial Fisherman

An important entity in the fishing community along the New Hampshire coast is the Portsmouth Fishermen's Cooperative (Coop.). The role of the Coop., is the sale of fish, caught by the local fishermen, to a processing plant. The processor then distributes the fish to the importing countries. The Cooperative also works with universities and organizations that have interest in small, fishery-related experiments.

According to R. Haymann, President of the Portsmouth Fishermen's Cooperative, the fishermen are in a state of denial that the fishery is in any danger of collapse and currently have no intention to incorporate aquaculture. Some of the fishermen are looking for an alternative fishery for fear that current

natural resources will soon be depleted. Haymann mentioned that the majority of fishermen can not afford to invest significant funds into an aquaculture project where there is no return for about one-and-a-half to two years (Haymann, R., President of Portsmouth Fishermen's Cooperative=, Personal communication, 1997).

Currently, the Cooperative is being faced with amendment 7, which restricts how much fish can be caught and the time periods in which fishing is allowed. In 1997, the Fishermen's Cooperative took a reduction of almost half of the allotted fishing days from 1996. In addition to this limitation, the use of any fixed gear has been banned in near-by Cape Cod, and the ban will soon include New Hampshire. This ban is due to the migratory pathways of the right whale. Over a span of forty years, two right whales have been entangled and killed by fishing gear. On the other hand, about three to five right whales are killed annually due to ship traffic. Restrictions like these lead to increasing tensions between the fishing and the scientific communities. In order for aquaculture to work, these two communities must learn to work together.

On a positive note, Haymann emphasized that aquaculture lends the ability to control the stock; that is, the amount of product that can be supplied at any given time is constant. In a natural fishery, there are no guarantees as to how much a fisherman will catch. He also noted that aquaculture by stock enhancement might be more successful and may get the fishermen involved. The fishermen could disperse the spat from their own boats, leave it for the appropriate amount of time, collect it, and sell it back to the spat distributor.

During site selection, the local fishermen might object to proposed locations , because they are wary that farms will limit their access to fishing grounds and fear that aquaculture sites will affect or deplete their stock. Resistance will also come from recreational shell fishermen who feel threatened

by the proposal of shellfish aquaculture (Langan, R., Director of Jackson Lab,U.N.H., Personal communication, 1996-97). Working together from the start will cause less friction and aid both parties. Eventually, fishermen may even be aquaculture farmers, or working jointly with farmers.

New Hampshire

At the present time, commercial shellfish aquaculture is non-existent along the New Hampshire coastline. Regulation of aquaculture in the state is controlled by various agencies such as New Hampshire Fish and Game, the U.S. Food and Drug Administration (FDA), and other state and federal agencies. The New Hampshire coast line, due to its small size, is full of competing users, such conflicts are stated in the above.

New Hampshire Fish and Game

The Department of Fish & Game is the licensing agency for marine aquaculture in the State of New Hampshire. The process, as outlined in New Hampshire law Fis 807.07, begins with an application that is submitted to the Executive Director and the Marine Fisheries Division. After the application is reviewed for completeness, a site assessment or evaluation is conducted, only between the months of May and October. The Executive Director then sets a hearing date and notifies the applicant of its date, time, and location. At least 21 days prior to the hearing date, written notice is sent to all abutters and littoral owners of the proposed project, and public notice is made. Copies of the application and hearing notification are also submitted to any other state or federal agency that may have permitting, licensing, or other jurisdiction over the project. These agencies include (NH Marine Aquaculture Strategic Plan, Appendix C, Draft 1996.):

NH Dept. of Environmental Services for water discharges and dredge & fill permits,

NH Dept. of Health and Human Services for shellfish sanitation,

NH Port Authority for placement of objects in tidal waters,

NH Office of State Planning - Coastal Program for consistency of the project with NH Coastal Zone Management goals,

US Army Corps of Engineers for dredge and fill activities in navigable waters,

US Coast Guard for federal navigational rules, e.g. placement of marker buoys,

US Environmental Protection Agency for water discharge permits, and

US National Marine Fisheries Service for issues regarding fishing in federal waters.

Any interested parties may submit written comments to the Executive Director up to 14 days after the hearing. The Executive Director then decides on the issuance of the license based on any unacceptable risk the project might present, conflicts or negative impacts on recreational, commercial or other uses in and around the proposed project area, and its potential for negative impact on the value or use of private property in and around the proposed project area. Further New Hampshire laws and rules on Aquaculture can be found in RSA 211:62e and Fis 807, and it is recommended that these laws be reviewed in their entirety by any prospective applicant. See the Appendix A for a copy of the Application for Marine Aquaculture License.

There are currently three obstacles facing the development of a commercial shellfishery in the State of New Hampshire. First, the Food & Drug Administration (FDA) in 1989 assessed administrative closures on New Hampshire shellfish beds due to the insufficient water quality data of the state shellfish sanitation program. Second, New Hampshire has not developed a water classification system in compliance with the standards set forth by the National Shellfish Sanitation Program (NSSP). The NSSP, which is

administered by the FDA, is a set of national guidelines for the classification of waters for the harvesting of shellfish. Without these federally-approved guidelines, shellfishermen would not be able to sell their products in interstate commerce. Third, it is the policy of the NH Dept. of Fish & Game that the natural populations of shellfish in NH waters could not withstand commercial harvest (T. Diers, NH Office of State Planning, Personal communication, 1997).

The NH Coastal Program of the Office of State Planning and the NH Estuary Project (funded by the US Environmental Protection Agency) are working to lift the FDA shellfish bed closures. The Office of State Planning, in conjunction with the NH Department of Health and Human Services, have run two sanitation surveys according to NSSP guidelines, one on the Great Bay, and the other on the Hampton-Seabrook Estuary. In addition, administrative rules for the shellfish sanitation program have been approved by the state legislature and conform to the NSSP guidelines. The state now needs to have these surveys and guidelines reviewed by the FDA. According to T. Diers, the oyster beds in those two areas will likely be opened for recreational harvesting in September 1997. The water sampling that will be done to certify the waters for recreational harvest will devise a parallel program for commercial harvest, and the funding for this sampling program is secured for the next three years. There are many problems in the Great Bay associated with non-point source pollution. Therefore, the opened shellfish beds would likely be classified as "conditional" and could face temporary closure during unfavorable weather conditions (T. Diers, NH Office of State Planning, Personal communication, 1997).

Maine

At this time, there are approximately 1,185 acres of ocean bottom leased to farms in Maine waters. Due to Maine's success in aquaculture, more than 515

full-time jobs have been created on thirty farms along the coast of Maine. Furthermore, aquaculture has provided off-season jobs to supplement the incomes of those who are involved in traditional fisheries, and fishermen can apply their skills and knowledge to these operations. (Information above obtained from the Maine Aquaculture Innovation Center website: www.mstf.org/~meaqua/index.html.)

The State of Maine allows for the leasing of submerged land under strict regulations. To obtain a lease site permit, an application can be retrieved from the Department of Marine Resources (DMR). The applications are then reviewed for environmental feasibility by the DMR. For more information on the application process for the State of Maine and other related information relating to aquaculture in Maine you can contact the Department of Marine Resouces at the following address:

Aquaculture Administrator

Maine Department of Marine Resources

P.O. Box 8

West Boothbay Harbor, ME 04575

Maine as well as the other coastal states are entitled to submerged lands up to 3 miles out to sea. In the State of Maine, those who regulate the distribution of aquaculture permits are the following; the Department of Marine Resources, the riparian owners, and finally the commercial fishermen who have traditionally fished in or near a proposed site. The DMR can only accept a site proposal if it is not impeding upon the public and private rights of the area under consideration. The following five marine uses are to be protected by any unreasonable interference:

1) the entrance and the exit of the riparian owner;

2) navigation;

3) "fishing and other uses of the area taking into consideration the number and density of aquaculture leases in the area";
4) "the ability of the lease site to support existing ecologically significant flora and fauna"; and
5) public use or enjoyment within 1000 feet of municipal, state, or federal parks, beaches or docking facilities

Maine has a multiple use policy which deals with the maximization of the 3-dimensional area of a lease site (Reiser, 1988).

Massachusetts

The Commonwealth of Massachusetts regulates all of their aquaculture sites through the government of the coastal communities. Massachusetts Marine Fisheries law leaves the specifics of management to local control, as long as the basic underlying laws are observed. The coastal communities can issue aquaculture grants which provide exclusive rights to areas for shellfish production. The selection of the sites are based upon the production of the site in a natural state; if the site is productive, then it cannot be used. The only sites that are granted out to aquaculture are those that are not productive, in hopes that aquaculture will help to enrich the area (Rask, 1993).

Connecticut

The State of Connecticut is already at the commercial level of aquaculture. Since its development, the aquaculture program has persistently succeeded, and the state has continued to increase its support. Its enthusiasm in aquaculture has pushed for the development of vocational schools for the education of the next generation. Connecticut is also in the continuing process of examining the possibilities, along with the advantages and disadvantages of

aquaculture (T. Visel, Coordinator, The Sound School Regional Vocational Aquaculture Center, New Haven, CT, Personal communication, 1997).

The Regulation of Aquaculture in Atlantic Canada

The Department of Fisheries and Oceans is the federal department of Canada which oversees the progress and regulations of aquaculture. The documents for understanding aquaculture between the Department of Fisheries and Oceans (DFO) and the Atlantic Provinces are different for each province. A person interested in applying for an aquaculture license, lease, or permit must submit an application for an aquaculture site. A license is a document that allows a person to practice aquaculture. The lease and permits usually grant the lessee exclusive access to a plot of bottom for a period of time. These applications are then sent to the headquarters of DFO where they are screened for validity in terms of completeness and feasibility. If the proposed is passed by the officials at the headquarters of the province, then the proposal is sent out to other provinces, and if passed it is then considered official. At this point a site-advisory committee meets to review the proposal and recommend its approval or its rejection (Cook and Simpson, 1996). Other countries such as New Zealand, Great Britain, France and Japan are examples of countries who have successful commercial aquaculture operations (Boghen, 1996).

Discussion

Benefits of Aquaculture in New Hampshire

Sustainable Fishery

Aquaculture is considered to create a sustainable fishery that provides a dependable supply of the product. Within the New Hampshire coastal waters, aquaculture could be used to enhance depleting stocks of the current fishery, and to supplement fisheries that do not exist during the winter where the harvest of *Placopecten magellanicus* is at its peak. The amount of product supplied by both of these methods could be easily tailored to the economic demand of the product.

Economy

If commercial aquaculture were to be implemented in NH coastal waters, an assortment of employment opportunities would bloom, in turn strengthening the economy of the coastal communities.

Aquaculture of *Placopecten magellanicus* would open a new market for a commercial species in this area. Currently, *P. magellanicus* is not commercially harvested, but, if this market were eventually established, it would probably create a new-found interest towards the product from the local communities.

The development of an aquaculture operation along the NH coastline would greatly benefit the local community by creating a variety of new jobs. The New Hampshire Fish and Game, Marine Fisheries Division is in charge of regulating most of the aspects of the aquaculture operations. With the new income from new commercial aquaculture licenses, NH Fish and Game will be able to more effectively regulate the aquaculture within the New Hampshire

coastal region in terms of hiring people to control the extra workload of aquaculture.

Eventually, spat hatcheries may be implemented within this area, which is a crucial part of the operation of an aquaculture farm. To be able to rear scallop spat, or other shellfish, would require the employment of an initial staff to develop the process and carry it out. Spat bags are a small investment, and this would hopefully increase into a large scale operation, not only for the use of the spat in this area, but also for sale of the spat to surrounding communities.

Once an aquaculture operation is developed and the product has been harvested, jobs could be created for the further handling of the product. The final products will need to be processed, distributed, and sold, hopefully, to local restaurants, allowing the community to receive the product fresh and enhancing the overall support of aquaculture in the community.

Tourism

As stated briefly throughout this document, the development of aquaculture in this area could increase the level of tourism within the community. The appeal of buying shellfish off of the dock or eating the fresh product in a local restaurant could attract tourists to the area due to the presence of the aquaculture site. Eventually, there could be the establishment of tourist packages which involve education of the aquaculture operations, visiting current sites, and taste-testing the product.

Education

The state of Connecticut is the first state to look at aquaculture as a form of agriculture. The state allows the leasing of the bottom for the purpose of aquaculture. In 1982, Connecticut passed a Clean Water Act which resulted in a

measurable increase in the oyster production, because of the drastic increase in water quality. It is obvious that Connecticut is extremely supportive of aquaculture and feels that in the long run the economy is going to be strongly dependent on aquaculture.

Looking at the fishing economy Connecticut realized that in the near future something will need to be done. The approach which they took was aquaculture incorporating it into education. Connecticut has recently constructed four fully equipped vocational-agricultural schools (vo-ag) dedicated for the sole purpose of aquaculture. These schools are supported by both the local governments and state. Both local organizations and community members were involved in the planning of these schools.

The vo-ag education allows for hands-on work. Students attending these schools are covering a broad spectrum of both the fundamentals of what aquaculture involves, as well as being involved in an operational aquaculture project. The newer of the schools have up to date laboratories, such as a boat building lab, a fish pathology lab, organic chemistry lab, and a Computer Aided Design (CAD) lab.

All this work for one state. Imagine how productive the New England coastal waters could be if more young people were learning the trade of aquaculture which will allow for the maximum production of the waters because these students are able to pursue it with the proper knowledge. If all of the students do not end up using aquaculture, they will have a clearer understanding of aquaculture's importance.

A story from an October 1996 issue of the Boston Globe, consisted of a group of seventh and eighth graders in Westport, Connecticut, who proved that there is no age limit, its all based on motivation and hard work. This group of students carried out the Bay Scallop Restoration Project, which aimed to bring

back the bay scallop to an area that was the remnants of a no-longer existing fishery. The students worked with one of the local fishermen to complete this project. The fisherman stated that he had not caught such a size since 1985. To think that the largest bay scallop nursery in the world was built by students is inspiring. It was estimated that 4,000 students and many adults volunteered 180,000 hours of hard work to make this aquaculture happen.

For this to happen in New Hampshire the support from all regulating areas would have to be unanimous. The education would have to begin at the middle school level where the students have a background in the environment and a comprehension of the economy around them and its importance. The program would teach the students about all aspects of aquaculture, from the good to the bad. As well as what is going on at the current time in the fishing industry. Then from this, depending on the current status, an emphasis could be placed on the future importance of shellfish aquaculture (Scott, 1996).

The general public should be educated on the idea of aquaculture and how it will positively impact the local community, as well as the local economy. and The State of New Hampshire.

Recommendations

Recommendations by Fish & Game

In its 1996 draft of the New Hampshire Aquaculture Strategic Plan, the Dept. of Fish & Game makes several recommendations for State action to improve its efficiency should marine aquaculture be promoted. They are summarized as follows:

1.) the formation of a single group of personnel from various State agencies that would implement the goals of the Strategic Plan for the advancement of marine aquaculture;

2.) the establishment of the NH Fish & Game Department, Marine Fisheries Division as the agency responsible for processing aquaculture permit applications and administering the applicable laws and rules;

3.) the review of existing law and rule controlling marine aquaculture by the above-mentioned aquaculture group (from recommendation #1);

4.) the publication of a Marine Aquaculture Handbook to guide prospective applicants in complying with applicable laws and rules;

5.) the establishment of a Marine Aquaculture Advisory Group that would provide the State with feedback from non-state governmental entities, and

6.) the interaction of the State with the New England Fishery Management Council to develop a coordinated plan for future aquaculture operations in the Exclusive Economic Zone.

We fully support the Fish & Game Department's efforts to facilitate discussion of this topic through the development of a strategic plan. Every

coastal New England state has published such a plan, and the foresight offered by this document is crucial. We fully concur with these recommendations .

Development of Commercial Shellfish Aquaculture

In order to establish a commercial market for aquaculture products, such as *Placopecten magellanicus*, we recommend that the State make the implementation of nationally-approved shellfish sanitation guidelines a top priority. Additionally, the State should request that the FDA review these guidelines and the recent sanitation surveys performed on New Hampshire's coastal waters. This action would lift the FDA's closure on the State's shellfish beds and allow the interstate commerce of shellfish aquaculture products. We also recommend that the Department of Fish & Game change its current policy to consider the use of aquaculture to enhance wild stocks of the sea scallop and other native shellfish species, allowing for commercial harvest of natural stocks.

Management Area Plans

A management area plan would efficiently allocate the New Hampshire coastal waters for its wide variety of uses. While gathering information for this document, we observed many ways that aquaculture could be implemented in New Hampshire. A few of these considerations were gathered during site visits in the Canadian Maritimes.

During our visit to Nova Scotia, we were able to spend some time working with Dr. M. Dadswell, a small-scale aquaculturist in Chester, Nova Scotia. Dr. Dadswell is currently a lease holder of a site for the specific culture of mussels and scallops in Chester's Mahone Bay. Mahone Bay is a very active

area for recreational boating and commercial fishing, making the site selection for an aquaculture operation a difficult task. The establishment of a management area plan and the acquisition of a site took approximately two-and-a-half years. Dr. Dadswell's site is located on a shoal, an area unnavigable by sailboats.

Following our meeting with Dr. Dadswell, we visited the Hillsburn Basin Scallop Company in Digby, Nova Scotia and met with the manager, Blair Cooper. Their site is located in Annapolis Basin due to a compromise among the competing commercial fishermen. B. Cooper explained that, before they applied for a lease site, they spoke with the fishermen to determine the location of their prime fishing grounds and agreed on the placement of an aquaculture site that would not interfere with them.

The Province of Prince Edward Island (P.E.I.) is an exception to the normal regulations of aquaculture in the Canadian Maritime provinces. In other provinces, both a provincial and federal (DFO) permit is required for marine aquaculture. In P.E.I., however, only federal authorization from the DFO is necessary. In addition, the DFO, in conjunction with other provincial agencies, administers an aquaculture zoning plan in which areas are categorized as "approved, "requiring review," or "unacceptable." (Boghen, 1996.) This plan incorporates input from the major "players" involved in site selection. These "players" include the DFO (represents the fisheries, sanitation impacts, and the Navigable Waters Act), the tourism industry, Parks Canada (the division of the Canadian government that is analogous to the U.S. National Parks Service), and riparian landowners, among others. These entities indicate where bottom and suspension cultivation techniques can or cannot take place. A zoning plan is devised, and these plans are then presented at town meetings where they are

ratified by the public. (Sephton, T., Department of Fisheries and Oceans, Personal communication, 1996.)

A management area plan that incorporates aquaculture into the New Hampshire coastal waters should model these site selection plans, which encompass areas that are not used for other activities. It may be difficult to find such a site in New Hampshire's small and crowded coastal zone, but we recommend that a management area plan should be considered for long-term resource management. As in the P.E.I. model, the involvement of all concerned parties and the approval of a plan by the public should play an important role in this process.

Recommended Methods And Sites

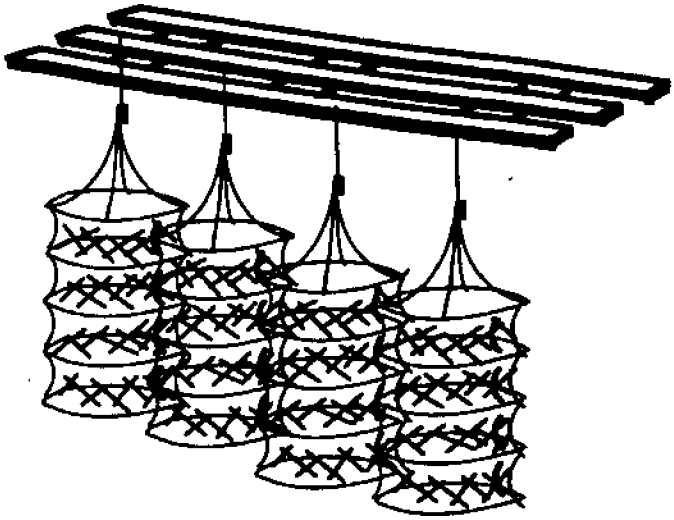
In 1984, there were 75 moorings in New Castle harbor (Baldwin, Carolyn et al., 1984). An aquaculture site could be located in this area, using the moorings to anchor the aquaculture gear. The Portsmouth Harbor is the only ice-free, deep-water harbor between Boston, Massachusetts and Portland, Maine. The fact that the harbor is ice-free would allow for the possibility of year-round aquaculture to take place. (To view the map of the Portsmouth Harbor, refer to Appendix C.) In our talk with R. Haymann, it was also stated that the fishermen have the boats and the knowledge to carry out some form of aquaculture. Our recommendation is to have the fishermen aid in the dispersion and collection of the stock. They would be supplemented with a percentage of the harvest and gain the opportunity to see how an aquaculture operation works. After such an operation has established itself, small businesses could possibly be established, and harvesters could sell directly to marinas.

Within New Hampshire coastal waters, enhancement would be the most sensible cultivation technique for an initial aquaculture operation (Langan, R., Director of Jackson Lab, U.N.H., Personal communication, 1996-97). This process could integrate the preliminary involvement of fishermen. The scallop spat can be collected naturally along the coast of NH. The scallops could then be grown out to a minimum size, and the fishermen could be in charge of seeding the bottom of a designated management area with scallop juveniles. They would later retrieve the adult scallops by dragging or diving since they already have most of the equipment and boats. This type of cultivation is currently being researched by Dr. R. Langan in conjunction with three local fishermen. Eventually, the fishermen could obtain the site and be a major contributor to the aquaculture farm and business. We recommend that potential marine farmers should enter into such a venture as a collaborative effort, rather than an individual one. This distributes not only the labor, but also the investment risk.

Near-bottom culture is another cultivation process that could be recommended for the waters of New Hampshire. Suspension culture may not be efficient in this area because of the strong current and surge present in the open waters. Near-bottom culture consists of placing cages on the ocean floor (Figure 7). This has two advantages in that 1.) the velocity of the surge lessens towards the ocean bottom, and 2.) the cages are sturdy enough to withstand any strong current or surge that may occur. This is also a viable technique for this area since it does not require the use of long lines. The use of suspension culture in open waters could be a potential problem since this coastline has limited available space and they could interfere with other users of these waters. The use of cages eliminates this conflict and would probably be more acceptable to the surrounding communities because there is no visual aspect of aquaculture gear on the surface.

Off-bottom cultivation is another type of aquaculture that can take place within the NH waters. This type of cultivation requires the use of suspension equipment, such as lantern nets or ear hanging. This may not be acceptable in open water because of the limited shoreline available and may not be efficient due to the strong water current. This is why we propose the use of moorings and marinas for this cultivation process. SB-184, a state bill regarding the leasing of submerged lands, is currently being reviewed by the New Hampshire State Legislature. This bill suggests that submerged land beneath existing structures, such as moorings, piers, and marinas, could be subletted to interested parties from the current lease holders (Diers, T., Office of State Planning, Personal communication, 1997). If this bill is passed, suspension lines and cages could be anchored to moorings in Little Harbor, New Castle, NH. The moorings used to anchor the gear act as artificial reefs, supplying a home for many lobsters, fish, and an assortment of other marine life (Dadswell, M., Mahone Bay Scallop Co., Personal communication, 1996). Nets could also be hung from Portsmouth piers or docks of the surrounding marinas (Figure 8). Cages may also be placed on the bottom directly underneath the piers and docks. The water quality in these areas would need to be tested for biotoxins and the amount of hydrocarbons being displaced from the engines of the boats (Robinson, S., Division of Fisheries and Oceans, Personal communication, 1997). These tests should be done to make sure the abductor muscle would not be contaminated. This way, the marina would benefit from the additional rental of the subleases, and they would help educate people on the topic of aquaculture.

FIGURE 8:



Example of hanging Chinese Lantern Nets below a float.

Dealing With Conflicting Uses

Public Forums

To educate the citizens of the New Hampshire Seacoast communities, we have considered a few recommendations that may help to accomplish this. We first recommend the organization of a series of public forums held in the area to educate the local people about aquaculture. These will include a discussion based on questions from the audience. The forums could be lead by both the local fishermen and people involved in aquaculture. This would hopefully give the New Hampshire coastal residents an understanding of aquaculture and also give them the opportunity to add their suggestions, state their concerns, and get involved with the aquaculture operations.

Fact sheet / Pamphlets

It has been suggested that a fact sheet be compiled to describe the benefits of aquaculture, its regulations, and the process of starting an aquaculture operation (Diers, T., Office of State Planning, Personal communication, 1997). This fact sheet could be distributed to the local fishermen and the local communities to give them a brief overview and understanding of aquaculture. This would hopefully lead to the initial involvement of fishermen and locals in the development of aquaculture.

Involvement of Fishermen's Cooperatives

Many options could be available in this situation. Fishermen's cooperatives, such as the Portsmouth Coop., could provide a support system for the aquaculture farmers. This would mirror the current relationship between the Coop. and the commercial fishermen. They would help fishermen sell their aquaculture products to markets, processors, and local restaurants. A marketing cooperative could be developed in the future, if aquaculture became viable in this area, that would involve brokers and distributors to handle the stocks supplied by fishermen.

Fishermen may also be able to sell their products independently. By offering fishermen education in publicity and marketing, they could establish a customer-based business that takes place on the docks. Advertisement of fresh shellfish sold to the public right out of the water would benefit not only the fishermen, but also the community by turning this type of market into a tourist attraction.

Over the years, tensions have been mounting between government scientists and the fishing community, based on numerous restrictions and regulations placed on the fishermen. We recommend that, for aquaculture to be

successful in this area, both the fishermen (such as the commercial fishermen who work within the Coop.) and the scientists must agree on the processes that must take place for an aquaculture operation to succeed. A logical place to begin would be collaborative efforts between U.N.H. scientists, local fishermen, and state agencies to enhance scallop populations.

Law Enforcement

If aquaculture is going to be successful in the coastal waters of New Hampshire, we believe that the government, whether it be state or national, should employ more law officials to patrol the waters thoroughly and establish stricter penalties. This could prevent poaching and illegal dragging in aquaculture sites. Currently in the state of New Hampshire, the fines for poaching are not large enough to deter these criminals. However, if these penalties were raised to include higher fines, loss of fishing license, impoundment of boat, and possibly arrest, fewer illegal acts may occur.

Officials should also consider banning large fishing vessels from the coastal waters, for they severely deplete the natural fisheries. We propose that the coastal fisheries should be restricted to those day-trip boats on which the owner is the captain. This would enhance the local economy, the lives of the NH fisherman, and most importantly the amount of finish and shellfish in this area.

Development of Recreational Saltwater Fishing Licenses

Many of these recommendations will require significant financial resources on behalf of the State for the development and promotion of

aquaculture. Additional revenue to fund the increase in personnel, extension and education programs, and the revised shellfish sanitation program could be partially funded through the implementation of recreational saltwater fishing licenses. To facilitate this new license requirement, New Hampshire could honor fishing licenses of neighboring coastal states. The revenues gained from out-of-state visitors could be substantial and this practice would be following the practice of most coastal states. Although the public would initially object to this new form of "taxation," the extensive benefits of aquaculture would far outweigh this inconvenience.

Appendix A

STATE OF NEW HAMPSHIRE
NEW HAMPSHIRE FISH AND GAME DEPARTMENT

APPLICATION FOR MARINE AQUACULTURE LICENSE

1. Applicant:

   Name:_____
   Business Name:_____
   Address:_____
   City/State/Zip:_____
   Telephone:_____

2. What species are to be managed or cultivated?

3. On a separate sheet, describe the proposed project, including:
   A. General methodology:
   B. Type of aquaculture (i.e. bottom culture, suspended culture, pen culture or land based system):
   C. Location and description of the geographic area where the proposed project is to be conducted (include latitude and longitude coordinates, loran, and/or marked up NOAA charts or, for land based facilities, a USGS map):
   D. Site specific information including:
      - tidal information
      - proximity to natural resources such as shellfish stocks, eelgrass, other species critical habitats.
      - characterization of sediment type
      - recreational and/or commercial activities in or around the site
      - navigational aspects, i.e. channels, buoys, vessel traffic, moorings, etc

E. Type, size and configuration of any gear used during the aquaculture operation (use a separate sheet if necessary):

4. Source of organisms to be used for the project:

5. Disposition of organisms i.e. transfer, sale, etc.:

6. A list of any biocides, algacides, antibiotics, or other chemicals to be used for control of noxious growth or disease.

7. A description of any restrictions on the public for use of the area proposed for the project:

8. A written statement to substantiate that the applicant either owns the land proposed for the project including access to the site or has the owners permission for such use of the land or for access:

9. List all agencies to whom copies of the complete application will be sent:

10. Include a copy of the current municipal tax map and a complete list of names and addresses of all abutters and littoral owners adjacent to the proposed site:

This completed application form and all associated maps, charts, etc. should be sent to the New Hampshire Fish and Game Department, Executive Director, 2 Hazen Dr, Concord NH 03301. A copy of the full application should be sent to New Hampshire Fish and Game, Marine Fisheries Division, 225 Main St, Durham NH 03824.

Appendix B

State Agencies

NH Department of Environmental Services - A key agency for approval of water discharges and dredge and fill permits.

Water discharge - Water Division - 271-3503

Dredge and fill - Water Division - 271-3503

NH Department of Health and Human Services Food Protection Section - The agency that deals with shellfish sanitation issues.

Food Protection Administrator - 271-4858

NH Port Authority - The state agency that controls the placement of object (moorings, rafts, floats, etc.) in tidal waters.

Port Authority Director - 436-8500

NH Office of State Planning - Coastal Programs - The agency responsible for ensuring coastal activities are consistent with the states Coastal Zone Management goals.

Office of State Planning, Director - 271-2155

Federal Agencies

U.S. Army Corps of Engineers - The federal agency that issues permits for dredge and fill activities including the placement of any material (e.g. shell cultch, bottom trays, etc.) in navigable waters.

Chief, Permits Branch Regulatory Division - (617) 647-8338

U.S. Coast Guard - The authority on rules pertinent to navigational rules including anchoring lights for floated objects (e.g. rafts).

Aids to Navigation Branch - (617) 223-8338

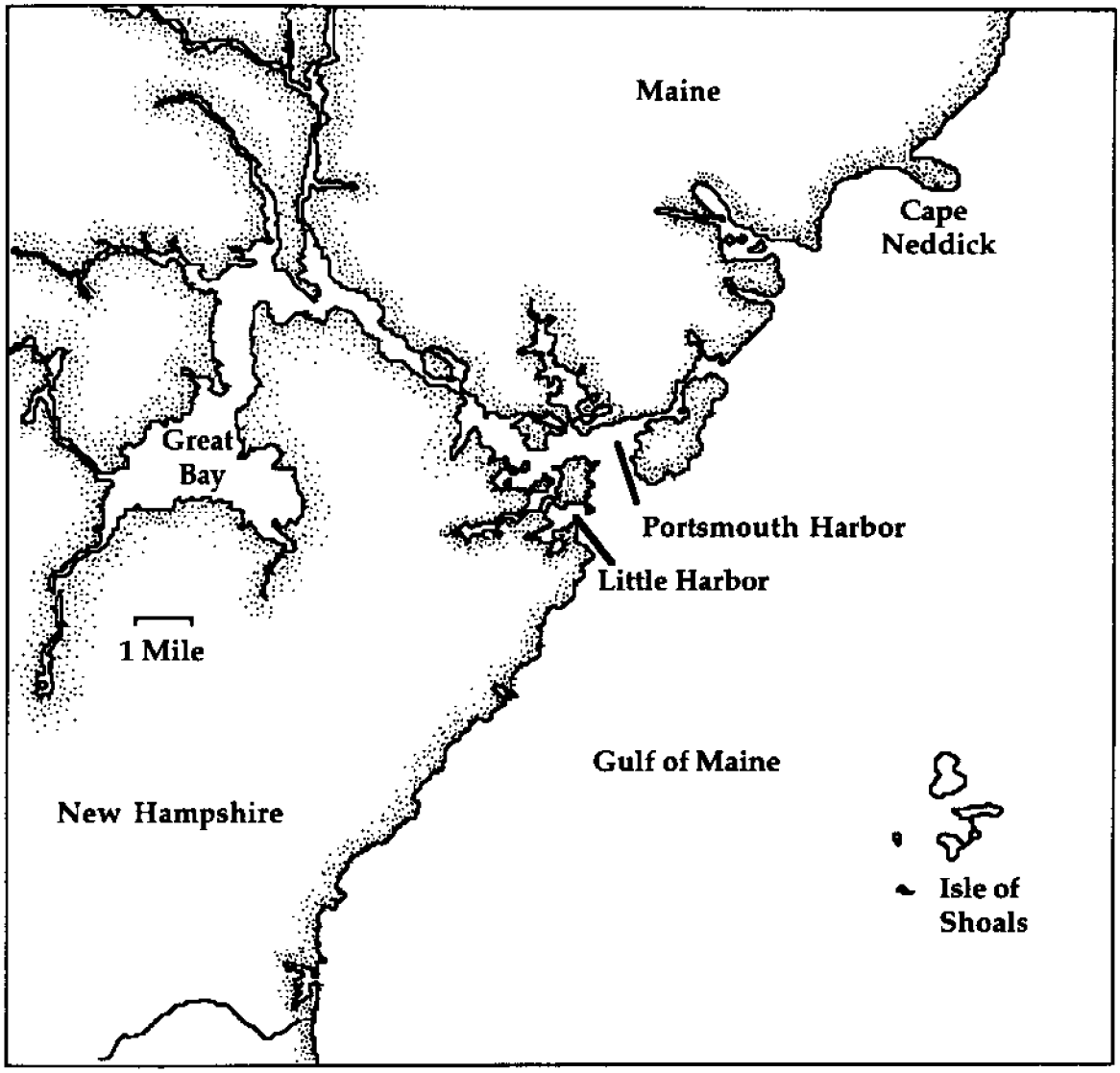
U.S. Environmental Protect Agency - The federal agency that issues permits for water discharges.

Office of Ecosystem Protection - (617) 565-3533

U.S. U.S. National Marine Fisheries Service - A key agency in matters pertinent to federal waters fishing.

Protected Species Coordinator - (508) 281-9254

Appendix C



New Hampshire Coastal Zone

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