

# ANNUAL REPORT FOR THE YEAR ENDED APRIL 30, 1973

## University of Maine - Coherent Project

# SEA GRANT PROGRAM

## UNIVERSITY OF MAINE AT ORONO, OCTOBER 1973



Research sponsored by NOAA—Sea Grant U. S. Department of Commerce Under Grant # NG-40-72

Ira C. Darling Center for Research, Teaching and Service

The Marine Laboratory of the University of Maine

An old dairy farm converted to a summer estate before its being given to the University in 1965, the property is an 125-acre point on the Damariscotta River, equidistant from the open sea and the head of navigation at the bridge joining the villages of Damariscotta and Newcastle. With over 6,000 feet of shoreline, it is an estuarine study area in itself, from the marsh at the head of Lowes Cove to the bold shore of the main channel. The water is classified SA, has a salinity of 30-32 parts per thousand, and can accommodate vessels up to a draft of 24 feet. The Darling Center is the locus of the Department of Oceanography of the Graduate School of the University of Maine.

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Darling Center Ref. No. 73-28

SEA GRANT ANNUAL REPORT

Year Ended April 30, 1973

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THE UNIVERSITY OF MAINE

at ORONO, MAINE 04473

# INTRODUCTION

by

David Dean, Coherent Program Director

This report for the year ended April 30, 1973 describes progress made on eight projects within the University of Maine's Sea Grant Coherent Area Program. All of them relate to more productive use of Maine's waters by Maine people, and point toward useful applications in other parts of the world.

Early in the year a new building, built specifically for the aquaculture program, was completed on the shore of the Damariscotta River, with a running sea water system and hatchery equipment. These enabled the program to be of service to several pilot commercial aquaculture enterprises begun within the year.

An economic analysis of some oyster markets in the Northeast suggests bright prospects for Maine-raised shell stocks.

A successful search for good oyster-growing areas may permit oysters to be marketed within two or three years.

A by-product of the deep-sea scallop fishery has been analysed as a nutritional competitor to the soybean as a poultry feed ingredient. Although the immediate supply of by-product may not make the process economically practical, the approach could prove compatible with the production of other marine by-products.

Extension of the shelf-life of fresh sea mussels through proper handling and storage may open more distant markets.

Advances, which are continuing, have been made in the genetics

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Dr. Dean is Professor of Oceanography and
Director of the Ira C. Darling Center

of shellfish, in the age-determination of both wild and cultivated mussels, and in rafting techniques for clams, mussels, and oysters.

Marine Advisory Services became fully active at the middle of the year, and in six months developed into an effective arm reaching the many publics interested in, and affected by, the Coherent Area Program projects.

The year also saw the evolution of a closer working relationship with the Sea Grant projects of Southern Maine Vocational Technical Institute and with the State's Department of Sea and Shore Fisheries. In addition, a plan has been initiated to combine the Coherent Area Programs of the Universities of New Hampshire and Maine into a joint Institutional Program.

The Sea Grant year has been a rewarding one for all those involved in it at the University of Maine. You will see this sense of accomplishment reflected in the progress reports which follow. Beyond the scope of this report, but eminently worth recording here, is the stimulation given by the Coherent Area Program to many researchers and University departments engaged in marine projects other than Sea Grant.

COHERENT PROJECT SEA GRANT PROGRAM

-- Program Summary --

| Project | Short Title | Principal Investigator | Status, year ending Apr. 30 72 | 73 | 74@ |
|---|---|---|---|---|---|
| R/A-1 | Shellfish Seed Production | Hidu | N | C | C |
| R/A-2* | European Oyster Maintenance | Hidu | N | C | C |
| R/A-3* | Evaluation for Mariculture | Hidu | N | C | C |
| R/A-4* | Scallop Biology & Culture | Dean | N | C | C |
| R/A-5* | Mussel Biology & Culture | Hidu | N | C | C |
| R/A-6 | Feasibility Crustacean Aging | Allen | | | N |
| R/A-7 | Bivalve Mollusc Genetics | Roberts | | N | C |
| R/LR-2* | Crab Biology & Dynamics | Ring | N | C | T |
| R/ME-2# | Oyster Market Potentials | Dunham | N | C | T |
| R/OE-1# | Submersible Rafts | Schneider | N | C | T |
| R/OE-3# | Field Rearing Techniques | Rowe | N | C | C |
| R/RRU-2# | Animal Food from By-Products | Gerry | N | C | C |
| R/P-2 | Thermal Addition Effects | Mazurkiewicz | | | N |
| E/AD-1 | Adult Education Development | McAlice | | | N |
| A/EP-1* | Aquaculture Implementation | Ring | N | C | C |
| A/PE-1 | Marine Advisory Services | Ring | | N | C |
| A/P-1 | Marine Advisory Publications | Ring | | N | C |
| M/D-1* | Program Administration | Dean | N | C | C |
| MD/D-1* | Program Development | Dean | N | C | C |

(Project Status: N - New; C - Continuing; T - Terminated)

* Formerly part of R/A-1 # Had R/A designation first year

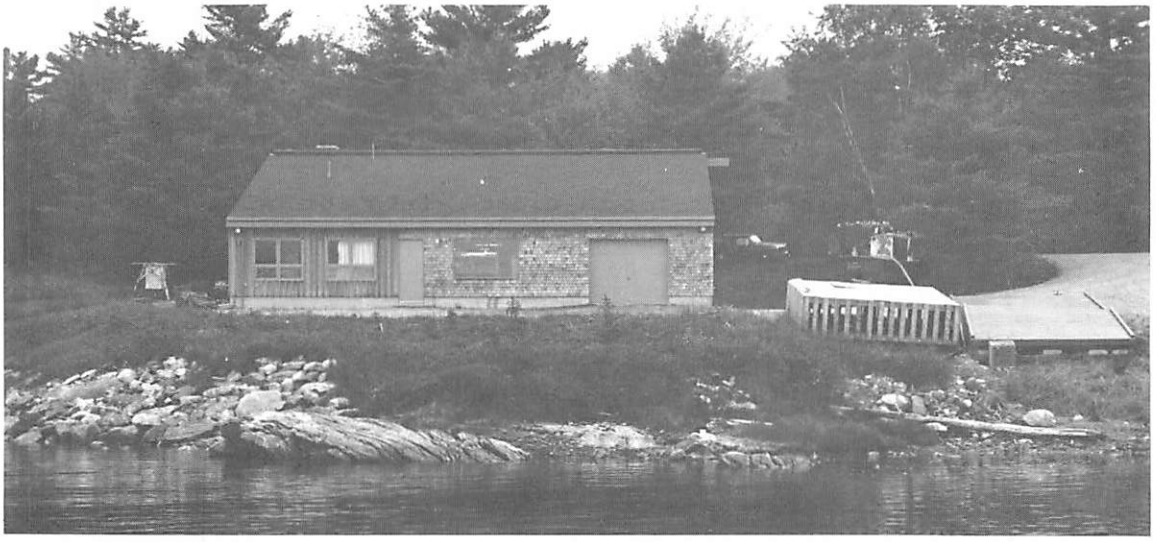
@ In 74 fiscal year, to December 31, 1973 only.

Culture of Resources in a Cold Water Marine Environment

A second year of work was completed April 30, 1973 on four groups of marine species with potential for increased utilization. The background for the research questions which guided the studies on each of these species groups is summarized below.

American and European Oysters. The American oyster was once abundant in Maine's upper estuaries, but numbers now are insufficient to support a commercial fishery. The European oyster was stocked in Maine's outer coastal regions in the 1940's and although populations have become established, they are not yet extensive enough to support a commercial fishery.

The Blue Mussel. Mussels are ubiquitous on the Maine coast but presently support only a small ethnic market in contrast to a high volume, high priced European market for the same species.



Aquaculture Building, occupied June, 1972, contains hatchery-laboratory for Sea Grant projects.

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Principal Investigator: Herbert Hidu, Associate Professor of Oceanography; Marine Research Associate, Paul D. Ring; Laboratory Technicians: Phyllis R. Coggins, Mark S. Richmond; Graduate Assistants: Richard Lutz, Robert Mant, Peter Schroeder; Student Volunteers: Sherry Riggs, Hugh Maxwell, Tom Sparks.

Since World War II the Maine mussel has been a far less utilized resource. The three principal limiting factors controlling the commercial exploitation of this species appear to be: (1) the lack of an adequate market, (2) a short shelf life, and (3) the presence of small pearls embedded within the meat of mussels obtained from certain populations along the coast. Much of the mussel research at the Darling Center to date has dealt with this latter problem.

Bay Scallops and Sea Scallops. With increased demand for sea scallops, expansion of the resource is needed. To serve this need, hatchery production of selected scallop strains is being attempted at the Darling Center to assist that purpose. According to economic analyses, the bay scallop holds an excellent potential for intensive aquaculture in northern New England.

Rock Crabs. Two widely distributed species of edible crabs (Cancer irroratus and C. borealis) comprise an extensive resource in Maine waters. Very little is known of standing crops, biology, movement, and general behavior of crabs. Such information is essential if catchability is to be optimized and a crab harvest made worthwhile for fishermen to pursue. This information gap can be reduced by comparing data from various locations to learn of the seasonal incidence, movement, molting cycles, catchability, and general biology of the two species in the extensive estuarine system in Maine.

## American and European Oysters

Research activity during the year was oriented toward two goals: First to accomplish the research and development necessary

for improved predictions and recommendations to assist commercial oyster culture ventures and second to involve citizens from the coastal community in pilot scale culture of shellfish in order to extend research into actual production situations. Some of the specific questions and Sea Grant assisted activities which generated new knowledge of the Maine situation are reported below.

Since natural oyster seed collecting areas are limited in Maine, can hatchery culture methods from elsewhere in the world be adapted for the Maine environment?

The new Darling Center hatchery went into operation in June 1972, and served as the center for shellfish culture work. Throughout the year shakedown operations and gear development were integrated with shellfish culture work. By spring 1973, the hatchery was 90 per cent operational, with development of additional field rearing apparatus in prospect. The new hatchery was employed immediately to move interacting projects forward. Several broods of both European oysters and bay scallops were reared to the juvenile stage. The new facility produced approximately 500,000 oysters during its initial operating year.

What is the potential of the Maine environment to grow oysters in an economically competitive way?

Second year evaluations of the Maine environment for economically feasible culture of shellfish rendered first year indications more conclusive, namely: Market half-shell American or European oysters can probably be produced in a period of two to three years from cultchless hatchery seed. American oysters do well in the protected, warmed, upper estuaries and the European species in the colder water, outer coastal sites. The special

advantage of the Maine environment is that summer water temperatures remain cool and favorable to oyster growth whereas these species of shellfish in the more southern mid-Atlantic environment expend their summer energy in reproductive activity.

Do 25 year old Maine stocks of European oysters represent a cold water tolerant gene pool and can we begin to select superior Maine-adapted oysters from these stocks?

Winter survival of European oysters, purchased as cultchless hatchery seed from California, was compared to progeny of edulis (European oysters) stocks which were introduced to Boothbay waters in the late 1940's. The Boothbay progeny exhibited superior overwintering qualities when compared to the California groups. Thus, the data obtained from investigation of the surviving Boothbay stocks support the possibility that they represent a superior gene pool of value to preserve for future expansion of oyster culture in Maine.

What is the present status of the European oyster introductions in Maine and can their numbers be increased through more intensive aquaculture?

The Maine Department of Sea and Shore Fisheries worked with the Darling Center's Sea Grant investigators to determine the present status of Maine's European oyster stocks and to learn of factors which might enhance their numbers. SCUBA diver surveys indicated that populations are considerably reduced from earlier numbers; however, there is considerable age class diversity and some amount of year-to-year set in population centers in the inner Boothbay waters. In 1972, field experiments were set up to learn

of the importance of the presence of adult oysters to recruitment or setting in the immediate area (Fig. 1). Although setting was extremely light in 1972, there was indication that the presence of adult oysters increased setting on adjacent cultch shells over control cultches with no adult oysters nearby.

Is enough known now to encourage pilot commercial ventures?

Shellfish growth test units previously placed in a variety of Maine marine environments with several private citizens continued to provide data to supplement results from more intensive growth studies based at the laboratory facilities at the Darling Center. The most encouraging results came from a cooperative test unit in a lobster pound environment. This test unit experience demonstrated that a lobster pound possessed advantages for product diversification through the addition of shellfish culture: It was under proprietary control; it presented a well sheltered location; it possessed structures well suited for conversion to hatchery facilities; it contained the possibility of high biological and

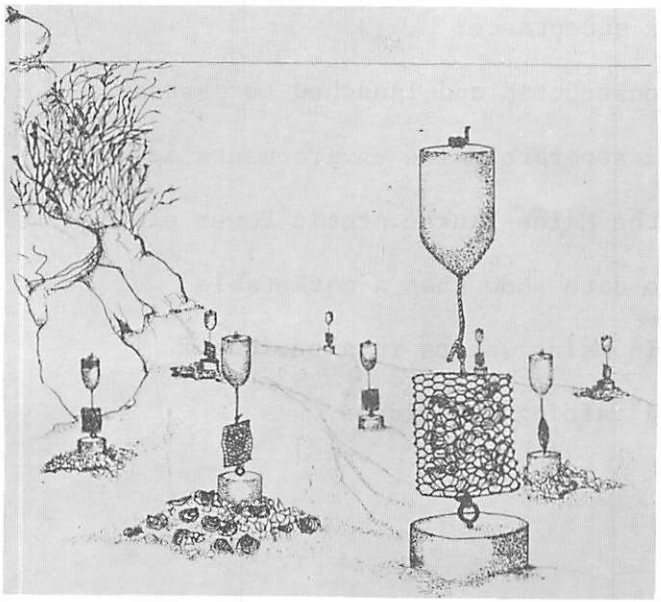


Fig. 1. Artist's view of the field experiments to determine factors important in recruitment of European oysters in Maine. Oyster setting was monitored on 3 bottom treatments: Unmodified controls, oyster shell piles, and oyster shell piles with live oysters. Early results indicate increased setting on shell piles containing live oysters. This experiment will determine the importance of gregarious setting in the field. Laboratory evidence indicates that adult oysters emit chemicals or "pheromones" which stimulate setting in their pelagic larvae. The ultimate understanding of such factors will be of aid in managing and in increasing field populations of oysters. (Sketch: P. Coggins)

economic productivity levels from excretions of lobsters. Approximately 70 lobster pounds in the state were identified and mapped. This number is indicative of the opportunity for expansion of this type of culture facility in the State of Maine.

## The Blue Mussel

Can the incidence of pearls and the time required for growth to marketable size be reduced as factors limiting quality and use of Maine mussels?

During the first year, statistical differences obtained between raft and shore populations of mussels indicated that rafted individuals contained fewer and smaller pearls than mussels of corresponding length obtained from adjacent shore populations. Moreover it appeared that the reason rafted mussels had fewer pearls was because of their very rapid growth rate. Research during the past year suggested that pearl production presents no problem to the commercial utilization of mussels in an environment where a marketable product is obtained in a period of less than three years. For this reason much of the 1972-73 effort was centered around the biological and economical feasibility of mussel raft culture.

Can rafting techniques be adapted to produce a superior product which would gain greater consumer acceptance?

Experimental rafts were constructed and launched to assess the aquacultural potential of six separate Maine environments including the discharge waters of the Maine Yankee Atomic Power plant located in Wiscasset. Results to date show that a marketable mussel can probably be obtained in Maine waters in a period of less than fifteen months by using rafting techniques.

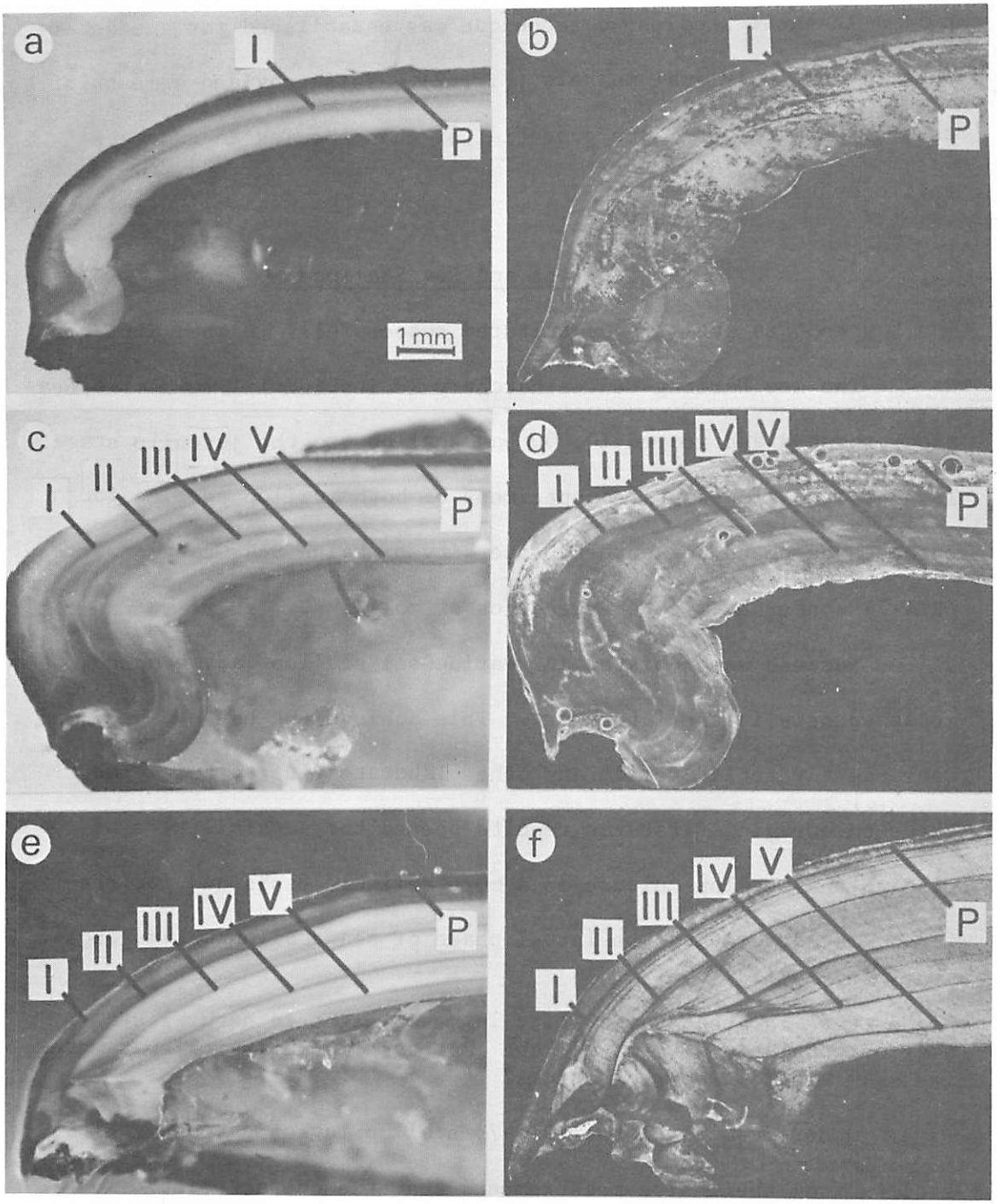



Fig. 2. Longitudinal sections through the shell of the blue mussel with corresponding acetate peels. Numerals designate dark winter bands or lines. Such patterns facilitate age determination of this species. Applied to growth-rate studies, these findings may make possible an accurate assessment of aquacultural potential for various environments throughout the state.

In basic studies, a technique was established for age determination of individual mussels (Fig. 2). This provided a means of assessing the growth-rate potential of this species in numerous environments.

## Bay Scallops and Sea Scallops

Can bay and sea scallops be cultured successfully in the laboratory?

The new Darling Center hatchery in its initial year of operation produced and reared 10,000 bay scallops to the juvenile stage. This project also supplied specimens of both scallop species for research purposes to another University of Maine Sea Grant project (R/A-7) concerned with the genetics of mollusks.

Success was achieved in rearing sea scallop larvae up to metamorphosis in the laboratory. This achievement has not been consistently replicated in any other laboratory up to this time. These encouraging first-run results opened the possibilities of placing sea scallop culture on a more reliable basis and for the first time describing the larval phase of sea scallop metamorphosis.

Since there is great variability in meat weight in natural sea scallop populations, what are the important morphological parameters for selection of superior stocks?

Other results of the 1972-73 scallop investigations include finding from shell size measurements that the characteristic most highly correlated with muscle meat weight is the thickness measured as the degree of concavity of individual scallop shells (Fig. 3).

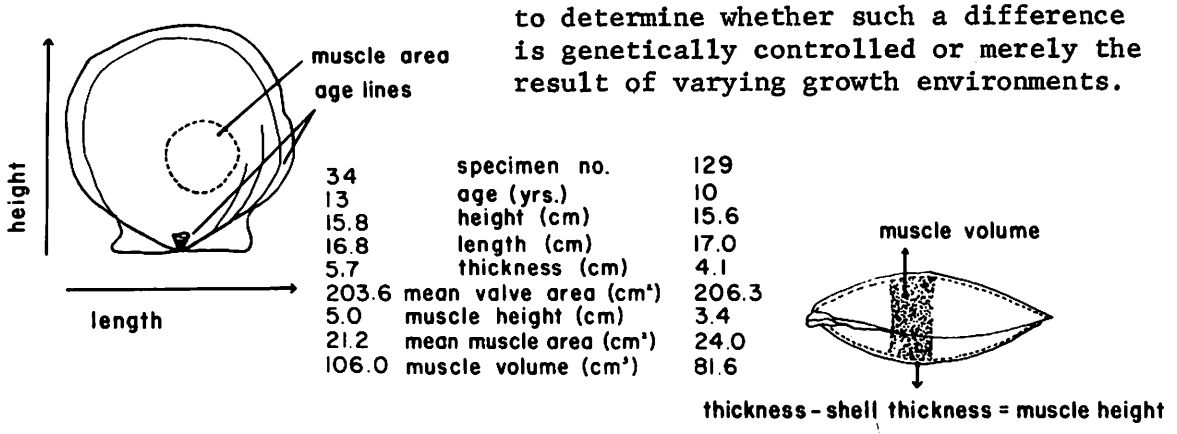



Fig. 3. Morphological variability in sea scallops may produce substantial differences in muscle volume. It is important to determine whether such a difference is genetically controlled or merely the result of varying growth environments.

What is the potential of the Maine environment for culturing the bay scallop?

Also during 1972, bay scallop progeny were reared from brood stock obtained from Long Island. These progeny were placed in test units in a variety of Maine estuarine environments and became part of the network of sources generating data for evaluation of potential for the culture of bay scallops on the Maine coast.

## Rock Crabs

What is the extent of the harvest of rock crabs in Maine and what appear to be factors limiting the utilization of the crab resource?

The research confirmed that, in northern New England, the rock crabs present a readily available resource with total Maine landings in 1972 valued at $63,020. It was found that the increased utilization of this resource is blocked by economic factors. Crabs are harvested by lobstermen as a marginal venture when lobstering is providing a low return. Thus, with the intermittent supply, wholesalers and processors have not invested in automated picking machines which could reduce costs, stabilize supply, and increase the market volume. Presently, all crabs in Maine are hand picked.

Can increased knowledge of the life history and movement of crabs providing the basis for a more efficient harvest be acquired by observing crabs in a Maine estuary?

The 15-mile Damariscotta estuary in Maine was selected for a study of the biology of crab incidence and movement. Trapping stations were set up at three locations on the estuary from the open coast to the uppermost range of crabs in the river. Crabs were trapped systematically for three days each month for one year (Oct. 1971-Oct. 1972) and measured for size, sex, molting stage, and reproductive state. Trapping data were backed up with SCUBA divers' observations whenever possible. In one year of sampling a total of 3,149 crabs were tallied.

The final manuscript is in preparation and includes the following conclusions.

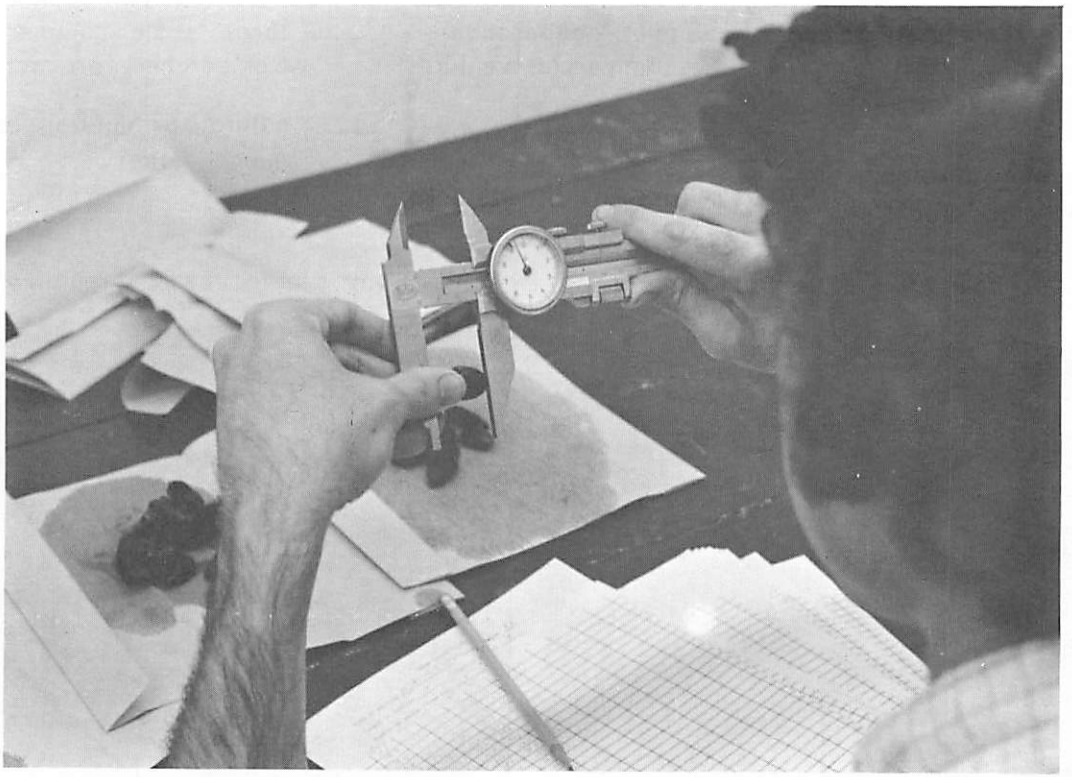
The Damariscotta River system contains an abundant but under-utilized population of C. irroratus.

The stage of molt in C. irroratus strongly affects seasonal activity patterns. Female C. irroratus pass through the winter months in the hard intermolt stage with lack of activity apparently related to extremely low sea water temperatures. The male crabs, however, molt in mid-winter and the post-molt crabs are extremely active in food getting, which accelerates the filling out of watery tissues with new meat.

No indications of seasonal estuarine migration were noted. The numbers of crabs and sex ratios caught appeared to be dependent on behavior related to molt stage rather than the size of total population present.

Asbestos panel covered with first-year mussels.

This research information shows how it is possible to develop recommendations for increasing human utilization of the crab resource, including areas and seasons for most efficient capture. It also establishes baseline data to determine future effects of harvesting in the Damariscotta River. Moreover, the research methodology is applicable to other areas of the coast.



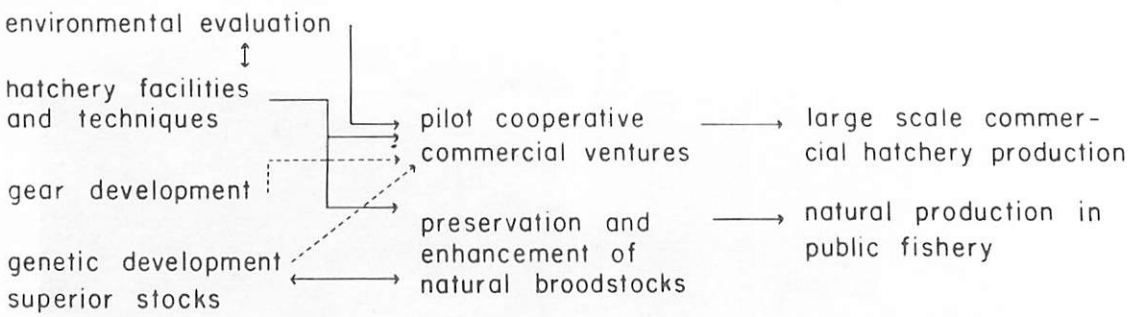
Measurement of blue mussels to determine comparative growth of rafted vs. shorebound populations.

American Oyster
(C. virginica)

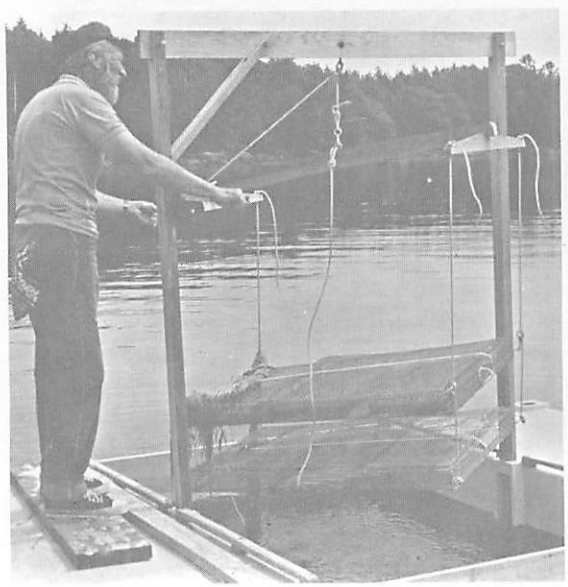
European Oyster
(O. edulis)

## Oyster Production in Maine O. edulis C. virginica

**Sea Grant project interaction and goals (projects RA-I-2-6-7)**




Tending oyster raft trays.



Assembling mussel raft components.


# Optimization of Field Rearing Techniques for Hatchery Cultured Shellfish in Maine Waters

The Agricultural Engineering Department has continued development of field-rearing techniques for hatchery-produced oysters.

The reattachment system studied last year proved biologically successful, but had economic and other drawbacks which left it with few advantages over tray culture. The long-line system of submerged trays proposed previously has many theoretical advantages, but in practice proved clumsy and difficult to use. At this point it was concluded that trying to develop a mechanized culture system for general application was the wrong approach, and that it would be better to develop the simplest possible tray rearing system for a particular, perhaps unique, situation. Problems such as excessive hand labor, fouling, icing, etc., would then be solved if and when they occurred, rather than by anticipation.

The result of this rethinking is that the major part of the Agricultural Engineering effort is now directed towards development of two specific rearing systems. The first involves a floating tray system in a sheltered, privately-owned lobster pound. Sophisticated engineering solutions are not called for; rather we are concerned with practical problems such as the design of a simple rope pulley system across the pound for retrieval of trays, and the logistics of tray submergence during the winter.

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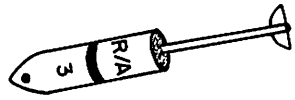
Principal Investigator: Richard J. Rowe, Professor of Agricultural Engineering; Associate Investigator, John G. Riley, Research Associate in Agricultural Engineering.

The second situation involves the adaptation of a lobster boat to handle bottom-resting modules of oyster trays. A prototype module has been constructed, filled with juvenile oysters, and deployed from the lobster boat. Strengthened scallop dragging gear on the boat will be used to retrieve the module. The large concrete base needed for stability and for prevention of movement by currents makes the module excessively heavy, especially after severe fouling.

There are as many different ways of field-rearing oysters in Maine as there are different situations -- biological, physical, and cultural. The ad hoc approach of developing the simplest system for a particular situation is adjudged the best way to go at this point, and appears to be a better utilization of resources than concentration on a single mechanized concept. It is also preferable to involve fishermen and pound-owners in the development process. In most cases they have a better understanding of what can or cannot be done in their environment than has the researcher without their contribution of local and practical knowledge. Once the problem has been identified and the solution initiated, much of the practical experimentation and engineering can and should be done by the individual concerned, with the Department available on a cooperative or consulting basis as required.




Market Development Studies on the European Oyster

Summary and Conclusions of Project

The primary objective of this project was to investigate the feasibility of developing profitable markets for the European oyster, Ostrea edulis. More specifically the objectives were:

1. Determine patterns of oyster supplies in the United States, Canada, and France.

2. Determine patterns of oyster consumption in the United States, Canada, and France and to develop a predictive demand equation for each of these countries.

3. Use the results of objectives one and two to see if opportunities exist to exploit these natural oyster markets by analyzing the significance of trends in oyster landings, imports, and exports and in analyzing the variables that appear to influence oyster consumption in each of these countries.

4. Estimate marketing costs and return to would-be oyster producers in Maine in supplying oysters to the half-shell trades of Boston, Montreal, and Paris.

The half-shell oyster appears to be the most feasible market form for Maine's production. The reasons for this are:

1. Half-shell oysters command premium prices,

2. No further processing, such as shucking, is required by the producer, and

3. With success in the economic cultivation of Ostrea edulis in Maine, the superior appearance and uniform shape of this oyster make it a desirable oyster for the half-shell trade.

One uncertainty does exist. This deals with the acceptance, in North America, of the flavor of Ostrea edulis. However, this species

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Principal Investigator: Wallace C. Dunham, Associate Professor of Agricultural and Resource Economics; Graduate Assistant, Munden M. Bray.

is well accepted in Europe and there appears to be no serious reason why Ostrea edulis would not be accepted here.

Based on an average wholesale price of 9.6 cents per half-shell oyster in Montreal, a margin of 7.2 cents per oyster was found available to cover production costs and profit. It this proves sufficient, the Montreal market can be an economic outlet for some of Maine's production. This, however, will depend on the entrepreneurial ability of Maine producers in developing this market and by providing consistently high quality oysters at competitive prices in the future.

A similar result was found for Boston, where 5.8 cents per half-shell oyster was available to cover production costs and profit.

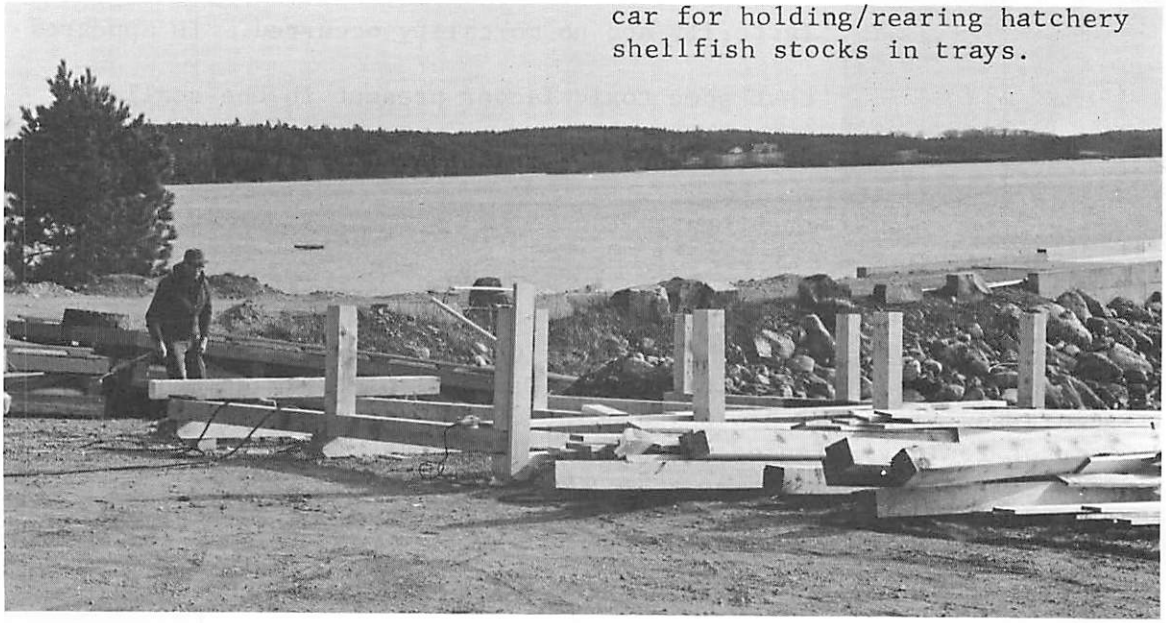
The market in Paris, France, does not appear to be a feasible one for Maine producers at the present time. This is due to a number of factors. Among them are the high cost of air transportation of oysters in the shell, a value added tax, and ad valorem duty on Crassostrea virginica (and Ostrea edulis over forty grams), and the relatively low price received for American oysters in Europe. However, if air cargo rates can be negotiated downwards, or if other forms of transportation such as sea transportation prove economically as well as biologically feasible, the Paris market may offer possibilities for Maine producers. This is particularly true if Maine-raised oysters grade and are priced as high as premium European oysters.

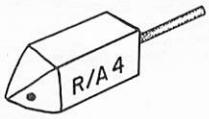
An analysis of oyster supplies in the United States, Canada, and France revealed statistically significant trends only in domestic landings for the United States and Canada. For the United States this production was downward, while for Canada it was upward. Only the trend for the importation of oysters into the United States proved to

be statistically significant. This was in an upward direction. Nevertheless, this increasing trend may have little effect on Maine producers since this increase in importation is composed almost entirely of canned and processed oysters. Maine's production is envisioned to go primarily to the half-shell trade. The exporting of oysters from both the United States and Canada was statistically significant, in a downward direction for both countries. None of the sources of supply for oysters in France indicated any significant trends. However, these results may have been due to the crudeness of the data available.

The only independent variable that appeared to explain the per capita consumption of oysters in both the United States and France was price. For Canada, none of the other independent variables tested proved to be significant. Neither per capita disposable personal income nor the prices of other shellfish appeared to have any effect on the per capita consumption of oysters in any of the three countries. The only data available were for total oyster consumption. If data had been available on half-shell consumption, a different picture might have emerged.

Construction of a modified lobster car for holding/rearing hatchery shellfish stocks in trays.

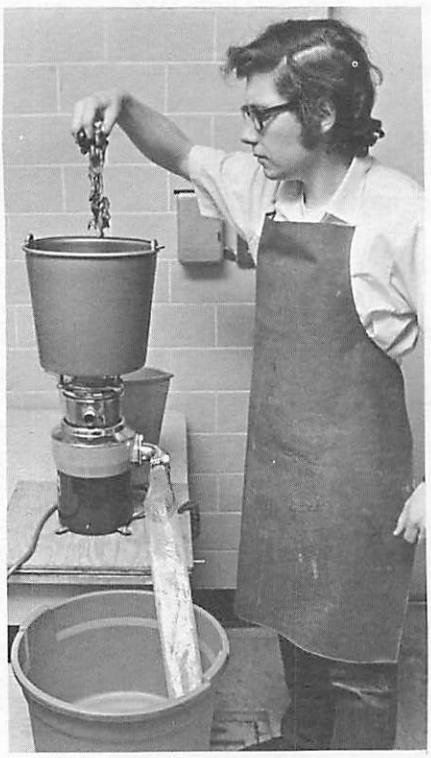





# Animal Food Additives from Maine's Fishery By-products and Under-utilized Species

This Department of Animal and Veterinary Sciences project has two objectives: The production of dry feed ingredient from scallop rims; the determination of the product value.

During the latter part of the first year and early in the second, about 2100 lbs. of raw scallop viscera from three locations were dried at a relatively low temperature (38° ± 1°C) or autoclaved at 15 psi and 108°C and dried. On the basis of its nutrient composition the dehydrated scallop viscera (DSV) showed potential as an ingredient in poultry rations.



Preliminary biological tests with broiler chicks, in which rations containing approximately 9 and 15% of DSV were fed, resulted in low performance and excessive mortality. These could not be explained on the basis of various mineral imbalances or paralytic shellfish poisoning. Chicks fed autoclaved viscera at a 9% level in their diet performed satisfactorily and no mortality occurred. It appeared that some toxic factor present in the scallop viscera could be inactivated by severe heat treatment.

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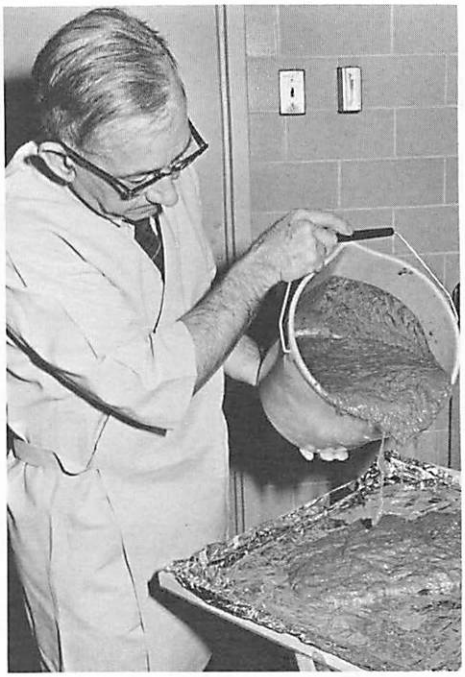
Principal Investigator: Richard W. Gerry, Professor of Poultry Science; Associate Investigators: David C. O'Meara, Associate Professor of Animal Biology and Paul C. Harris, Associate Professor of Poultry Science; Laboratory Technician: Vaughn MacDonald.



The preliminary test with chicks led to the designing of a practical eight-week broiler trial in which duplicate groups of 10 male and 10 female chicks were used per treatment. In addition to a control, the treatment included each of the three dried samples (I, II, and III) and an autoclaved sample number III. Each diet contained a 5% level of DSV. It was felt that with this lower level, the apparent toxic substance present in DSV would possibly not exert adverse effects on chick performance. This was true with all samples of DSV to 5 weeks of age and with sample III autoclaved throughout the eight-week trial. Between 5 and 6 weeks of age, some of the chicks fed dried sample III began to show neurological symptoms (head retractions, paralysis, and eventual death). This was observably the classic symptom of thiamin deficiency; it was postulated that the toxic factor in DSV was a thiaminase (anti-thiamin enzyme) such as had been previously reported as present in several types of raw fish. This hypothesis was supported by the fact that when some of the most severely affected chicks were injected intramuscularly with a relatively large dose of thiamin HCL (10 mg.), recovery was dramatic. The chicks fed dried sample III grew very poorly after 5 weeks of age; most died before the end of the test. Those fed dried sample I and II were not as severely affected but grew more slowly than the controls after 5 weeks and a few showed neurological symptoms.

A second practical 8-week broiler trial was under way at the end of the second year. In this trial, the treatments included a control, a 5% level of autoclaved DSV III, a 2.5% level of DSV III, and levels of 5% DSV III and 4% DSV II with and without added thiamin HCL. Apparently the added thiamin was beneficial, since none of the chicks fed DSV III with added thiamin had shown any neurologic symptoms while all chicks fed DSV III without thiamin added were affected (most died) by the seventh week. Computer calculations with the practical broiler rations indicated that, based on its nutrient composition, DSV competes with soybean oil meal.

A sample of DSV was sent to the Massachusetts State Lobster Hatchery, where Director John T. Hughes attempted to feed it to small lobsters with no success. Apparently some factor present in the DSV made it unacceptable to lobsters.

About 1000 pounds of raw scallop viscera have been obtained for further tests of autoclaving and drying the material under conditions which will preserve the protein but destroy the antithiamin factor.

# The Potential of the Blue Mussel as Food in the United States

In the summer of 1972 the effects of three storage conditions were evaluated on the "shelf life" of sea mussels (Mytilus edulis). Mussels in-shell were held at 32°F with excess ice and good drainage as well as in sea water at 32°F with regular changes of water (three-day intervals), shucked at various time intervals and evaluated for appearance, odor, biochemical changes and associated microbial flora. All samples appeared flaccid or limp on examination between three and six days depending on storage conditions. As judged by mortality (gaping) of less than 4% and no objectionable odor or further change in appearance over that observed at three days, iced mussels were acceptable at 13 days but not at 17 days; mussels held in sea water at 32°F were acceptable at 10 days but not at 13 days; and those held in sea water at 50°F were acceptable at 3 days but not at 6 days. While iced mussels had an off-odor when 30% were dead, the sediment of mussels held in sea water tended to be putrid. Biochemical tests such as pH, total volatile base, trymethylamine, amino nitrogen, tyrosine value, and total carbohydrate or glycogen concentration of tissue homogenate exhibited no trend that could be used to predict quality of stored mussels. Similarly, associated microbiological examination did not indicate the total viable count to be a good indicator of incipient spoilage.

Effect of handling and storage on mussels iced in-shell with

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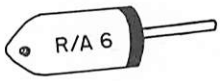
Principal Investigator: John M. Hogan, Professor of Food Science; Associate Investigator; Bohdan M. Slabyj, Assistant Professor of Food Science.

good drainage conditions were examined in the spring of 1973. Harvested mussels were submerged in the sea in burlap bags and wooden containers for 24 hours before being transported to the laboratory where they were iced in trays or in burlap bags. There were no differences in shelf life between handling and storage conditions, although overall acceptability extended to 25 days as compared to 13 days observed in the case of mussels harvested in the summer. Verification is required to ascertain whether this difference is indeed due to seasonal variation. Biochemical and microbiological analyses again proved poor indicators in predicting spoilage.

A trial run with attached mussels was performed in the spring. This experiment consisted of holding the mussels in running sea water for one week to allow their reattachment to untreated boards. Boards and mussels were then removed and packed in ice without disturbing the byssal threads. These mussels were examined for mortality as well as appearance and odor when shucked. Although they tended to be less hydrated as compared to mussels that were not reattached, there was a significant number of individuals that were putrid by the 20th day. This storage difference of 20 versus 25 days between mussels that were reattached versus those that were not is probably due not to the phenomenon of reattachment, but rather to different microbial flora.

Preliminary taste panel evaluation of blue mussels packed in ice indicates that this shellfish remains acceptable for a period of at least 11 days. Biochemical analyses of mussel liquor appear promising indicators of quality.




Design of Submersible Rafts for Aquaculture;
Systems Analysis of Hatchery Procedures

In concept, submersible rafting can overcome three problems associated with large surface rafts: Winter ice, interference with navigation, and visual pollution, particularly in Maine estuaries. If the ability to control depth and attitude is added to the concept, the species being cultured can be presented with an available natural food supply.

At the beginning of the year, a prototype submersible raft was readied for field-testing. The design reflected the need for a low center of gravity for submerging, surfacing, and on-bottom stability. An air tube leading from the surface to the raft's flotation chamber made it possible to retrieve the device by filling the air chamber from a SCUBA tank at the surface.

The design did not deal with the economics of submersed raft culture; the prototype's objective was to test the design concept and to provide hydrodynamic and biological data from which to arrive at a commercially acceptable model.

In the early summer of 1972, oyster containers were suspended from the four steel angle irons. McNichol plastic trays

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Principal Investigator: Walter L. Schneider, Associate Professor of Mechanical Engineering; Graduate Assistant: Roger H. Morin.

and aluminized-steel trays were filled with hatchery produced yearling American and European oysters. Placed in 15 feet of water in the lower Damariscotta River, the model was checked at several intervals by SCUBA and by two surface retrievals. The raft stayed in place in currents approaching one knot; survival and growth of both species of oysters were equivalent to rates on conventional rafts used as controls; the flexibility of the McNichol trays was the apparent cause of oyster loss; there were negligible losses from the aluminized-steel trays; fouling and consequent lowering of circulation were less for the steel trays.

The performance data from the prototype has led to a more advanced production model. Using waterbeds for buoyancy, as well as for control, the raft will support 32 steel trays; it can be positioned at any point in the water column by operation of two lines from a small boat; retrieval of the two lines by SCUBA permits repositioning; SCUBA relocation of the raft guys allows a 90-degree change in attitude toward the current, a feature giving all the oysters an equal chance at the in-current food. A Maine fisherman could tend a series of these rafts from a lobster boat by recovery of the anchor-control lines using a grapnel or by continuous attachment to one of his nearby lobster traps.

Understanding of the potential for individual enterprise using submersible rafts for the culture of oysters has been advanced by the experience gained on this project. Findings from this and related market and biological studies make it possible to formulate reasonable assumptions and to estimate returns

possible from investment in raft equipment for culturing oysters under Maine coast conditions.

Recent history has shown prices for half-shell oysters ranging between $20 and $30 per bushel.

A submersible raft, fabricated to tested designs with a capacity to grow 64 bushels of oysters and supplied from a hatchery with juvenile oysters, can be put in place for a capital investment of about $1600. By practicing "scrounge" economics, imaginative persons with an eye for salvageable materials may be able to put equal capacity rafts in place for $800 each.

By assuming various survival rates, a three-season growing cycle, upper and lower levels of typical prices, and raft operating costs of $900, calculation of estimated annual rates of return on capital is possible (Table 1).

Table 1. Estimated Annual Rates of Return on Capital from Raft Culture of Oysters. Parentheses denote losses.

| Survival Rate | Surviving Crop | Approximate Annual Rates of Return on Capital, % | | | |
|---|---|---|---|---|---|
| | | $800/raft | | $1600/raft | |
| Percent | Bushels | $20/bu. | $30/bu. | $20/bu. | $30/bu. |
| 100 | 64.0 | 15.8 | 42.5 | 7.9 | 21.2 |
| 80 | 51.2 | 5.2 | 26.5 | 2.6 | 13.2 |
| 60 | 38.4 | ( 9.7) | 10.5 | ( 4.8) | 5.2 |
| 40 | 25.6 | (16.2) | ( 5.5) | ( 8.1) | ( 2.8) |
| 20 | 12.8 | (26.8) | (21.5) | (13.4) | (10.8) |

Hatchery Culture Apparatus

The conventional hatchery technique of placing new cultchless oysters in closed-system flowing-water screened boxes causes some difficulty by windrowing the spat. In concept, apparatus designed to agitate the new spat would overcome some of the smothering and starvation loss and encourage the spat toward more active feeding.

A pilot-model agitator (Fig. 4) was constructed to test this notion. An overhead flow of water into alternate chambers causes a rocking motion. The rocking rate can be regulated by the pumping rate of the closed-system water.

A thousand new cultchless European oysters were placed in the device during the spring of 1973 and held for two months at 18-20°C with a daily water change and daily feeding of Isochrysis galbana.

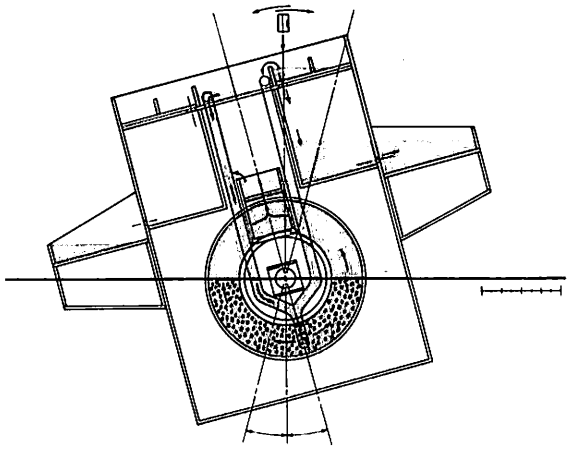

FIGURE 4

In both survival percentage and growth rate the experimental oysters exceeded the control groups confined by conventional screening. The results have to be considered as preliminary, but they do justify expansion to larger-scale controlled pilot-production in later research.

## Cytogenetics of Marine Species

The work on this project has been divided into several areas, with emphasis on karyotypic analysis. Major attention has been given to the following studies: (1) Chromosome description of two scallop species, Aequipecten irradians and Placopecten magellanicus; (2) Seasonal pattern of gonad maturation in Placopecten magellanicus; (3) Chromosome study of an Atlantic salmon cell line; (4) Chromosome study of the blue mussel, Mytilus edulis; (5) Electrophoretic study of isozyme markers of Mytilus edulis, and the oyster species, Ostrea edulis and Crassostrea virginica. Results from each of these studies are summarized below:

(1) The karyotypic analysis of the scallop species was done with dividing cells from adult gonadal tissue. Specimens were exposed to colchincine before sacrifice. Gonadal tissue was removed, slides were stained in aceto-orcein and squashed under #1 coverslips. A total of 260 counts were obtained from 18 specimens of A. irradians, including both meiotic and mitotic cells. The diploid complement proved to consist of 32 single-armed chromosomes.

P. magellanicus was handled in the same manner, and a total of 271 counts from 21 specimens were used in the analysis. This diploid complement consists of 38 chromosomes made up of 16

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Principal Investigator: Franklin L. Roberts, Associate Professor of Zoology; Graduate Assistants: Patricia Albert and Frank Willard; Laboratory Technician, Francine Kaiser.

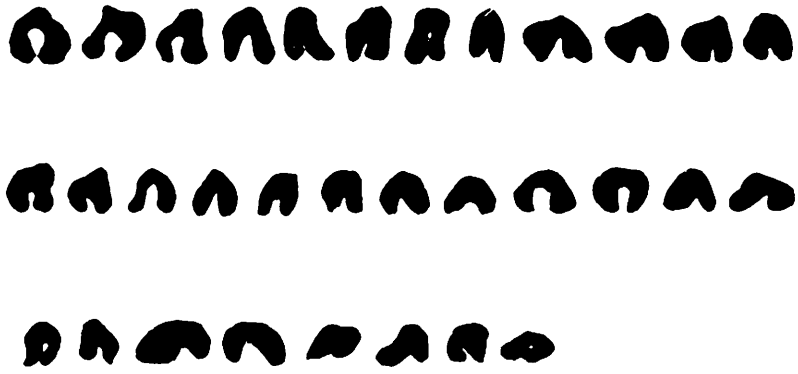


Figure 5. Karyotype of Aequipecten irradians.

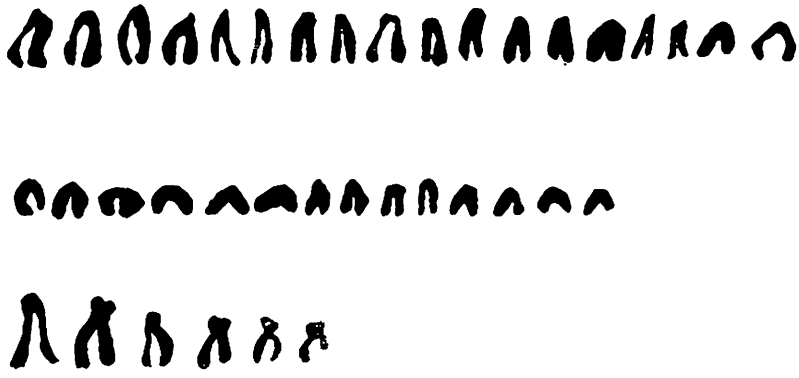


Figure 6. Karyotype of Placopecten magellanicus.

pairs of single-armed chromosomes, and 3 pairs of two-armed chromosomes. Karyotypes from these species are shown in Figures 5 and 6. The karyotypes of the two species are very different, a situation in marked contrast to other pelecypod families, as the Ostreidae, where infrafamily variation has not been noted. A manuscript reporting this work has been prepared and submitted for publication.

(2) Data on the seasonal reproductive patterns in P. magellanicus were collected from a group of 60 scallops maintained in the aquaculture laboratory and also from a field population, in order to determine if any differences existed between the two groups. The field population was located in the Damariscotta River near the intake source for the laboratory sea water system. This arrangement insured that both populations were exposed to similar changes in salinity, temperature, and food supply. At one month intervals, gonad maturation was assessed macroscopically, histologically (sections) and cytologically (tissue squashes). As of this time, the results are still being analyzed; the most striking apparent effects were for the laboratory population to spawn earlier and to spawn incompletely. Furthermore, the wild population showed greater gamete production. This investigation is being continued because of its obvious implications for aquaculture, and is scheduled for completion by September 1973.

(3) The Atlantic salmon chromosome study is the only part of the project not directly involved with shellfish, and has been primarily a completion of research that has been underway in our laboratory for several years. Over the past year, this work has been a karyotypic analysis of a cell line isolated from a specimen from the Craig Brook National Fish Hatchery. The objective was to gain more insight into Robertsonian centric fusion patterns, i.e., the union of two one-armed chromosomes into single two-armed chromosomes through reciprocal translocations. This change appears to occur commonly in salmonid fishes, and has the effect of regularly altering salmonid karyotypes at the intraspecific level. Data gathered from the cell line indicated such a centric fusion pattern, suggesting that comparable mechanisms are acting both in vitro and in vivo. Karyotypic data have been collected from more than 500 cells of the cell line, and the data are being analyzed in several ways. In conjunction with this study, limited success has been obtained in inducing chromosome banding that would make it possible to identify individual chromosomes and arms.

(4) The chromosome study of the blue mussel, Mytilus edulis, was initiated during the latter part of the grant period. Best karyotypic results have been obtained from embryos, and because of this a spawning program has been started. To date, all specimens have shown a diploid number of 28, but with apparent variation in chromosome morphology. In view of reports of extensive polymorphism in this species on the West coast, future efforts will be devoted to comparing Maine karyotypes with those elsewhere. The existence of this intraspecific chromosomal variation pro-

vides a potentially useful tool for separation of populations, and for the study of natural selection. Consequently, samples from different locations, including different parts of the tidal zone, are presently being analyzed.

(5) The last area of research during the grant period has been the electrophoretic study of isozyme markers in Mytilus edulis, along with some very preliminary work on two oyster species, Ostrea edulis and Crassostrea virginica. This work was undertaken at the end of the grant period, and subsequently is making up a major portion of our research effort. With Mytilus in particular, these genetic studies are aimed at elucidating the mechanisms by which the species responds to environmental variations within its range. Evidence suggests (Koehn and Mitton, 1972) that knowledge of these mechanisms might be used as a basis for genetic selection of species amenable to aquaculture in Maine.

The isozyme analysis has been carried out in conjunction with the chromosome studies on Mytilus. To date, the electrophoretic work has been largely concerned with the selection of tissues, buffers, and enzyme systems which will yield repeatable results with adequate polymorphism to establish population identities and allelic patterns.

Techniques from several laboratories have been combined in the analysis of three tissues (gill, mantle, and digestive gland). Several enzymes have been run, four of which have yielded constant reliable results. Of these four, malate dehydrogenase (MDH) and glutamate oxalate transaminase (GOT) have shown homogeneity, i.e., allelic fixation, both within and between populations that

have been sampled. These populations have been from Bar Harbor, Walpole, and York, Maine, separated respectively by approximately 75 nautical miles.

Leucine amino peptidase (LAP) has been found to be polymorphic for at least two alleles in the Bar Harbor population. Preliminary data indicate comparable polymorphism, but with quite different allelic frequencies, in the Walpole population. Furthermore, a comparison of a small population growing on the underside of a dock at Walpole with one on nearby tidal rocks has shown a much higher degree of genetic variability for the dock population. A typical zymogram with both populations represented is shown in Figure 7. The fourth enzyme, phosphoglucose isomerase (PGI) has been studied so far only in the Bar Harbor population, but preliminary results indicate that several alleles are present. Investigation of all these enzymes is continuing, and a population from Eastport, Maine has been added to those which are being sampled. In addition, the chromosome investigation is providing larvae from individual crosses under hatchery conditions, and these larvae are being used to trace the pattern of inheritance of these loci.

Publications:

O'Brien and Roberts. A chromosome study of two species of scallop, Aequipecten irradians and Placopecten magellanicus. Manuscript submitted for publication.

Literature cited:

Koehn, Richard K., and Jeffry B. Mitton. 1972. Population genetics of marine Pelecypods. I. Ecological heterogeneity and evolutionary strategy at an enzyme locus. Amer. Nat. 106(947): 47-56.

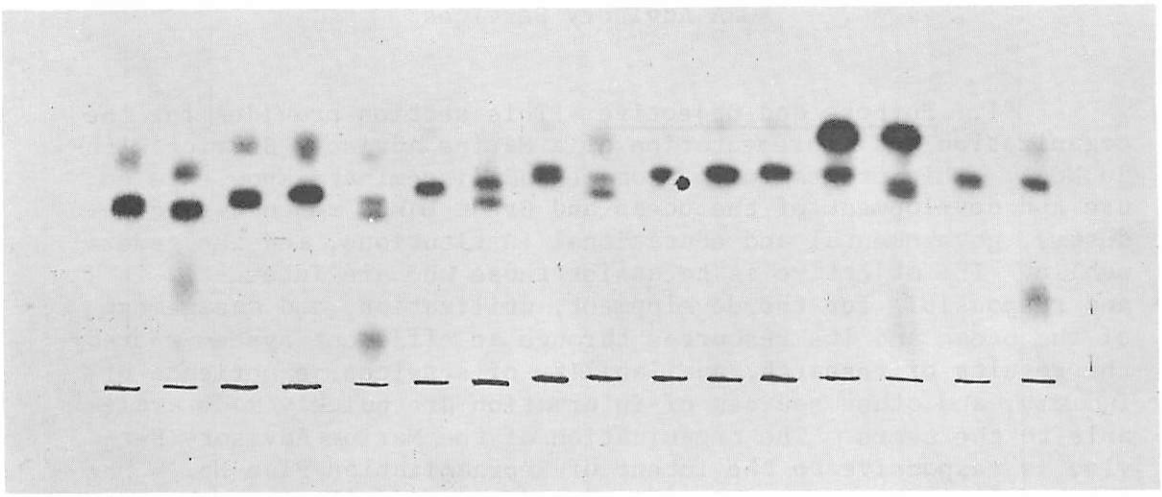


Figure 7. Leucine amino peptidase (LAP) zymogram for Mytilus edulis from Walpole, Maine showing several genetic variants.

Murray Hall at the University of Maine at Orono houses the Department of Zoology

NOAA Advisory Services

"1. Purpose and Objective - This section provides for the organization and implementation of a Marine Advisory Service within NOAA. This program will promote and disseminate knowledge on use and development of the ocean and Great Lakes resources to industry, governmental and educational institutions, and the general public. The objective is to assist those who are interested in and responsible for the development, utilization, and management of the ocean and its resources through an efficient system whereby the results of research, availability of services, experience of industry, and other sources of information are quickly made available to the users. The organization of the Marine Advisory Service is responsive to the intent of Reorganization Plan No. 4 which established NOAA and it is based additionally upon the authorities of Public Laws 89-688 and 88-309 which among other things concern advisory services in Sea Grant and Fishery programs respectively.

"2. Scope - The subject matter involved in the Marine Advisory Service includes the full range of information required by ocean activities and includes, in addition to technical information, social, legal, and economic aspects. Examples of principal subjects of strong current interest include recreation, environmental quality and pollution control, environmental monitoring and forecasting, living and non-living resources, transportation, coastal zone management, and other activities in research, education, and government. The subject areas of concern include those for which NOAA and Sea Grant programs are responsible and extends also to responsibilities of other Federal agencies where their missions can be facilitated by cooperation in the Marine Advisory Program.

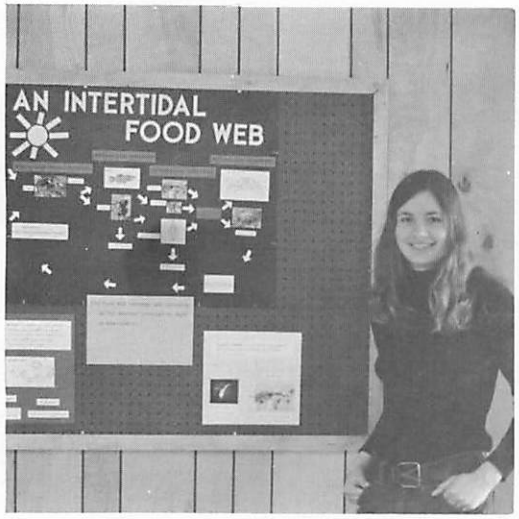
"3. Organizational Structure and Responsibilities - The NOAA Marine Advisory Service is to be organized on the premise that States working via Sea Grant or other programs will provide a means of coordinating marine advisory services on a local basis. The primary interface between the advisory program and the public will be carried out at the local level by State or Sea Grant organizations. NOAA, in cooperation with other Federal agencies, will work through and support the local organizations and at the same time assume the basic responsibility for the continuity, completeness, and overall success of the advisory program."

## Marine Advisory Services

Marine extension activities were initiated November 1, 1972. A marine specialist position was created within the University of Maine Cooperative Extension Service to be part of the National Oceanic and Atmospheric Administration (NOAA) Marine Advisory Service. The NOAA Directives Manual (Chapter 16, Section 15) describes the Marine Advisory Service (see page 38).

The five objectives of this project provide the framework for the following narrative. Our first objective was "to educate the public about the marine environment and the proper utilization of its resources." The Cooperative Extension Service has arranged lectures, seminars, exhibits, work sessions, and other educational experiences for students, town selectmen, and the general public throughout the state.

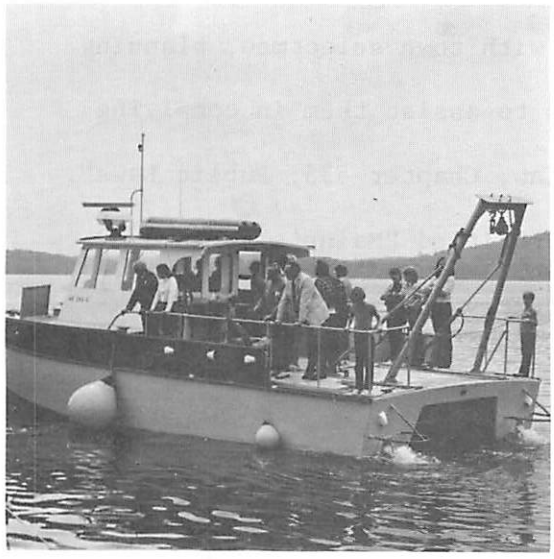
Coordinator: Paul D. Ring, Marine Specialist; Secretarial Staff: Kathi Brown, Patricia Higgins, Avis Ingalls, Joy Winters; Student Volunteer: Mary Elizabeth Mitchell.




Self-guided educational experiences were planned and implemented at the Ira C. Darling Center, the University of Maine's marine laboratory. This system enables any visitor to observe marine research and development in operation from 9:00 a.m. to 4:00 p.m. Monday through Friday throughout the year.

The faculty and staff of the Ira C. Darling Center held an open house on September 9 and 10, 1972. Approximately 1000 citizens visited the marine laboratory to view marine research in action. After the official opening of the new Aquaculture Building by Maine Sea & Shore Fisheries Commissioner Spencer Apollonio, the Sea Grant aquaculture program was a major attraction.

Extension personnel have assisted in the development of marine education programs in public and private schools. To this end we have gone into the schools to talk about marine resources and ways the students can study the marine environment in the classroom or in the field.



Two portable instructional modules were designed and constructed. One module (2' x 2' x 6') is for printed information display, the second (2' x 4' x 6') contains a built-in slide show. These modules were designed for use at town meetings, county fairs, workshops, and schools. Topics displayed include information on shoreland zoning, boating, marine trades, aquaculture, marine education, and marine research.

A layman-oriented summer workshop series entitled "The Damariscotta River: An Estuarine Environment" is planned for July and August. The objective of this series is "to enlighten those living, walking, or sailing alongshore". Workshop topics include: cultural history, coastal planning, marine plants, marine law, geology, ecology, aesthetics, sea farming, hydrography, and finfish. Instructors for this year's workshops will be from the Maine State Department of Parks and Recreation, Maine State Planning Office, University of Maine Department of Oceanography, University of Maine Cooperative Extension Service, and a private law consultant.

Work sessions have been held with town selectmen, planning boards, and conservation commissions to assist them in complying with the State's "Shoreland Zoning Law, Chapter 535, Public Laws".

A workshop was held in March entitled "Maine's Fresh and Salt Water Pleasure Boat Service Industry Boating Business Workshop". The workshop was jointly sponsored by the Maine Boat

Builders and Repairers Association, Maine Marine Trades Association, and the University of Maine Cooperative Extension Service. Topics discussed were: accounting, financing, insurance, the Occupational Safety and Health Act, planned Socio-economic research on the boating trades, operations of the Maine Department of Transportation Bureau of Waterways, service shop management, fiberglass repairs, store management, effective advertising, safety standards, operations of the Maine Department of Environmental Protection, a new excise tax for boats and motors, and new boating laws. Another workshop is planned for October 29, 1973. We shall be sponsoring two workshops each year thereafter. The objectives of these workshops are: 1) to increase communication within the pleasure boat service industry in Maine; 2) to share common problems and practices in discussions with knowledgeable professionals; 3) to initiate, discuss, and formulate positions on new boating legislation for the betterment of the industry in Maine; and 4) to help produce a well coordinated environment for boating in Maine.

Our second objective was "to provide efficient information exchange between all agencies". Extension activities have included clearing house activities for public information contributed by all marine agencies and businesses. This includes interaction with more than forty public and private agencies and businesses.

Extension efforts to catalyze commercial aquaculture in Maine have been well received. Seven commercial enterprises have begun and are expanding their production capability. Raft at right is being rigged with manila line for rope-culture of mussels.

The Extension Service, State Office of Economic Opportunity, and Fisheries Development Corporation sponsored a work session for state Community Action Program directors on the potential for aquaculture in Maine and technical training needs. Group is in Aquaculture Building, comparing European and American brood stock.

Extension and library professionals from Sea Grant and Land Grant programs throughout New England have met to discuss retrieval systems for handling marine resource information. We have planned the distribution of a composite list of serials and journals to assist information transfer. The Marine Resource Information Center (MARIC) bulletin will update the list periodically.

The Extension Service has been working with state and federal agencies, other academic institutions, marine industry representatives, and interested citizens on plans for the formation of a marine information center. The idea for such a center came from the recommendations of the Communications Task Force. This task force was formed by participants at the Renewable Marine Resources Development Conference held May 2 and 3, 1972. We are assisting in the preparation of a project proposal.

Objective number three was "to provide the researcher with ideas for applied research projects and transmit useful information to the marine community".

Extension personnel have worked with more than sixteen University of Maine departments and offices, the National Marine Fisheries Service, Maine Department of Sea and Shore Fisheries, Maine Department of Transportation Bureau of Waterways and Boat Registration and Safety, State Planning Office, New England Regional Commission, and several other state and federal agencies. Private groups worked with include: The Fisheries Development Corporation, Ocean Research Corporation, Maine Bait Company, Maine Marine Trades Association, Samoset Algae Company, Maine Boat Builders and Repairers Association, Town of Bristol Selectmen and

citizens, and numerous other community groups. The exchange of information or recognition of a need for information on marine resources generated in working with the above groups has led to several project proposals. Person-to-person contact is emphasized to insure quick and accurate information transfer.

Objective four was "to work with the Fisheries Extension Service of the Maine Department of Sea and Shore Fisheries to improve the total marine education and information effort".

Extension professionals from the Cooperative Extension Service and Fisheries Extension Service have met on many occasions to discuss problems in youth and adult education, publications, assistance to fishermen's cooperatives, public relations, presenting research information to the public, communications systems, and the like. The possibility of a common format for our Sea Grant publications was discussed, and under consideration is a joint proposal for work in marine education. We have given joint talks on marine resources to interested groups.

The fifth objective was to "report current information, existing potentials, and recent developments in marine resources through publications and news releases".

Three information leaflets were published: "Marine Research and Development Projects being Conducted at the University of Maine", "Marine Related Films Available from the University of Maine Film Rental Library", and "Problems in Marine Science I. Ocean Currents". One bulletin was published on "Maine's Fresh and Salt Water Pleasure Boat Service Industry Boating Business Workshop", along with other reports and news releases written on marine research and resource utilization.

The New England NOAA Marine Advisory Service programs, including Rhode Island, Massachusetts, New Hampshire, and Maine, feel that a formal regional coordinating mechanism would be of great value. The coordinators of each program have met on several occasions and are in the process of drafting by-laws for a regional association.

National coordination of our marine extension efforts is enhanced by participation in the Marine Advisory Service Committee of the Association of Sea Grant Institutions.

The Marine Advisory Service program has three primary goals for 1973-1974, represented by a project each in extension programs, in public education, and in publications.

1. To catalyze commercial aquaculture enterprises in Maine by bringing the state-of-the-art to the potential aquaculturist and helping him get established in aquaculture.

2. To develop an integrated program in public education about Maine's marine environment and the alternatives available for the utilization of its resources; provide a medium of exchange between researcher and consumer.

3. To prepare information leaflets, bulletins, and technical reports on recent and potential developments in the utilization of Maine's renewable and non-renewable resources for distribution to the public.

COHERENT PROJECT SEA GRANT PROGRAM

-- Budget Summary --

| Project Number | University Department | Sea Grant Support | University Contribution | Total |
|---|---|---|---|---|
| R/A-1 | Oceanography | $ 90,301 | $45,576 | $135,877 |
| R/A-2 | Agricultural Engineering | 16,220 | 8,206 | 24,426 |
| R/A-3 | Agricultural and Resource Economics | 5,651 | 6,846 | 12,497 |
| R/A-4 | Animal and Veterinary Sciences | 8,873 | 13,679 | 22,552 |
| R/A-5 | Food Science | 6,798 | 8,011 | 14,809 |
| R/A-6 | Mechanical Engineering | 9,792 | 7,335 | 17,127 |
| R/A-7 | Zoology | 12,365 | 10,342 | 22,707 |
| A/A-1 | Cooperative Extension Service | 20,970 | -- | 20,970 |
| | TOTAL | $170,970 | $99,995 | $270,965 |

All projects budgeted for the full year ended April 30, 1973 with the exception of A/A-1, Marine Advisory Services, activated November 1, 1972 with funds reserved from the previous year.

## INTERACTION

FEDERAL

USDA: Soil Conservation Service; Div. of Consumer Protection
U.S. Dept. of Commerce: National Marine Fisheries Service

REGIONAL

New England Regional Commission
New England Marine Resources Information Program

STATE

State Planning Office
Department of Sea & Shore Fisheries
Office of Economic Opportunity
Dept. of Education & Cultural Services
  Div. of Library Dev. Service
  Div. of Educational Service
  Bureau of Vocational Education
Department of Environmental Protection
Legislative Commission on Marine Resources
Department of Parks & Recreation
Department of Commerce & Industry
Dept. of Transportation
  Bureau of Waterways
Bureau of Watercraft Registration & Safety
Pine Tree Legal Assistance
Coastal Economic Development Corporation

INSTITUTIONS

Maine Maritime Academy
University of New Hampshire
Southern Maine Vocational Technical Institute

INDUSTRY

Abandoned Farm, Inc.
Ocean Research Corporation
Maine Coast Oyster Corporation
Tern Rock Ocean Products, Inc.
Acadia Aquacultural Enterprises, Inc.
Maine Marine Trades Association
Fisheries Development Corporation
Central Maine Power Company
Maine Sea Farms (Callahan Mines)
Reachwood, Inc.
Reed and D'Andrea
Somerset Sea Products
Maine Boat Builders & Repairers Association

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Blamberg, D.L., D.C. O'Meara, R.W. Gerry, P.C. Harris and T.A. Bryan. 1973. Preliminary Observations Concerning the Nutritive Value of Dehydrated Scallop Viscera as a Component of Poultry Rations. Life Sciences & Agriculture Experiment Station, University of Maine.

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SITE OF FIELD STUDIES OF SURVIVAL AND REPRODUCTION OF EUROPEAN OYSTERS (Ostrea edulis) INTRODUCED TO MAINE WATERS IN LATE 1940's. SEE TEXT FOR FURTHER DESCRIPTION OF RESEARCH ON THIS AND OTHER SPECIES.

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SCUBA DIVER SUITING UP TO RECOVER OYSTERS FOR HATCHERY STOCK AND TO OBTAIN CULTCH FOR LABORATORY ANALYSIS.

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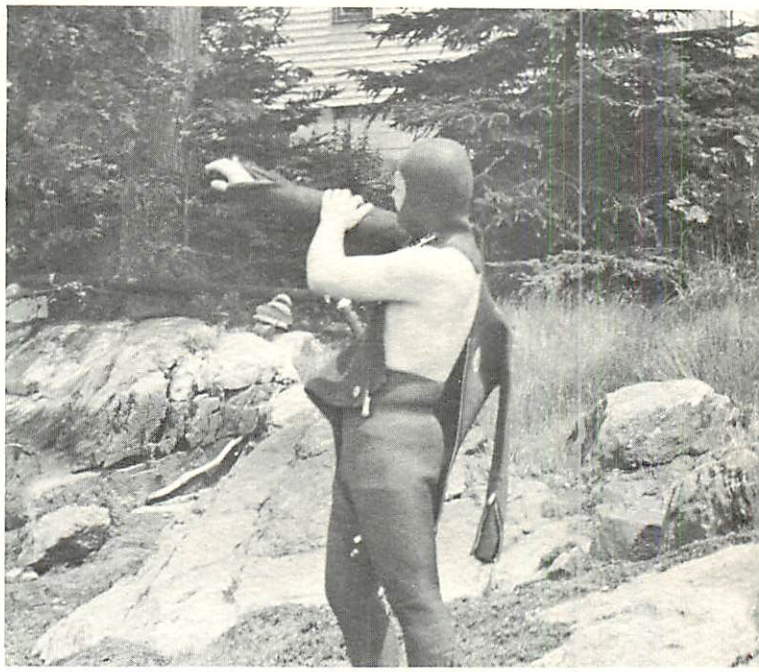
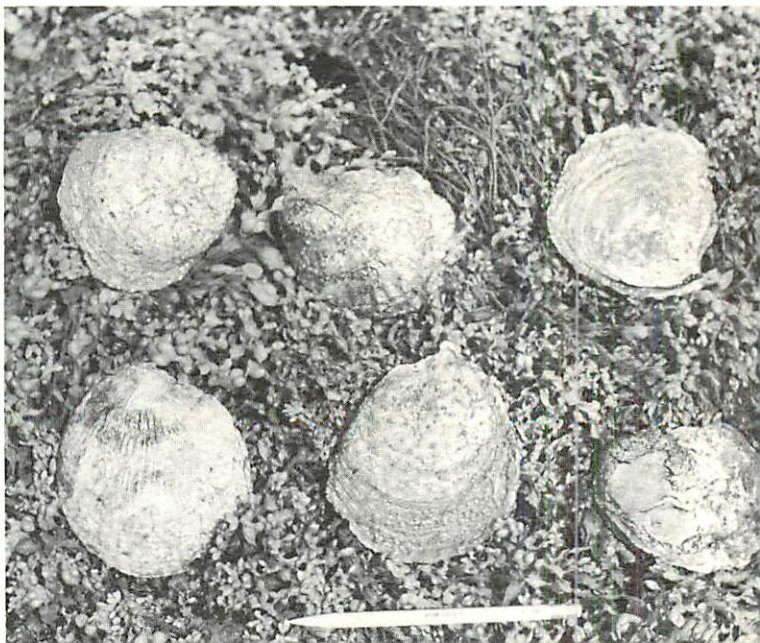


DIVERS REPLACE SUBMERGED MARKER BUOYS AT THE TEST SITE AND GATHER OYSTERS SAMPLES. SEE TEXT, p. 8 AND Fig. 1, p. 9.

←



EUROPEAN OYSTERS FROM MAINE WATERS -- SUBJECT OF SEA GRANT SUPPORTED RESEARCH BY UNIVERSITY OF MAINE AND MAINE DEPARTMENT OF MARINE RESOURCES TO INCREASE PRODUCTION OF FOOD FROM THE SEA.

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