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Final Report

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"Increasing Income Through New Technology Development for Sea Urchin Fishermen"

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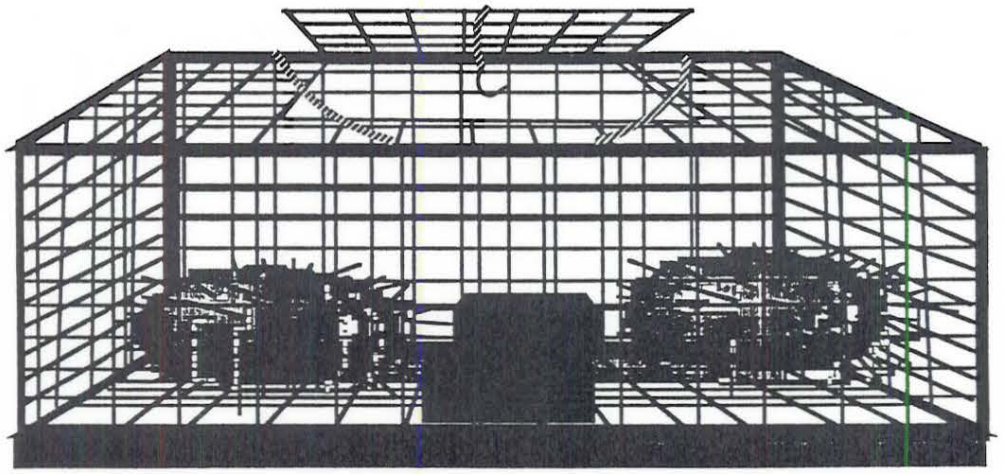


I. Summary

The sea urchin industry in Maine and Massachusetts experienced a dramatic period of growth in the late 1980's and early 1990's that raised concerns about its long term sustainability. In order to increase the value of the catch to the fishermen and minimize the effects of harvesting on the sea urchin habitat we undertook a study with the primary objectives of developing an economical method of trapping and holding urchins for enhancement of their roe. This study developed an in-sea caging and roe enhancement system that can be used by fishermen to increase the value of their catch and control its delivery to market so as to take better advantage of price fluctuations. The feasibility of this system was demonstrated in a field trial in which the roe content of urchins maintained in cages in the field were more than doubled (from less than 6% to more than 12% on average) in two months when fed either their natural food, *Laminaria*, or a processed feed consisting of soymeal, fishmeal and molasses. The urchins fed on either diet had a high commercial quality roe (or uni) in content, color and taste. In addition, this study tested two designs for trapping urchins and found them both to be very unproductive in the field. It also provided valuable new information on the timing of spawning, recruitment, and gonadal tissue development in sea urchin populations of Massachusetts. This information should help the managers of the industry in this state make the necessary decisions to insure a sustainable fishery.

II. Introduction

This Report summarizes the findings of an 18 month long FIG grant aimed at helping sea urchin fishermen in the New England region. At the time the grant was applied for, the sea urchin industry in New England had just gone through a dramatic period of growth. Fishermen were harvesting urchins either by diving or dragging and having to sell them immediately to processors. Having a method for holding urchins and to potentially increase their roe content would give fishermen a considerable benefit in determining the market price of their catch. Our grant was aimed at developing such a method. In addition, because there were reports from divers of extensive damage caused by dragging for urchins, we investigated the potential of trapping as an alternative, non-destructive method of harvesting urchins.

III. Purpose

A. The Problem

As the more traditional fisheries have diminished over the past ten to twenty years, fishermen of the New England region have turned increasingly to alternative species to supplement their income. One species which has become increasingly attractive to fishermen is the green sea urchin *Strongylocentrotus drobachiensis*. This urchin is commercially harvested for its ripe gonads, or roe. Sea urchin roe (or "uni") is a delicacy for the Japanese, who purchase as much as $1.6 billion dollars worth annually and pay as much as $120 per pound. Urchin harvesting began in northern New England and eastern Canada in the 1980's. However, it wasn't until the early 1990's that the demand for uni dramatically increased and the industry really took off. In 1992, for example, the urchin harvest in Maine was over 22.5 million pounds, worth

approximately $12.6 million dollars. It increased to 41.1 million pounds worth $26.5 million dollars in 1993, which was the peak harvest. In 1994 and subsequent years, the size of the harvest has shown a decline. Although the size of the fishery in Massachusetts has always been much smaller than that in Maine and harvest records are not as complete, the story appears to be the similar to that for Maine with a gradual increase in harvest size to 1994 - 1995.

Initially, sea urchin harvesting was carried out by scuba divers. However, in the late 1980's and early 1990's dragging became increasing popular. At the time of this study, most of the sea urchin catch in Maine and nearly all of it in Massachusetts was coming from dragging. For most of the draggers, dragging for urchins was something the fishermen did during the off season when they weren't fishing for lobster or another resource. As dragging for urchins has increased, concerns have increased about the amount of damage being done to bottom communities where urchins are being harvested. Anecdotal observations by a number of divers suggested that dragging for urchins was being very destructive to urchin habitats and could be having a detrimental impact on juvenile lobsters and flounder nurseries.

Thus, the urchin industry in the early 1990's was experiencing a number of problems typical of a fast-growing resource that is harvested essentially by hunting-gathering techniques and for which there is no ability to hold the catch or improve its quality. Since roe price is connected to Japanese holidays, being able to hold urchins and increase their roe content for a Japanese holiday would create greater price control for the fishermen. In addition, at the time of this study, there was great concern over whether the resource was being overharvested and urchin dragging was causing damage to other fisheries.

B. Objectives

Our FIG project was designed to address the multiple issues described above. The general goals of the project were to develop an economical method of trapping and holding urchins in order to insure the long term sustainability of the fishery and maximize its economic value to fishermen. We believed that by practicing a simple form of aquaculture, fishermen could greatly enhance the value of their catch and thereby smooth out of the gluts and shortages in the flow of urchins to market that currently exist. More specifically, this project examined the feasibility of holding urchins in cages in the sea and feeding them for a month or two prior to the most important Japanese holidays to enhance their roe content and value. If such a cage system could provide roe enhancement at low cost and little capital, we felt it could be beneficial to fishermen. In addition, in order to minimize the potential damage caused to sea urchin habitats by dragging, we wanted to test an alternative harvesting method, sea urchin trapping. Trapping and caging would together improve and stabilize the sea urchin industry for fishermen at a crucial time in its growth.

In order to accomplish these goals, we had seven specific objectives which are described below. After the grant began, we added an eighth objective at the encouragement of the Massachusetts Division of Marine Fisheries to provide valuable fishery management information on sea urchin populations in Massachusetts. Despite the size and value of the sea urchin industry in Massachusetts, very little was known about the abundance, size class composition, and spawning of sea urchin populations in this state. Such information is crucial for making appropriate regulatory decisions concerning the fishery.

C. Specific Objectives

1. To design and test an efficient sea urchin trap,
2. To develop an economical sea urchin bait for trapping,
3. To design an in-sea cage system for holding and enhancing lower-value urchins,
4. To develop an economical urchin feed for maximizing the gonadal development and market value of caged urchins,
5. To develop a simple, non-destructive test for measuring urchin gonadal development for use by both fishermen and processors,
6. To conduct underwater studies for evaluating the effects of dragging on sea urchin habitats,
7. To develop a program for educating urchin divers, draggers, and processors on how to adapt the technical advances developed by this project, and
8). To conduct quarterly field studies of harvested and unharvested populations to determine their urchin quantity, size distribution and % gonadal content.

IV. Approach

A. Work performed

1). Development and testing of a sea urchin trap.

Two types of sea urchin traps were made and tested. The first trap was designed and built by Joe Sinagra and consisted of half of a slime eel barrel cut lengthwise, with 1" wire mesh for a bottom. The trap was 10" x 40" x 24" in size. One end consisted of a latched door of 1' mesh with a 6" x 19' opening for urchins to crawl through and bent wire barbs to prevent them exiting. The second trap was designed by Dick Winchester and built by Winchester Fishing Co. of Gloucester. It looked basically like a lobster trap (48" long x 27" wide x 12 " high) made of 1' wire mesh, except that it had four 7.5" x 9" openings made of wire hoops with string bridges into the cage. Both traps were first tested in a large seawater tank at the Marine Science Center (MSC) in which their ability to attract and "trap" urchins could be observed using a video camera. Later their ability to attract and trap urchins in the field was tested at one of our monitoring sites near the MSC, Dive Beach, which had an abundance of urchins.

2). Development and testing of a sea urchin bait for use with trapping.

During the trapping experiments conducted in the MSC seawater tank, we used the sea urchin's natural food, *Laminaria* or kelp, as bait, which appeared to work well. However, in the field experiment conducted at Dive Beach, we tested not only *Laminaria* but also several of the artificial, processed feeds that we were also testing in our caging experiments (see below). The processed feeds were prepared for us in a wide ribbon form. These ribbons and the *Laminaria* were stuffed into 2' long, 7.5 mm mesh bags that were attached to the inside of each trap.

3). Development and testing of cages for holding sea urchins.

We conducted several in-sea caging experiments to determine their feasibility. The cages we used for these trials basically resembled a lobster trap except that they had a door in the top and no side openings. The cages were made of 0.5" wire mesh and were 36" long x 24" wide x 8" high (Figure 1). They had two bricks inside to weight them down and 1" thick wooden runners lengthwise along their bottom to keep them up off the bottom substrate. They were built by Winchester Fishing Co. of Gloucester at a cost of $39 each. For most of our caging experiments, we put 100 legal-sized urchins into each cage, and tied three cages together to form a trawl, with floats at both ends. The cages were stuffed with enough feed to provide the urchins a rate of 1 g of feed per urchin per day for 10 days. Cages were supposed to be checked and feed replaced every 7-10 days. Only one feed was tested per cage but three cages (or replicates) were tested per feed. The feeds used in our caging experiments are described below. Most of our in-sea experiments were conducted at a site outside of Gloucester Harbor in approximately 25-30' depth. This site had a sandy/rocky bottom and was somewhat protected from wave action and storms.

4). Development and testing of an economical sea urchin feed.

In general, we wanted to develop a processed feed that fishermen could use as an alternative to the urchin's natural food, *Laminaria*, which would be both durable in the field and easy to store. We started by testing a variety of processed feeds first in laboratory feeding trials and then in field trials. Our laboratory feeding experiments were of two types: a Y-maze that tested the attraction of two feeds simultaneously and little plastic containers that housed two urchins and allowed us to measure the amount of feed they consumed. In the Y-maze design, the preference for two types of food was tested simultaneously by placing samples on either side of a plastic Y at one end of a shallow tank and a group of urchins at the opposite end of the tank. A total of 37 combinations of different algae and processed feeds were tested. Those that showed the greatest attraction were tested for their consumption in small plastic containers (4.5" x 7.5" x 5.5") that housed two urchins at a time. The small plastic containers were attached to weighted bread racks and covered with a 7 mm wire mesh plus a second rack to hold them in place. The racks were placed on the bottom of a large closed-system seawater tank at the MSC. Each feed was given to twenty urchins. The

processed feeds were presented in the form of small patties (approximately 15-25 grams) and *Laminaria* as pieces of blade. The processed feeds were prepared by Susan Godhor and Radu Giurca at facilities of the Center for Applied Regional Studies. Feeding preference and durability were assessed daily for five to nine days by making quantitative measurements of the fecal pellets in each container. Using the results of these feed consumption tests, we had samples of several different types of feed prepared by a commercial aquaculture feed company, Zeigler Bros., Inc. of Gardners, PA. The advantage of using a commercial feed company was that they could produce a feed in whatever shape we wanted and with a drier moisture content than the feeds Godhor and Giurca produced. Several different feed compositions and shapes (e.g. ribbons, sheets and whips) were produced by Zeigler Bros. and tested in field caging experiments described above.

5). Development of a new, non-destructive test for measuring the gonadal content or urchins.

We tried three alternative methods for measuring urchin gonadal content. The first method was to measure an urchin's density and see if it could be used as an indicator of its gonadal content. Density was measured by weighing individual urchins underwater and then in air and calculating the difference between the two, which should be a function of their percent lipid and, we thought, correlated to gonadal content. We also tried imaging the amount of gonadal tissue in urchins using X-ray analysis and ultrasound analysis. The latter were performed with the assistance of Dr. Howard Krum and Robert Cooper at facilities at the New England Aquarium.

6). Evaluation of the effects of dragging on sea urchin habitats.

In conjunction with Arnold Carr of the Massachusetts Division of Marine Fisheries, we undertook a joint study to investigate the impact of the typical dredges used for sea urchin dragging in this state, the so-called "Green" and "Irish" dredges, on the following: 1). lobsters and sea urchins in the path of the dredge, and 2). the survival of sublegal urchins discarded after dredging operations. Two vessels were used in the study; Northeastern University's research vessel, the R/V Mysis, from which divers operated, and a commercial sea urchin dragger which conducted the dragging. A study site located in Salem Sound was selected, which consisted of one area that was dragged for urchins and an adjacent area that acted as a control. Divers video taped the dragging process itself, as well as sampled transects before and after dragging using both video and still cameras. At the end of each tow, the catch was sampled to determine the weight of the urchins, their size composition and the number of injured urchins. Subsamples of legal and sublegal urchins were placed in a holding cage set near the dragging site for assessment of short term survival after 5 days.

7). Education of urchin fishermen on the results of this project.

Two articles describing our in-sea caging and roe enhancement experiments were prepared for *Commercial Fisheries News*. and appeared in the February, 1998, edition (copies attached). This publication was selected as a way to reach a large

number of fishermen because of its broad exposure to fishermen in the New England region. The first of these articles described our caging system and the use of processed feed to enhance roe content. The second article focused on permitting problems that a fisherman can run into if they want to practice our caging and feeding system on a commercial scale.

8). Monitoring of populations to determine their urchin quantity, size distribution and % gonadal content.

Six sea urchin populations in Massachusetts were sampled on a regular basis (6-11 times) for one year. The sites included two populations that are commercially harvested in Salem Sound (Dry Breakers and Coney Island), two commercially harvested sites in Boston Harbor (Outer Brewster and Flip Rock), and two sites that are not commercially harvested near the Marine Science Center (Pumphouse Beach and Dive Beach). At each site, we determined the abundance of urchins in twenty 0.25 m^2 quadrats, the size distribution of the populations, and the % gonadal content and gonadal color of both legal-sized (i.e. 50 mm or more in diameter) and sublegal-sized urchins. Size distribution was determined from a random sample of 100 urchins that were measured to the nearest millimeter to obtain size frequencies for 5 mm size classes. Gonad color quality was judged using the commercial color scale.

B. List of major participants

1). Donald P. Cheney, Marine Science Center, - PI; responsible for most of the objectives other than feed and bait production and informing fishermen of our results

2). Susan Godhor, Center for Applied Regional Studies - Co-PI; responsible for the feed and bait production and preparing articles for informing fishermen of our results

3). Mark McLaughlin, Masters of Science graduate student at the Marine Science Center; conducted laboratory and field feeding and cage experiments and the population samplying

4). Radu Giurca, Associate Researcher at the Center for Applied Regional Studies; worked with Susan Godhor developing processed feeds

5). Joe Sinagra, Gloucester fisherman and boat captain; designed and built sea urchin traps, and provided key help in final two field trials of caging system

6). Joseph Novello, Gloucester fisherman; provided advice and consultation during the early design phases of the project

7). Daniel O'Maley, Gloucester sea urchin diver and boat captain; provided advice and consultation on trapping and caging of urchins

8). Mark Subramanyam, Zeigler Bros., Inc., Gardners, PA; provided advice and oversaw the production of our final processed feeds

V. Findings and Accomplishments

1). On developing a sea urchin trap and bait for trapping.

We were unsuccessful in developing a productive sea urchin trap. We built and tested two different traps designed by fishermen, and while both appeared to be promising in laboratory seawater tank experiments, they failed miserably in the field, trapping fewer than a handful of urchins over a two week period. I don't think their failure was due to a lack of urchins in the area around the traps. The traps were tested in an area of high urchin density and low seaweed abundance. Urchins should have been attracted to the traps because they were stuffed with *Laminaria* and processed feeds that had attracted urchins in laboratory experiments. My conclusion is that it is not practical and productive enough to attempt to harvest urchins by trapping and that further testing of this concept will be a waste of time. Besides, I am not convinced that a new alternative method for harvesting urchins is necessary (see comments on dragging below).

2). On developing an in-sea cage system and feed for roe enhancement.

Probably the most important accomplishment of this project was its development of a successful method for the in-sea caging and feeding of urchins for roe enhancement. In the final field trial of the project, we were able to demonstrate that we could more than double the gonadal content of urchins kept in a cage over a two month period and fed either *Laminaria* or our processed feed. Details of this field experiment are described in the 8th Quarterly Report. A diagram of the cage we used and the results of this experiment are repeated here as Figure 1 and Table 1.

What is important to note about this field trial is that the average gonadal content increased from 5.4% to 13.2% with our best processed feed and 5.4% to 12.4% with *Laminaria*, from 11/2/96 to 1/5/97. Thus we showed that a processed feed which is dried and easy to store, could serve as an alternative to *Laminaria* as a reliable food source. In addition, when tested by a commercial urchin processor, all or nearly all of the urchins had commercially acceptable gonad content and all had a commercially-acceptable color and taste. Thus, the urchins from this experiment would have been highly desirable to a processor because of their uniformity and high quality. Furthermore, I think the increase in gonadal content we saw could have been even greater if the urchins had been fed on a more regular basis. As it was, there were two time periods during the experiment when the cages were not checked for over 20 days and the urchins were probably without food. Nevertheless, I believe this experiment demonstrates the feasibility of our caging system. In addition, I have no doubt that the experiment could have been cut short by two weeks so that the urchins in the cages could have been sold for the Japanese Christmas holiday, which offers one of the best prices for roe of the year.

3). On developing a new, non-destructive test for measuring urchin gonadal content.

We tested three new methods for assaying gonadal content: 1). correlating the amount of gonadal tissue with urchin density, 2) detection of the gonadal mass by X-rays and 3). detection of the gonadal mass by ultrasound. All three failed. We could not see any correlation between the amount of gonadal tissue and an urchin's density as measured by us. Also, X-rays and ultrasound did not show an image of the gonadal contents, presumably because the urchin's test is too hard. However, in retrospect I don't think that a new method is that important, since in our experience a relatively small number of urchins (e.g. 15-20) can serve as a reasonable estimate for a population or a tote, which is what is currently being used by both processors and fishermen.

4). Evaluation of the effects of dragging on sea urchin habitats

Although my remarks are based upon the one study we conducted with the Massachusetts Division of Marine Fisheries (see 1st Quarterly Report) and observations we made in Maine (see 5th Quarterly Report), I believe that dragging can be performed without causing great harm to the urchin population or its environment. An analysis of the slides of the before and after dragging as well as the video tape reviewed far less damage to the bottom than what I and Arnold Carr expected. This doesn't of course mean that dragging is harmless. The level of harm dragging causes appears to be related to how it is done and the type of dredge used. If a heavy dredge with lots of chain is dragged over an urchin bed over and over again, it will cause great damage. However, it does appear from this one study that dragging can (I repeat CAN) be conducted with causing a minimal amount of damage. As a result of these observations and the fact that our efforts at trapping urchins failed, I believe that there is no need for a new urchin harvesting method. Furthermore, I think that urchins can continue to be harvested using the two current methods, diving and dragging, without destroying the fishery, as long as some management regulations are installed concerning the size and weight of the dredge used.

5). Education of urchin fishermen on the results of this project.

Two articles describing our results appeared in the *Commercial Fisheries News*. in the February, 1998, edition (copies attached). This publication was selected as a way to reach fishermen because of its broad exposure to fishermen in the New England region where urchins are harvested. The first of these articles described our caging system and the use of processed feed to enhance roe content. The second article focused on permitting problems that a fisherman can run into if they want to start an in-sea caging and feeding operation. When we began our study, we did not anticipate that getting permits to practice our caging method on a commercial scale would be a difficult process. However, at the time the articles were written, getting the permits necessary to practice our caging method of roe enhancement appears to be a hassle, especially in Maine which has the largest urchin harvest. This may have changed by now. If not, it is a major problem for fishermen to use our system.

Unfortunately, it was clear from the inquiries that Susan Godhor received after her articles appeared, that this permit problem discouraged fishermen from trying our caging system for roe enhancement.

6). Monitoring of populations to determine their urchin quantity, size distribution and % gonadal content.

This was the first study in the state of Massachusetts to look at its sea urchin populations in detail. As such, it provides valuable new information that can be used to help manage the fishery and make it more sustainable. Two of our most important findings, for example, were the determinations of when sea urchins spawn in Massachusetts waters and when new recruits first appear. Most of the six populations we sampled appeared to have spawned by late March, and we saw our biggest increase in our smallest size classes (i.e. urchins less than 10 mm in diameter), which we presume to be new recruits, around May and June (Table 2). In addition, we showed that although the abundance of urchins varied from site to site and seasonally, it tended to be greater at the two sites in Salem Sound than in Boston Harbor (Table 2). Outer Brewster and Flip Rock, for example, had average yearly densities of 87 and 108 urchins/m^2, respectively, whereas the two sites in Boston Harbor, Dry Breakers and Coney Island, had average yearly densities of 29 and 51 urchins/m^2, respectively. The average yearly densities of urchins at our two unharvested sites near the Marine Science Center were no greater than those of populations to the north and south, despite the fact that they experience little of no harvesting. That is, Pumphouse Beach and Dive Beach had average yearly densities of 29 and 76 urchins/m^2, respectively. However, what was markedly different about the unharvested sites, Pumphouse and Dive Beaches, and their harvested counterparts, was their size-class distributions. That is, in general Pumphouse and Dive Beaches had a higher proportion of legal size and greater diameter urchins making up their populations than the harvested sites. A dramatic example of this can be seen in a comparison of the size distributions of Dive Beach for August 21, 1996 with that of Flip Rock from September 9, 1996 (Figures 2 and 3). We also are the first to discover when the % gonadal content of populations in the state are sufficient enough to open the harvesting season. The % gonadal content of most populations we sampled was not of sufficient commercial grade until September. This supports not opening the urchin season before October 1st. Allowing harvesting before that time would result in the harvest of a lot of poor quality urchins and would not benefit the fishermen in the long run. Both types of information, % gonadal content development and size-class distribution, provide valuable new information for managers of the industry in this state which should help them make the necessary decisions to insure a sustainable fishery.

VI. Evaluation and Conclusions

In retrospect, this project probably had too many objectives, eight in all. Still, overall I think we did a good job at meeting the goals of this project. Most importantly, we met our primary goal, that of developing and testing an economical method for fishermen to hold sea urchins and increase their roe content and quality. The in-sea

caging and feeding system we developed in this study gives the fisherman new freedom to control the value of his catch. For relatively low cost and little capital investment, we have shown that it is possible to double the roe content of urchins in a two month period. It may even be possible to do so in less time, as long as the urchins are provided sufficient food. The economic benefits of holding urchins for the fisherman would depend upon how much of an increase in roe price is realized at the end of the holding period and the price of the food used. Holding urchins for one of the Japanese holidays would probably result in the biggest price increase. Food cost would depend upon whether *Laminaria*, which is free, or a processed feed was used. A processed feed has the advantage that it is easy to store and use when the fisherman can't get *Laminaria*. However, a processed feed such as we used is relatively expensive at this point because it has to be made up in such small quantities by the feed producer. For example, we paid Zeigler Bros. between $5-$6.00 per pound for our final processed feed. If bought in larger quantity, I am sure the price could be reduced. In addition to the cost of processed feed, other disadvantages of our method are that they require getting permits, which can be a hassle, and they require frequent maintenance. But I think the advantages of an in-sea caging system outweigh the disadvantages when one considers what it can offer and the capital equipment cost, for example, of trying to do the same thing in an on-land facility. Now that we've demonstrated "proof of concept" of our caging system, hopefully a fishermen's co-operative or group of fishermen will decide to test it further and determine its economics.

Other things that we accomplished in this grant that might also affect fishermen are our findings that trapping for urchins appears to be a waste of time, while dragging for urchins appears to not cause too much damage to the environment if done properly and with a light-weight dredge. In addition, the information we gathered on the timing of spawning, recruitment and gonadal development in Massachusetts sea urchins will be helpful to the managers of the industry in this state in protecting the fishery and making it sustainable.

Table 1.

Results from our in-sea caging experiment #4 (11/2/96-1/5/97)

Initial Gonadal Content: 5.4 % (1.9-11.1) (n= 30 urchins)

	Survivorship	Avg. % Gonad (n= 20 urchins)
Trawl #2		
Cage #4 Proc.*	95%	12.6% (9.3-15.6)
Cage #5 Lam.	92%	12.4% (5.1-22.8)
Cage #6 Urchins	71%	8.8% (3.3-17.9)
Trawl #3		
Cage #7 Proc.*	87%	13.8% (6.7-25.2)
Cage #8 Lam.	86%	12.5% (6.9-24.4)
Cage #9 Urchins	95%	7.6% (4.7-11.6)

*The processed feed used in Cages #4 and #7 was our Feed #4, which consists of a mixture of soymeal, fishmeal and molasses, with 10% binder. It was produced by Zeigler Bros. in long ribbons, approximately 3-4" wide and 12-14" long, which were stuffed into the cages.

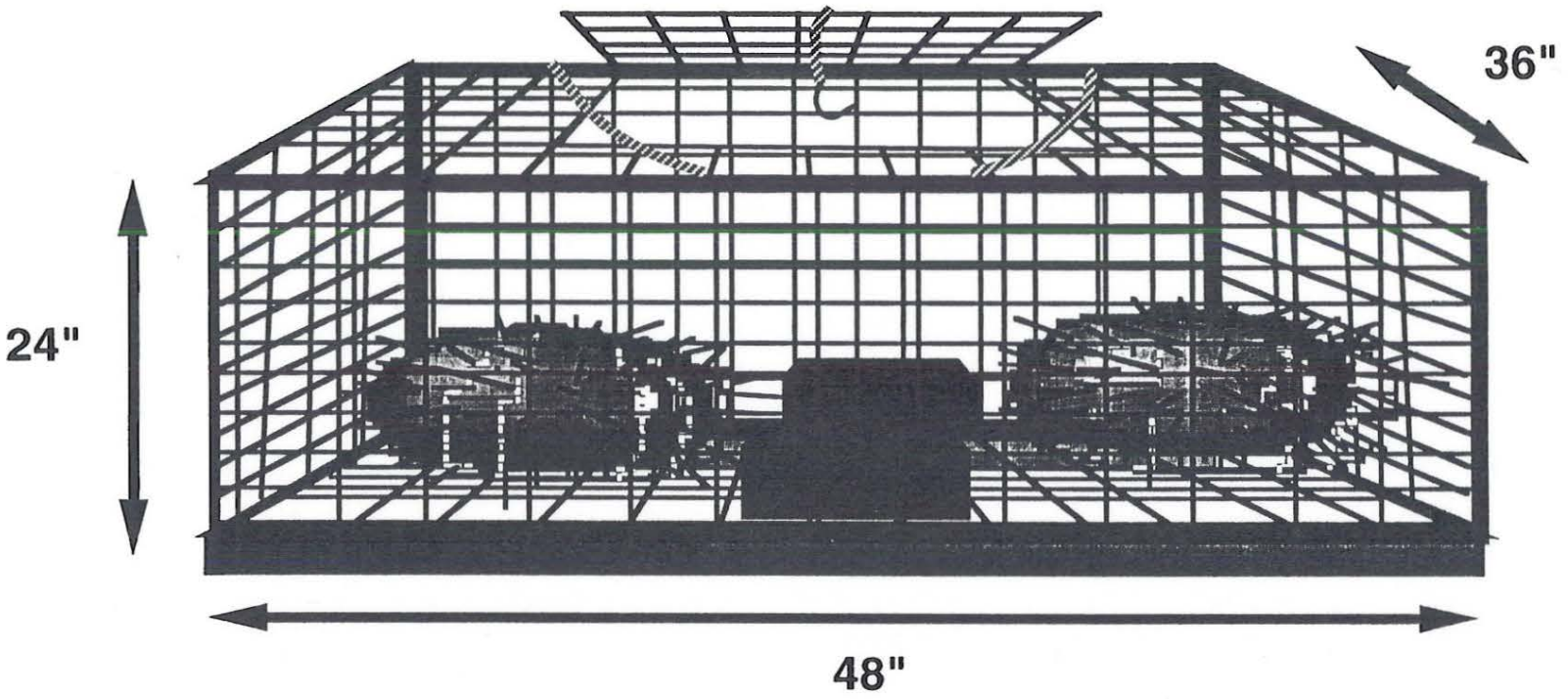
Table 2. Summary of population analyses.

Sea Urchin Information from Field Sites			Updated through 10/30/96			
Site	Date	# of Urchins/Quadrat	#of Urchins/m^2	% of Urchins Legal	Avg. % Gonad Legal	Avg. % Gonad Sublegal
Outer Brewster	7/27/95	35.8	143.2	30.1	11.5	8.1
	11/10/95	15.5	62.0	4.0	9.6	7.6
	2/28/96	10.7	42.8	25.9	18.0	13.6
	4/23/96	9.9	39.6	20.0	6.8	6.7
	5/28/96	23.2	92.8	14.0	6.5	4.0
	8/19/96	35.1	140.4	24.0	7.3	4.7
Flip Rock	7/27/95	24.0	96.0	10.2	Not Available	Not Available
	11/10/95	5.6	22.4	16.9	5.4	3.6
	2/22/96	Not Available	Not Available	Not Available	14.0	11.3
	4/23/96	36.3	145.2	1.0	11.1	9.7
	5/28/96	43.7	174.8	0.0	11.2	12.6
	9/6/96	25.5	102.0	0.0	8.1	7.9
Pumphouse Beach	6/8/95	Not Available	Not Available	Not Available	5.4	3.6
	8/11/95	7.9	31.6	15.6	11.3	7.3
	9/19/95	1.2	4.8	31.9	12.5	9.2
	10/26/95	3.2	12.8	27.6	13.3	11.3
	12/6/95	6.6	26.4	24.0	18.0	15.4
	2/6/96	4.6	18.4	26.0	22.4	20.5
	3/27/96	5.6	22.4	26.4	9.4	10.4
	4/22/96	4.7	18.8	29.0	11.8	6.6
	5/22/96	7.7	30.8	52.0	6.5	4.8
	7/8/96	10.0	40.0	41.0	9.9	6.1
	8/14/96	11.5	46.0	30.0	8.1	7.3
Dive Beach	6/24/95	53.4	213.6	11.4	8.5	7.5
	7/24/95	31.3	125.2	13.4	8.1	6.3
	9/7/95	17.2	68.8	13.1	9.1	6.9

Table 2 (continued) . Summary of population analyses.

	10/25/95	14.6	58.4	5.0	12.3	10.3
	1/23/96	6.0	24.0	22.0	16.9	18.2
	2/20/96	8.6	34.4	40.9	15.1	14.5
	4/12/96	7.3	29.2	33.0	8.0	5.3
	5/21/96	10.6	42.4	41.0	7.2	5.1
	7/10/96	18.1	72.4	19.0	7.4	4.7
	8/21/96	22.7	90.8	37.0	6.7	4.7
Dry Breakers	8/1/95	8.8	35.2	16.8	16.7	16.1
	8/29/95	5.9	23.6	34.6	16.1	14.6
	10/18/95	5.3	21.2	26.6	15.4	12.1
	3/21/96	12.2	48.8	17.3	6.2	5.1
	5/1/96	5.2	20.8	46.0	10.8	7.3
	6/19/96	5.0	20.0	50.0	7.3	6.5
	8/16/96	8.4	33.6	22.0	7.4	9.2
Coney Island	8/1/95	12.4	49.6	41.4	7.8	8.7
	8/29/95	20.0	80.0	12.7	4.9	4.2
	10/18/95	9.8	39.2	19.6	11.2	10.2
	3/21/96	15.8	63.2	29.0	11.6	8.0
	5/1/96	7.2	28.8	31.0	10.5	7.1
	8/16/96	11.3	45.2	21.0	10.8	9.9

Figure 1.



Sea urchin holding cage. Constructed with 0.5 inch wire mesh. Two bricks give cage negative buoyancy while two one-inch thick wooden runners keep cage from sinking into soft bottom and allow for clearance of waste material. One hundred urchins were placed into each cage to optimize survivorship, but each could hold more than 200 urchins (Figure drawn by Lars Schlichting).

Figure 2. Size class distribution for Flip Rock

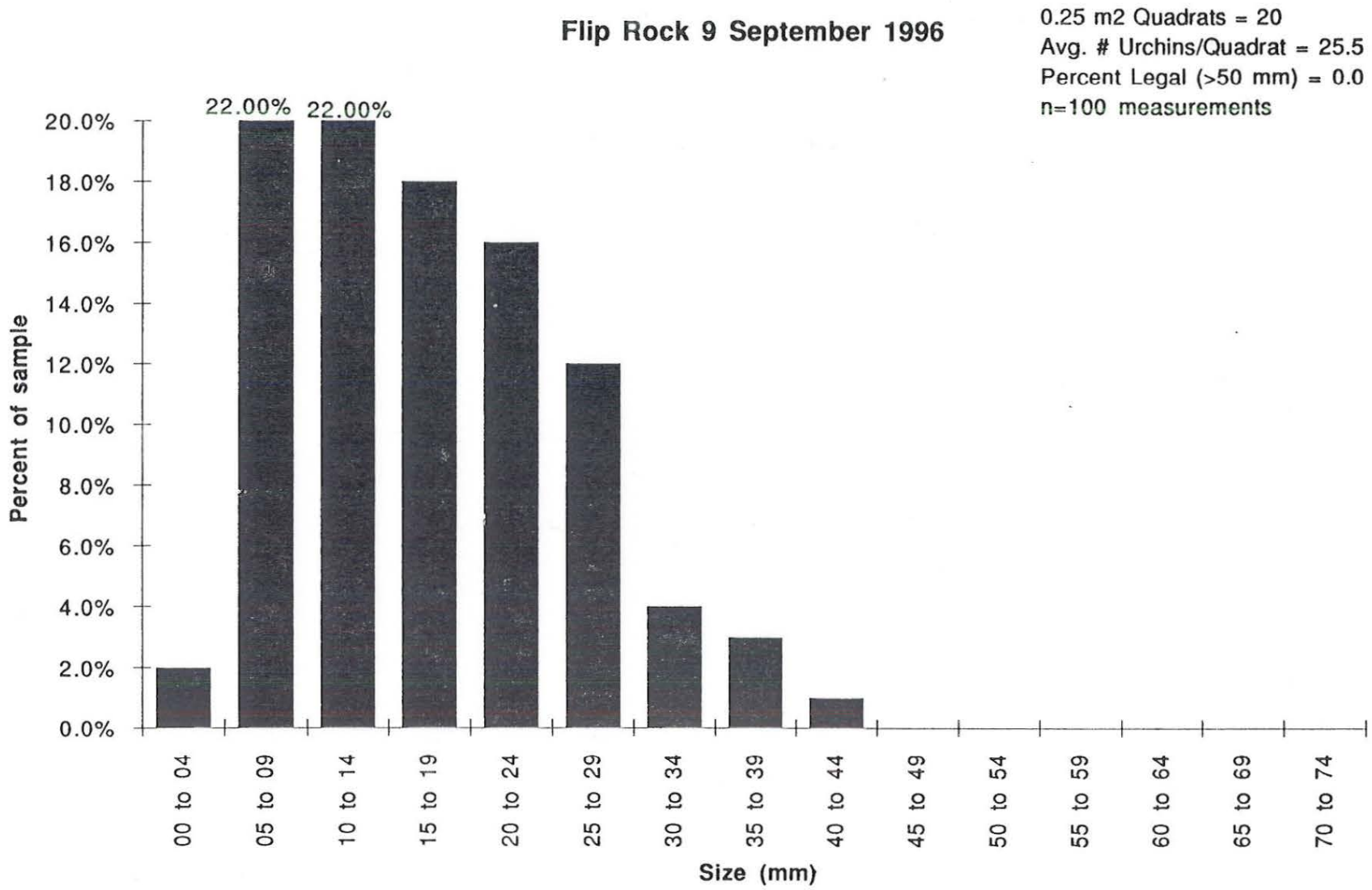
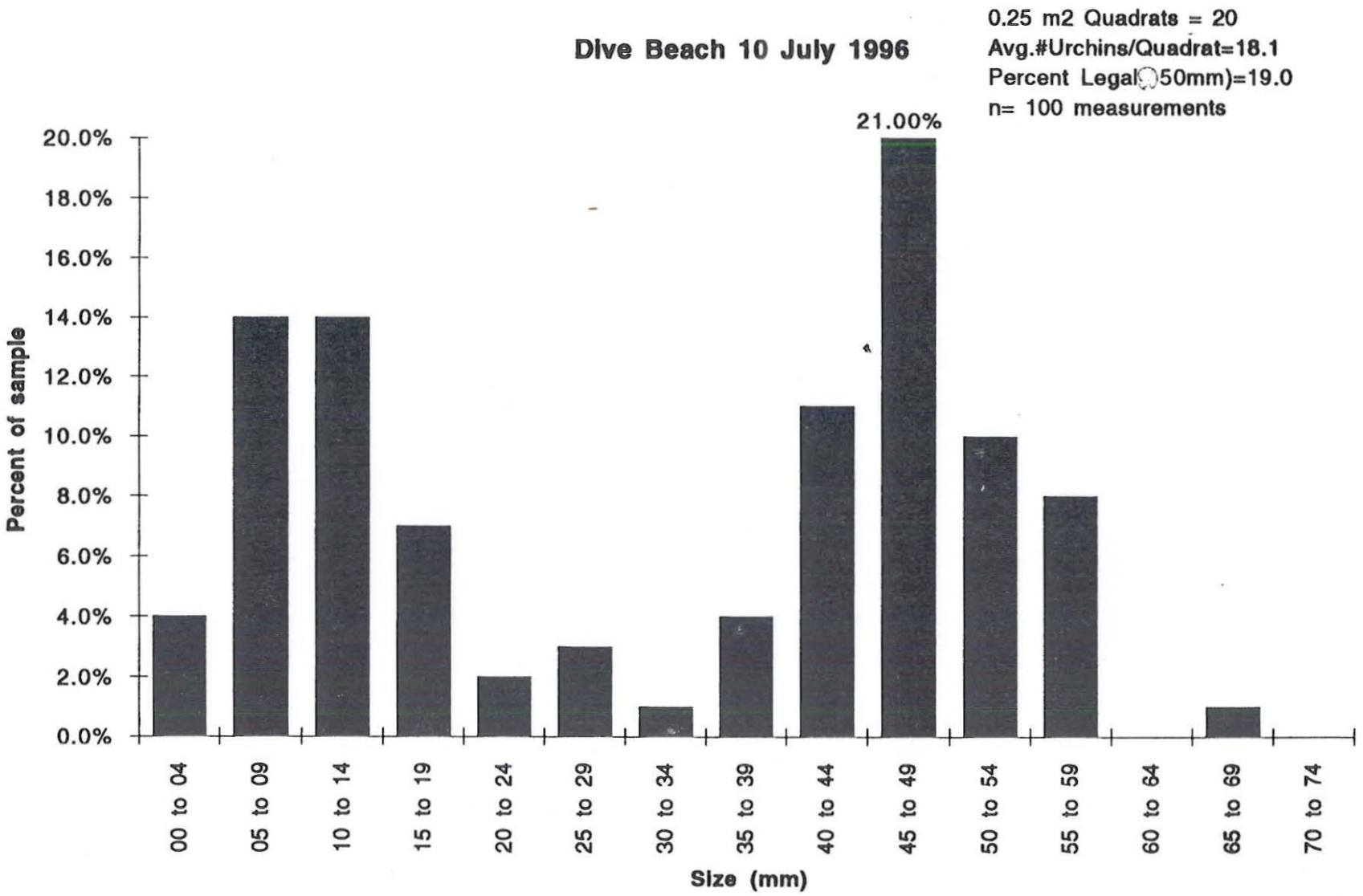


Figure 3. Size class distribution for Dive Beach



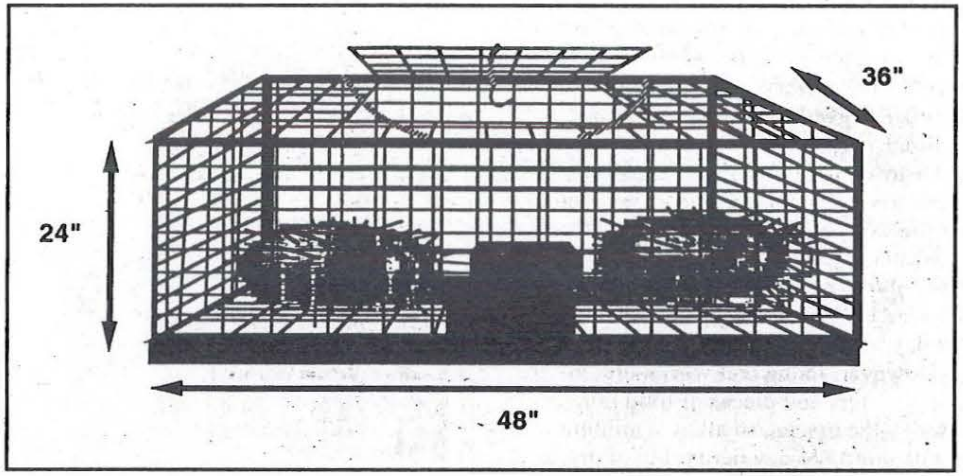
Urchin ranching presents permitting challenge

CAMBRIDGE, MA - Intrigued by the prospect of ranching urchins? The biggest challenge probably lies in securing the necessary permits to get started.

Regulators have a number of concerns about new ideas like this, including possible pollution, user conflicts, and impacts on protected species, such as whales.

An urchin ranching proposal may also require making adjustments to current rules. For example, if you wanted to capture urchins out of season to hold and feed for a later Japanese holiday, you would need a permit to fish for urchins out of season.

The information presented here includes suggestions for going about the permitting process in Massachusetts, where the situation is more flexible than in the state of Maine.



Lars Schlichting graphic

Sea urchin holding cage. Constructed with 0.5" wire mesh, and with two bricks to sink it and 1" runners to keep it from sinking into soft bottom. With a capacity of about 200 urchins, only 100 were put in the cages for the project to insure survivability.

Environmental permitting

Happily, environmental permitting is not a serious problem for this kind of sea urchin operation. Usually, the Environmental Protection Agency (EPA) requires a permit if the facilities will be in place longer than 45 days and if more than a certain amount of feed — generally about 1,000 pounds/day — will be fed.

Phil Colarusso was in charge of open ocean aquaculture permitting at EPA when this article was written in the summer of 1997. He suggested that the easiest way to avoid having to even think about a permit is to spread the cages out and, if they're going to be in the water longer than 45 days, move them, which makes good sense from a farming viewpoint as well as from a regulatory viewpoint.

Structural permitting

The agency in charge of structural permitting is the US Army Corps of Engineers. The corps recognizes that the small, seasonal cages that would be used for urchin farming are quite different than, say, a large, permanent salmon net pen.

Since urchin cages would be small and temporary, the corps would require only a letter containing a detailed description of the proposal and requesting permission.

The description should include a diagram of the setup and of the cage design, location (preferably with GPS coordinates), number of cages and urchins, type of feed, and feed ingredients.

Applicants should also demonstrate that they have attempted to forestall any conflicts by coordinating with other users, such as local fishermen, lobstermen, and pleasure boaters.

Suspended cages will raise more concerns than bottom cages because they are more likely to be involved in marine mammal entanglement incidents. For the same reason, uplines should be kept to a minimum. If possible, the corps would rather see a string of cages held together b groundlines, with one upline, than see each cage with its own upline.

Corps official Grant Kelly suggested that applicants send in a draft of the permit request letter for his office to take a look at. This allows time to make changes and incorporate suggestions before the process becomes official.

Fattening urchins for the winter market in Japan is not a problem, but fattening for the August holidays is, since it would

See URCHIN PERMITTING, next page

Urchin ranching permitting contacts

- **Environmental Protection Agency**
  Jeannie Brochi, phone (617) 565-3582 or fax (617) 565-4940;
- **Army Corps of Engineers**
  Grant Kelly, phone (781) 647-8491 or fax (781) 647-8303;
- **Massachusetts Division of Marine Fisheries**
  Jim Fair, phone (617) 727-3193, ext. 363.

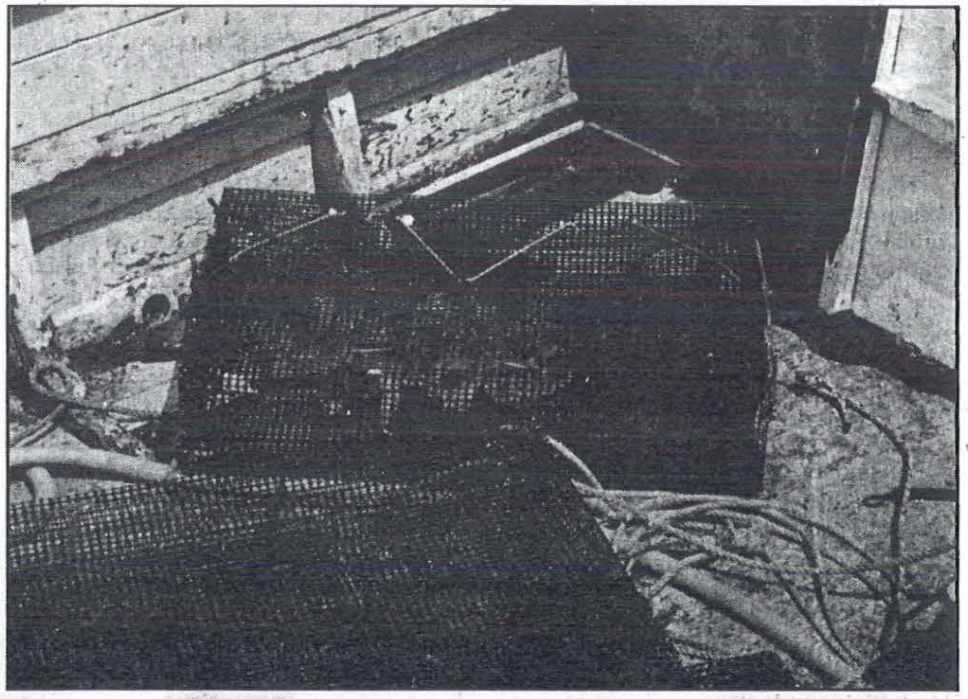
Urchin ranching: Diet, cages, opportunity

Helping fishermen get the most out of a resource was the idea behind a Commerce Department Fishing Industry Grant (FIG) project entitled "Increasing Income through New Technology for Sea Urchin Fishermen."

The $100,818 project brought researchers, fishermen, and others together in 1996 to test methods to hold and feed urchins before sending them to market.

These two articles are condensed versions of papers written by Dr. Susan Goldhor from the Center for Applied Regional Studies in Boston and Cambridge. Goldhor describes some of the study's findings and offers fishermen tips on getting their own urchin "ranching" operation up and running.

Readers interested in learning more about urchin ranching can get the full text of both papers, plus urchin feed recipes. Write or call Susan Goldhor, 45-B Museum St. Cambridge, MA 02138, phone (617) 876-7252. —Editor



Mark McLaughlin photo

Urchin cages with feed added, ready to go back into the ocean.

CAMBRIDGE, MA - While the urchin market may be suffering from setbacks in the Asian economy, the legendary Japanese appetite for uni makes it a good bet that demand will pick up in the future.

A year-and-a half ago, we were intrigued when several Gloucester fishermen suggested that one way to increase profits would be to hold urchins in cages and feed them for a month or so prior to the most important Japanese holidays.

Caging lets you feed captive urchins to enhance roe development or just hold urchins for relatively short times — with or without feed — to ride out temporary down turns in market price.

Urchin farming has become a hot international aquaculture topic, but, like most aquaculture, requires capital, land, and sophisticated facilities. Short-term urchin fattening, on the other hand, may be one form of aquaculture that fishermen can enter without vast amounts of training and capital.

Armed with a Commerce Department Fishing Industry Grant, we set out to see how this idea would work. The principal investigators on this project were Professor Don Cheney, a specialist in seaweeds from Northeastern University's Marine Science Center at Nahant, MA, and myself.

Other participants included: Dr. Radu Giurca, an aquaculturist from the Center

Each cage held 100 urchins, but could probably have held more. The cages were manufactured by the Winchester Fishing Co. of Gloucester for $40 each.

We found that the urchins seemed to do better in water with wave action than in still water, but they are more fragile than they look. If cages are knocked around, the urchins can be seriously injured.

Joe Sinagra said that he'd always choose hard sand rather than mud for siting cages. We all agree. He also said he'd lift them further off the bottom than the 1" we did.

Diverse diets

So what exactly do urchins eat? That depends on the species urchin. The common sea urchin in our waters is the green urchin, *Strongylocentrotus droebachiensis*. We had originally assumed that our urchin fed almost entirely on seaweeds, but it turns out to be an omnivore that enjoys young mussels as well.

Many have assumed that kelp is this urchin's favorite food. But that assumption poses two problems. First, if kelp is simply pulled up, it can't regrow, and kelp beds are important habitats for lobsters and juvenile fish. Kelp should be cut through the broad leafy section, at least 6" above the narrow stem, or collected on beaches after storms.

Second, at least one Maine experiment has shown that gonadal development is greater on non-kelp seaweeds or on prepared high-protein feed than it is on kelp — although high-protein feeds

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investigators on this project were Professor Don Cheney, a specialist in seaweeds from Northeastern University's Marine Science Center at Nahant, MA, and myself.

Other participants included: Dr. Radu Giurca, an aquaculturist from the Center for Applied Regional Studies; Mark McLaughlin, a graduate student at Northeastern University; and Joe Sinagra, a Gloucester fisherman.

Divers Andrew Arnold of Rockport and Tim Donovan of Gloucester worked faithfully on the project, which is also indebted to Joe Novello of Gloucester, who brought the participants together and sparked the project.

Building cages

Our project focused on cages that sat on the sea floor on "feet," which lifted them up off the bottom by at least a couple of inches. Other researchers have looked at suspended cages. Our cages were marked with a lobster buoy and could be lifted by hand or winch.

The cages (see photo) were made of 1/2" wire mesh and were 3' long, 2' wide, and 8" high. Each was weighted down with two bricks and had 1" thick wooden runners attached lengthwise to the bottom.

collected on beaches after storms.

Second, at least one Maine experiment has shown that gonadal development is greater on non-kelp seaweeds or on prepared high-protein feed than it is on kelp — although high-protein feeds including kelp as an ingredient are better than those without seaweed ingredients.

Which seaweeds are best? Work by University of Maine researchers Brian Beal, Bob Vadas, Tim Dowling, and Jill Fegley showed that urchin gonads increased most on dulse (*Palmaria*), next best on sea lettuce (*Ulva*) or a diet of mixed seaweeds, and least on kelps. This makes sense because dulse and sea lettuce have higher protein contents than kelps.

Making feed

Dowling, a diver and grad student at the University of Maine, was one of the first to develop his own feed, starting with ingredients like fish meal, potato, and dried seaweed.

He learned that he had to hold these ingredients together with a binder so they wouldn't fall apart in water and that he had to add a preservative to keep them from spoiling.

See URCHIN RANCHING, page 18B

Urchin ranching

Continued from page 16B

When we made feeds for our project, we used a different preservative and a different binder, but the principle was the same — and we tried to make ours more palatable by adding molasses.

Purchasing feed

We also bought commercial, pelleted urchin feed. It cost 45 cents per pound FOB and can be ordered by calling Galen Rokey at Wenger Manufacturing, phone (913) 284-2133 or fax (913) 284-3727.

One problem we found with the pellets was that they became smaller as the urchins fed on them and fell through the mesh of the cage. We enclosed the pellets in mesh bags but this limited urchin access. So we were glad to learn that Wenger now also offers urchin feed in sheet or strip form.

We also worked with a Pennsylvania-based aquaculture feed company, Zeigler Bros. Inc. Zeigler, which has been working on sheet form abalone feed, made up variants of it for our urchins. While this feed is not yet in large-scale production, the company would appreciate hearing from potential urchin farmers so that it can learn if the market is large enough to warrant an investment in commercializing this feed. Any questions or comments can be directed to Zeigler's Mark Subramanyam at 1-800-841-6800.

You don't want to give urchins too little feed, because you won't get maximum growth, but you also don't want to feed too much — particularly processed feed — because you'll waste money and have rotting material around. For the record, seaweeds are less likely to rot.

Since commercial feeds are usually dry and seaweeds are 90% water, an urchin needs to eat 10 times as much seaweed to get the same amount of nutrients. In our and others' experiments, an adult urchin eats only about a third to a half a gram of dry feed or three to five grams of seaweed per day.

However, in the real world, urchins are sloppy eaters and pieces of food fall through the cracks, so allow a minimum of one gram per day per urchin of dry feed or 10 grams of seaweed (there are 450 grams in a pound).

Urchins like to sit on their food, so make sure there's enough food area or chunks for each urchin to have some. Also make sure that the food is denser than seawater so it doesn't float out of their reach.

Finally, urchins are cold blooded. When the water is warm, they eat more and grow faster than when it's cold.

There's much more research to be done, but the idea of ranching to fatten not only urchins, but fishermen's wallets, is definitely worth pursuing. We'd like to hear your experiences and your results if you try it.

Susan Goldhor

Mark McLaughlin photo

Urchins are almost buried under ribbon-shaped feed. There are 80 or so other urchins in the cage.

Urchin permitting

Continued from previous page

require catching urchins in June when the Massachusetts fishery is closed.

Jim Fair, assistant director of the state Division of Marine Fisheries (DMF), said DMF is willing to consider proposals for divers — though not dredge boats — to harvest urchins out of season for short-term culture.

He suggested starting the process in mid-winter for June harvesting. Because such a proposal would require requesting a change in the regulations, it would have to go through a formal rule-making process involving the state's Marine Fisheries Commission. Another possible route would involve obtaining an aquaculture permit to allow harvest in conjunction with an aquaculture operation.

Fair said DMF is "cautiously tryin support innovative aquaculture projects that use native species, don't degrade the environment, and have a good chance of success."

Susan Goldhor