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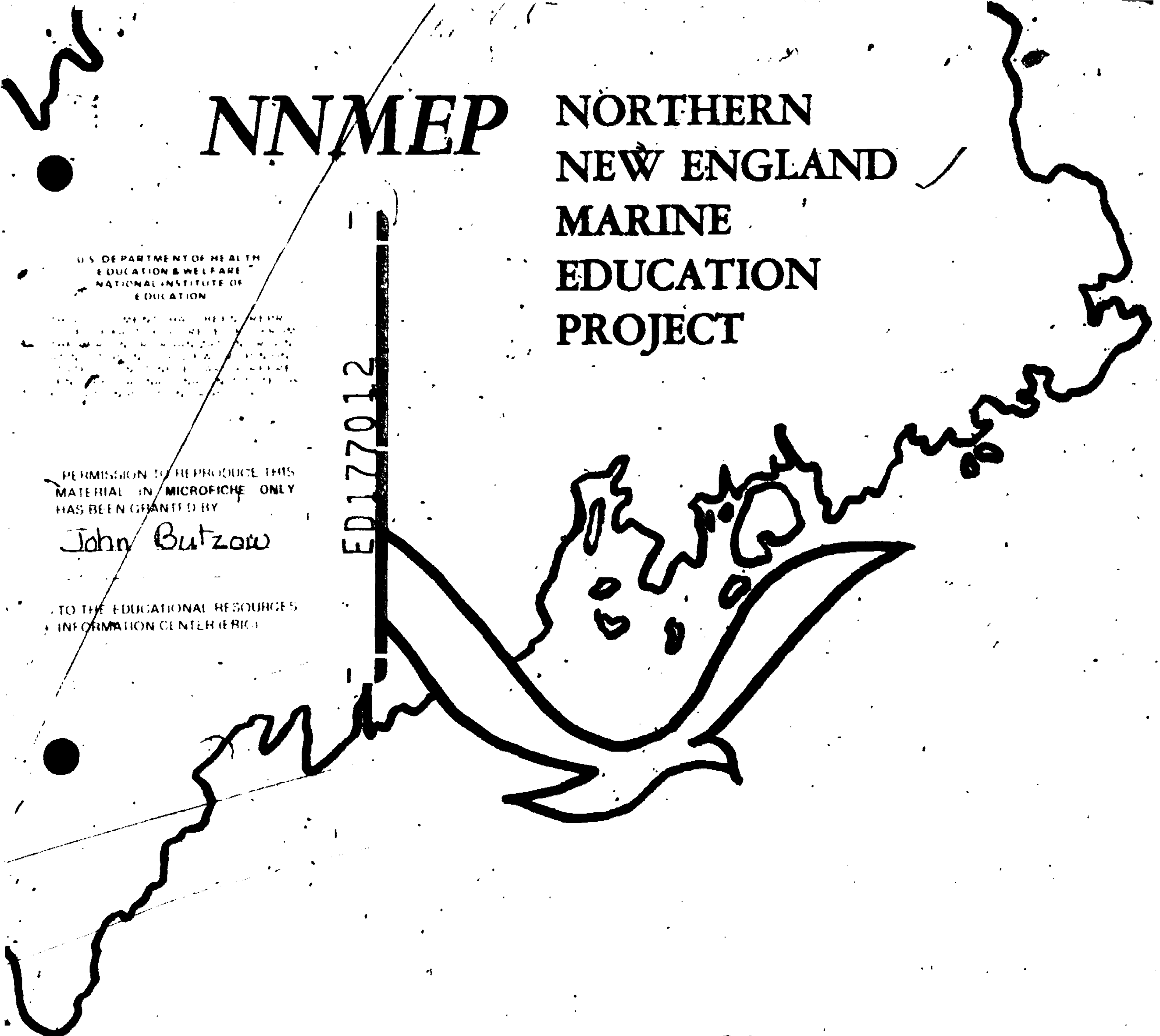
ABSTRACT

This unit provides lessons utilizing aspects of aquaculture to portray concepts in several secondary school disciplines. Extensive background is provided on four marine species currently cultured in Maine. The history of aquaculture in Maine is provided. A bibliography of sources of information on aquaculture follows the background section. Two lesson outlines are provided. Each includes an introduction, overview, teacher and student background, and suggested activities according to the discipline being considered. Appendices include a list of marine aquaculture companies, directions for the establishment of a marine aquarium, and a list of information resources. (RE)

NNMEP NORTHERN NEW ENGLAND MARINE EDUCATION PROJECT



THE OCEAN: SOURCE
OF NUTRITION FOR
THE FUTURE

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TITLE: THE OCEAN: SOURCE OF NUTRITION FOR THE FUTURE

*Concept: A.

1. Cultural evolution led to dominance of the environment.

   a. THE GROWTH OF SCIENCE AND TECHNOLOGY INCREASED MAN'S USE OF NATURAL RESOURCES.

**Marine Concept: B.

1. Man is part of the marine ecosystem.

   a. The marine environment has affected the course of history and the development of human cultures.

      1. PROXIMITY TO THE OCEANS AND THE AVAILABILITY OF MARINE RESOURCES HAVE INFLUENCED THE CULTURES OF MANY SOCIETIES.

Grade Level: 9-12

Subjects: Biology, Science, Social Studies, Home Economics

Class Periods: Variable

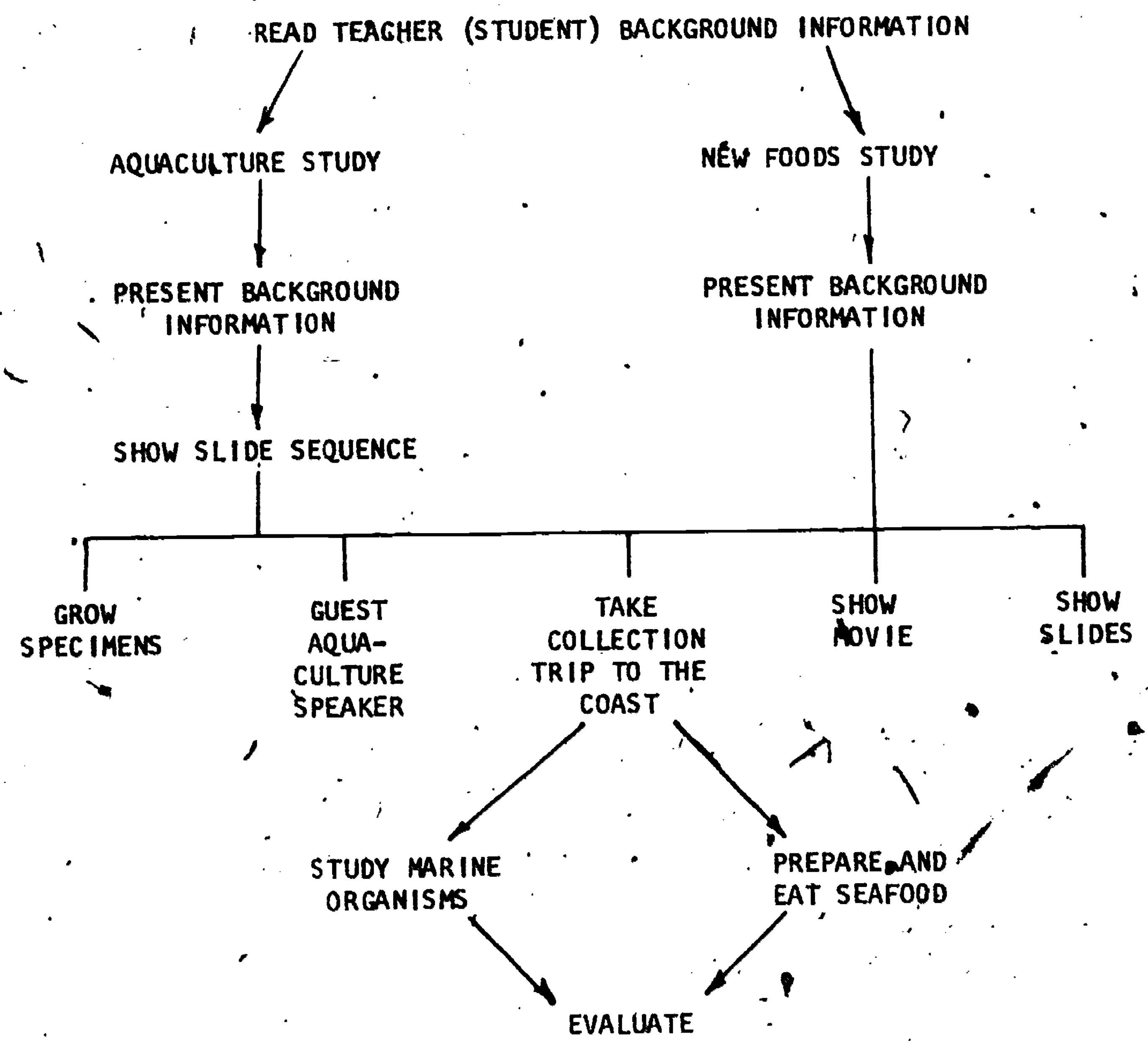
Author: Robert S. Pratt

Editor: Harry H. Dresser, Jr.

*From A Conceptual Scheme for Population-Environment Studies, 1973. Cost $2.50

**From Marine Environment Proposed Conceptual Scheme, 1973. No charge. Both conceptual schemes are available from Robert S. Stegner, Population-Environment Curriculum Study, 310 Willard Hall, University of Delaware, Newark, DE 19711.

AQUACULTURE FLOW DIAGRAM



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TEACHER BACKGROUND

Oysters

Since 1971, Maine has made great strides in aquaculture. Most of this progress has been made possible through federal funding. Much of this money has reached the State in the form of Sea Grant money from the National Oceanic and Atmospheric Administration and is administered by the UMO/UNH Sea Grant office. A portion of this money has been used to foster research in commercial oyster aquaculture in Maine. The culturing of two species of oyster, The American oyster (Crassostrea virginica) and the European oyster (Ostrea edulis), is currently under investigation. Sea Grant Bulletin #2, Commercial Oyster Aquaculture in Maine, describes the techniques recommended for oyster culturing in Maine. This informative publication is available from the Ira C. Darling Center, Walpole, Maine (563-3146). The Maine Department of Marine Resources has also been active in aquaculture research, and information is available through that office at State House Annex, Augusta, Maine 04331.

Early in the 1970's, the University of Maine using combined state and federal funds built an aquaculture building at the Darling Center. This building is complete with all necessary systems, including running hot and cold water, and seawater.

Researchers at the Center have tried many different methods of culturing young oysters. At this time, they are allowing the very young oysters to "set" on small shell chips, and this has proven to be very successful. Both American and European oysters are being cultured this way. When the tiny oysters reach sizes between 2 and 3 mm, they are sold to small, seafarm companies for "grow out," or raising to market size.

Early in the 1970's, the researchers gave the tiny oysters to people interested in investigating the process of raising oysters. Some of the people introduced to oyster aquaculture in this manner have now taken up commercial seafarming, while others still raise only enough oysters for their own consumption. The "seed" oysters are still available to noncommercial seafarmers.

The cooperative program which was started informally in 1971 has become a very productive effort. The early program began with the Darling Center's supplying small oyster samples and asking the cooperator to gather information on growth rates. They have recently formalized the interaction with the cooperator to a greater degree - an approach which has evolved through several stages:[1]

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[1]Pratt, R.S. and Hidu, H. 1975. Cooperative Shellfish Experiments, p. 2.

Not only have scientists obtained valuable comparative oyster growth and survival information, but the program has allowed cooperators to evaluate their aquaculture sites and derive pre-liminary cost estimates at little or no expense to themselves. Growth determinations were made by photographing typical specimens at the beginning and end of each season.[2] The study was designed to provide more data for documentation of the intensive work done by Mr. Robert Packie on the Damariscotta River estuary. Mr. Packie's study related oyster performance to environment on the wide estuarine gradient presented by the 20-mile "Arm of the Sea" Damariscotta River. Briefly, Mr. Packie's study indicated that market oysters, American or European, could be produced in a time as short as two years, depending on specific environmental conditions.

Initially, oyster seed was donated to those people expressing an interest and having a suitable area for culture. Persons were given advice on culture methods and were asked to aid in periodic measurements of growth, some physical parameters, survival, and overwintering performance. At the end of each season, the comparative figures were tallied and supplied to each cooperator to give him/her an indication of relative success. These figures may have discouraged some cooperators but they retained the oyster seed and were invited to contact us should they contemplate further action. This initial interaction was really a search for persons with a genuine interest in growing oysters commercially, and with personal ability and a suitable environment for carrying out the operation.

Later, those who had suitable sites and who wished to continue and expand were invited to take a more active part in our research effort. Research interaction has involved testing the relative performance of Maine and California stocks of European oysters, and improvement in methods of overwintering. More recently biologists have interacted with the pilot commercial and commercial starts with the aim of improving the overall efficiency of the operations.

The overwintering experiences of cooperators in previous years has revealed several problem areas. In the winter of 1973-74, the Maine Coast Oyster Corporation had thought it best to relocate their oysters for the winter. Subsequently, their oysters were moved over 100 miles from Salt Pond in Blue Hill to the lower Damariscotta River, where, in previous winters, low winter mortalities had been experienced. This was expensive, and was unnecessary because those oysters which were left in Salt Pond survived the winter as well as the transported group. Consequently, nearly all groups were placed on bottom at the growth sites for overwintering during 1974-75. The silting of trays has been a major problem in previous winters, and several cooperators have recently modified overwintering gear to solve this problem. Nearly all previous overwintering efforts have required the services of divers. The Darling Center, up to now, has been able to provide

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[2]Pratt, R.S., 1976. Prospects for Shellfish Culture Utilizing H. R. 1833.

this service free, but in the future, a commercial enterprise should take this expense into account. Overwintering gear must be designed to minimize or eliminate the need for divers.[3]

The silting problem was worked on by several cooperators. Dr. Brown and Mr. Richardson, working cooperatively, have developed two methods. Dr. Brown tied cinder blocks to the bottom of his overwintering sled to hold it off the bottom and prevent any movement of the sled during the winter (Figure 1). Mr. Richardson placed his sled on 18" long, 1 1/2" diameter iron pipes that were attached to 2 x 4 wooden runners (Figure 2). This method places the bottom oyster trays 15" to 18" above the silty bottom. Mr. McCollum put iron legs on the sides of his lobster crates to hold them off the mud (Figure 3). Drs. Mineau and Abelson as well as Messrs. Archambault, Peterson, and Hagan used positive buoyancy in their anchored trays to keep them about 18" above the bottom (Figure 4).

The major overwintering project was again with Maine Coast Oyster Corporation. The Richmonds redesigned their sleds so that in-season growth trays could be utilized (Figure 5). Ninety-six trays were bolted to each of eight sleds. These sleds, containing 500,000 oysters, were then placed on the bottom with the aid of a new service raft and winch. The entire overwintering operation took two weeks, with four days of diving service. Again, diving service could be a high-cost factor and every effort should be made to eliminate the need for it.

Other cooperators have worked to eliminate the need for diving. Dr. Brown used a roped anchor method. He attached a line between the trays and an anchor on the bottom. A surface buoy supported a trip line from the anchor. If the buoy is cut off by accident, Dr. Brown is still able to locate the anchor line by dragging. Mr. Richardson placed two vertical steel rods above his trays and connected them with a short rope. He plans to grapnel for the rope to retrieve trays in the spring. Messrs. Abelson, Archambault, Peterson, Hagan, and Mineau plan to use a mine sweeper method for tray retrieval. They place a chain between two skiffs and row through the area. The chain will catch the 18" anchor rope attaching the trays to their mooring.

The latest development has been to leave trays attached to the longline and merely weight the longline and add floatation to the bottom of the tray stack. This technique eliminates the need for divers, keeps the trays off bottom, and eases the process of retrieval. The commercial people have developed many types of gear. The University program, on purpose, has not discussed gear construction and design with them. This was done so that those individuals that are seafarming will come up with their own unique designs and provide others with innovations in seafarming techniques. The evolution of the tray has now gone to lantern nets which are being imported from Japan. A second type used is the pearl net, which is much smaller and triangular in shape.

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[3] Ibid, page 27.

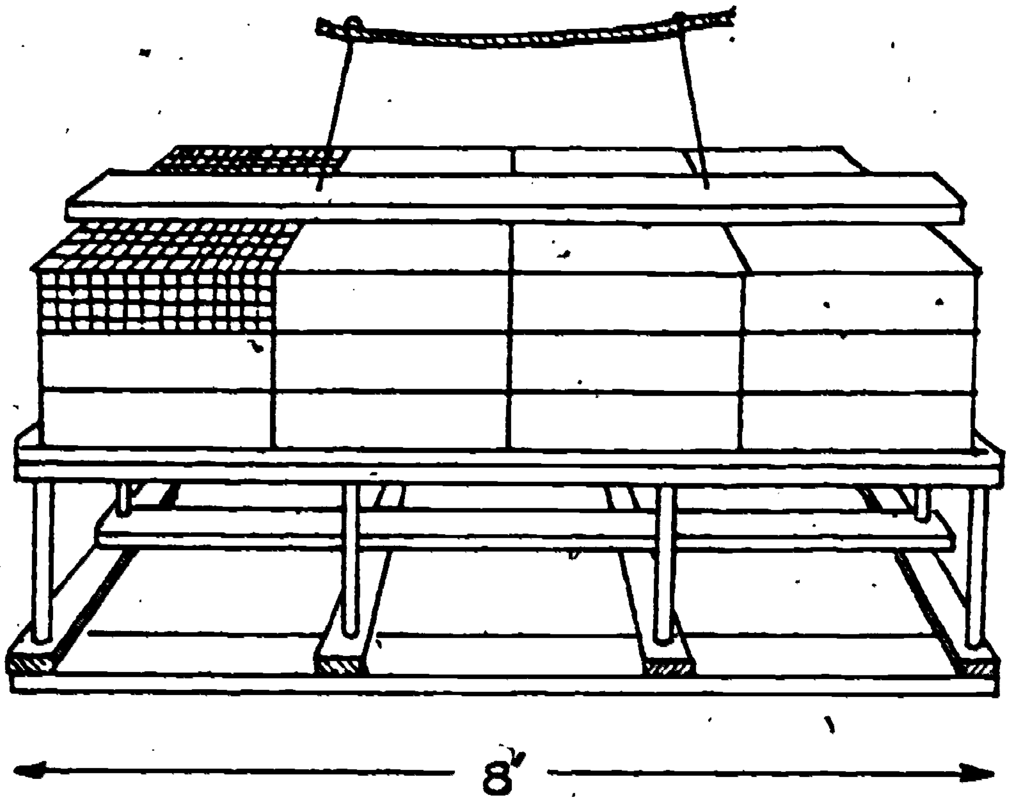


Fig. 2.

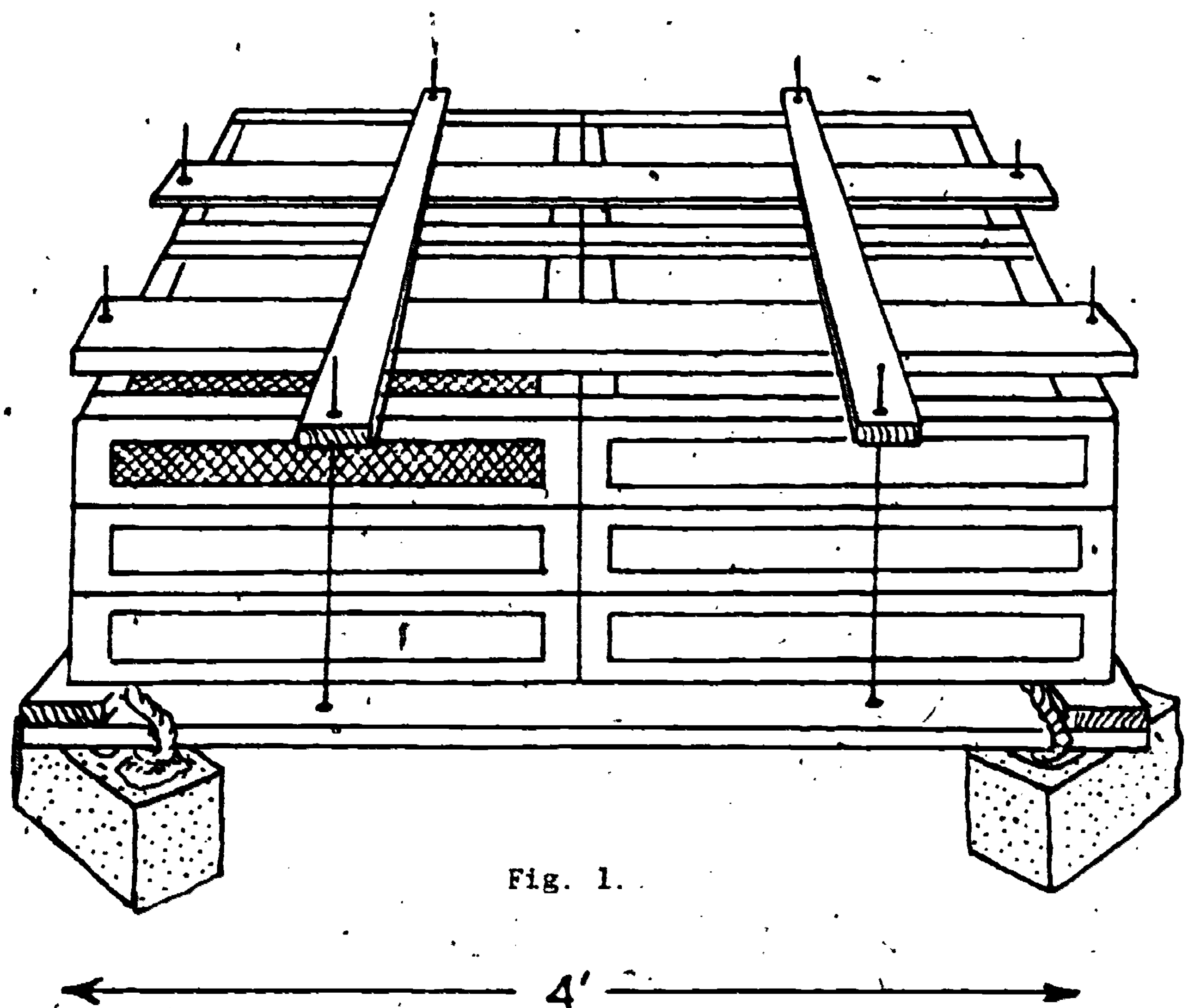


Fig. 1.

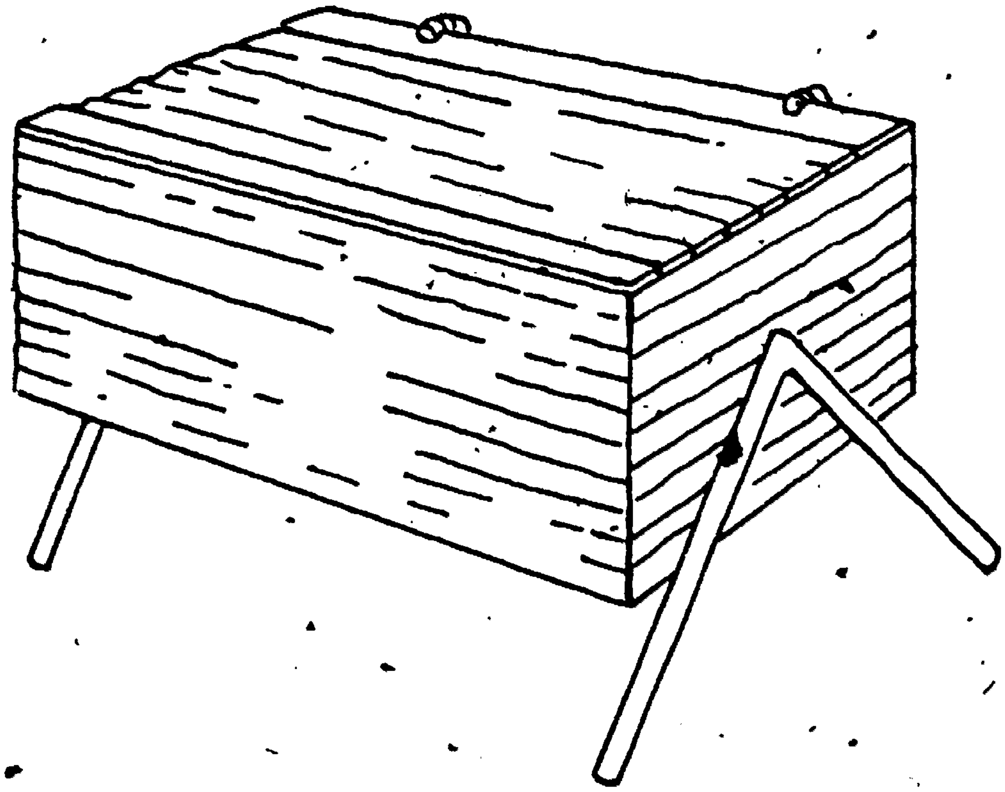


Fig. 3.

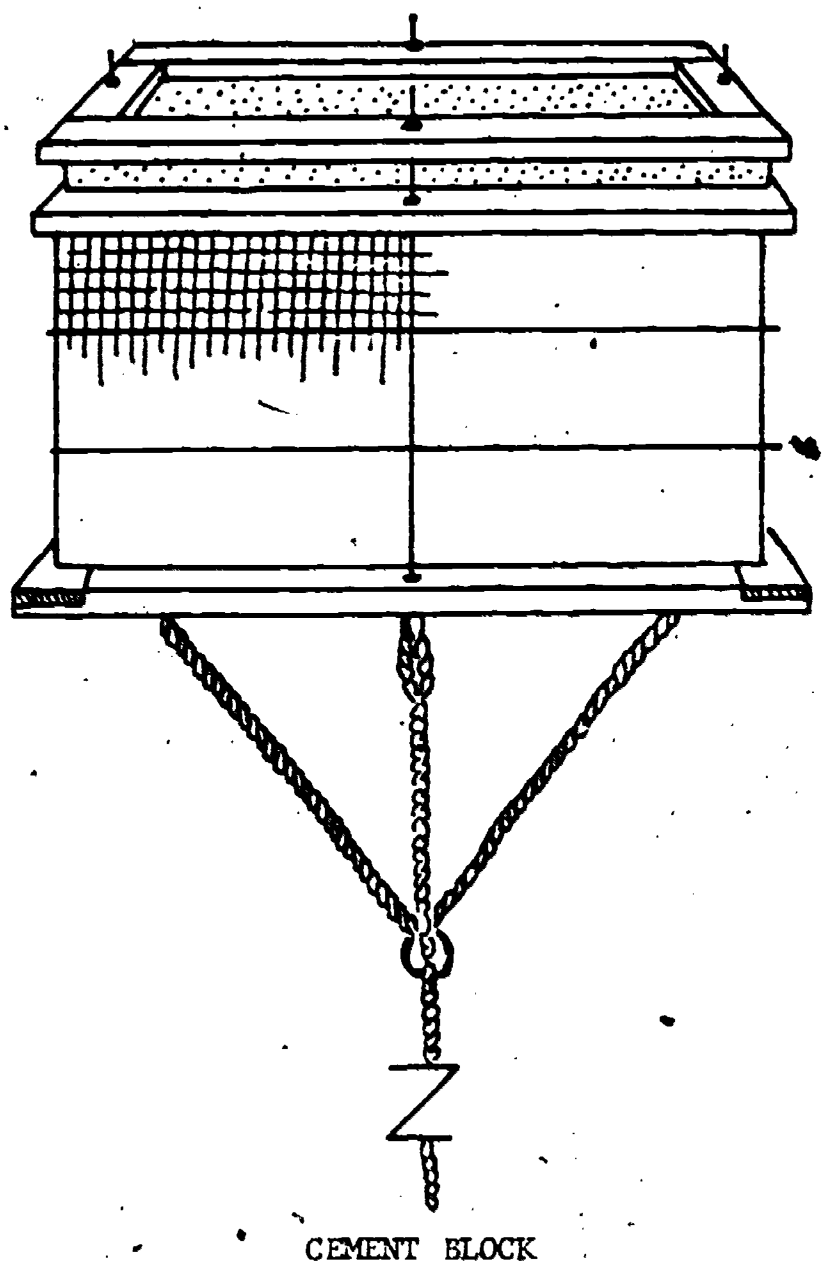


Fig. 4.

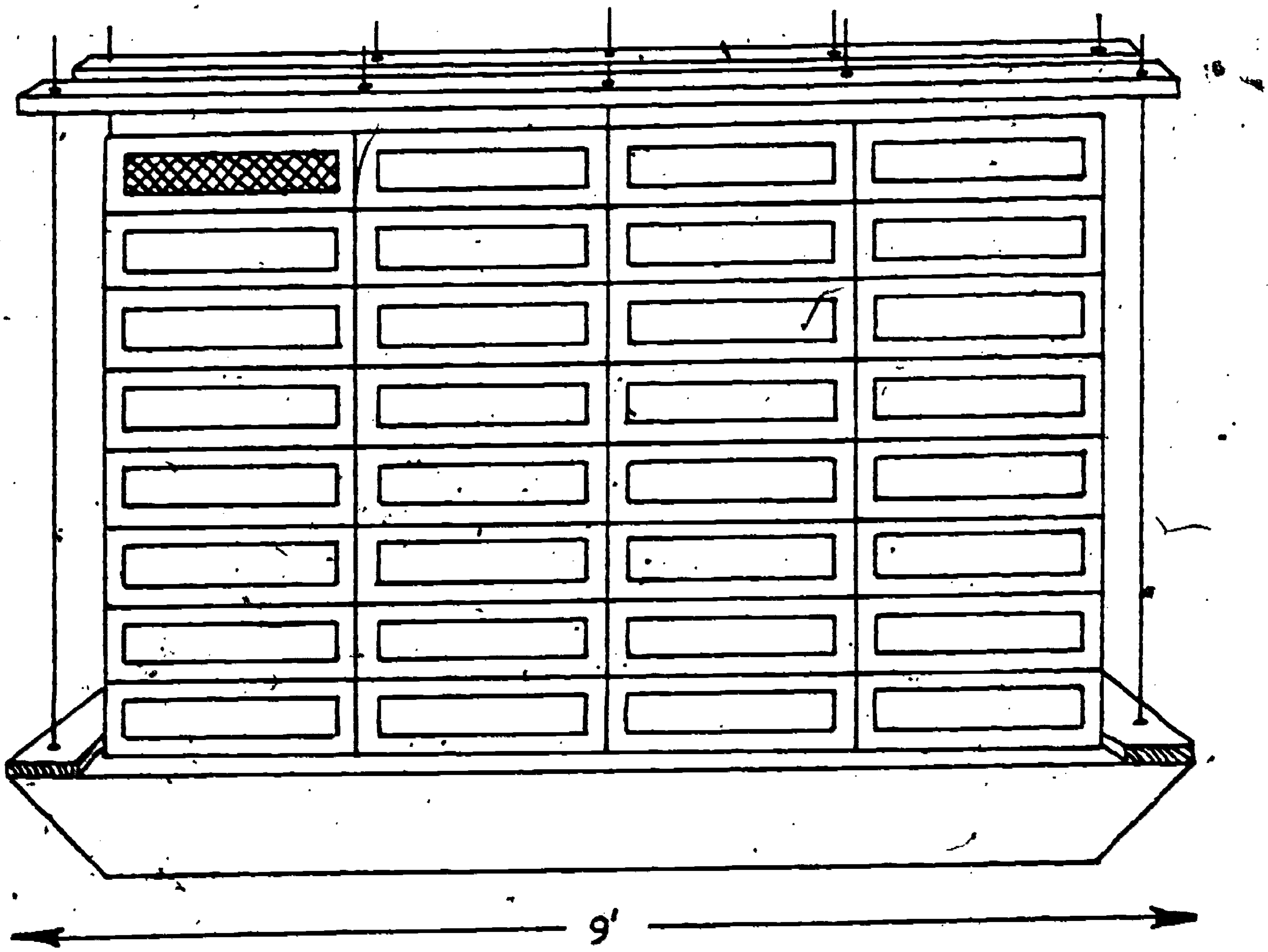


Fig. 5

The lantern nets are relatively inexpensive, costing about $20.00 each. They hold about 1000 to 1500 market sized oysters, and yet collapse down to about 5 or 6 inches in depth when they are not being used. Their life span is projected to be about 6 to 10 years in Maine waters. Being double-dipped galvanized, and then double-dipped vinyl, with nylon mesh, they are almost indestructible.

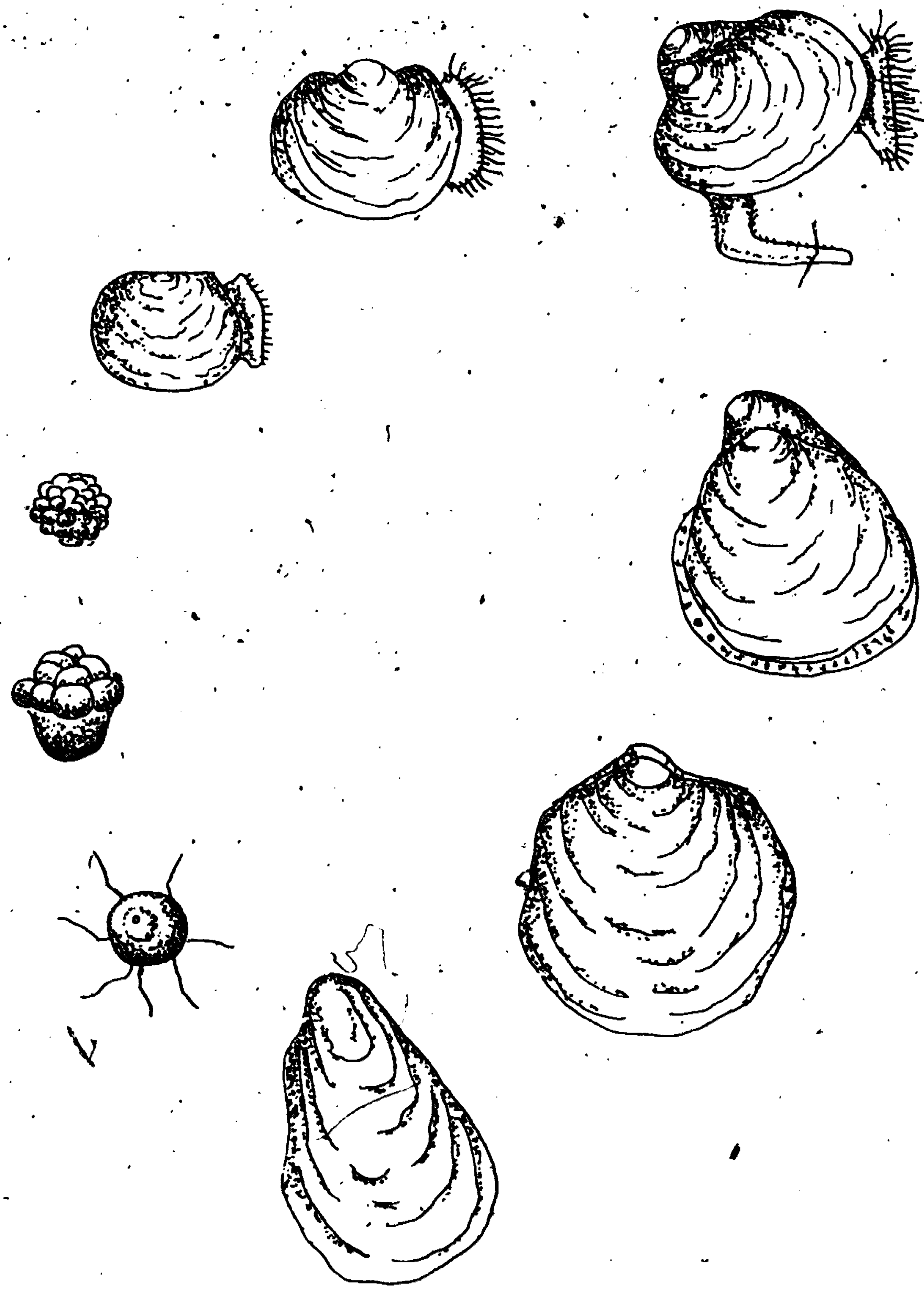
The older system that the Maine Coast Oyster Company uses in Blue Hill uses ten square wooden trays that float just under the surface of the water supported by blocks of styrofoam. These are becoming obsolete because our water temperatures are getting warmer so teredo worms will attack the wood. The plastic and metal trays should therefore work much better. Farmers have developed new trays which they call flip-flops. The trays float right on the surface, and although an area is contaminated very heavily with teredo worms which would spoil wood at a depth of 2 to 3 feet, they have no teredo worm problem on the surface. The tray is meshed both top and bottom and it is flipped every day. This eliminates all types of fouling organisms as the exposure to air and sunlight prevent attachment.

During the winter of 1976-77 the water temperature at the Darling Center went below 0° C for more than thirty days. Salt water freezes at about -2° C. Many oysters died during this cold spell; others died in the spring from what appears to be stress from the winter. It is felt that oysters in shallow water are more susceptible to cold water deaths than those in deeper water.

Life Cycle of the Oyster

The following diagram depicts some of the developmental stages in the life cycle of the oyster. Beginning at the lower left corner of the diagram is the fertilized egg; spawning results when the water in the oyster bed reaches the appropriate temperature. The mature oysters of the entire bed will cast their eggs and milt into the water. The next two diagrams on the left side show several of the segmentation stages of the developing embryo. The next three stages depicted are the straight-hinge stage, the early umbo stage, and the late umbo stage. Each of these larval stages is free-swimming. The mature umbo stage oyster glides on its ciliated foot until it finds a suitable place to attach itself, or "set."

The middle diagram on the right hand side represents the newly set oyster, or spat. The spat quickly loses its swimming appendage, and its ciliated foot after it cements itself to the substrate. The next two stages show the oyster as it matures in the cultch.



Mussels

Mussels are the second marine crop grown in Maine. The seafarmers use the Spanish Raft technique for collecting seed and growing mussels. In Spain the production rates are as high as 50 tons of meat per acre per year. This is the greatest production of any husbandry presently being practiced. This product is possible for the following reasons: one, better circulation of nutrient-laden water and the mussels; two, greater utilization of available space; three, best use of the available nutrients, organic matter, and plankton; four, reduction of predation by snails, crabs, and starfish.[4]

In practice, the method is relatively simple and consists of hanging ropes (varying in length from 10 to 30 feet) from floating platforms of various constructions. Ropes are spaced at approximately two-foot intervals and allowed to hang free in the water. In areas influenced by strong currents, certain precautions may have to be taken in order to prevent the entanglement of ropes (underwater spacing devices such as long pipes or structural frames attached to and interconnecting the bases of several ropes).

In a series of preliminary experiments undertaken at the University of Maine's marine laboratory, manila rope was found to be superior for the collection of spat (newly settled mussels) to both nylon and dacron although the differences among the three types of rope were small. In general, the more "hairy" the rope the more suitable it will be for use in spat collection. The unavailability of ropes such as coir, sisal, and those made from esparto grass, all of which have proved to be very successful throughout Europe, necessitated the use of manila and nylon for experimental work in Maine.

According to Field (1922), the spawning season of mussels along the Atlantic coast begins in April and continues on through the summer well into September. In Maine, spawning appears to be delayed until late in the spring (late May) and continues throughout the summer, often with two peak spawning periods, one in late May - early June and the other in late August - early September.[5] In most environments throughout the state it is advisable to place the ropes in the water during late April or early May. This allows sufficient time for the ropes to "condition," ridding themselves of the excess processing oil that may inhibit larval settlement and can be toxic to larvae in large concentration. In addition, this period of "conditioning" allows time for an accumulation of filamentous algae on the ropes that may stimulate the settlement of mussel larvae according to Scottish (Mason, 1969) and British workers.[6]

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[4]Lutz, R.A., Raft Cultivation of Mussels in Maine Waters--Its Practicability, Feasibility and Possible Advantages. page 4.

[5]Ibid. page 5.

[6]Ibid. page 5.

Certain areas along the Maine coast are more favorable than others for the collection and growth of spat. In addition, a particular locality will vary from year to year with regard to success encountered in the collection of spat. Therefore the definitive recommendations have not yet been established.

In years of good settlement the ropes will be covered with spat by the end of July. By the following fall (in favorable environments) a large number of mussels will have reached marketable size (two inches or greater in length) and can be removed from the ropes. The culling of individual marketable mussels from the ropes is not only time-consuming but also results in considerable loss of smaller mussels. For this reason, it is advisable to haul individual ropes to the surface and remove all the mussels from the rope surface. Vigorous shaking of the ropes over large containers should be sufficient to facilitate such removal (Andreu, 1968). Marketable mussels can then be separated and the smaller individuals reattached to the ropes. The standard method of reattachment, recommended for use in Maine Waters, consists of surrounding the cultivation ropes with mussels with the help of a very fine mesh net of cotton or synthetic fibers (Ryther and Bardach, 1968). The mussels eventually attach themselves firmly to the rope. The mesh net should be weak enough so that once the mussels have firmly attached themselves onto the ropes they can readily break through. In many areas overcrowding may cause a marked decrease in growth rate. In general, the fewer mussels per rope, the faster the growth rate. It is recommended that the growing population be thinned periodically before harvesting. The mussels removed can be replanted on additional ropes.[7]

The biggest problem we have had with the wild mussel is the pearl. The trematode worm Cymnophallus gets in the mussel and the pearl is formed around it. The adult host is the Eider duck, or Scoter, which are plentiful in Maine. Dr. Richard Lutz, from the University of Maine, did some research to see how to eliminate the pearl, or how to get around it. He found that the pearl is forming in all of the mussels, but if the mussel grows very fast (12-18 months) you can get it to market size and into somebody's stomach before the pearl is big enough for the consumer to detect. So, if you harvest mussels in Maine, below the low water mark, you are not apt to be able to detect the pearl. However, if you harvest mussels high in the intertidal zone, where it takes a much longer time (up to 5 years) for them to grow, then the pearl is much more prevalent. Because of their rapid growth, the farms guarantee the mussels to be free of pearls.[8]

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[7] Ibid. page 10.

[8] Lutz, R.A. and L.S. Incze. A comprehensive review of the Mussel Industry in the United States. page 8.

Finfish

Coho salmon and steelhead trout are the two finfish products currently cultured in Maine. These species are not native to the east coast so the eggs are purchased in the Northwest. In the fall, the eggs arrive in Maine from state or federal hatcheries in Idaho, Oregon, or Washington. The eggs are hatched in one of two private hatcheries, one in North New Portland, the other in Harborside.

When the young salmon are about 50 to the pound, they start the physiological change known as smolting. At this period in their life cycle, they move from fresh to salt water. This transfer is made under the controlled conditions of the farm. The finfish grow until they are about 12 oz. in weight and 14 months old; they are then harvested. The pan-sized fish are excellent for restaurant trade. Maine salmon and trout have been marketed from the Maine coast to Florida.

The three farms in Maine feed a combination of prepared dry food and a natural diet of whole ground shrimp to their salmon. The natural diet is readily accepted by the fish, producing a superior food product with pink meat.

The diet for trout does not include the natural feed since the pink meat color is not necessary. The fish are processed on the farm, packed in ice and shipped out fresh. Therefore, the farmer must possess the talents of a grower, processor, shipper and marketeer. This hard work all pays off when the fish sell for better than $2.25 each.

The first company, Maine Sea Farms, is found in Goose Pond, the old Callahan mine at Cape Rosier. It is a copper zinc pit which was depleted, then filled with water to start an aquaculture project. A graduate student from the University of Maine was hired to manage Maine Sea Farms, doing some experiments with oysters, mussels, salmon and trout. Callahan quickly became disinterested and sold everything to Bob Mant who is now marketing steel-head trout and Coho salmon. His, like all other operations, has had heavy debts and poor cash flow until the bicentennial year. During that year, the Queen of England came to the United States and ate coho salmon in Boston, Massachusetts. There was a lot of publicity in Maine and all around New England about how much the Queen enjoyed our cultured fish. This helped marketing a great deal. When the United States culinary olympics team went to Germany in 1976 to compete, they took Maine Sea Farms salmon with them and won a gold medal. Bob Mant does not have any difficulties marketing his fish now. He may shortly be one of the only aquaculture companies in the country to go into the black.

This farm is able to use a rather large 40 x 50 x 60' pen for culturing the marine stages of the fish. Maine Sea Farms has a rather harge hatchery which can produce about 300,000 smolts per year.

The second operation is at an oil fired generating station in Wiscasset, called Maine Salmon Farms. They use a much smaller pen which is about 15 x 15 x 15' because of the shallow depth and restricted area into which they can place the pens. Maine Salmon Farms has marketed over 70,000 yearlings in the past three years. They were the first company in twelve years to market salmon from Maine waters. Previously, some atlantics were fished for the marketed in Maine.

The Island Fisheries on Vinalhaven, uses a 15 foot circular pen that is 15 feet deep. The pen is designed to conform to the schooling and swimming habits of the fish. By having a circular pen, Spencer eliminates the waste of corners in a square pen. The pens are covered with large plywood doors that keep out both types of two-footed predators, man and bird. Birds are a serious problem to fish farmers who do not cover the pens. Sea gulls, kingfishers and other birds of prey could reduce inventories dramatically if precautions are not taken.

Lobster

The final cultured species is the lobster. The only lobster farm is in Kittery. Emile Plante and Saunders Associates have combined forces to produce a very unique method of penning the cannibalistic crustacean. Emile developed a cylindrical container that is divided into compartments stacked one on top of the other. This structure is affectionately called the lobster Hilton. The animals are fed using a long rod dropped down through a hole in the top of each divider. Water is circulated from the bottom of the Hilton, causing good flushing action.

The entire life cycle of the lobster is controlled in the rather small building. Saunders, an engineering firm from Nausha, N.H., is planning a major development over the next few years. It is their plan to hold up to 3 million pounds of adult lobsters in a new multi-million dollar facility to be located somewhere in Maine.[9]

Seafarming has been compared to chicken farming of 20 years ago. Chickens were grown on the range; small houses were placed in the field with the hopes that the hens would use them for laying. Research indicated that barns could be used to more efficiently grow the birds and gather eggs. Presently, the egg factory is standard. Hens are placed in small pens which they never leave. Eggs roll out the chute and into a container. Aquaculture is about 20 years behind the egg industry.

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[9] Chapman, Paul. Sanders Associates. Personal contact.

THE EVOLUTION OF SEAFARMING IN MAINE

Now that most of the various methods of aquaculture have been explained, let's look at how seafarming has fared and its future prospects. There have been three major aquacultural efforts in Maine, the oldest is the work done by the Maine Department of Marine Resources (formally Sea and Shore Fisheries). Even though their projects have been many and diverse, they have not been active in creating an aquaculture industry. The Department's extension branch has been very active in traditional fisheries. The researchers have experimented in the culture of many species. The following includes much of the work done by the DMR from 1966 to present.

Oysters, Crassostera virginica and Ostrea edulis, have been cultured in Spinney Creek since 1966. The oyster culture project was successful in the creek and, therefore, specimens were transplanted to the Marsh River. With the cooperation of the town of Brunswick, the program involved the cultivation, expansion and evaluation of aquaculture. Oysters were grown on scallop shells. (Not the 1978 standard method.) This New Meadows project also included a study of the potential of Quahogs, Mercenaria mercenaria, which has since been discontinued.

Presently there are two oyster farms, one at each of the two sites. Hustin Oyster Company of Brunswick is a direct result of the activity of the Department.

During the construction of the Maine Yankee Atomic Power Plant at Wiscasset the DMR experimented with bloodworm Glyeera dibranchiata culture. Work was started at the oil fired plant (Mason Station). Maturation studies were conducted on gametes in the coelom of gravid females. Work was also conducted on nutrition and the effect of temperature on the rate of growth. Despite years of work, researchers have been unable to fully understand the life cycle of the blood worm. This project was terminated around 1974.[10]

The second agency involved has been the University of Maine's Marine Laboratory, the Ira C. Darling Center. Their efforts started in 1971 with a Sea Grant to study the potential of Oysters Ostera edulis, scallops Aquipecten irradians, and blue mussels Mytilus edulis. The researchers, Dr. David Dean and Dr. Herbert Hidu, developed hatchery techniques for hatching the European oyster Ostrea edulius in Maines'. boreal environment. Dr. Lutz developed the techniques for mussel culture. Scallops were not attempted at this time but were cultured in 1978.

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[10] Dow, Bob, 1969-1973. Partial Report of Aquaculture Studies conducted by the Department of Marine Resources based on a five year grant by Maine Yankee Atomic Power Company.

Mr. Samuel Chapman was hired as the shellfish hatchery manager during the 1973 season. Seed oysters were raised in the modern aquaculture building and enough were produced to sell some to local sea farmers, thus competing with the California hatcheries. The hatchery effort has continued to the present with an ever-increasing volume of seed. Local interest in the hatchery techniques grew enough so that two of the growers started hatcheries in 1977. In 1978 two other growers have been contemplating such action. The hopes of a vertically integrated industry have been realized. The hatchery research continues today but now includes research in the culture of clams (<u>Mya arenaria</u>), Bay Scallops (<u>Aquipecten irridens</u>), and hard clams (<u>Mercenaria mercinaria</u>).

The extension effort which was developed at the request of the farmers continues with assistance to commercial hatcheries in two major areas, new techniques, and aid in collecting brood stock. The Marine Advisory Service has had a full-time professional extension person assigned to aquaculture since 1974. This person has been responsible to work as a liaison between researchers and farmers; to assist new growers with site evaluations, lease procedures and legal problems; to develop educational tools for increasing awareness of sea farming among students; to assist in the development of associations and co-ops; and to promote the cultured species.

Appendix A shows a list of all companies active in 1978. All of the oyster farms except Maine Coast Oyster Company have been formed since 1974. Except for Abandoned farms, the mussel farms are also new, and two Salmon farms got their start before 1974 (Maine Sea farms and Maine Salmon farms) indicating a very rapidly expanding interest in sea farming.

The finfish efforts have been slightly separated from the Darling Center activities but have relied heavily on the talents of the University of Maine. Most people involved in sea farming have been trained at the center. This training has taken the form of workshops, graduate courses, inservice training, and personal contact. One such workshop has been the aquaculture convention held every fall. A "Spring Fling" has also been held when national authorities have been invited to address the growers. Perhaps the most productive method of information transfer has been the personal contact with the marine specialists. They have been active in dealing with the day to day problems of the farm and in providing technical assistance. The major technical service has been site evaluations which include checking salinity, temperature, current flow and direction, legal restraints, type of gear to be used, proposed species to be cultured, biological competitors and financial commitment. Growth analysis is done as a part of periodic visits to the farms. Advice is given to reduce shell abrasion and fouling.

The last of the three largest efforts in aquaculture has been conducted since 1976 by the Aquaculture Workshop. This program is funded by the Coastal Economic Development Corporation. Economic stability has been the major thrust of the Workshop. Mr. Richard Clime has been attempting to aid fishermen to use aquaculture as a second crop. To this end the Workshop has given two 10-12 week courses in sea farming, set up a growers co-op, and has been very active in the Aquaculture Association. Like most programs they lack money and a long term committment.

There have been many other projects done by various organizations in the aquaculture field. The College of the Atlantic has developed an interest among students. Karen Ray Waters wrote a paper entitled, Aquaculture Feasibility Study Of The Pinkham Farm, Lamoine, Maine in 1976, after a year long study of the farm.[11] The Coastal Resource Center has aided sea farmers with grant money for developing gear and marketing contacts. Their success was insured by the thoughtful approach of a professional staff. Southern Maine Vocational Technical Institute has promoted aquaculture in their marine technician program. Students are taught much about sea farming as it exists today. The Bates College biology department has had a work study program for the last three years in which students work at various sea farms as a part of their educational experience. And, the Maine Aquaculture Association has been quite involved in marketing promotion, gear development, and lobbying among other involvements. In the next few years this association will be concentrating its efforts on public awareness of sea farming.

With this level of effort from so many interested people, the future of aquaculture looks quite good. Factors other than the people involved must be considered when contemplating the future of aquaculture in the Northeast. Shellfish have been one of the more important seafood products throughout the long fishing history of the New England coast. Major quantities of clams, oysters, mussels, quahogs, and hard clams have been supplied to the U.S. markets from the New England states. This shellfish population has declined over the past 40-50 years, due in part to pollution, disease, predation, over harvesting, and lack of governmental interest.

Because of these stresses, the future of some of these shellfish could be bleak. For example, the green crab predation of the soft-shelled clam (Mya) in Maine will manifest itself in a marked decline of marketable clams over the next few years. However, as the water temperatures decline and the winters become colder, the green crab population should decrease, thereby allowing a greater survival of the spat fall. It is ironic that as the winters become more severe we should see a marked decrease in populations of some other shellfish. In Maine we saw a 50-70% loss of European oysters due to the severe weather of this past winter.

One of the greatest potentials for the shellfish industry is aquaculture. Land farming produces about 300 lbs of beef per acre/per year, while the Spanish mussel raft technique produces 300,000 lbs of mussel meat per acre/per year. With the increased demand for land and

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[11] Waters, Karen, 1976. College of the Atlantic.

the growing interst in good, pure, nutritious food, an ever increasing pressure will be placed on the sea and its estuaries for food production.

Mussels, a relative newcomer to the marketable shellfish industry, hit their peak harvest of 2.6 million pounds in 1944. They declined to 40,000 pounds in 1947 and presently are at the 2.0 million level (1977). Because of their high nutritional value, fast growth rate, and ability to withstand adverse environmental conditions, it is felt that the future of mussels as a source of food is good. The wild stocks are presently being harvested by use of the Maryland dredge, scallop drags, and hand-forking.

Aquaculture will play an important part in New England's future shellfish plans. Terrestrial agriculture has had massive governmental economic input over the last 200 years while the technological developments have not increased dramatically over the last ten years. The U.S. presently spends only about \$5 million a year on aquaculture. This is equal to about 2¢ per person. A new bill presently in Congress will add about \$7 million per year, for a grand total of \$12 million, or about 5¢/person/year. This is a small amount of support when compared with the \$75/person/year spent annually in support of agriculture.

With the soaring cost of petroleum products, and its impact on the cost of fertilizers, pesticides, and ultimately grain and animal protein, technological developments will tend toward "wild crops, minimum tillage production, water weeding," and small, energy-efficient farming.

Our present shellfish harvest methods, although labor intensive, are not oil intensive. The mechanical dredges and drags do need and use fossil fuel, but if you look at the clam industry, oystering in Chesapeake Bay, and present aquaculture projects, you will note that very few gallons of oil are used for harvesting. Further, no oil is required for alteration of the organisms' environment, for pesticides, or for fertilizer. The harvest methods should remain much the same for the future.

Technological developments should increase growth rates, survival rates, and predator control without increasing fuel dependency.

Man, at this time is primarily a tertiary consumer, thus creating a great energy waste. He will be looking for a food source less dependent upon oil. Presently, Japan consumes 75 pounds of seafood per person/year while the U.S. consumption is only 12.3 pounds per person annually, and 66% of that is imported. We produce only four pounds of seafood per person per year. A search will be on for protein sources which make more direct use of solar radiation. Only unicellular algae stand between shellfish and sunlight. Therefore, it is possible that molluscan protein will become one of the most inexpensive proteins ever known.[12]

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[12]Pratt, R.S. 1977. Some Present and Future Prospects for Shellfish Culture.

If we look at the poultry industry, we recall three major areas of improvement, genetics, nutrition and disease control. As problems in these are conquered or controlled, the industry concentrated on marketing. Sea farmers must investigate the major problems of aquaculture and conquer them. Their efforts could well be concentrated on genetics, disease control, nutrition and site location. In the shellfish area, nutrition is not as important because it is handled naturally. In the future, this could become an area of research and development. Site location and technology are now the major considerations in improving production.

One way to increase productivity is to raise the animal from the bottom to the surface. Raft culture is the most efficient system now in use for shellfish culture, potentially 1,000 times more effective in presenting food to the animals per unit of area.[13] Off-bottom culture not only increases the food flow by the animal, but also the temperature and food concentration per unit volume. The surface culture affords about 1,000 times greater yield than does bottom culture. Bottom culture in Chesapeake Bay averages about 15,000 metric tons of oyster and clams per year, while surface grown oysters average about 250 tons per acre.[14] At this rate, you could expect the total annual harvest of the Chesapeake Bay on about 60 acres of water. The rafting technique could be very important in commercial production. Using this method the shellfish grow at a much faster rate and they can be cleaned, culled, graded, and watched.

If one were to look back at land farming, as a reference to see what will happen to aquaculture, one might be surprised at the similarities. For example, the chicken industry in the United States did not get started until the early 1920's. At that time a large chicken farmer had a flock of about 250-500. The chickens were usually penned up in a coop with a fenced in yard. The farmer fed the chicks about 3 times a day. When the chickens were sold they provided the farmer with about 60% of his yearly income. In the 40-50's the farmers experimented with range farming. All the birds were left in a field with small shelters located in various spots around the field. This technique was labor intensive and the mortality was high (due to predators). In the 1950's chicken houses sprouted and this appeared to be the best method. Lights were used to control photoperiod, to speed growth and to retard laying. When the chickens were brought into close contact with each other, disease became one of the major concerns of the farmer. The two other areas of concern, genetics and nutrition, were improved so greatly that they were no longer of major concern. Farmers now house 50 to 100 thousand birds annually.

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[13] Ryther, John, 1969. The potential of the Estuary for Shellfish Production. Proc. Natl. Shellfish Assoc., 59.

[14] Ibid

The trout, salmon, oyster and mussel industries will all have to consider these areas as major concerns during the next 100 years. The finfish farmers have now spent most of their research and development money on nutrition and disease.

Early in 1978 the oyster farmers discovered they too had disease problems. Mussels have been the only species that have not been greatly concerned in these areas. The genetics and feed are natural. Diseases are certainly present in wild populations but no major kill has been reported. The mussel's major area of development will be marketing.

It is hoped that by examining the problems of a different industry that the sea farmers will be able to overcome some of the pitfalls of their counterparts from the poultry industry.

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LESSON I

Introduction

The question of future sources of food is posed with increasing frequency as the amount of arable land per person decreases with population growth. The role of the ocean as a food supplier is currently being explored. The ocean has the potential to produce products already is use in greater quantities as well as new products.

This learning experience is divided into two major areas: 1) an overview, 2) aquaculture. Each lesson is intended for a daily forty-five minute class period, but may be expanded or condensed depending on time and student interest.

Lesson I: An Overview

Concept: The world population is growing at a rate faster than present food sources can support. The ocean has many untapped resources for feeding a growing population.

Objectives of this section of the unit are for students:

1. To list possible sources of food from the sea that are rarely or never used today.

2. To taste foods from the sea which may be important sources of nutrition in the future.

3. To overcome psychological barriers to certain foods to which students are not accustomed.

Teacher and Student Background

From the graph (Figure 6), it can be seen that it took 1,850 years, from 1 A.D. to 1850, for the population to double from one-half billion to one billion. Demographers predict that the present population of 4.5 billion will increase to 6.5 billion by the year 2000.

In order to keep pace with the increasing annual population rate of three per cent, food production must increase at the rate of four per cent annually. However, present world food production is increasing at the rate of only 2.7 per cent per annum.

Early man was a hunter, although he also ate berries and seeds. In order to gather enough food for his family, he needed about two square miles of land for hunting. The United States, with an area of 3,600,000 square miles, would only be able to support 1,800,000 families in a hunting society.

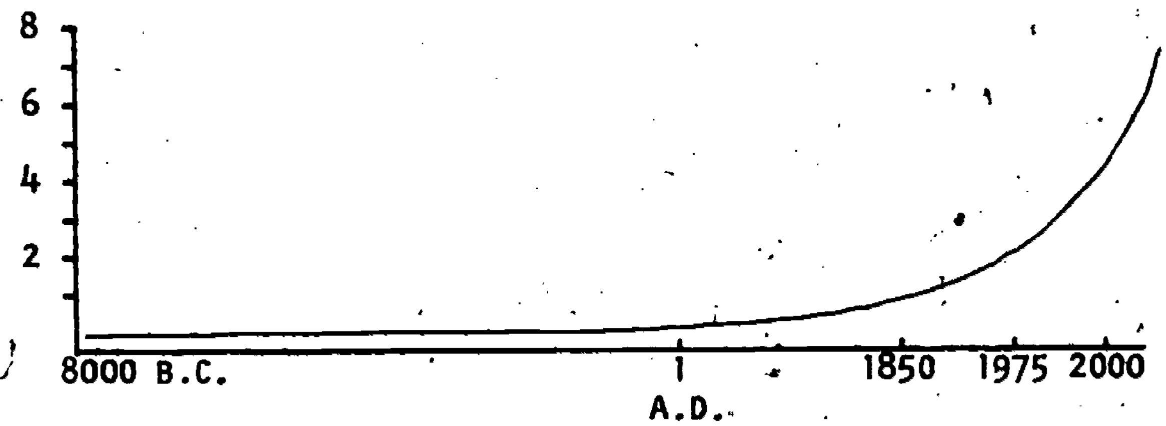

Figure 6

About 10,000 years ago, man first started growing crops and raising animals. Thus, he increased his food yield to support the growing population. With experience and technological improvements, man has been able to grow and raise even greater amounts of more nutritious food products. However, the increased food yield from the land is not sufficient to support the present world population.

Since 70 per cent of the earth's surface is covered by water, man is turning more and more to the sea for food resources. However, today he is at the same stage with sea foods that early man was with land foods, i.e., hunting wild stocks of fish and shellfish. In order to increase the yield of food from the sea, man must perform more scientific research, utilize new ocean food sources, and begin to do more farming of the ocean.

Research has recently been begun on increasing the yield of traditional sea foods as well as developing methods for utilizing other sea life. This new field of study is known as aquaculture (agriculture is from the Latin for cultivation of fields; aquaculture is from the Latin for cultivation of water). The Japanese are very advanced in aquaculture because there is so little land to farm in Japan.

Aquaculture efforts include decreasing the growing time of marine organisms, breeding marine organisms to increase number and size, and culturing previously unused resources such as seaweed, algae, mussels, and other forms of marine life. Alternate forms of sea food such as fish protein concentrate are also being developed. Foods from the sea include seaweeds, fish and fish products, and shellfish, such as oysters, clams, shrimp and lobsters.

Many people have a psychological barrier against eating many kinds of seafoods, even if they have never tried them before. Since seafoods will become an important source of nutrition, it is important that these barriers be overcome. In this section, a seafood meal will be prepared in an attempt to counter such attitudes.

Suggested Activities - Home Economics

1. In a class discussion have students make a list of possible food resources from the sea. Discuss the list and possible additions to it.

2. Have students prepare a meal which consists of seafood products that have a potential for increased future use. They should assemble this menu from recipes they have developed and/or collected.

   In the process of preparing this meal, the students should learn:

   to shuck clams, mussels, and scallops
   to pick crabs, and lobsters,
   to fillet fish, and
   to process and freeze seafood.

   Local experts can be identified and invited to the classroom to help with this teaching.

   The following special items will be required:

   a. Dishes, serving dishes, and utensils for the meal
   b. Filleting and shucking knives
   c. Food items
      (1) Maine seaweeds (i.e., laver, dulse, Alaria, Chondrus)
      (2) Seafood (available at supermarkets, seafood restaurants, fish markets, or collected along the coast)

   A Suggested Menu

   Appetizer: Squid salad, dulse, mussels, sea urchin roe, seaweed soup stock

   Entree: Clams, shark, eel, periwinkles, octopus, seaweed, bread

   Dessert: blanc mange, seaweed, laver

   Students should prepare a similar meal at home and collect family reactions to the new foods.

   Audio-Visual Aid

   An excellent introductory movie on the subject of seafood is "Food from the Sea," available from Instructional Resources Center, University of Delaware, Newark, DE 19711.

   The slide sequence on aquaculture is available without charge from the Instructional Systems Center, University of Maine at Orono, Orono, Maine 04469.

3. Have students report on the nutritional value of seafoods.

Suggested Activities - Science/Home Economics

1. Take a field trip to the coast to collect seafoods.

   a. Pre-trip experience

      (1) Learn about food which is available from the sea in your area.
      (2) Discuss quantities needed for the group.
      (3) Collect appropriate recipes.
      (4) Acquire needs tools for harvest, such as traps, hooks, lines, and hoes.
      (5) Check laws on harvesting (state and local).
      (6) Check for "red tide" restrictions and other pollution warnings.

   b. Trip experience

      (1) Learn habitats of specimens collected.
      (2) Collect needed quantity only.

   c. Post-trip experience

      (1) Prepare and cook food.
      (2) Eat the meal.
      (3) Summarize the experience.

2. Dissection and anatomical studies could be developed for some or all of the species collected.

   Special Items Required For Field Trip

   Clam hoes
   Fishing poles
   Crab traps (check state law)
   Hip boots
   Buckets
   Camera
   Fillet and shucking knives

3. Show the aquaculture slide sequence. It is available free through the Instructional Systems Center, University of Maine at Orono, Orono, Maine 04469.

Mathematics

Students could collect and analyze demographic data related to seafood consumption or sales in the local area. They should consider restaurants, food stores and family homes.

LESSON 11

Aquaculture

Concept: Through the widespread practice of aquaculture, the yield of many water organisms can be substantially increased to provide nutrition for a larger number of people.

Behavioral objectives:

Students should be able

1. to describe possible advantages and disadvantages of increasing food production through aquaculture,

2. to list the organisms that can be farmed along the northern New England coast, and to describe the basic techniques involved,

3. to assess the nutritional value of aquacultural products, and to test some in class,

4. to compare U.S. land farming (including subsidies) with U.S. water farming,

5. to demonstrate construction and collection techniques,

6. to identify principal features of the external and internal anatomies of selected species,

7. to explain the life cycles of selected bivalves and finfish,

8. to resonably project the future impact of aquaculture on world food supply including forecasting economic advantages of sea-farming.

Teacher Background

Acre for acre, the sea can be more productive than land, especially in near-shore regions. As opposed to the land, however, man still gets most of his food from the sea by hunting. In many cases, this method is inefficient. Man is just beginning to realize the advantages of aquaculture--farming the aquatic environment.

Presently, there are four basic types of aquaculture. The first is represented by the hatchery in which large numbers of young are raised in controlled environments. They are then released into their natural setting where it is expected the population of that species will increase. This technique has been successful in the United States with members of the salmon family. Overall, however, hatcheries have been unsuccessful because the fish, when released, are unable to fend for themselves. Further, the numbers released do not add significantly to the existing natural population.

The second type of aquaculture involves capture and impoundment of the species like lobsters and tuna. In this way, more food may be provided. The third type of aquaculture is the raising of marine organisms like mussels from youth to marketable size. The final and most advanced method involves full control of the life cycle and closely approximates land farming. Eggs are hatched and the various stages are raised and fed until marketing. A brood stock is also maintained to provide more eggs. Finfish and oysters are cultured in this way.

The criteria for successful aquaculture limit the number of marine animals which may be used. The organism should be 1) capable of being raised easily from the egg; 2) fast-growing; 3) able to eat inexpensive or abundant natural food, preferably plants; and 4) resistant to disease and unfavorable environmental conditions. Thus many open sea fishes which require large amounts of space and food are not suitable for culturing. However, many of these fish schools can, with proper management, be caught efficiently year after year.

Oysters have been the most successfully farmed marine organism. They are attached animals, live in shallow, brackish waters, produce large numbers of eggs and feed on plants. The oyster larvae swim for a couple of weeks. They then settle on a hard surface as spat, whereupon they develop into adults. In oyster culturing, hard surfaces are provided for spat settling. During development, spat are separated to prevent crowding. The growing adults are often cleaned of fouling organisms which may inhibit their filtering apparatus. Oyster predators such as starfish and oyster drills are controlled.

The first of the three aquacultured products in Maine were the salmonids. There are presently three salmonid operations in Maine: Maine Sea Farms in Harborside, Maine; Maine Salmon Farm in Wiscasset; and, Fox Island Fisheries in Vinalhaven.

Mussels are the second crop that has been cultured in Maine. Abondoned Farm, Inc. in South Bristol is the first commercial mussel culture project in the state.. Mr. Edward Myers collects his crop naturally, because they are indigenous and spawn well in nature. During the Spring and Fall, the spat are collected on ropes. Studies indicate that hemp ropes collect best. The nylon and dacron, however, last better in the water. The mussels reach market size (2") in about 12 to 14 months.

The State of Maine has not been noted as an oyster state, but that may change. American oysters have always been found on our coast. They were found in the Piscataqua, New Meadows, Sheepscot and Damariscotta Rivers. In 1949, Dr. Loosanoff brought European flat oysters to

Boothbay Harbor. During the warmer months they spawned. A small population remains to this day.

This oyster has been selected by all 12 oyster farms because of its tolerance to low temperatures and high salinities, and because it is considered the gourmet choice around the world. Both types of oysters found in aquaculture projects have been removed from the substrate upon which they set. They are called cultchless, which means they grow free from any pressures of other oysters. This allows their shell to grow very uniformly, making them choice for the half-shell trade.

We have two different types of aquaculturists in Maine. One is commercial and the other is the amateur who would like a few oysters in his "backyard ocean garden." This person may have the greatest economic impact in the aquaculture field over the next few years. These people often come from a generation that ate oysters and who have the place, time, and money to invest in such a project.

Aquaculturists have two major obstacles to overcome in the immediate future. The first is fouling, which is the overgrowth of other organisms on and around the oysters. The organisms may compete for food, block the tray to prevent the oysters from getting food, or even smother the oysters.

The second is overwintering. The oyster must be taken from its summer growing spot on the surface and placed on bottom away from ice and the colder water. They are placed off-bottom far enough to prevent predators (starfish and drills) from preying on them.

Aquaculture in Maine is growing, but it is still in its infancy. There are still many man-made obstacles impeding the progress of aquaculture. Shore regions are needed for many methods of aquaculture. However, this land is in high demand by recreationists, developers and industrialists. Thus, the high costs may act as a deterrent. One of the greatest threats to the aquaculture industry is pollution. Sewage, industrial wastes, pesticides and radioactivitiy all affect marine organisms and thus affect aquaculture.

Suggested Activities

1. Discuss various aspects of aquaculture as presented in teacher background material.

2. Collect larvae and grow animals in a saltwater aquarium. (See Appendix B)

3. Discuss the problems which must be overcome for aquaculture to become productive and profitable.

4. Individual reports: Have individual students report on the ways in which various species are harvested and/or cultured. These reports should include information on the life cycle of the chosen organism.

5. Have a guest speaker talk about aquaculture. Contact your university marine extension agent and/or the Department of Marine Resources.

6. Show the film "Take Two from the Sea." This film describes harvesting, culturing, processing, cooking, and serving of oysters and clams. Write for the free film catalogue and plan to book the film at least three months in advance.

   National Oceanic and Atmospheric Administration
   U.S. Department of Commerce
   Motion Picture Section
   12231 Wilkens Avenue
   Rockville, MD 20852

APPENDIX A

Maine Commercial Aquaculture Companies 1978

Oysters

John Smith
Pratt's Island Road
West Southport, Maine 04569

Terry Haskell
Box 533
Ellsworth, Maine 04604

Dodge Cove Marine Farm
Dick Clime & John Stewart
Box 211
Newcastle, Maine 04553

Maine Coast Oyster Corp.
Dean A. Richmond, Vice President
Box 171
Blue Hill, Maine 04614

Maine Mooring Oyster Co.
Chester Brown
South Bristol, Maine 04568

Open Sea Oyster Co.
Nelson Grindle
Sargentsville, Maine

Huston Oyster Co.
Alan Huston
R.F.D. #1
Topsham, Maine 04086

Fox Island Fisheries
Spencer Fuller
Box 427
Vinalhaven, Maine 04863

Maritec
On the Gut
South Bristol, Maine 04568

Sheepscot Oyster Co.
Reg & Gil Gillmor
Box 286
Newcastle, Maine 04553

Spinney Creek Oyster Co.
Ian Walker
Eliot, Maine 03930

Maine Bioservices
John Sheldon
High Island
South Bristol, Maine 04568

Tom & Lynne Haudenschield
R.R. #1 Box 97G
Steuben, Maine 04680

Joel Cowger & Barry Dowdy
c/o Boothbay Marine Lab
DMR
Boothbay Harbor, Maine 04538

Royce Randlett & Peter Hessler
Box 472
Camden, Maine 04843

Paul Durgin
Clark's Cove Road
Walpole, Maine 04573

Kim Messer & Schuyler Westworth
1 Pine Street
Wiscasset, Maine 04578

Ken Lutte
Box 8
New Harbor, Maine 04554

Harry Etzel
River Road
Newcastle, Maine 04553

Paul Steinberg
Box 195
Henniker, New Hampshire 03242

Downeast Sea Farms
Tom Murphy
Dutch Neck Road
Waldoboro, Maine 04572

Ken & Phil Gray
South Bristol, Maine 04568

Dick Emmons & Bill Sereta
Freeport, Maine 04032

Mussels

Abandoned Farm, Inc.
Edward Myers
Walpole, Maine 04573

Intertide
Chris Heinig
South Harpswell, Maine 04079

Doug Hamill
Dutch Neck Road
Waldoboro, Maine 04572

Paul Blais
Box 201
Damariscotta, Maine 04543

Salmon/Trout

Maine Sea Farms
Robert & Linda Mant
Harborside, Maine 04642

Maine Salmon Farms
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Fox Island Fisheries
Spencer Fuller
Vinalhaven, Maine 04863

Beautiful Valley Trout Farm
William Schoenthaler
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APPENDIX B

How to Establish and Build A Marine Aquarium

Introduction

If you collect, an aquarium (either temporary or permanent) in your classroom is a necessity. Salt water aquariums are tricky, but certainly not impossible! Several good publications are already in print that give you lots of good information about aquarium set up (See Bibliography). Our purpose here is to give you a bit of information to get you started.

Equipment

tank	sea water
sand	pump
filter	hydrometer
aerator	other equipment optional

Methods

Prepare your tank before you collect your specimens. Remember to allow about 24 hours for the tank to filter out the suspended sand and detritus that will be suspended in the water due to the set up activities.

First, buy, borrow or make a 10-15 gallon tank. This should be either glass or plastic as sea water will rust the stainless steel part of a metal-braced tank or corrode the aquarium cement. Also make sure that all of the equipment in your tank is plastic, since many metals are toxic to marine invertebrates. A subsand filter tends to be the most efficient, but the ordinary box-type filter is also effective. Sufficient aeration is very important and is crucial to the use of your subsand filter.

To begin setting up your tank, first wash it well. Then place your subsand filter and air pipes in the bottom. Above this layer pebbles and then sand. Next, fill the tank with seawater. Allow the filter system to clear the water before adding your specimens. Natural sea water is advisable, rather than trying to mix artificial sea water.

When your system is set, you are ready to begin collecting your specimens. Remember to always make sure that you have permission to collect at your site. Decide what specimens you would like to have in your aquarium before you collect. When you collect, take only what you need and make sure you have provided for their comfort en route. Use plastic containers to carry your animals. Do not try to transport glass or metal containers while you are on the rocky shore. Small specimens should be collected and placed in plastic jars containing sea water. Overcrowding can result in the loss of all of your collection. A few live, healthy specimens are better than many dead or dying ones. One or two organisms per gallon of water is about right. In transporting the collections to their new home site, they must be kept cool. If you are traveling for any distance, place your containers in a styrofoam cooler with ice in between and fresh seaweed on top. Once at home, allow the specimens time to become accustomed to their new surroundings by floating them and their containers in your aquarium overnight to allow water temperatures to equalize. The water in your aquarium may not look substantially different from the water your animals have been transported in, but to your new charges direct transfer to their new aquarium water could be a shocking experience.

The aquarium may be kept cold by enclosing it in a window area in the late fall through early spring months. Ice cubes placed in plastic bags and floated in the aquarium can cool the aquarium inexpensively for short periods. Aqua-chillers are complete units that can cool a series of aquariums or very large ones. These are quite expensive but may be your students may want to raise funds through a project. The key to success in keeping organisms alive is to keep the water cold (about 40-50°F).

To maintain your aquarium, you'll have to keep the salinity of the tank stable. When you first fill the aquarium, mark the water level with a piece of tape on the outside of the tank. The density of the water in the composed aquarium is important and can be checked with a hydrometer (available at a pet store). It should show a reading of 1.025 when natural sea water is filling the aquarium. As water evaporates and the salt concentration in the tank rises, pure distilled water should be added to the original water level mark. Any salt accumulating on the edge of the glass should be scraped off the sides and returned to the tank.

To maintain your animals, feed them as follows:
The starfish and clams can be fed with frozen clams. Turtle food and fish food may be added to the water to provide nourishment for mussels and small fish. For a while you may try an experiment of adding a few extra mussels and not feeding the animals frozen food. In this more natural situation, crabs and starfish will find their own dinners. You and your students will have the opportunity to watch crabs and starfish opening the mussels. The small fish will "clean up" after the crabs are finished.

There are a few simple steps to remember for a successful aquarium:

1. Use natural sea water and maintain a constant water level.

2. Keep the water well aerated.

3. Keep the water temperature low. If you need to reduce the temperature in your tank, float ice cubes in plastic bags or containers. Never add ice cubes directly to the water. Also, avoid rapid temperature changes.

4. Don't overcrowd your aquarium.

5. Find out which animals are voracious predators. You may want to isolate these.

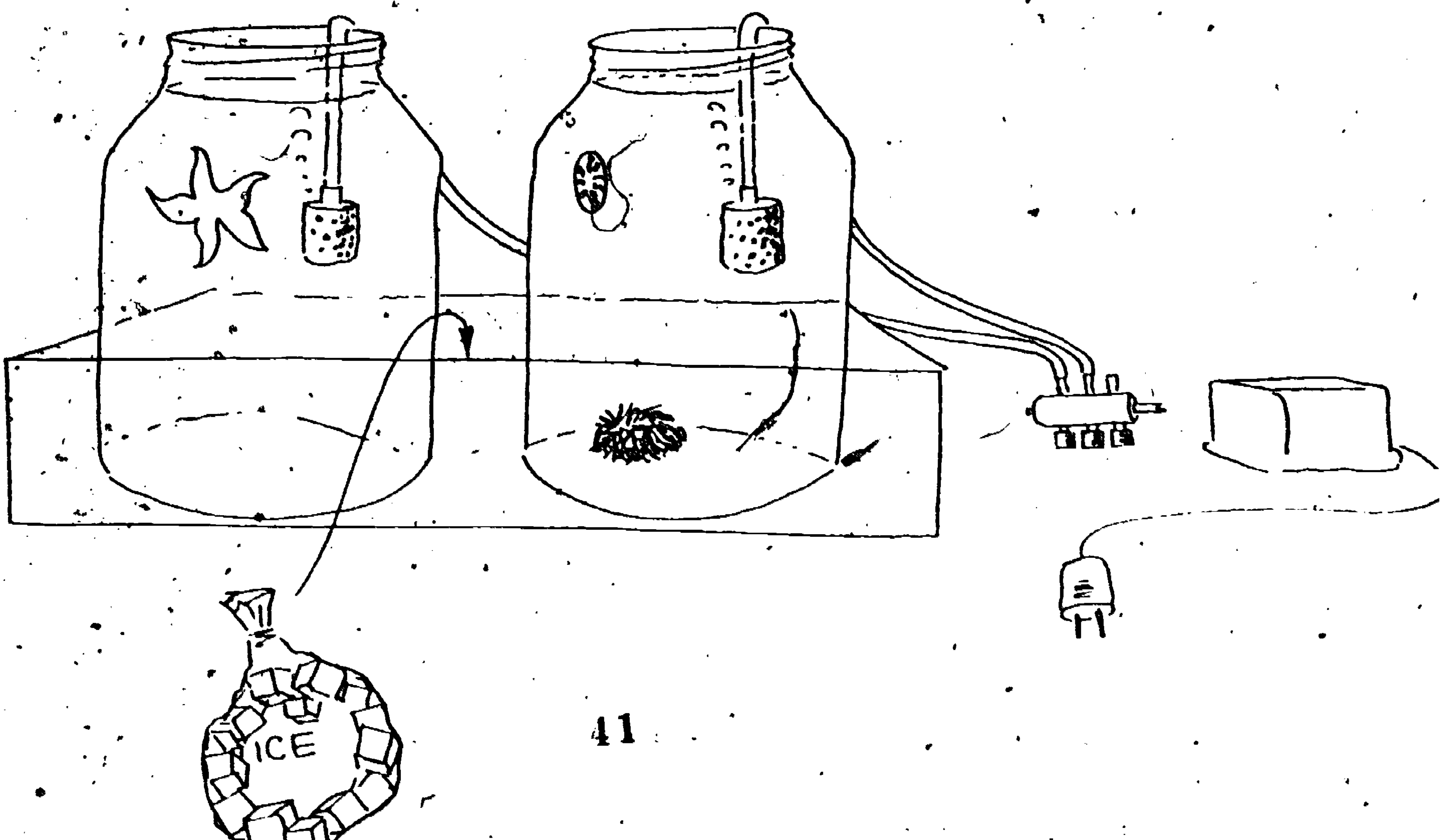
6. Feed your animals regularly and remove all uneaten food or dead animals to prevent fouling.

7. To avoid excess evaporation, keep the aquarium covered.

8. Keep the aquarium out of direct sunlight.

Specimens can be obtained from a marine supply house, but it is less expensive and more interesting to make your own collections. You can expect to find mollusks, crabs of various species, starfish, small marine fish, snails, barnacles, anemones and urchins, to name a few. Around a jetty or a rocky beach at low tide is the best place to look and collect. Collect various types of seaweed to enhance the attractiveness of the aquarium. You probably won't need any supplemental lighting unless you want to support several species of the green algae. The predominant red and brown seaweeds do fine with regular fluorescent or incandescent light from your ordinary lighting.

Additional resource materials and activities can be found in: The Aquarium, a second grade Maine education unit in this series.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APPENDIX C

SLIDE SCRIPT

1. Sea farming, or aquaculture, is a new industry on the Maine coast.

2. Early efforts at farming the sea along the Maine coastline involved oyster culturing in the early 1970's.

3. Since that time, through the efforts of the University of Maine, the State Department of Marine Resources, UMO/UNH Sea Grant, and interested individuals, the industry has grown and has begun to solve some of its problems.

4. In Maine, finfish, a crustacean, and several mollusks are being cultured. Oysters are one of the mollusks currently being raised.

5. Both the American oyster (Crassotrea virginica) on the left, and the European oyster (Ostrea edulis) on the right, are cultured in Maine at this time. The American oyster is indigenous to this area. The sought after European oyster was first introduced to Maine waters in 1949. A small population of European oysters still lives in Boothbay Harbor.

6. Much of the research on oyster culturing has been carried out here at the Aquaculture Building at the Ira C. Darling Center in Walpole, Maine.

7. This laboratory in the Aquaculture Building is very complete. It not only has hot and cold running water, but it also has seawater piped in from the Damariscotta River. All of the piping in the lab is plastic, since dissolved metals in the seawater would be harmful to growing organisms.

8. During early oyster culturing efforts in Maine, the Darling Center was the only oyster hatchery. Now, several individuals are in the business of producing commercial quantities of oyster 'seed'.

9. Tiny oysters used to be encouraged to 'set' on shells like these. Young oysters 'set' when they permenently attach themselves to some substrate.

10. Cultchless oysters are oysters which have 'set' on tiny chips of shells not near any other setting oysters. Cultchless oysters have more perfectly shaped shells and are preferred for the "shell market."

11. Sea farmers buy 'seed' oysters when they are between 2 and 3 mm in size. They then grow them out to market size. This process takes about 2 years.

12. Various types of apparatus have been devised for containing the developing oysters.

13. Some float at the surface and solve the fouling problem by letting the air and sunlight kill algae as the trays are turned over daily.

14. Other containers, such as these Japanese lantern nets, hold young oysters,

15. and are suspended from a longline,

16. which is moored at each end. The raft is the platform from which the nets are worked.

17. Fouling is fought often with high pressure hose.

18. If fouling is not combated, the oysters will be killed as the flow of water with its food and oxygen is restricted.

19. Grow out trays like these require a great deal of storage space when they're not in use.

20. Tending the oysters during the growing season requires the efforts of many people.

21. This rack was designed at the Darling Center to hold stacks of trays. Buoyancy is provided for the trays by blocks of styrofoam at the bottom of each stack. The trays rise to chest height when unrestrained, enabling one person to tend them.

22. One of the more serious problems facing oyster farmers in Maine is over-wintering the oysters. These are some of the devices currently employed to keep oyster populations near the bottom during the winter months. The idea is to keep the trays down away from the bitter cold and ice, and up out of the suffocating silt at the same time.

23. Losses like this can occur during the winter. This pile is about 5' deep.

24. Harvested oysters can be scrubbed and graded like this, or

25. can be done by this machine. The machine is still being developed.

26. If you raise your own oysters, you might harvest a few to eat on the halfshell on your dock.

27. But, if you don't raise your own, you'll be able to buy Maine oysters to enjoy, anyway.

28. Culturing of mussels has been going on for many years in several European countries.

29. The methods employed along the Maine coast most closely resemble the Spanish raft culture method.

30. Ropes are suspended for pole rafts and mussels are allowed to grow on the ropes. Periodically, the ropes are hauled up and the mussels thinned to allow them more room to grow. The culled mussels are transplanted to empty ropes.

31. Maine has a large natural population of blue mussels, but these mussels often have pearls in them. These pearls are formed around encysted trematode worms, and, while harmless, they are annoying to consumers and are potentially dangerous to teeth.

32. Pearl formation is related to growth time in mussels; so, cultured mussels which are exposed continually to an abundance of nutrients grow faster and have smaller pearls. Cultured mussels reach their 2" market size in 12-14 months. In that time, pearls do not reach noticeable size.

33. Two Northwestern fish, the Coho salmon, and the steelhead trout are currently cultured in Maine.

34. The eggs arrive from the Northwest in the fall.

35. and are hatched out in one of Maine's two private hatcheries. These hatcheries are located in North New Portland and Harborside.

36. The fry are raised in the hatchery until they are about 50 to the pound.

37. At that time, they begin smolting. This is the physiological change that prepares them to leave the fresh water and enter seawater. These are smolts.

38. When the fish are ready to enter the sea, they are placed in cages like these steelhead cages on Vinalhaven. The covers prevent predatory birds from eating the fish, and also provide the shade in which the fish develop most quickly.

39. The fish must be fed many times a day.

40. They are fed prepared fish food and shrimp processing wastes. The shrimp helps develop a poink color in the flesh of the young trout.

41. This pen is used for rearing Coho salmon in an abandoned mine.

42. Lobsters are being raised experimentally on the Maine coast.

43. These carnivorous crustaceans must be isolated early in their development to prevent them from eating each other. This is accomplished by raising them in vertical plastic tubes partitioned with grids which permit a continuous flow of water through the lobsters' homes.

APPENDIX D

Resources

Environmental Task Force
New York State Education Dept.
New York, New York

Maine Department of Marine Resources
State House Annex
Capital Shopping Plaza
Augusta, Maine 04330

U.S. Department of the Interior
Washington, D.C.

U.S. Government Printing Office
Washington, D.C.

Aquaculture Thesaurus
James A. Lanier
Virginia Institute of Marine Science
Gloucenter Point, Virginia 23062

Natural Resources Council
20 Willow Street
Augusta, Maine 04330

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Sea Grant Office
Rockville, Maryland 20852

Creig Brook Federal Hatchery
Orland, Maine 04472

Conservation Education Foundation of Maine
Room 600
State Office Building
Augusta, Maine 04330

Massachusetts Marine Educators
New England Aquarium
Boston, Massachusetts 02110

Darling Center
University of Maine
Walpole, Maine 04573
Tel: 563-3146
Contact: Bob Pratt

Aquaculture Workshop
Main Street
Damariscotta, Maine 04543

Coastal Resource Center
Firehouse Hill
Bar Harbor, Maine 04609

Beautiful Valley Trout Farm
North New Portland, Maine 04954

TRIGOM
Box 2320
South Portland, Maine 04106