Management Options for the Sustainable Development of a Common Marine Resource in Maine: The Green Sea Urchin

by

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ABSTRACT

As the industry for exporting sea urchins to Japan has peaked on the West Coast of America due to over-harvesting, the sea urchin population in Maine's coastal waters have been harvested in increasing volumes since 1987 to meet the demand of the Japanese market. In order for Maine harvesters to avoid the decline experienced on the West Coast, steps must be taken by participants within the industry to voluntarily control harvesting activities in order to ensure the continued reproductive success of the sea urchin population, and thus the export industry itself.

This thesis begins by documenting the evolution of the sea urchin industry in the state of Maine as an example of the utilization of a common property resource in the marine environment. Garrett Hardin's "Tragedy of the Commons" is considered in light of computer experiments performed in game theory which test the success of cooperative behavior between competitive individuals in an autonomous environment. A change in perspective toward the limited stock of natural resources in the environment is advocated in light of alternative valuation techniques for unique natural resources. The lobster industry in Maine will be examined in order to determine what cultural and regulatory conditions have allowed that harvesting activity to be sustained over so many years.

The most important factor affecting the sustainability of ecologically sound harvesting activities is the maintenance of stable and limited populations of harvesters where accountability for infractions of locally accepted norms is enforced by the members of the population of harvesters.

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Table of Contents

Chapter IV

Sea Urchins as a Finite, Renewable, Common Property Resource

Chapter V

Managing Resources in a Closed Economy

Chapter VI

Successful Management of Another Bottom-Dweller: Lobsters

Chapter VII

Conclusions and Recommendations for the Sea Urchin Industry in Maine

List of Figures

Chapter I

Introduction

Purpose of the Thesis

This thesis is an investigation of the sea urchin industry in the state of Maine in light of concepts and insights gained from a consideration of diverse ideas offered by various thinkers on cooperation within economic systems and the valuation of their components in the natural environment. The central idea around which these concepts will be discussed is stated below.

> The sustainable development of the green sea urchin, *Strongylocentrotus droebachiensis,* a common property resource in the state of Maine is contingent upon:
>
> 1) the maintenance of stable and limited populations of harvesters
>
> 2) the utilization of ecologically sound harvesting techniques
>
> 3) the direct empowerment of the agents within the industry in managing the resource in conjunction with oversight agencies in the state government.

While this thesis is concerned mainly with sea urchins as a finite, renewable economic resource within the state of Maine, the biological characteristics and ecological environment must be considered as these concepts directly

affect the continued vitality of the population through successful reproduction. A generally qualitative study of game theory, particularly the Prisoner's Dilemma scenario, will be undertaken in order to gain guidelines in inducing cooperative behavior within a population of marginally competitive agents. Consideration of some useful tools in properly discerning the value of a resource in its natural state will be necessary in order to defend conservation measures which must be implemented in the course of managing the resource in order to assure the availability of the resource to future members of the industry.

Outline of the Chapters

Chapter I will present the central idea of this thesis and the scope and limitations of the components within the paper. Brief summaries of the ensuing chapters are presented for the reader as well.

Chapter II will examine the growth of the sea urchin industry in the United States and as an export product in Maine. The number of harvesters participating in the market, the volume of urchins caught annually, and the value of the urchins exported from Maine to Japan will be documented. The steps taken by the state management authority to regulate the harvesting and processing of the sea urchins will also be documented.

Chapter III will describe the biology and ecology of the sea urchin as it relates to the value of the export market in Maine. The techniques associated with the harvesting and processing of sea urchins will then be described. The

influence of external factors on the harvesting and processing activities within the state (overseas demand characteristics, agents in the sale and transport of urchin products) on the amount and type of harvesting will also be examined.

Chapter IV will be a more general presentation of a social dilemma commonly referred to as "The Tragedy of the Commons." Through a brief description of Hardin's essay and consideration of his conclusions, an understanding may be gained of the constraints under which the activities associated with harvesting sea urchins occur. The concept of using game theory in economic problems, such as "Prisoner's Dilemma," is then explored as a tool for examining some of the conditions in which cooperation between competitive agents may evolve with minimal assistance from state regulators. This "organic" concept of cooperation, characterized by a community of self-policing agents, is encouraged as a means of ensuring that all participants in the harvest and processing of sea urchins abide by the agreed upon limits to the activity of removing sea urchins from their natural environment.

Chapter V will propose a necessary change of attitude toward the limited stock of natural resources on our planet. Concepts useful in the discussion of sustaining the stocks of a resource such as option value, existence value, and the discount rate will be presented through a consideration of valuation tools which are necessary for the sustainable utilization of a natural resource. The use of these valuation tools along with the concepts gained from the consideration of game theory is encouraged as a means of achieving the sustainable development of the sea urchin industry.

Chapter VI will examine the techniques implemented in the

management of the lobster industry, as this is an example of a finite, renewable, common property resource that has been successfully maintained over a substantial period of time. The regulatory framework, as well as the market organization of relationships between harvesters, dealers, transporters and buyers, will be documented in order to glean any understanding of what concepts might be useful to the successful management of the sea urchin industry.

Chapter VII will integrate the information and ideas of the previous chapters into a set of conclusions and recommendations for the future management of the sea urchin industry in Maine. A summary of the thesis will also be presented.

Chapter II

Evolution of the Sea Urchin Industry in the State of Maine

Realizing the Value of Sea Urchins in America

Sea urchins, long considered only a sea-pest to many of the coastal fishermen on both Atlantic and Pacific coasts, underwent a drastic re-evaluation in California during the late 1970's. With the escalating popularity of sushi bars in the hip culture of California, it was discovered that the spiny bottom-dwelling creatures, specifically, the fleshy, yellow/orange colored sex organs of the organisms, were considered a delicacy in Asian countries, predominantly in Japan. While a small number of fishermen in Maine sought to scoop them out of the waters since the 1930's for ethnic communities in the Northeast, the yearly catch was minuscule compared to groundfish levels, hovering at a constant level of about 100,000 pounds per year. For the most part, it was done in order to carry them through the off-seasons of the major groundfish and lobster industries.[1]

For the Japanese, an island people, seafood has always been a staple of their diets. With the advent of

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[1] Scattergood, L.W. The Sea Urchin Fishery. (Fishery Leaflet 511: U.S. Dept. of the Interior, Bureau of Commercial Fisheries, Washington, D.C., 1961), 2.

transportation technologies which are able to send fresh seafood products around the world, it became feasible to the Japanese to import more of their food products. Japan has historically been the major harvester of sea urchins, but this has changed significantly in the last decades, with its share of the global catch falling from 73 percent in 1975 to 17 percent in 1992. The United States has become the largest supplier of whole sea urchins and processed roe, reaching a value of $155 million in 1994. This has been attributed to: healthy demand by Japanese consumers; declining harvest levels in Japanese waters; different peak seasons in Japan's and the U.S.; and a strong yen relative to the U.S. dollar. Tariffs are applied to U.S. exports of sea urchin products, under an agreement reached through the World Trade Organization, of between 9 and 12 percent depending on how the urchins are packaged, with no tariffs applied for live urchins.[2]

One of the most thriving locations for the transactions of these fresh products is in Tokyo, at the Tokyo Wholesale Fish Market which supplies seafood to more than 25 million people in the Tokyo area. Depending on the quality, the urchin roe at the market can sell for between $15 and $100 a pound. It is prepared in a variety of ways for consumption, but most often the ovaries are prepared as a component of sushi, the traditional dish of vinegared rice and raw fish. In department stores, the roe can be found in bottles, canned or as a paste. Because Maine's green sea urchin is comparable by sight and taste to the native purple/black urchin found in Japanese waters, it is often sought out over urchins

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[2] Sonu, S.C. The Japanese Sea Urchin Market. (NOAA Technical Memorandum: National Marine Fisheries Service, Long Beach, CA, September, 1995), 12.

originating from others locations around the world.[3]

The predominance of the urchins along the West Coast, combined with their stationary existence, made them easy picking to anybody who had access to a boat and scuba gear. From 1982 to 1992, the value of urchins brought onto the docks of California's seafood market rose dramatically from $3.5 million to $29 million.[4] Not surprisingly, with the rising value of the urchins as a component of the California's seafood market, reaching nearly one quarter of the $131 million market, more people became involved in the harvesting and the stocks began to be depleted. Regulations on the number of days at sea divers are allowed, size limits, and a reduction of the total number of licenses issued to divers (from a peak of 915 to a goal of 400) were enacted by the Department of Fish and Game. These regulations have been successful in reducing the total number of urchins harvested, dropping from 52 million pounds to 30 million pounds by 1988.[5]

As well as the current demand for sea urchins as a delicacy for consumption, there is a significant potential for sea urchins to be in demand for the chemical compounds that are stored within their organs. As pharmaceutical companies continue their search for sources of new drug bases to combat various ailments, sea-borne organisms are increasingly being researched for possible compounds that might be gleamed from the millions of years of the sea urchin's evolutionary development. For example, compounds called mycosporin-like

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[3] Kleiman, D. "Scorned at Home, Maine Sea Urchin is a Star in Japan," New York Times, 3 October 1990, p. 1C.

[4] Munk, N. "Choppy Waters." Forbes, 25 October 1993, p. 108.

[5] Ibid.

amino acids, have been found in sea urchins that consume a marine algae which produces the compound. The more algae consumed, the more the compound is bio-accumulated. Tests have shown that this compound plays a factor in protecting sea urchin eggs from the harmful effects of ultraviolet rays. Currently, research is being carried out, by Malcolm Schick of the Department of Zoology at the University of Maine, in an attempt to isolate the compound in order to determine if it would be useful as a pharmalogical product. While this approach is many years away from fruition, the possible impact on the demand of sea urchins should not be discounted in future analyses.[6]

Geographic Shift in Harvesting Pressures

With the implementation of protection measures by the authorities in California, harvesting activities shifted to new locales, notably Massachusetts, Washington, Oregon, British Columbia, and Maine in 1987. At the time, dollar/yen exchange-rates were quite favorable, making the long transport route economically viable. The peak harvest season in Japan is from approximately April until September, but the peak consumption period is during the holiday season in December and January. This translates into an advantageous position for Maine harvesters, as the prime picking season extending from November until March, during the period of greatest demand and weakest supply in Japan. This caused a dramatic

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[6] Goad, M. "Ocean Yields Treasures for Biomedical Uses," Maine Sunday Telegram, 19 November 1995, p. 16B.

rise in the volume of urchins landed in Maine, as shown in Figure 1 below.

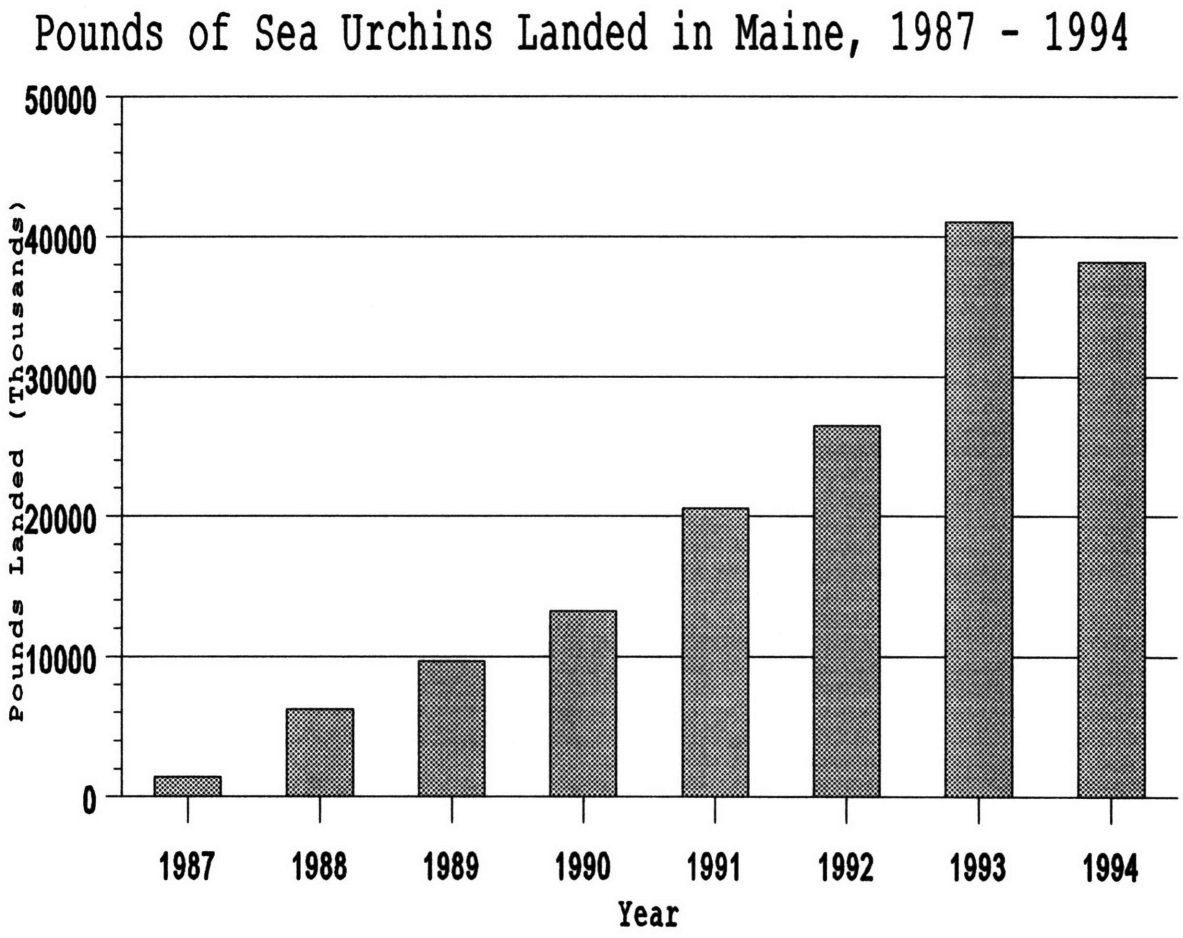

Figure 1

Because of the distinguishing market preference prevailing in Japan, quality, as appraised by color and size consistency, determines the value of the roe; if it is appealing to the eyes and palate of the Japanese dealer, it can easily command more than $100 per pound.[7] This translated into rising wharf prices for Maine harvesters.

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[7] Sonu, p. 25.

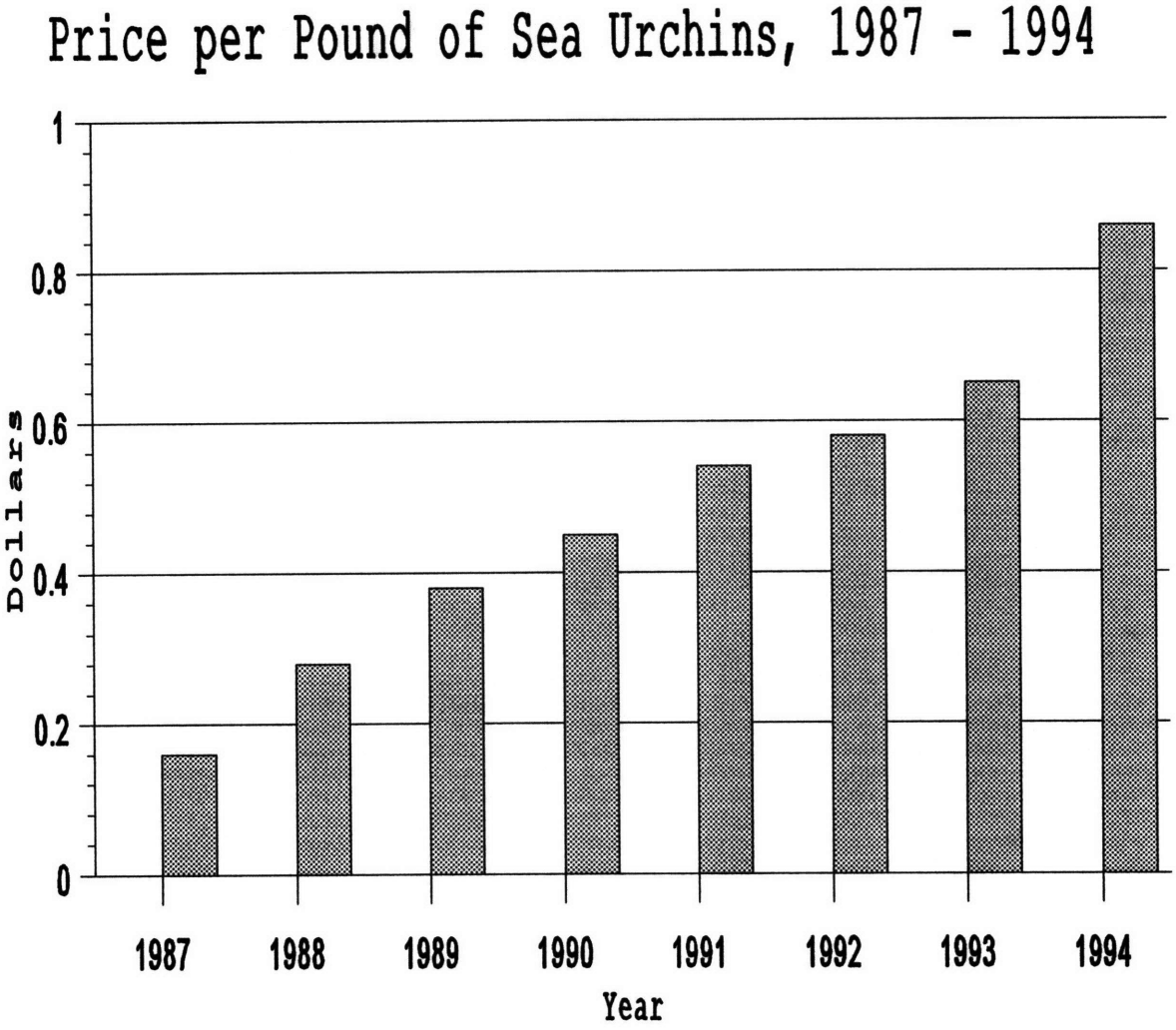

Figure 2

As shown in Figure 2 above, the price per pound paid at the wharf in Maine more than quadrupled, from less than 20 cents to more than 80 cents, in eight years.

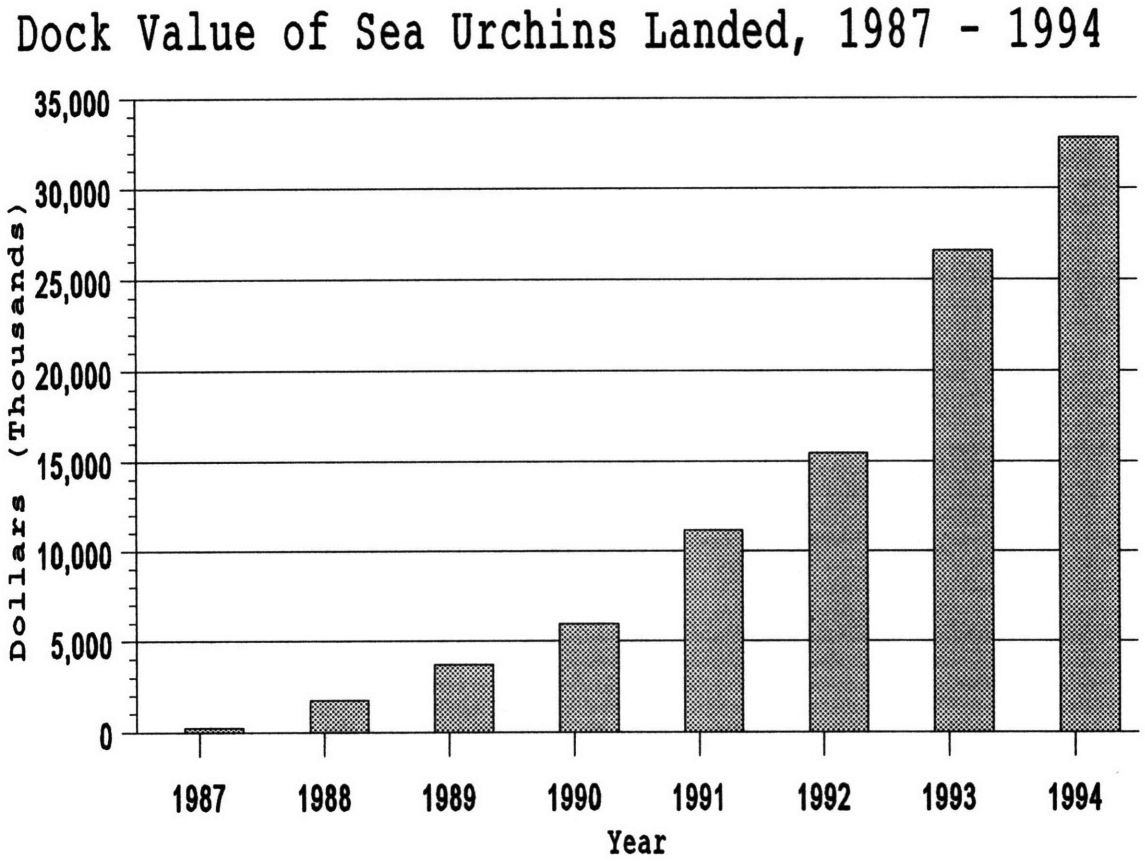

Figure 3

The rising dock values, combined with the increasing volume of urchins being exported, resulted in a substantial escalation of the total value of the resource to the industry within the state, as shown in Figure 3 above. This was third in fisheries revenues for 1993, after lobsters and pen-raised finfish.

Legislative Response to the Boom

The response to the increase in urchin harvests on the West Coast has been varied across the three states of California, Oregon and Washington. In California, the fishery expanded to 25 million pounds landed in 1981, predominantly in southern California. By 1985, pressures had increased in northern California and statewide landings grew to a peak of 52 million pounds in 1988. In 1987 the Department of Fish and Game and the Sea Urchin Advisory Committee agreed upon a plan which: reduced the number of harvesting permits from 915 to 400; set a minimum size for urchins landed; enacted seasonal restrictions; required log books to be maintained and turned in by divers; and closed certain areas to harvesting permanently for ecological studies.[8]

In Oregon, the fishery first developed in earnest after landings started falling in southern California in 1986 and the harvest peaked at 9.3 million pounds in 1990. In 1988 the first management restrictions were enacted which limited the number of harvesters by a non-transferable permit system with non-issued permits allocated by lottery and minimum landings of 20,000 pounds in the previous year required for renewal, a minimum harvest depth, a diameter limit of 3½ inches.[9]

By 1976 the landings in Washington had increased to

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[8] Haaker, P. "The Southern California Red Sea Urchin: A Case History." In Sea Urchins, Abalone, and Kelp: Their Biology, Enhancement and Management. Eds. C.M. Dewees and L.T. Davies. (La Jolla, CA: California Sea Grant College, 1992), p. 30.

[9] McCrae, J. "Oregon Sea Urchin Fishery, 1986-1991." In Sea Urchins, Abalone, and Kelp: Their Biology, Enhancement and Management. Eds. C.M. Dewees and L.T. Davies. (La Jolla, CA: California Sea Grant College, 1992), p. 32.

approximately 1.5 million pounds which prompted more stringent regulatory measures after surveys were conducted on suggested management measures. Prior to this, only licenses and records of landings were required of harvesters. Fishing districts were formed which were rotated for harvesting every three years; this allowed replenishment to occur in depleted areas. Upper and lower size limits were also established to ensure successful reproduction, and closed seasons were enacted to coincide with maximum roe yield. When landings reached 8.1 million pounds in 1989, the first emergency closure was ordered to preserve the industry. In the following season, sea urchin divers and state officials jointly authored a limited-entry system with a goal of establishing 45 vessels to harvest the coastal waters. This measure, however, was rejected by the court as too restrictive, so the goal was increased to approximately 100 vessels and limits on the fishing week and number of persons on a boat were enacted.[10]

With the dramatic rise by 1987 of the volume of urchins being harvested in Maine, due in part to the "wild west" mentality of the 1,439 licensed harvesters in the otherwise unregulated environment, attention was finally turned to the resource with six fatalities of urchin divers during the 1992-93 season. Most of the accidents in the operations have been the result of attempts to maximize productivity during time at sea, putting the examination of safety issues in a secondary position. During the 1994 legislative session, emergency measures were enacted requiring safety training for all urchin

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[10] Bradbury, A. "A History of Red Sea Urchin Management in Washington: The Manager's Perspective," In Sea Urchins, Abalone, and Kelp: Their Biology, Enhancement and Management. Eds. C.M. Dewees and L.T. Davies. (La Jolla, CA: California Sea Grant College, 1992), p. 33.

and scallop divers. This was the opening shot fired from the regulators of marine resources in the state, leading to the implementation of more specific restrictions on the type and timing of activities allowed in the harvesting of sea urchins in the coastal waters of Maine.

The law stipulated that all divers and tenders must take a safety course offered by the Department of Marine Resources prior to receiving their 1995 permit licenses. This law had a special importance to participants in the harvest, as those persons not holding licenses for the 1995 season would not be able to reapply until 1999. A provision was included in the law grandfathering all current licensed harvesters who had been active for three years prior to the enactment of the law would not have to take the course, but only a safety seminar. Waivers were granted to those persons who were already adequately trained for diving, through such programs providing SCUBA certification, diver/rescue training, CPR/first aid, or equivalent. Proof of open water scuba certification is a prerequisite for taking the course. While many of the independent-thinking harvesters grated at the idea of authorities telling them how to do their job, the post-course opinions have been predominantly positive, with the manner in which material is presented being more suggestive than imposing.[11]

In order to control the number of individuals participating in various aspects of the industry, licensing requirements were established by the Legislature for the following activities in the industry: diving; dragging;

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[11] "Safety Course Mandatory for Diver Licensing," Commercial Fisheries News, February, 1995, p. 4B.

tendering to a diver; operating a platform; transporting sea urchins or parts; possessing and dealing sea urchins; and processing sea urchins.

A sea urchin hand fishing license requirement was adopted in 1993, § 6748 was **Hand fishing sea urchin license:**

> 1. **License required.** It is unlawful for a person to engage in the activities authorized by the license under this section without a current hand fishing sea urchin license or other license issued under this Part authorizing the activities.
> 2. **Licensed activity.** The holder of a hand fishing sea urchin license may take sea urchins by hand or possess, ship transport or sell sea urchins taken by that licensee.
> 3. **Eligibility.** A hand fishing license may be issued only to an individual and is a resident license.
> 4. **Fees.** The fee for a hand fishing sea urchin license is $89.

A sea urchin draggers license requirement was adopted in 1993, § 6748-A **Sea urchin draggers license:**

> 1. **License required.** It is unlawful for a person to use a boat for dragging for sea urchins unless that boat carries a sea urchins dragging license issued by the commissioner.
> 2. **Licensed activity.** A boat licensed under this section may be used for dragging for sea urchins. The license also allows the captain and crew members aboard the licensed boat to drag for and possess, ship, transport and sell sea urchins.
> 3. **Eligibility.** A sea urchin dragging license may be issued only to an individual and is a resident license.
> 4. **Fee.** The fee for a sea urchin dragging license is $89.

A license allowing persons to perform the duties of tending a boat during sea urchin harvesting activities was created in § 6748-B **Sea urchin boat tender license:**

> 1. **License required.** It is unlawful for a person to operate a boat as a platform for harvesting of sea urchins by hand unless that person is licensed under this section or section 6748.
>
> 2. **Licensed activity.** A person licensed under this section may operate a boat as a platform for the harvesting of sea urchins by hand. A sea urchin boat tender license does not authorize the holder to harvest sea urchins.
>
> 3. **Eligibility.** A sea urchin boat tender license may be issued only to an individual and is a resident license.
>
> 4. **Fee.** The fee for a sea urchin boat tender license is $89.

The specification on what constituted a drag, and on how an acceptable drag could be used was provided in 1993, § 6748-C **Drags:**

> Except as provided in this section, it is unlawful for any person to fish for or take sea urchins using a drag, or any combination of drags, in any coastal waters of the State.
>
> 1. **Exception.** The commissioner may adopt rules that allow the use of a drag that is designed to minimize impact on the benthic environment and harvested resources. Rules adopted by the commissioner under this section must describe the type of drag that may be used, including any limitations on type or size of drag components or limitations on the length or width of the drag.
>
> This article is repealed January 1, 1999, pursuant to 12 M.R.S.A. § 6749-T.

Absolute seasonal limits on the harvesting of sea urchins from the all of the State's coastal waters were imposed in § 6749 **Sea urchin harvesting season:**

> It is unlawful for a person to fish for or take sea urchins from May 15th to August 15th, both days inclusive.

The state's coastal waters were divided into two zones which segregate the timing of harvest activities in a legislative act passed in 1993. This limitation is imposed for a finite period of time, from 1995 to 1998. The law, § 6749-N **Closed areas: 1995 to 1998**, reads as follows:

> Notwithstanding section 6749, in calendar years 1995, 1996, 1997, and 1998, it is unlawful for a person to fish for or take sea urchins from:
>
> 1. **Zone 1.** Zone 1, from April 1st to August 15th. For the purposes of this article, "Zone 1" means all coastal waters west of a line beginning at the easternmost point of Fort Point State Park on Cape Jellison then running southwesterly to channel marker #1 south of Sears Island, then running southwesterly to channel marker W2 located between Marshall's Point and Bayside in the Town of Northport, then running southwesterly to channel marker #9 east of Great Spruce Head located in the Town of Northport, then running southerly to Graves channel marker northeast of the Town of Camden, then running southeasterly to the Penobscot Bay Buoy east of Rockland harbor, then running southerly to the TB1 whistle southwest of Junken ledge, then running southeasterly to Red Nun #10 buoy at Foster Ledges, then running due south to the boundary of the State's coastal waters; and
>
> 2. **Zone 2.** Zone 2, from May 15th to October 1st. For the purposes of this

> article, "Zone 2" means all coastal waters east of that line established in subsection 1, including all coastal waters of the Penobscot River north of Fort Point State Park.
>
> The commissioner shall report annually to the joint standing committee of the Legislature having jurisdiction over marine resource matters on the quantity and type of sea urchin licenses sold in each zone in each year.

A moratorium on the extension of licenses to new members was adopted by the legislature in 1993, § 6749-O **Limited entry:**

> The commissioner may not issue a hand fishing sea urchin license or a sea urchin dragging license for calendar years 1994, 1995, 1996, 1997 or 1998 to any person unless that person possessed that license in the previous calendar year.
>
> This section is repealed January 1, 1998 pursuant to 12 M.R.S.A. § 6749-T.

The restrictions and limitations associated with the licenses issued by the commissioner for the harvesting of sea urchins were stipulated in § 6749-P **Licenses by zone:**

> For calendar years 1995, 1996, 1997 and 1998, a person eligible to purchase a license under section § 6749-O, may purchase those licenses only for Zone 1 or Zone 2. All of those licenses issued to any one person in any one year must be for the same zone. A sea urchin dragging license must list the documentation or registration number of the vessel to be used by that licensee when dragging. A vessel documentation number may not be listed of more than one sea urchin boat license.
>
> This article is repealed January 1, 1999, pursuant to 12 M.R.S.A. § 6749-T.

Limitations on the minimum size of sea urchin that may be removed from coastal waters are stipulated in § 6749-A **Minimum size:**

> It is unlawful for a person to take, possess, ship, transport, buy or sell a sea urchin having a shell measuring less than 2 inches in the longest diameter, exclusive of spines. A violation of this section does not occur if a harvested sea urchin measuring less than 2 inches in the longest diameter is culled on board immediately after harvesting and is liberated live into the marine waters.

Restrictions were passed by the Legislature prohibiting the simultaneous possession of sea urchins and lobsters on a boat in § 6749-B **Sea urchins and lobsters; simultaneous possession or transport prohibited:**

> A person licensed under section 6748 to take sea urchins by hand may not simultaneously possess or transport sea urchins and lobsters aboard a registered vessel.

The authority of the commissioner to adopt rules regarding the handling and processing of sea urchins, including the right to impose management restrictions, was made explicit in § 6749-C **Rules:**

> 1. **Importation and processing.** The commissioner may adopt rules under this subchapter that require a sea urchins processor to maintain records sufficient to identify the point of origin of sea urchins received by that processor.
> 2. **Fisheries management.** The commissioner

may adopt rules under chapter 607, subchapter I to promote the conservation and propagation of sea urchins. Those rules may include, but are not limited to, limits on size of drags used to take sea urchins, limits on the nighttime dragging of sea urchins and tolerance allowance for the harvesting of sea urchins less than 2 inches in the longest diameter.

3. **Minimum size.** Before January 1, 1994, the commissioner shall adopt rules establishing the method for determining whether a sea urchin measures less than 2 inches in the longest diameter. If necessary, the commissioner may use emergency rule-making authority under chapter 607, subchapter II to adopt rules under this subsection.

In order to raise the funds required to successfully manage the sea urchin resource, surcharges are assessed on licenses purchased over a period of 3 years, § 6749-Q **License surcharges:**

The following surcharges are assessed on licenses sold for calendar years 1995, 1996 and 1997:

1. **Hand fishing sea urchin license.** $160 on a sea urchin hand harvesting license;

2. **Sea urchin dragging license.** $160 on a sea urchin dragging license;

3. **Sea urchin boat tender's license.** $35 on a sea urchin boat tender's license;

4. **Wholesale seafood license with a sea urchin buyer's permit.** $500 on a wholesale seafood license with a sea urchin buyer's permit; and

5. **Wholesale seafood license with a sea urchin processor's permit.** $2500 on a wholesale seafood license with a sea urchin processor's permit.

The commissioner shall deposit all surcharges assessed in this section in the

Sea Urchin Research Fund established in section 6749-R.

This article is repealed January 1, 1999, pursuant to 12 M.R.S.A. § 6749-T.

The Sea Urchin Research Fund was established in order to determine what course of action the department should undertake in managing the sea urchin fishery. § 6749-R **Sea Urchin Research Fund:**

The Sea urchin Research Fund, referred to in this section as the "fund," is established in the department. Balances in the fund may not lapse and must be carried forward and used for the purposes of this section:

1. **Uses of the fund.** The commissioner shall use the fund for research directly related to sea urchin fishery management information needs. The purpose of that research must be to determine, with the highest reliability possible given available resources, the greatest level of effort that may be applied to the sea urchin fishery without harming the long-term economic and biological sustainability of the sea urchin fishery.

2. **Sources of revenue.** The fund is capitalized by surcharges assessed under section 6749-Q. In addition to those revenues, the commissioner may accept and deposit in the fund money from any other source, public or private. All money in the fund must be used for the purposes set forth in this section.

3. **Reports.** The commissioner shall submit an interim and a final report on expenditures from the fund and research findings to the joint standing committee of the Legislature having jurisdiction over marine resource matters. An interim report must be submitted by July 1, 1996. A final report must be submitted by January 1, 1998.

This article is repealed January 1, 1999, pursuant to 12 M.R.S.A. § 6749-T.

In order to maintain the necessary information base for the management of the sea urchin industry, the Legislature has required that log books be kept by buyers and processors, § 6749-S **Log books for sea urchin buyers and processors:**

> The commissioner shall adopt rules requiring any person holding a wholesale seafood license with a sea urchin buyer's permit or a wholesale seafood license with a sea urchin processor's permit to maintain a log book. The rules must indicate the type of data that must be recorded in the log book, the manner for producing the log books and the method for analyzing the data from the log books. The commissioner shall charge a fee for the log book that is sufficient to recover all costs associated with the production of the log book and analysis of the data, except that any personnel and operating costs associated with the log book must be paid from allocations from the Sea Urchin Research Fund. Fees received from the department from the sale of log books are dedicated revenue and must be used by the department for the purposes of this section. The log book and data analysis may be produced and conducted by the department or may be produced and conducted by a public or private entity under contract with the department. Disclosure of any data collected under this section is subject to the confidentiality provisions of section 6173.
>
> This article is repealed January 1, 1999, pursuant to 12 M.R.S.A. § 6749-T.

The privilege of engaging in activities involving the dealing or processing of sea urchin parts within the State is restricted in § 6851 **Wholesale seafood license:**

> 2-B. **Wholesale seafood license with a sea urchin buyer's permit.** At the request of the applicant, the commissioner shall issue a

wholesale seafood license with a sea urchin buyer's permit. A person holding a wholesale seafood license with a sea urchin buyer's permit may engage in all the activities in subsection 2 and may buy, sell, ship or transport whole sea urchins. A license under this subsection does not authorize a person to engage in the processing of sea urchins or to buy, sell, ship or transport sea urchin parts.

2-C. **Wholesale seafood license with a sea urchin processor's permit.** At the request of the applicant, the commissioner shall issue a wholesale seafood license with a sea urchin processor's permit. A person holding a wholesale seafood license with a sea urchin processor's permit may engage in all the activities in subsection 2 and may buy, sell, process, ship or transport whole sea urchins or sea urchin parts.

6. **Fees.** The fees are as follows:

A. $217 for a wholesale seafood license or a wholesale seafood license with a lobster permit, sea urchin buyer's permit or sea urchin processor's permit.

There are concerns regarding the enforceability of the zoning laws, however, because of the difficulty in catching a boat harvesting outside of its licensed zone. If confronted, the boat could simply claim that it was recreationally diving or pursuing scallops. Even if it were caught, the penalties involved are insignificant enough that the damages could be recouped in a single day of work. There is currently an effort underway in the Legislature to increase the penalty for any infraction of the existing regulations to $500. Some within the industry, however, feel that even a fine of this size is insignificant in relation to the daily income from catches.[12]

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[12] Kyle, B. "Urchin Harvesters Pack Hearing on Two Proposed Bills," Bangor Daily News, 30 January 1996, p. 1A.

Concerning the law on the maximum size of drag allowed in harvesting, this does not address the *type* of drag involved, thus allowing draggers to continue practicing indiscriminate dragging techniques which are detrimental to the overall health of the benthic environment. On the West Coast, dragging for urchins is not allowed because of these harmful effects. In addition, draggers often cull their catches away from where urchins were removed, thus greatly reducing the probability that those urchins will be able to rejoin the reproduction process.[13]

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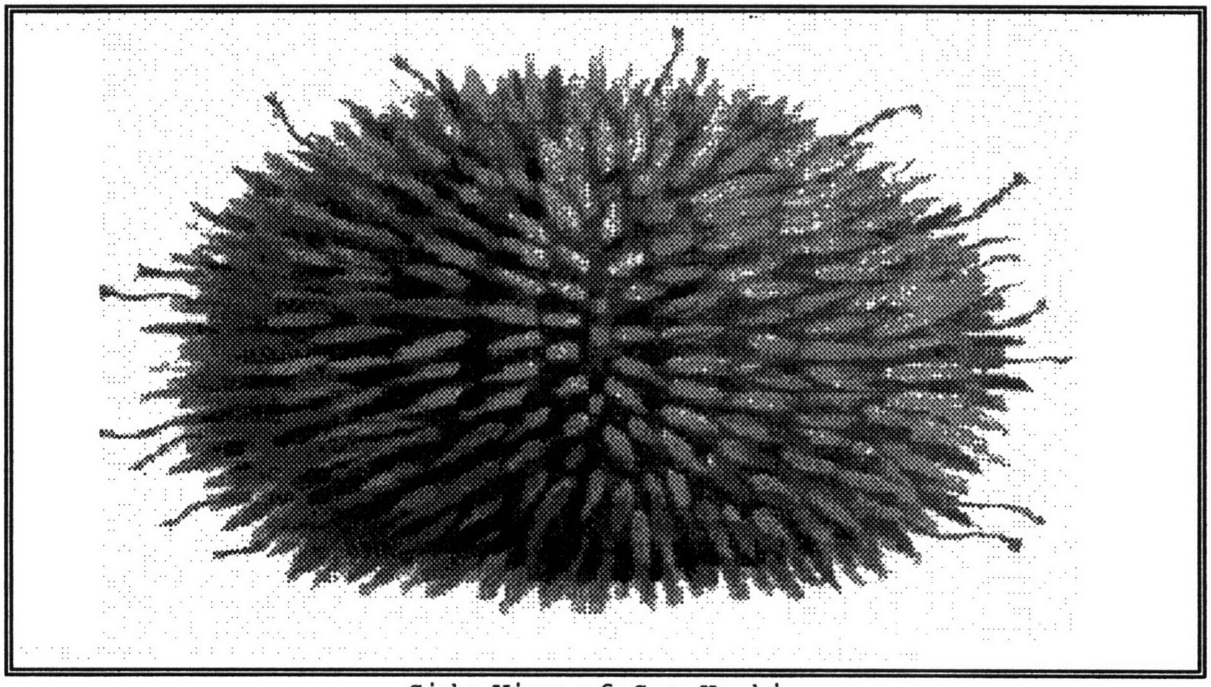
[13] Baldwin, L. "Rocky Reefs Yield New Treasure." Bangor Daily News, 20 May 1995, p. 1A.

Chapter III

The Trade of Exporting Sea Urchins

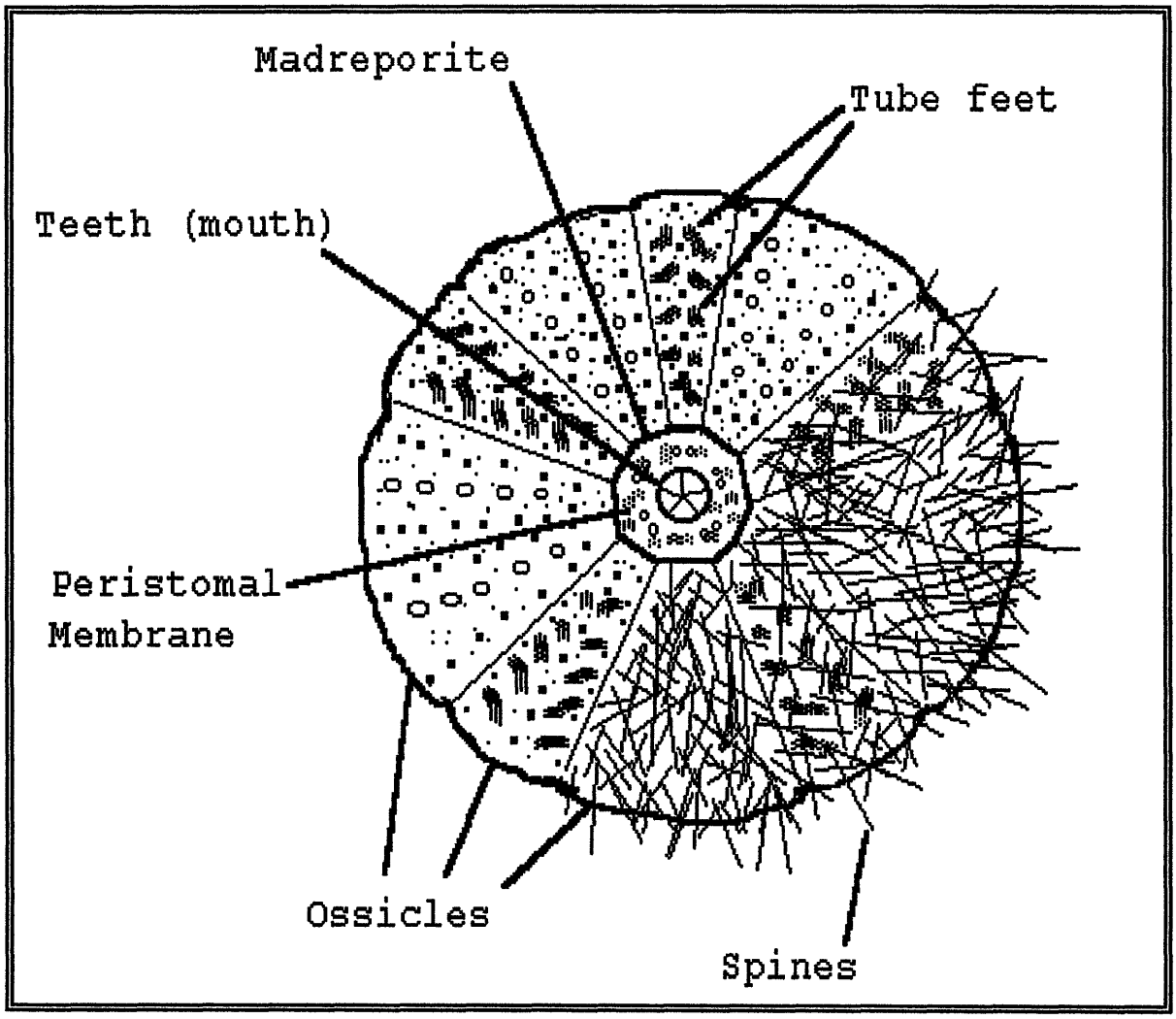
Biology and Reproduction of the Green Sea Urchin



Side View of Sea Urchin
Figure 4

The species of sea urchin harvested in Maine, *Strongylocentrotus droebachiensis,* is called the green sea urchin and is classified within the phylum *Echinodermata,* subphylum *Echinozoa,* class *Echinoidea.* The organisms of this phylum all are invertebrates with an internal skeleton, comprised of 10 plates of calcite ossicles, chemically composed of calcium carbonate. As adults, the rigid sea

urchin skeleton, or test, exhibits a fivefold symmetry in its discoid shape and has many spines extending outward which protect it from predators and strain food from the water column. Every other ossicle has openings between the spines which allow tube feet to extend out and capture food, provide locomotion or hold on to the substrate.[14] Figure 5 below shows a basic diagram of the exterior of a sea urchin.

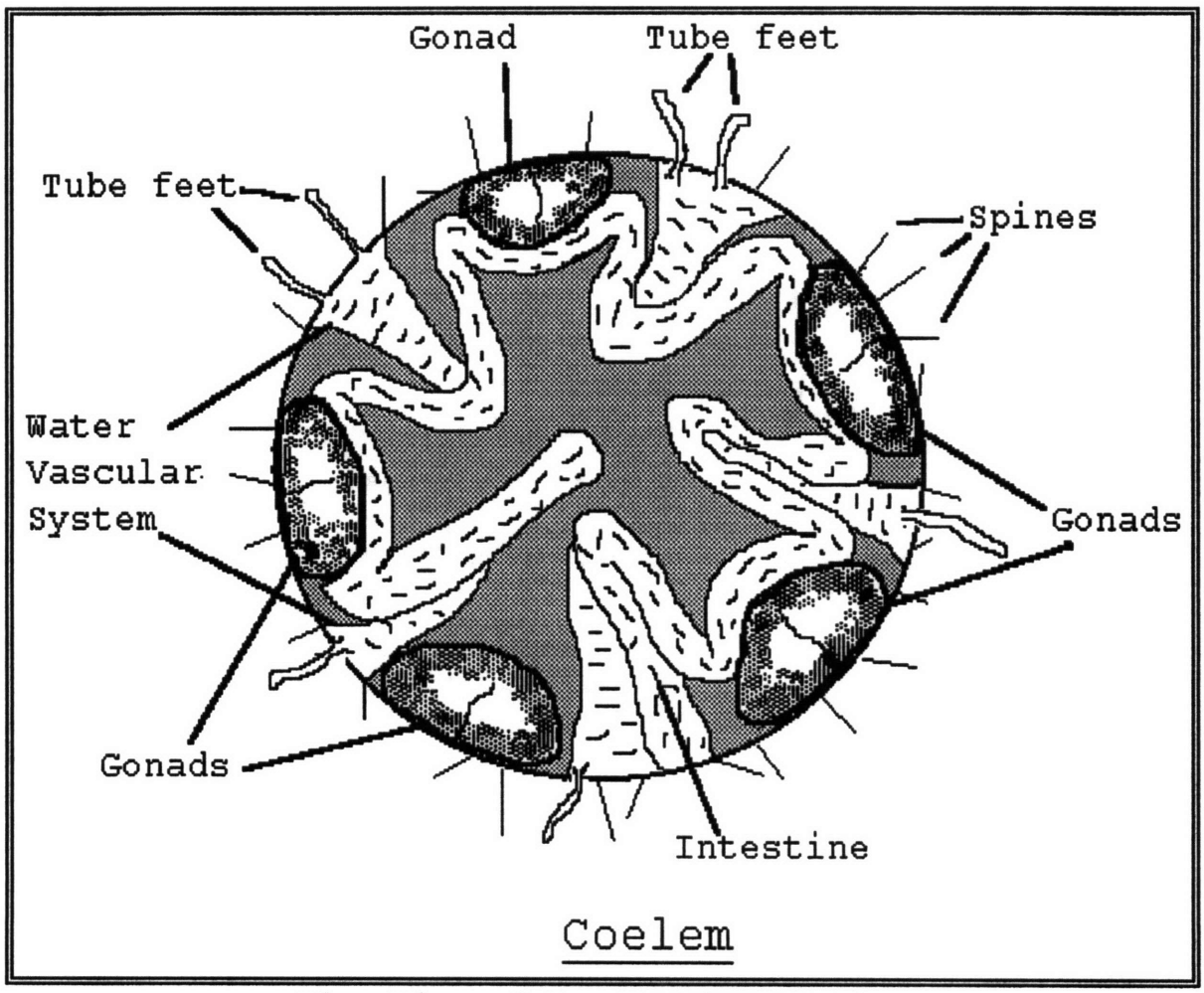


Plan View of Sea Urchin Exterior (bottom)
Figure 5

[14] Sea Grant Extension Program Publication, California Sea Grant College Program: University of California Cooperative Extension, http://seaurchin.org/Sea-Grant-Urchins.html/, April 1995.

Within this skeleton resides a system of fluid-filled vessels radiating out from the upper pole of the test, down the interior walls of the main body cavity, or coelom, to the ring at the lower pole of the test, called the madreporite.

This vascular systems serves several essential purposes for the organism, including locomotion, feeding and sensory perception. Along the walls of the water vascular system within the coelom are numerous tube feet which are used for locomotion, capturing food, sensory perception and respiration. As shown in Figure 6 below, these tube feet may



Plan View of Sea Urchin Interior
Figure 6

be in contact with the exterior surroundings by extending through the ossicles.

Spawning occurs at various times, depending on many oceanographic environmental factors, and may commence as soon as February, but predominantly occurs during the months of March and April. It is thought that chemical cues are responsible for the onset of reproduction, since this occurs nearly spontaneously among a given population.[15] The urchins must be congregated in a sufficiently dense population so that the sperm and eggs can couple; studies of the red sea urchin on the West Coast show that sperm released from males are only active for a few minutes.[16] Thus the spontaneous emission of gametes within a sufficiently dense population of urchins increases the chances of successful reproduction. Naturally, the urchins have their lowest roe content after spawning has occurred, during the months of May, June and July.

As larvae, urchins are microscopic and drift for six to eight weeks before reaching sufficient size to drop out of the water column. At this stage, they are very sensitive to temperature, bacteria and pollutants; the eggs do not develop well in temperatures above 50° F but can withstand temperatures slightly below 32° F. Upon falling to the sea floor, the larvae quickly change to small juvenile sea urchins of only one or two millimeters in diameter and begin foraging on whatever food is available in the vicinity. If they are not consumed as prey during this vulnerable stage of their lives, they can reach diameters of up to 2 inches and sexual

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[15] Harris, Larry. Personal Communication. 15 February, 1996.

[16] Sea Grant Extension Program Publication, University of California Cooperative Extension.

maturity in three to four years.[17] It is generally thought that urchins reach sexual maturity at a size of about 1-1½ inch body diameter, although research elsewhere suggests that maturation is dependent on geographic characteristics of an area, such as the amount of light and nutrients fostering the growth of kelp, their main source of food. As many nutrients are carried and deposited by the water column, the amount of water flow past the population site is also a significant factor in the vitality of the benthic environment and thus the urchin population. Where urchin populations are particularly dense, competition for food may restrict the amount of roe that develops in the urchins, thus making them less desirable for marketing.[18]

Larry Harris of the University of New Hampshire has carried out research into the effects of environmental conditions on the settlement, recruitment and growth of green sea urchins. One finding was that populations become increasingly sparse in deeper waters, yet the survival beyond three months may increase with depth for an individual organism. While their growth rates are highly variable, depending on the availability of nutrients in the benthic region, those urchins whose diets were omnivorous were most robust in growth, although their roe was not as high in quality as kelp-fed urchins.[19]

Urchins are known to have eaten whole forests of kelp in

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[17] Chenowith, S. The Green Sea Urchin Fishery in Maine. (Boothbay Harbor, ME: Maine Department of Marine Resources, 1994), p. 6.

[18] Baxter, p. 4.

[19] Lannin, J. "Invasion of Sea Urchins 'a Plague,'" Maine Sunday Telegram, 20 July, 1986, 15A.

coastal California waters, and have eaten kelp as a component of their diet in Maine as well, particularly that of a type known as *laminaria*. As a population of urchins approaches a region of kelp growth on a ledge uprising, they progressively move upward gaining mass as they consume more kelp. As such, their roe content is greater and because of the beta-Carotene rich kelp diet, which is responsible for the bright-yellow coloring prized by Japanese consumers, the roe is of higher quality and therefore more valuable to the industry. The immature urchins in lower depths continue to move into the forest, reaching the "feed line", a conceptual demarcation of the bottom just below a kelp bed, generally at a depth of 30 to 40 feet. In order to grow to sufficient size so that they can successfully reproduce, it is thought that urchins must be allowed to reach this level.[20] One study found that urchins in shallow waters had gonads which were larger and or better quality than those of deeper waters, which is most likely attributable to the availability of more and/or better food.[21]

The organism's sexual organs or eggs, being the most valued parts by the consumers, are ideally harvested at the time of year when they comprise their maximum possible percentage of total weight of the organism. This weight standard, referred to as the roe standard by harvesters and processors, is one of the driving criteria by which harvesters decide when their activities are carried out during the season. The growth of the urchin's reproductive organs is

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[20] Canfield, Clarke "Urchin Boom May Lead to Crash," Maine Sunday Telegram, 22 December 1991, 1B.

[21] Kramer, D.E., and Nordin, D.M. Physical Data from a Study of Size, Weight and Gonad Quality for the Green Sea Urchin (Strongylocentrotus droebachiensis) over a One-Year Period, p. 34.

thought to commence during the summer months after spawning and continues to reach a maximum after late October or early November.[22] There was no significant correlation seen between the coloration of the gonads and the time of year; however, they were found to be darkened somewhat after spawning had occurred, roughly from March to July.[23] Coloration is thought to be more of a function of the quality of diet accessible to the urchins, as mentioned above. The urchins carry their greatest value during that period when their roe content is greatest, the color is brightest, and the texture is firmest. This occurs for *S. droebachiensis* roughly during the winter months in Maine, from November until March.[24] The seasonal variation in roe content has important implications for the marketing aspect of exporting to Japan, as the period of least supply by local Japanese harvesters coincides with the period of greatest gonadal yield and supply in Maine.

Harvesting, Processing, and Exporting the Urchin Roe

The majority of sea urchin's harvested during the early growth of the industry in Maine were brought to the surface using dragging equipment similar to that used by scallop draggers. This was largely due to the fact that their methods are able to remove greater numbers of urchins in a given amount of time than an equivalent number of urchin divers, and

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[22] Chenowith, p. 5.

[23] Kramer, p. 38.

[24] Chenowith, p. 3.

they are able to harvest areas that are inaccessible to divers for safety reasons. Some urchins are damaged, however, during the process of dragging over the bottom, either from the weight of the equipment or from rocks being caught in the drag. This damage reduces the likelihood that the urchins will be acceptable to processors who depend on a high quality product. Because draggers can only operate over relatively flat areas of the ocean floor, they can only harvest those urchins that eat various organic materials and algae floating in the water column, a sub-optimal diet for value on the consumer market. In subsequent seasons more divers have acquired licenses for harvesting sea urchins, as shown in Figure 7 below, but the number of both types of licenses has declined in the last year due to the five-year moratorium on issuing new licenses.[25]

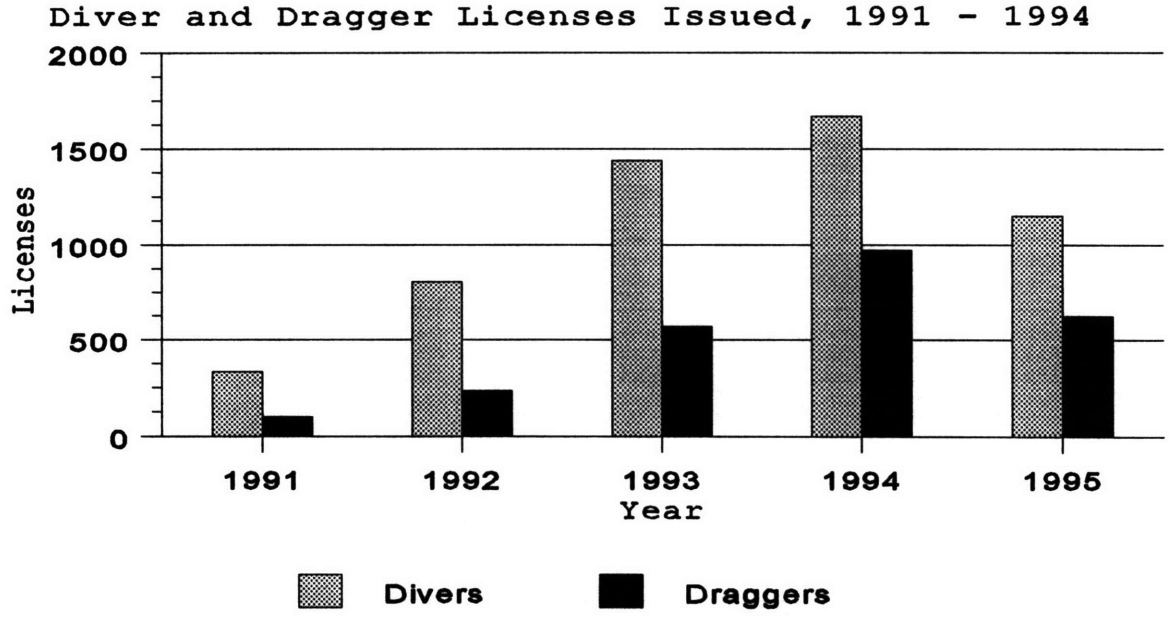

Figure 7

[25] Creaser, Ted. Maine Department of Marine Resources. Personal Communication. 25 March, 1996.

Divers, on the other hand, use hand-held rakes to dislodge the urchins from ledges and gather them into small piles before placing those individuals that exceed the minimum size in net bags which are tied to a buoy on the surface. When the bag is full the diver tugs on the buoy, signaling to the dive tender that it can be winched up to the surface. A sample of urchins is taken from the catch and opened to discern the color of the roe and thus determine if the rest of the catch will be marketable.

There are efforts within the research community to develop technologies which would avoid the harmful effects of drags on the benthic environment. At Northeastern University, Dr. Susan Goldhor is developing a technique where baiting could be used to trap urchins until they are brought to the surface. Using nuisance seaweed which washes up on beaches, *Pilayella littoralis,* the researchers are testing various cage assemblies with fishermen to test their effectiveness. Once caught, they intend to hold the urchins, feeding them a diet of higher quality nutrition in an effort to raise the roe content, and thus the value, of the individuals.[26] Trapping would most likely only be an option in the summer months, after spawning has occurred and the urchins have lost most of their mass. At this time, they are more mobile, as they search more aggressively for food in order to regain mass lost during reproduction.[27]

Another prospective method for bringing urchins to the surface has been through the use of a suction device, a

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[26] "Increasing Income through New Technology Development for Sea Urchin Industry," Commercial Fisheries News, October 1995, p. 3B.

[27] Baxter B., and Chamberlain, B. The Harvest of Green Sea Urchins on the Coast of Maine, (Boothbay Harbor, ME: Department of Marine Resources, 1988), 5.

creation of Bruce Chamberlain's in Maine's Department of Marine Resources.[28] Using suction from compressed air created by a boat's engine, urchins are forced to the surface through a 6 inch diameter hose. This method, which can be reproduced for under $1,000 or less, avoids damage to the urchins shell which can occur as a result of the weight of a drag. Once an urchin's shell is cracked and sea water gets inside, the value to the Japanese consumer of the roe inside is lost.

Once the urchins are brought to the shore, they are either sold directly to a processor operating in the harbor or sold to a dealer who arranges for their overland transport to a processor within a day. The urchins are then sampled again by the processors and sorted by quality before either being sent to be processed directly or placed in storage, depending on operational conditions in the facility. They are then opened either manually by using a hand-tool to ply the test apart, or by a conveyor-operated cutting machine that removes the bottom portion of the test. Once opened, the gonads are then removed using a spoon-like device by handlers who sort the roe by color and place them on metal trays where a preliminary washing by cold saltwater is done to remove any bits of shell or other organic matter. A final cleaning is then performed by handlers using tweezers to remove all remaining foreign matter. The gonads are then placed in stackable plastic containers and soaked in a cold saltwater bath having a controlled concentration of a potassium solution for between 15 minutes and an hour, until the roe becomes firm

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[28] Kreis, D.M. "Maine's New Cash Crop," Maine Times. 29 July 1988, p. 27.

enough for shipment. The roe is then drained and placed in small wooden trays (approx. 4"x6"x1") which are stacked and tied in bundles of up to 15 trays. The bundles are then bagged in plastic and refrigerated until final preparation for shipment. At that time, the bundles are placed in insulating cartons which are filled with an artificial coolant. From the processing center, the urchins are trucked to the airport in Boston and flown directly to the Japanese market in Tokyo. From landing on the wharf to arrival in Japan, the processing and shipment of the urchin roe takes six to seven days.[29]

As the scale of a processor's operation continues to grow, the amount of wasted product, that lost or damaged during extraction becomes increasingly important. In the first few years of large scale exporting from Maine after 1987, the urchins were packed and shipped whole to the factories in Japan for processing, at a cost of approximately $1.50 per pound. In order to survive the trip, they were packed in specially insulated cartons at 30° Fahrenheit. After processing at the Japanese plants, 90% or more of the urchin shipment, by weight, is discarded as waste from normal processing operations but also from the rejection of roe that is unacceptable to the Japanese market. Obviously this was an area where costs could be reduced by processing the urchin domestically, saving much of the weight from being transported. In order to do this however, another cultural difficulty would have to be accounted for: the long-standing consumer loyalty exhibited by the Japanese towards processing houses in Japan which have been in operation for many

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[29] Turgeon, Kathy. Personal Communication at I.S.F. Trading, Inc. 21 March, 1996.

generations under the ownership of a family claiming the highest quality roe.[30]

In response to this, the Japanese started setting up processing centers in the United States, two of them located within the state of Maine. Along with processing centers of domestic ownership, the trend has reversed to the point where the great majority of the valued roe is extracted from the urchins before shipment to overseas markets. Now that much of the processing activities are carried out locally, there is more focus on how these activities can be carried out with minimal investment in man-hours and loss of product due to damage during extraction. There are currently efforts underway to increase the utilization of automated roe-extraction machines in processing centers. Currently, there are four sites within Maine where these machines are being used and negotiations are under way for the sale of these machines to processors in California, South Africa and Chile.[31]

One of the greatest concerns in the processing of the urchins is the amount of product lost as a result of breakage to the roe during extraction and discards which are found to be of substandard quality for marketing in Japan. It is estimated that 60 percent or more of the urchins removed from the ocean are lost during one of the many steps in harvesting, processing and shipping to destinations.[32]

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[30] Austin, P. "In Japan's Seafood Market, Lowly Maine Sea Urchin is a $100-a-Pound Steal," Maine Times, 7 September, 1990, p. 12.

[31] Stevens, L. "Cutting Machine 'Revolutionizes' Urchin Processing," Commercial Fisheries News, December 1994, p. 7B.

[32] Austin, P. "Sea Urchin Fiasco Illustrates Failure of State Policy," Maine Times, 5 March, 1993, p. 3.

Growing Pains for the Industry

As the industry increases in its scale of operation, conflicts are certain to arise between competitors at various levels of the export process. During the fall of 1995, there were concerns raised by a group of urchin processors, represented by the Maine Sea Urchin Processors Association, that unfair practices were being employed by out-of-state processors. It is alleged that processors based in New York were bidding up wharf prices for urchins in Maine to levels where Maine-based processors could not compete. They are able to do this, it is alleged, by employing Asian immigrant labor through "temporary" agencies, paying them cash at wages well below the minimum levels required by law. An investigation into the allegations has been initiated by the Maine Attorney General's Office along with U.S. Immigration authorities.[33]

In addition to conflicts between competing urchin processors, there have been disputes between the harvesters and dealers within the state resulting from the instability of urchin prices at the wharves. Urchin draggers and divers initiated a strike over allegations that prices were being held at artificially low levels upon the opening of the state's northern harvesting zone in early fall. Wharf prices dropped from $1.25 per pound to 70 cents, with occasional bids at a paltry 25 cents for a pound during the first few open days of the northern zone. Prices were sustained at levels above $1.00 in the state's southern zone. Even during the middle of a zone's open period, bidding wars would

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[33] Baldwin, L. "Urchin Processor's Claims Prompt U.S., State Probe," Bangor Daily News, 19 October 1995, p. 1A.

occasionally break out where prices would fluctuate from $3.00 to as low as 40 cents per pound.[34]

Dealers contended that the slide in prices is merely a result of a stretch of good weather, which allows more days at sea for the harvesters, and decreased demand from Japan. As a result, harvesters asserted that the lower prices encouraged the extraction of more urchins than would normally occur in an effort to make up for the loss of revenue. As a parallel effect of bringing in a greater number of urchins, the quality of the product would be diminished because of less selective harvesting efforts, thereby exacerbating the downward trend in prices. It was argued, the benchmark price of $1.00 per pound would be a form of conservation measure, ensuring the economic viability of a harvesters day at sea under normal conditions. The issue was resolved after eight days when the divers and draggers agreed with dealers on a minimum bid price of $1.00 per pound for urchins containing a minimum of 10% roe by weight.[35]

This experience of discord between the dealers and the harvester's brings to light one of the strategic problems encountered in the export of sea urchins. Because of the high dependence of the roe's value upon its perceived quality by the dealers in Japan, attempts by Maine harvesters to export substandard roe in an effort to maintain a certain volume of flow could have damaging consequences on the future working relationship between the agents. This effect would be in addition to the lost revenue from spending time at sea harvesting

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[34] Baldwin, L. "Sea Urchin Divers Seek $1 a Pound," Bangor Daily News, 13 October 1995, p. 1A.

[35] Baldwin, L. "Sea Urchin Harvesters End Strike," Bangor Daily News, 19 October 1995, p. 1B.

urchins rejected by dealers at the wharves, by processors who reject urchins during preparation. If the substandard product makes it to the market in Japan, the processor incurs the additional cost of shipping the roe. During the 1987/88 season, it was estimated that the industry received revenue for only one of every ten urchins harvested.[36] While there is no doubt that this inefficiency in the process has been diminished as the industry moves along the learning curve, harvesters must remain educated of the damaging consequences indiscriminate harvesting will have on the future competitiveness of the industry.

Another factor in the volatility of the market is the exchange rate between the dollar and the Japanese yen. With the dollar relatively low compared to the yen, the cost of shipping overseas has been held in check, despite continuously increasing fees charged by airlines for shipping. According to Chris Duffy of the University of New Hampshire, if the dollar were to rise while other currencies where urchins are exported to Japan remain stable, the cost of shipping could increase beyond the range of economic viability for American exporters.[37] Trade agreements with other nations may also upset the balance that supports the export season in Maine. For example, in 1987 the former Soviet Union and Japan entered into a trade agreement which disrupted the demand for urchins from Maine. By increasing the number of destinations where urchins are shipped, such as to European and other Asian countries, fluctuations in the demand of urchins from Japan can be buffered so as to have a smaller impact on the harvesters and processors operating in Maine.

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[36] Baxter, p. 1.

[37] Kreis, p. 27.

Chapter IV

Sea Urchins as a Finite, Renewable, Common Property Resource

Introduction to Hardin's "Tragedy of the Commons"

Who owns the air we breath? Or the water we drink? As resources which do not readily accept being confined to any border of space, it can be argued that they do not fall under the ownership of any one individual. Rather, because they are utilized by all of the individuals comprising a population, they are referred to as collective resources, that is, resources which are considered the common property of the general population. As our technology grows increasingly able to alter the environment around us, the barriers which previously prevented us from harnessing the benefits offered by these resources fall, and as a consequence, those resources no longer remain free to all in equal measure but instead are bestowed upon those having access to the technology which makes the beneficial properties of that common resource available at all. Examples can be considered for many common property resources: dams that contain the water in rivers, factories and vehicles that consume the air we breathe, signs and other messages carried by visual media that infiltrate our sight, noise from various activities that assaults our ears, minerals and rare elements that are mined, trees on government

land that are harvested, and living resources in the sea that are caught for food. All of these common resources were brought under the domain of a certain number of individuals through the application of technology. Those who had access to the technology are able to use the common resource for their own purposes, taking some unit of benefit that they alone receive while the owners of the resource, the general public, receives no direct compensation for the unit depletion of their resource.

This idea of the utilization of common property resources has been discussed in an article by Garret Hardin, entitled The Tragedy of the Commons.[34] In this article, a situation is described wherein there exists a finite population of a common resource, a field for example, where a certain number of agents use the common resource for their own purpose by herding their cattle on it, to continue with the example of the field as a common resource. In order to gain the greatest benefit from the field, each herder will try to maximize the number of cattle that he can graze on the field. In considering the benefit that he will gain by adding one additional animal to his herd, he realizes that he will gain one corresponding unit of benefit entirely to himself. On the negative side, he realizes the incremental damage that this animal will inflict upon the field, but this negative impact is shared between all of the agents who are using the field to graze their cattle. Thus that particular herder sees the negative impact as detracting only a fraction of the positive benefit resulting from the animal's grazing activity. Seeing

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[34] Hardin, G. "The Tragedy of the Commons." Science 162 (13 December, 1968): p. 1243-1248.

this result, the herder can thus rationalize that he may add additional animals to his herd, gaining the benefits from the increase while allowing the detrimental effects to be shared among himself and his fellow herders.

The problem arises when all of the other herdsmen utilize the same logic, so that they increase the number of animals in their own herds, realizing the benefit individually while allowing the detriment to be shared generally. At this point, the "tragedy" is realized, where the freedom of each individual to add an animal to his herd contributes to the collective degradation of the resource when the detrimental effects are aggregized over all the herdsmen. As long as the field is large enough to provide for the amount of cattle grazing on it, there is no problem with the situation; but when the carrying capacity of the field is reached by all of the herdsmen taken together, either there will be a voluntary limitation by the herdsmen of the size of their herds or there will be a natural failure of the herd to sustain itself on the limited land available.

Correlation to the Sea Urchin Industry

The translation of this hypothetical situation to the sea urchin industry is straightforward. Sea urchins, found in the environment of the coastal waters and under the jurisdiction of the state, are a common property resource. As such, they are under the stewardship of the state government, in turn representing the ultimate owners of the resource: the citizens of the state of Maine. The fishermen who harvest the sea

urchins are the agents utilizing the resource in order to earn a living. While they are the agents who actually remove the urchins from the natural habitat, the various people associated with the processing and exporting of sea urchins should be considered equal partners in realizing the benefits that result from the utilization of the common property resource; without either of these agents, the market value associated with the sea urchins could not be gained at all. The citizens of the state, including of course those agents involved in the various aspects of bringing the urchins to the market, are the ultimate owners of the resource and thus have a stake in ensuring that the vitality of the population is maintained for succeeding generations who will need the resource in order to earn their living as well as for the health of the coastal ecosystem in general.

In light of this situation, a balance must be reached where the immediate interests of the current agents are recognized while not curtailing the future market potential of the resource. A traditional response to this need for temperance of current utilization would be to resort to administrative statute in order to restrict participation in the harvest, the methods allowed by the harvesters, or some other measure to limit the removal of urchins from coastal waters. Such an approach is often met with the ire of the people to whom it is directed, as it is being imposed from a governing body which resides outside of the culture which is directly affected by the decrees. Such prohibitive rulings are often seen as being unfair to the unique cultural setting in which the activities are carried out. In this case, the coastal fishing communities of Maine have a strong history of

independence developed through many generations over the years of hard work in the rugged ocean environment. Any attempt by people outside of the community to impose restrictions on their way of life is met as an assault on their traditional ways of earning a living.

To their credit, the people who have been harvesting the various fisheries have been able to maintain their way of life for many years. Yet the incremental changes in technology over recent decades and the resulting influence on the increased scale of harvesting activities must be acknowledged. Traditional attitudes toward the oceans as unlimited sources of living resources have to be reconciled with the greater freedom provided by new technologies which allow fishermen greater range and time out at sea. The recognition of necessity for this change must emerge from within the population of agents in order for the corrective course of action to have any acceptance over a significant period of time. The challenge is to devise a system whereby the authority in limiting the action of the agents is born of and respected by the equal participation of the agents themselves. Modeled after the democratic institutions devised by this country, in combination with the traditional significance of local town meetings in Maine, such an authority could operate as a ruling council recognized within the industry as promoting the long-term stability of the resource.

The willingness of the agents to abide by the limits imposed on the resource is one of the biggest obstacles to the successful management of the resource. An individual faced with the decision of complying with the limits imposed on their activities will face what is referred to in Hardin's

article as the double bind: if the person doesn't comply, he is openly condemned by the population for not acting responsibly; if that person does comply, he is condemned as a simpleton while the rest of the population takes advantage of the commons. This bind, however, dissolves away when it is recognized that the limitations apply to all participants in equal measure, as mutually agreed upon restrictions.

The perception of a loss of freedom by that individual may be transformed into a recognition that this sacrifice in the short term will lend itself to greater freedom in the long term, showing itself in non-marketable commodity called option value. Option value is the existence of future freedom in choosing future courses of action in regards to the management of the resource. For example, the decline of groundfish species in the Northeast fisheries, as demonstrated in Figure 8 below,

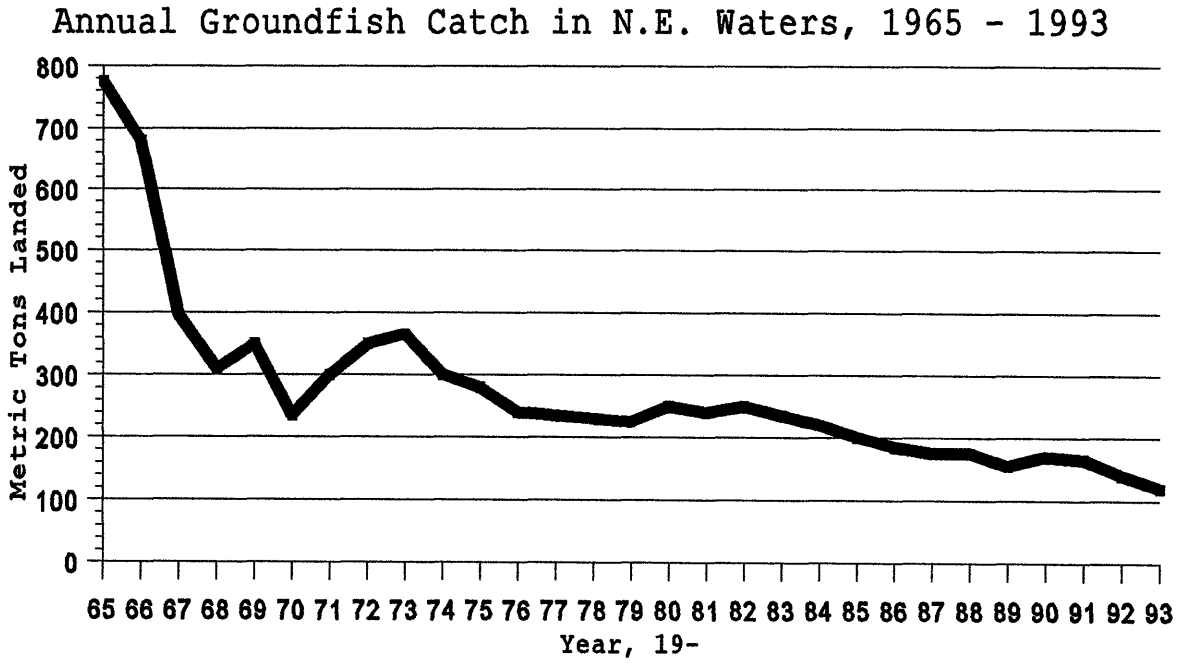

Figure 8

8 was a result of many years of overfishing in an area where there was no control exerted by the population over who had access to the stocks and how much of that stock they could remove.[35]

Before passage of the Magnuson Fishery Conservation and Management Act by the U.S. Congress in 1976, there was an unbridled effort to catch fish in the richest areas of the coast of New England because foreign fishing vessels were established in the region and showed no concern for preserving any of the stocks to ensure reproduction. With the foreign vessels removed from within the 200-mile limit and no other effective conservation measures in place, the domestic fishing fleet invested much money in equipment which allowed harvesting and processing activities to occur on a larger scale than was possible with the foreign competition in place. Essentially, the open access to the fishing stocks by the domestic fleet continued the problem to where, according to one fisherman, "Nobody wants to forego an income in the present if they're not going to benefit in the future. People don't see the benefit of investing in conservation in an open access fishery."[36]

The delay in acting to preserve the resource resulted in a catastrophic loss of option value when there was no choice left but to close the most productive areas of George's Bank fishery entirely to further harvesting. A lawsuit filed by the Conservative Law Foundation in 1991 to halt the further decline of fishing stocks resulted in Amendment 5 being

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[35] "Fishing in New England by the Numbers," Boston Globe, 11 December 1994, p. 53.

[36] Pollack, S. "Finding a Fix for Northeast Groundfish," National Fisherman, November 1990, p. 12.

implemented by the New England Fishery Management Council. This calls for a 10% decrease in fishing mortality each year for five years, yet some scientists say that even this will not be enough to allow stocks to replenish. Total closure of the areas is being recognized by many as the only way to ensure that stocks are able to recover. According to the chief scientist at Northeast Fisheries Center in Woods Hole, Massachusetts, "They've refused to bite the bullet for the last 15 years, and now it's over." Now the only option being considered is how to limit access to the stocks, and in this effort, a boat buy-back program has been implemented in order to encourage people to leave the industry, for many fishermen, the only way of life they have known.[37] This experience demonstrates that by preserving the option value of a resource, future market value may be realized on a consistent basis, albeit on a necessarily smaller level than at those enjoyed in the years when the available technology didn't allow harvesting to occur on a scale that threatened the continued existence of the various groundfish populations.

In order to implement these necessary limitations on the level of harvesting activities, Hardin calls for "mutual coercion mutually agreed upon by the majority of the people affected." Coercive forces in the form of fines have been a traditional tool in punishing those participants who do not abide by the rules established by a legislative body. But this approach can have the opposite of its intended effect when the person who paid the fine tries to recoup the financial losses by exerting an even greater pressure on the

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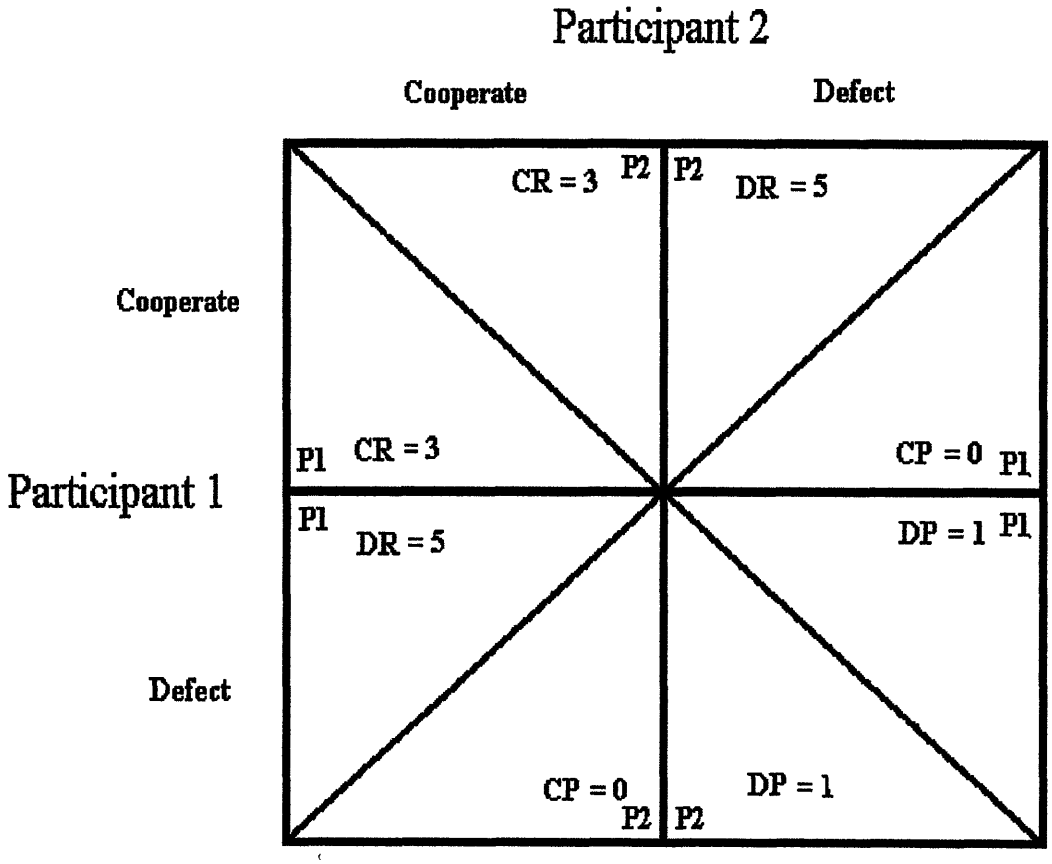
[37] Kelley, K. "New England Deals with the Latest Bad News about Groundfish," National Fisherman, November 1994, p. 18.

resource. Instead of fostering a spirit of cooperation among the agents in limiting the harvesting activities of the resource, the effect is to emphasize the perceived importance of gaining the benefit of harvesting the resource as soon as possible so that revenues can be accrued in order to offset penalties which are assessed as a necessary cost of doing business. The resulting situation is a stalemate among possible cooperators who would be willing to abide by the agreed upon rules if assurance could be obtained that other participants would respect the rules as well.

Application of Game Theory to the Problem

At this point, it would be instructive to look at the guidelines that game theory provides in such a situation where a limited number of participants in an activity are faced with the choice of either cooperating with each other in pursuing long-term gain or defecting from the rules in an attempt to attain a short-term profit. The most simple example entails an activity where there are only two participants in a scenario, referred to as the Prisoner's Dilemma. In this situation, both participants are faced with a decision to either cooperate with each other in abiding by the rules of a situation or defect in pursuit of immediate short-term gain. There are variable returns for each decision, depending on how the other person faced with that same set of choices responds. Each participant does not know in advance how the other person is going to respond to the choice, but does know the results that entail the possible combination of responses. The

possible combinations are represented in the matrix of Figure 9 below.



Payoff Matrix for Prisoner's Dilemma
Figure 9

From this figure it is seen that if both players cooperate the payoff for both is the cooperator's reward, CR = 3 points, while if they both defect the payoff is the defector's penalty, DP = 1 point each. If one player defects while the other player cooperates, however, the payoff is greater for the player who defects, so that person gets the

defector's reward, DR = 5 points, while the other player receives no points at all; he has been taken advantage of by cooperating with a defector and gets the cooperator's penalty, CP = 0 points. From this situation, it would seem that each participant's best interest would be to defect, in order to minimize losses should the other player defect as well. With no future consequences to consider in making the decision, the payoff for defection is guaranteed to result in at least one point, while cooperating has the possibility of being stuck with no points at all. There is no value given at all to future conditions which would result from the participants' individual choices, thus there is no accountability for a participant's decision. This would reflect an economic situation where the discount rate, the preference of gaining payoffs in the current situation relative to payoffs which may result in the future, is near unity. Obviously such a condition cannot exist, as there are always future consequences with which to deal for past behaviors, so the Prisoner's Dilemma should be iterated over several meetings between unique participants, where a memory is retained of how each participant has behaved in previous encounters.

In carrying out these iterated encounters, the strategy that each participant employs becomes very important in determining how the relationship evolves. For example, if a participant demonstrates a strategy of always cooperating regardless of how the other player responds, then the best outcome for the other participant would be to defect on each encounter, since there is no penalty for doing so. If the other participant initially cooperates but responds to a defection with a defection on the ensuing encounter, then the

reduced payoff for defection might serve as an incentive for the original defector to cooperate on the next encounter. In this case, it is in the interest of both participants to cooperate so as to both receive the modest payoffs on a consistent basis into the future.

The success or failure of various strategies was investigated in a tournament carried out by Robert Axelrod at the University of Michigan in the late 1970's. Different strategies were submitted by people all over the country and entered into a series of round-robin encounters, where all strategies were matched against each other in successive head-to-head Prisoner's Dilemma meetings. Each match-up consisted of a finite but random number of individual encounters between opposing strategies where the cumulative payoffs for each strategy was recorded. These totals were added up over all of the match-ups and examined. Of all the strategies submitted, it turned out that the simplest of them, a strategy named Tit-for-Tat, fared best when all of the encounters were considered over the whole tournament. This strategy starts by always cooperating initially, and then mirrors the other player's response for the remainder of the turns, repaying a defection with a defection and cooperation with cooperation. Because it always is one step behind in following a defection, it is never ahead in an individual match-up. However, because the scenario is not a zero-sum situation, it is possible for one participant to gain points without taking them away from the other participant. By being able to create situations where mutual cooperation evolves with many of the various strategies, Tit-for-Tat avoids situations where mutual defection occurs; such protracted reprisals among other

strategies were sufficient to lower their point totals when summed up over the entire tournament.

When this outcome is integrated with the concept of evolution over successive generations where those with higher point totals are more prosperous and thus leave more offspring to carry on the traits of their successful strategy, it becomes likely that those strategies that foster cooperation will grow in number. The conditions under which this progression occurs most successfully are desired when a system is being constructed which will manage the interaction among a number of participants who are seeking to ensure their future survival. While the participants seek to better their own living conditions, they must do so in concert with others who desire the same outcome.

From the results of the tournament, it is seen that if participants meet repeatedly, recognize one another and retain some knowledge of their previous encounters, then cooperation may ensue.[38] These are the conditions that allow a population of mutual cooperators to exist in a stable relationship within their community. Such conditions require that the population of participants must be closed, and if not closed, that mobility is sufficiently limited so that repeated encounters may occur.

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[38] Axelrod, R. The Evolution of Cooperation (New York: HarperCollins Publishers, 1984), p. 68.

Stability of a Population

Whether or not a population of mutual cooperators can withstand the intrusion of participants who exploit the commons is of interest as it suggests the ability of the population to maintain its health as elder members retire and new members are allowed in to replace them. A strategy of cooperation between participants is collectively stable if no other strategy can successfully enter the population of participants and be able to flourish to such an extent that the other cooperative strategies are no longer feasible.

For example, if a new strategy is introduced to the population, it will be interacting with those cooperating members and in doing so may be able to take advantage of their behavior individually, gaining benefits by this approach which are greater than the average gained by other cooperating members interacting among themselves; while other strategies are cooperative and gain a payoff of 3 amongst themselves, the defector gains 5 as long as it can keep meeting participants who have not encountered this strategy of defection. This strategy will not be able succeed if there are enough future interactions where the members of the population identify the defector and engage that individual in mutual defections, thus decreasing the payoff to 1 until that defecting individual does not have the resources to continue. This is reflected in the fact that if the discount rate mentioned earlier in the chapter is small enough, that is, each member of the population knows that there are enough future interactions so that uncooperative actions will be punished, then no strategy will be able to invade and thrive within a population of

mutual cooperators.[39]

If a population of participants employing a strategy of Tit-for-Tat is to be collectively stable, then the realized payoffs for various behaviors must be stated clearly and be known and understood by all of the participants. This implies a degree of information among the participants that is assumed in the setting of game theory to be perfect. Obviously such a condition cannot be met in real life situations, but there are measures that can be employed by the managing authorities where this deficiency can be compensated. This matter will be considered in the context of the sea urchin industry in the next chapter, but for now, consideration will be given to the relative values of the payoffs and their collective influence on the necessary value of the discount rate for a population to be collectively stable.

For the purposes of the discussion with respect to game theory, an alternative definition of the discount rate will be employed. The *discount parameter* is defined to be the value that a participant will give to the possible payoffs of the next decision relative to the value of those same payoffs faced in the current decision. So if the payoffs of the next round are only worth half as much as those payoffs gained in the current round, then the discount parameter would be ½. Thus it is similar to the discount rate in that it is a measure denoting how much future payoffs are discounted relative to current payoffs; the discount rate, however, expresses the same sort of discounting of future payoffs, only in a different mathematical setting. Briefly, the discount rate, d, is shown most simply in the following mathematical

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[39] Ibid., p. 58.

statement expressing the perceived present value, PV, of future benefits, B, (or costs) to a person:

$$PV = B / (1 + d)^t.$$

In the scenario considered earlier, the payoffs corresponding with the possible outcomes were CR = 3 for mutual cooperation, CP = 0 for cooperating with a defector, DR for exploiting a cooperator and DP = 1 for mutual defection. It has been shown by Axelrod that if the valuation of future conditions is great enough (the discount parameter is great enough), then a population of participants employing the Tit-for-Tat strategy cannot be successfully invaded. He showed that this value of the discount parameter is the greater of the following formulations:

$$(DR - CR)/(DR - DP) \text{ or } (DR - CR)/(CR - CP).$$[40]

Inserting the values used in the above example, the values would be:

$$(5 - 3)/(5 - 1) = \tfrac{1}{2} \text{ and } (5 - 3)/(3 - 0) = \tfrac{2}{3}.$$

So the smallest discount parameter that could be employed and still maintain a population of cooperators is ⅔, under the payoff values assumed above. This underscores the importance of maintaining penalties at significant levels and applying them when the first traces of uncooperative behavior emerge. If it is apparent to a participant that other members of the population are not going to be present in subsequent rounds, for reasons of either weakness or voluntarily, then the

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[40] Ibid., p. 207.

apparent discount parameter falls because the structure of reciprocal relationships will not be maintained. This failure of reciprocal relationships can be seen in many different fields, from politics to business, where outgoing members may lose clout and thus cooperative relationships among other members.

The Physical Space of Cooperation

If the population is to maintain the reciprocally cooperative behavior among its members, it is necessary for each of the members to understand that their inter-relationships are going to be durable, that they will be held accountable for their behavior by others at a time in the future when they meet again. This can best be accomplished by controlling the size and composition of the population and ensuring that the frequency of interaction is great enough that those who do fail to behave cooperatively are confronted and penalized promptly. A prompt retribution of significant proportion will ensure that the penalties have a present value which weighs significantly on their current behavior as well as communicating with certainty as to why the sanctions are being imposed on that individual. If there is too much time in penalizing a defector, then the possibility exists that that participant will receive the wrong message in the mean-time: that defections will not be penalized and thus gains may be made by breaking the rules. By waiting longer, this deviant behavior can be reinforced after repeated rounds with no intervention. Having paid the penalties for their

behavior, however, the defectors will be allowed to continue their activities utilizing a strategy in compliance with the rules agreed upon by the population.

As it does so, the other members must be able to recognize this person and recall their past behavior so that they can amend the tone of the interaction in accordance with the strategy of Tit-for-Tat, repaying defection and cooperation with the appropriate respective response. The maintenance of frequent interactions will both help members recognize each other and keep them apprised of their records of behavior, allowing those who have changed from defective to cooperative behavior to inform their neighbors of the fact so that they may alter their responses to these reformed members in keeping with the principle of reciprocity espoused by the Tit-for-Tat strategy.[41]

The shared experiences of the members of a population in interacting with their immediate neighbors fosters a familiarity of members with each other in subgroups within the population. Clusters of participants who frequently come in contact obtain information on how their neighbor is behaving, and if this behavior is appropriate, it may serve as a role model for members who in the past attempted defections periodically. The familiarity with neighbors to which human participants can attain is a feature which also may avert one of the unfortunate characteristics of a strict Tit-for-Tat strategy. If a defection occurs, real or apparent, accidental or by intention, the immediate reprisal can have the unintended effect of initiating a series of defections

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[41] Sigmund, K. Games of Life (London: Oxford University Press, 1993), p. 203.

alternated with cooperation.[42]

This "echo effect" can be averted by introducing a small amount of consistent leniency in the strategy, as was done by a deviation of Tit-for-Tat which allowed for two defections by a participant before reprisals were enacted. This strategy, called Tit-for-Two-Tats, avoided the costly retaliatory strings but in subsequent rounds was found to be susceptible to strategies which exploited this forgiveness by defecting once and then cooperating in a periodic fashion.[43] Familiarity with neighbors such as that which occurs between human participants, allows the participant to employ a strategy of appropriate leniency depending upon the circumstances of the situation. In doing this, however, it is of utmost importance that both the strategy and the reasoning for employing the strategy is communicated to the neighbor in an unambiguous manner. This will alleviate any suspicions of ulterior motives that may be harbored by the neighbor. The simplicity and clarity of the variations of the Tit-for-Tat rules facilitates this communication.

This clear understanding of consequences for deviant behavior is one of the keys to ensuring the stability of cooperative behavior. This, in turn, depends upon the fact that the punishment for deviant behavior is sufficient enough to deter that action should it appear as a strategy by a participant. In general, any feasible expected payoffs can be maintained in an equilibrium as long as each participant has

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[42] Poundstone, W. Prisoner's Dilemma (New York: Doubleday, 1992), p. 243.

[43] Axelrod, p. 120.

an expected payoff, through cooperation, at least as large as what would be guaranteed if all other participants colluded to defect on that one participant.[44] If all participants are told by all others to stick to the agreed upon cooperative behavior or else the entire population will impose the punishment, then no single player has any incentive to deviate.

This is the basic condition for what is known as a Nash equilibrium, with the relationships between the participants being strategically stable.[45] Within the limited sense provided in the setting of game theory (i.e., perfect information, fixed player strategies) this equilibrium situation provides a unique solution to the conditions and strategies defined by the game scenario. So it turns out that while game theory may be an interesting tool for theorists to gain insights about the behavior of groups of individuals acting self-interestedly in a closed population, the applicability to real world situations is limited. From the discussion above, general guidelines can be gained which may useful to managers who are attempting to implement operational constraints upon participants who are competing over scarce resources.

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[44] Kreps, D. A Course in Microeconomic Theory (Princeton, NJ: Princeton University Press, 1990), p. 508.

[45] Gibbons, R. Game Theory for Applied Economists (Princeton, NJ: Princeton University Press, 1992), p. 8.

Chapter V

Managing Resources in a Closed Economy

Emerging World-View of the Spaceship Earth

At this point, a discussion of how the resources of the community are to be utilized over time is necessary. This will provide the basis upon which the concepts gained from game theory may be applied. At the very core of this discussion is the necessity of a change in world-view held by the people who both consume products and prepare them for consumption. This change has been described by Kenneth Boulding as a change from viewing the earth and its resources with a frontier mentality to one of a "spaceship mentality."[45] The former mentality saw the environment as one that always offered new spaces to move to after the current one was depleted of utility to the inhabitants. From the dawn of mankind's existence on earth, this has been a sufficient point of view, and one that accurately reflected the conditions under which mankind lived. As evolving technologies gradually allowed people to move to increasingly harsher and more distant regions from the cradle of Africa, the new environments were surveyed for their resources and habitats established where conditions were found to be favorable.

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[45] Boulding, K.E. "The Economics of the Coming Spaceship Earth." In Valuing the Earth: Economics, Ecology, Ethics. Eds. Daly, H.E. and Townsend, K.N. (Cambridge, MA: The MIT Press, 1993), p. 297.

Finally, with the completion, in only the last century, of the policy of "manifest destiny" by the settlers in America, all of the frontiers of the planet have been conquered and settlements established where the environment is conducive to the various economic activities required by the diversified global economy.

With the growth and expansion of these activities across the landscape, the harmful effects on the natural environment can no longer be eluded, so we are faced with the task of maintaining the environment so that our species may continue living on the planet, our spaceship earth. In economic terms, this transformation in our relationship to the natural resources of the earth is from that of an open system, where raw materials are continuously and indefinitely used as inputs into a conversion process which provides outputs for consumption, to that of a closed system, where the outputs of all parts of the economic system are considered as inputs into other parts of the system.

In keeping with the mentality of the open system historically held by the various governmental organizations across the globe, there has been a persistent goal of maximizing the throughput of the economy. In other words it has been a goal to enlarge the scope and rate at which materials are converted from input materials to output products for consumption by the populace. The measure of this rate of conversion by a country is generally agreed to be the gross national product, or GNP. With the diversification of the economy, this measure has been amended to included non-material products, or services, as well. Not included in this measure, however, is the contribution to the economy provided

by naturally existing ecosystems. For example, a stand of trees conserves soil and thus keeps waterways clean, provides clean air as well as habitat for wildlife. The contribution to GNP only occurs when the trees are harvested and sold as a converted wood product. Even man-made disasters such as oil spills are considered as benefits as they contribute to the GNP because of the money spent on clean-up activities. GNP is not a very good measure of economic health because of this inability to distinguish costs and benefits as they relate to the ecosystem.[46] Nonetheless, the goal remains for the country to maximize the GNP so as to allow the economy to continue to grow, thus providing more wealth to be shared among the constituents of the population within the economy.

Boulding points out that the closed system, in contrast, holds as its goal the minimization of the throughput, or flow, of materials within the economy. Instead of this measure, other factors are considered of paramount importance in determining the health of the economy, such as the nature, quality, and diversity of the capital stocks within the economy. These stocks would include knowledge and environmental assets, but most importantly the members of the population themselves, since they contribute substantially to the production of goods and services, and these same characteristics for capital stocks would be applied to the states of their minds and bodies. It may be argued that flows play a more significant role in contributing to the well being of people than do stocks; this need not be contested in order for the main tenets of a closed system economy to be applied,

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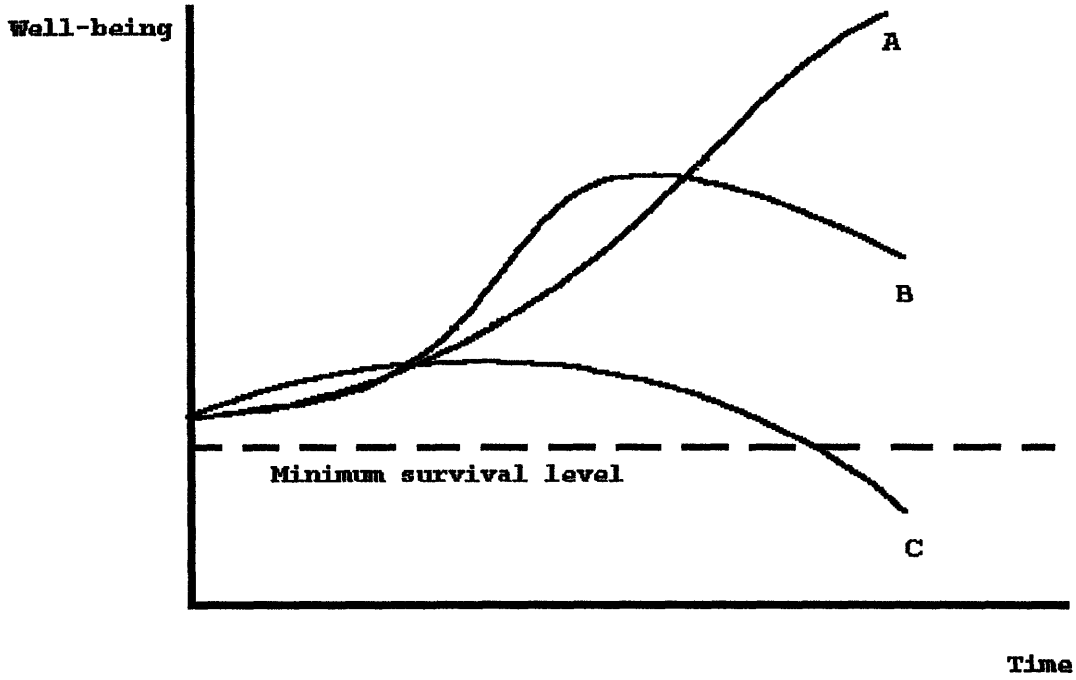
[46] Bartholomew, J.A., et. al. "Goals, Agenda, and Policy Recommendations for Ecological Economics," In Ecological Economics. Ed. R. Costanza. (New York: Columbia University Press, 1991), p. 11.

however, as the stocks available at a point in time determine the *capability* of people to earn income and thus maintain their well-being. As long as the stocks are maintained at levels which are sufficient for future use, the flow of resource usage through the economy can be minimized to as great a degree as possible while still maintaining the quality of life of the individuals consuming, or preparing for consumption, the resource. Maintaining this quality of life is the ultimate goal of any development strategy, yet it is not possible beforehand to know what the future conditions will be under a given level of usage. This idea can be communicated in Figure 10 below:[47]



Possible Sustainable Development Paths
Figure 10

[47] Adapted from Pearce, D.W. Economic Values and the Natural World. (Cambridge, MA: The MIT Press, 1993), p. 48.

These different paths represent various possible outcomes of a management strategy, where path A appears to be sustainable, path B is not sustainable, although it might be efficient under the circumstances, and path C is neither sustainable nor sufficient to support the people utilizing the resource. While it may be possible to detect signs of non-sustainability on path C because of the declining well-being at a relatively early stage, path B, which appears much the same as A early on, suffers the same fate of decline, only at a later time. Furthermore, once these signs of decline are detected, it may be too late to reverse the effects. Because of this, it is necessary to determine whether or not the conditions of sustainable development are being met.

These conditions of sustainability that hold the key to the manager's ability to maintain the natural resource stocks must therefore be discovered through research efforts which seek to understand the dynamic linkages between the various components of the local ecosystem in which that particular resource resides.[48] Understanding the linkages and incorporating them into a model of the local ecosystem would help the manager determine the scale of resource usage, one of the keys related to sustainability. The scale of conversion of a resource refers to the size of the flow of depletion relative to the amount available in the environment (the natural stock) left for usage at a later time. In the case of the sea urchin industry, the scale would refer to the number of urchins removed from Maine's coastal waters in a unit of time relative to the number left in the environment which will be able to reproduce. If the industry is to be able to

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[48] Pearce, p. 50.

maintain itself indefinitely, then the rate at which urchins are removed must be no greater than the regeneration rate at which urchins are able to replenish their population. As long as there is any uncertainty over the stock level necessary to sustain the population against harvesting activities, the managers should err on the side of caution until there is strong evidence from the research that a greater scale of extraction can be safely supported.[49]

Determining the Value of a Natural Resource

When considering how the resources of a closed system are to be allocated, a distinction can be made between those people who will be using the resource in the immediate future and those who will be inheriting the resource for use in later generations. These two general areas of concern may be referred to as intra-generational and inter-generational valuation, respectively. By considering only the interests and values of the current generation, there is a biasing of those same concerns which will likely be faced by future generations unless there is some mechanism whereby those issues will be accounted for in the decisions made today.

It is common practice for members of the business community to discount future costs and revenues associated with a prospective activity by a certain factor, the discount rate mentioned earlier, because of the inflationary nature of currency in the economy, opportunity costs which arise from having capital unavailable for other economic uses, and

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[49] Bartholomew, p. 17.

uncertainty about what future conditions will exist for economic activity which will utilize a particular resource. Depending upon the outcome of their analyses, it is possible to determine whether an activity can be carried out in a profitable manner.

As a necessary step in calculating the cash flows that are expected from an economic activity, assumptions are made about the demand for a product to be offered for sale, and thus for the amount of currency that a share of the consumptive market will be willing to pay for the product. By determining what price is likely to be attained per unit of a product and how many units of that product can be moved to market in a certain amount of time, future revenues can be assessed, and through the process of discounting by an assumed discount rate, the present value of that activity can be estimated. Incorporating the estimated future costs that are incurred by the individual in the course of the activity into the discounting analysis, the net present value is attained. This is a more complete formulation than that used earlier in the discussion of the discount rate in that it includes both revenues and costs associated with the use of a resource. The formula used would thus be:

$$NPV = \sum_t \left[(R_t - C_t)/(1 + d)^t \right]$$

where R_t and C_t represent the estimated revenues and costs, respectively, accrued by the individual engaging in the activity, and d is the assumed discount rate. The summation is over the period of time into the future that the individual wishes to carry out his or her analysis. If the net present value, NPV, of the activity is found to be positive then, according to this formulation, it would be profitable for that

individual to engage in the activity; if the NPV is negative, then it would not.

This whole process, however, is based upon assumptions that individuals make of the consumer's willingness to pay. In the case of the sea urchin industry, the Japanese consumer is the ultimate determining factor of the willingness to pay, which in turn is determined largely by the quality of the urchin's roe. This price is, in effect, paid to all of the participants in the chain of events which are necessary to bring the roe in marketable form to the consumer. From the Japanese wholesalers and retailers, to the American exporters and processors, to the dock-side dealers in Maine, and finally to the harvesters, the price ultimately determines whether the resource is of more value extracted from its natural habitat or left to perform its ecosystem function. In this scheme, market prices provide an autonomous and voluntary mechanism for expressing the best use of the resource. This efficiency standard of resource use, in theory, results in a market outcome which is satisfactory to all participants and provides the greatest social gain; bidding for a pound of whole urchins on the dock proceeds until an equilibrium is reached at which there is no other allocation of that resource which will provide a greater benefit to the harvester. Akin to Adam Smith's invisible hand, this bidding process is purported to yield the best, or most efficient, allocation of the resource.

What this model fails to incorporate, however, is the existence of negative externalities of the use of a particular resource upon third parties who are not directly involved in the bidding process. These negative externalities may take

the form of a degraded ecosystem, where the general public is ultimately the recipient of consequential adverse effects. More directly, recipients of these adverse conditions are fishermen of other resources whose species depend, at some part of their life cycle, upon the existence of sea urchins, either as a food source or in a more complex symbiotic relationship, such as providing a habitat, for those species. In the strict market-oriented scheme, the determination of proper resource use through market forces does not account for these negative externalities. For this reason, other valuation criteria are necessary in order to place the entire benefit that a resource has within the ecosystem within the sphere of market forces.

At this point, the economic tools for measuring these characteristics of a closed economy are largely lacking in any practical form, and where they do exist, the measures are likely to be seen by empirical scientists as far too subjective for analytical purposes. Nonetheless, the applicability of these concepts should be pursued so that when popular recognition of the existence of the closed economic nature of our global ecosystem does occur, these tools will be available for use by tomorrow's managers.

Valuation Tools Necessary for the Closed Economy

Of increasing significance to many people is the value of living organisms and habitats by their very existence; they have value in and of themselves, whether or not there are

human beings who appreciate them.[50] This intrinsic value is evidenced by the proliferation of many organizations dedicated to preserving species and habitats simply for the purpose of protecting the unique characteristics they possess. They may view the value in such species and habitats either aesthetically, which appeals to many members of the population, or more scientifically as a repositories of accumulated information stored in the genetic make-up of the various species within the habitat. A benefit which results from this preservation of the resource in an undisturbed state is the fulfillment of the specie's natural function in the ecosystem mentioned earlier; the organisms may provide an important source of food for other commercially valuable species or may stabilize the ecosystem by consuming plants which would otherwise grow unchecked and eventually disturb the environment. This class of values lies entirely outside of the realm of current economic evaluative tools; it might be said that the two classes of valuation, economic and intrinsic, are incommensurable. As such, they cannot easily be brought to the table of discussion and considered on equal terms without some approximating method which can translate the intrinsic value to units of economic valuation.

The willingness to pay criterion is one method of such a translation, where people express what amount they would be willing to pay in order to preserve a resource. The National Oceanic and Atmospheric Administration has studied the use of survey-based techniques to determine the value to society of a pristine environment by polling how much people would be

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[50] Pearce, p. 14.

willing to pay to preserve an environment.[51] This contingent-value technique would be a step towards determining the best use, or non-use, of a resource that holds multiple use potential. An unfortunate aspect of such an approach is that it is presented as a hypothetical situation to the people being polled, and thus may have significant elasticity if the bill for such preservative measures were to ever come due. In addition, the theory of pricing may not be appropriate for naturally occurring, long-term features of the environment that are not traded in everyday life in a market situation; the lack of understanding of how these environments contribute to their lives would also interfere with their ability to form an accurate currency figure for the value of such resources.[52]

Another measure which may be of use in ascertaining the total value that a resource holds is that of option value. This concept identifies the value that individuals place on the resource in order to guarantee that it will be available for use in the future.[53] In a sense, it is akin to an insurance premium that ensures the availability of a resource whose future viability would otherwise be uncertain. Again, it is necessary to translate the terms of this valuative technique into units which are commensurable with those of current economic theory, thus the tools of the willingness to pay principle would be employed in order to provide a basis of comparison for value realized through the consumption of the resource.

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[51] Passell, Peter, "Disputed New Role for Polls: Putting a Price Tag on Nature," The New York Times, 6 September 1993, p. 1.

[52] Bartholomew, p. 10.

[53] Pearce, p. 20.

Unlike the existence value above, which is strictly intrinsic, option value does ultimately realize the market value of the resource, only at a later date. At that point in the future, it may be that the market value of the resource is much greater than it is currently. The information stored within the genetic make-up of the organism would be one such source of value, as in the case mentioned in Chapter II where chemical compounds from sea urchins are being used in a study of ways to reduce the harmful effects of ultra-violet rays. The proliferation of pharmaceutical companies performing research into other sources of naturally-occurring compounds which are of medical use is evidence of the great value which can be realized as scientific understanding of the myriad of species in the global ecosystem increases with time.

These tools for estimating the non-market value of a resource are in their infancy of development and thus are not easily considered on an equal basis by many of the people utilizing natural resources today. As the concept of sustainable development becomes more familiar and accepted among a healthy majority of the population, their proper use, and the benefits that will ultimately be delivered with their use, will ensure both the future economic and biologic value that the natural resource holds.

Sustainability: The Goal for Reciprocal Cooperation

The acceptance of sustainability as a goal for economic activity has been slowly growing among many segments of the population in recent years, as seen by the changing vocabulary often seen in discussions of resource usage. This evolution of our vocabulary occurs as a mixture of new and old concepts from the open and closed economic mindsets held by different members of the population. It is a gradual process, and rightfully so, as any attempt to impose new concepts and restrictions on economic activity in the name of sustainability could cause such dislocations in people's ability to earn a living that they would likely become entrenched in their unwillingness to consider new ideas in resource utilization.

For instance, there is a tendency for many people to speak of "sustainable growth" yet this demonstrates the misunderstanding of our earth as an open system that persists in our discourse. For something to grow it increases in size or scale, relative to the environment in which this activity occurs. As the economy is a subsystem of the ecosystem, it can grow to incorporate an ever-increasing proportion of the total ecosystem but must reach a limit at 100 percent, if not before.[54] It would be more agreeable then, to refer to sustainable development, as this infers an emphasis on the evolution of the activity, achieving greater potential in quality, becoming more stable in operation and more complete

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[54] Daly, H.E. "Sustainable Growth: An Impossibility Theorem." In Valuing the Earth: Economics, Ecology, Ethics. Eds. H.E. Daly and K.N. Townsend. (Cambridge, MA: The MIT Press, 1993), p. 267.

in equity. While this may be seen as simply quivering over semantics, the distinction in meaning over the terms has a significant impact on the future course of action in managing limited resources. The World Commission on Environment and Development, in the Brundtland Commission report, has suggested a definition of sustainable development as that which "meets the needs of the present generation without compromising the ability of future generations to meet their own needs."[55]

The state of Maine has undertaken new efforts to promote greater economic activity in hopes of promoting job growth in its key industries. As part of this effort, a strategic task force was created by the Maine Legislature in 1993 with the intention of developing a long-term plan for the state's economy, based on economic opportunity for all citizens. As part of its charge, the Legislature explicitly asked that "sustainable development" be considered in all of its deliberations. The name of this task force, unfortunately, is the Maine Economic Growth Council, but this may be seen as the result of the gradual transition from the differing mindsets; it need not be seen as a undiminished devotion to the continuous and unyielding growth of the economy. They offer the following as their vision statement:

> Our vision for Maine is a high quality of life for all citizens. Central to this vision is a sustainable economy that offers an opportunity to everyone to have rewarding employment and for businesses to prosper, now and in the future. The people of Maine bring

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[55] Brundtland, G.H. et. al. Our Common Future: Report of the World Commission on Environment and Development. Oxford: Oxford University Press, 1987.

> this vision into reality by working together, and building on our tradition of hard work, dedication, and Yankee ingenuity.[56]

In addition to this statement, several ideas have been proposed as underlying principles of their discussion of growth issues. First, and in great concord with the statement made on sustainable development by the Brundtland Commission, is that:

> We must invest and act now in such a way to ensure the prosperity of the current generation without sacrificing the opportunities for future generations. Above all, this means paying close attention to how we use the environment and natural resources.[57]

In addition to this statement, two other observations have been made by the council which are important to the success of their efforts:

> Economic growth is the result of a complex interaction among economic, environmental, and social factors; success cannot be defined by examining the separate parts, only by understanding the cumulative interaction of the parts.
>
> Efforts to achieve sustainable development must be continually monitored.[58]

As a step in achieving these goals for the various fishing industries, there is recognition within the leadership

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[56] Maine Economic Growth Council. Goals for Growth: First Report of the Maine Economic Growth Council. (Published in Greater Bangor Business Monthly, September, 1995), p. 1.

[57] Ibid., p. 3.

[58] Ibid., p. 4.

of the Maine government that the participants of the industry must ultimately take responsibility to conserve the resource. Speaking to a gathering of industry participants at the Maine Fisherman's Forum, Governor King asked the industry to be active in developing a "Maine solution" to save the stocks for the next generation while avoiding federal legislation. His administration's slogan for reforming the industry is "power to the peapods" in seeking solutions from working fishermen.[59]

As these efforts at including all participants in the reform process, from working fishermen to processors and scientists to legislators, are initiated, the sense of working toward a common purpose of ensuring a sustainable fishery resource must be at the forefront of all discussions. With this common goal, it would still be expected that differences between segments of interested parties will arise as to what are the fairest and most efficient means of achieving this goal. For a particular course of action to be accepted as being ethical by the participants, it is necessary that each person goes beyond the "I" or the "you" in their deliberations to the universizable judgement, to the lofty standpoint of the impartial spectator.[60]

This would be in accord with John Rawls' suggestion that each person work toward just rules for all from an original position behind a "veil of ignorance" which hypothetically prevents them from knowing their eventual position in society

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[59] Meara, E. "King Challenges State Fishermen to Save Industry," Bangor Daily News, 6 March 1995, p. 1B.

[60] Singer, P. Practical Ethics. (New York: Cambridge University Press, 1979), p. 11.

and thus how the rule would eventually affect them.[61] These ideals would go a long ways toward heeding Hardin's advice of mutual coercion mutually agreed upon by a majority of the people. Living in a fallible world as we are, however, this may not be a practically attainable standpoint for many people, so it would be instructive to look at the experience of managing common property resources in other fisheries in Maine as well as in other areas of the world to learn from their experiences.

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[61] Tientenberg, T. Environment and Natural Resource Economics. (New York: HarperCollins Publishers, 1992), p. 67.

Chapter VI

Successful Management of Another Bottom-Dweller: Lobsters

Regulatory History and Organization of the Industry

Lobsters have been harvested from the waters of New England since the early days of American colonialism, and could be bought in the markets of Boston in the mid-eighteenth century. The industry did not begin in earnest, however, until ships were equipped with holding tanks so that the catch could be kept alive until they reach their markets on shore and further inland. The ships became common along the coast of Maine in the mid-nineteenth century. Canneries helped the industry to grow further toward the end of the nineteenth century, allowing the meat to be shipped to more distant locations inland.[62] The decline of the lobster population in the Cap Cod region after 1810 eventually led to a crash the 1880's, so fishing pressure shifted to Maine waters whose lobster populations eventually began to suffer because of the indiscriminate processing of all lobster sizes, large and small, by the canneries.[63]

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[62] Martin, K.R. and Lipfert, N.R. Lobstering and the Maine Coast. (Bath, ME: Maine Maritime Museum, 1985), p. 13.

[63] Ackerman, E.A. New England's Fishing Industry. (Chicago: University of Chicago Press, 1941), p. 41.

In response to this decline in lobster catches, the Legislature enacted a regulation in 1872 which forbade catching, buying or selling egg-bearing females in an attempt to ensure they would be able to successfully reproduce. This was repealed two years later, however, and a size limit of 10½ inches, from head to tail, was imposed as well as a statewide closure of the fishery from August 1 to October 15.[64] The effect of this seasonal closure was to make the canneries unprofitable, and the last lobsters were canned in Maine in 1895. Following these measures, the lobster catch has been remarkably steady, from levels of approximately 25 million pounds landed in 1898 to about 22.8 million pounds in 1965, with a dip to about 5 million pounds during the Depression, attributed largely to over exploitation by fishermen desperate to make a living in spite of the meager prices being offered for the catch. In fact, in the last few years there have been growing record harvests of lobsters, causing some within the industry to have reservations about the future stability of the resource.

The regulations that have allowed this consistent growth in the industry have included: minimum and maximum sizes allowed for harvesting; prohibition of harvesting egg-bearing females; closed seasons (both local and statewide); licenses restricting access to the industry; and gear restrictions. The size limits (of the lobster's carapace or main body segment) have fluctuated around a minimum of 3¼ inches, currently at $3^{5}/_{16}$ inches) to a maximum of 5 inches since 1960 (§6431). The harvesting of egg-bearing females throughout the

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[64] Kelly, K.H. A Summary of Maine Lobster Laws and Regulations: 1820-1992. Lobster Informational Leaflet #19: Maine Department of Marine Resources, Augusta, ME, 1992.

year has been forbidden since 1889 and since 1948, any egg-bearing female caught has to be marked with a V-notch on the tail; if the lobster is subsequently caught, it must be released immediately, whether or not it is bearing eggs at that time (§6436). This regulation, along with the maximum size limit, ensures that there are a sufficient proportion of mature lobsters in the population to reproduce.

There have been no statewide closures of harvesting activities since 1895; various local regions have been closed from around July 1st to August 31st in accordance with the wishes of the lobstermen who tend the respective areas, but these laws have been repealed and exist now only informally. The existence and enforcement of the informal laws will be considered later in this chapter. There do currently exist, however, limitations on the number of traps attached to a buoy in certain delineated regions of coastal waters (§6439). Again, these restrictions are codified in accordance with local practices. The Commissioner of Marine Resources also has discretion to close certain regions should there be signs of the lobster population being depleted, or any other ecological distress, in that region (§6192).

Licenses have been required for all lobster harvesters since 1915; before this time only non-residents of the state were required to obtain a license. The residency requirement for a license has varied from 10 years in the 1940's to as little as 6 months since 1979, with provisions being made for veterans in this period to provide them special access. Currently three classes of licenses are offered for sale, with a progressive fee for the three classes, which allow a person to harvest, possess, ship and sell whole lobsters within the

state: class I allows no unlicensed individuals to assist in harvesting; class II allows one individual to assist; and class III allows two individuals to assist (§6421). Additional licenses are required for the wholesale transport, retail sale, processing or storage of lobsters or lobster parts.

All gear belonging to a lobster harvester, if a harvester chooses to catch lobsters using traps, has been required to be identified with an owner since 1885. Since 1965, all lobsters must be harvested using traps, with the dimensions of openings specified by law, providing escape openings for lobsters that happen to be undersize. Color patterns that a harvester uses as the buoy marker are required to be displayed conspicuously on the boat as well(§6432). Should traps become separated from the buoys, biodegradable escape panels must be built into the traps to prevent unnecessary lobster mortality (§6433).[65]

At this time, the majority of lobsters harvested domestically are marketed in the shell. Having the meat removed and canned would reduce the value of the unique crustacean, as it would then have to compete with other canned meat products. The New England Fishery Management Council (NEFMC) estimates that 87 percent of landings within the U.S. are marketed in the shell, either live or freshly cooked.[66] The organization that is in place to deliver the live product from the wharfs to the dinner plate of the consumer consists of a series of dealers. Meeting the lobstermen at the wharves

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[65] Ibid.

[66] Botsford, L.W., et. al. Joint Standing Committee on Marine Resources Study on Biological and Economic Analysis of Lobster Fishery Policy in Maine. (L.W. Botsford and Associates, April 1986), p. 18.

are the primary wholesalers who are trying to meet the demand of secondary wholesalers who operate tank shops. These tank shops store the lobsters until markets are located which are offering acceptable prices for the catch. In doing this, the tank shops even-out seasonal variations in supply, and if necessary, seek lobsters from Canadian dealers in order to meet their demand levels. The secondary wholesalers, in turn, provide the lobsters to retailers, who might be supermarkets, restaurants, or simply seafood retailers, who then provide it to the consumers at a considerable mark-up over the prices paid to the lobstermen at the wharf. This mark-up provides profit to the wholesaler as well as covers the transportation costs and the costs incurred in maintaining the stock of lobsters kept alive in holding tanks until they are sold at favorable times of the season.[67]

In an effort to bypass the primary dealers who may be offering what are perceived to be unfair prices in a relatively isolated fishing community, some lobstermen have chosen to form cooperatives as an alternative to the wharf-side dealers. Particularly in the 1940's, these arrangements provided alternative prices to what the dealers would otherwise be offering them for their catch. At that time, the availability of bait for the traps was used as leverage by the dealers in forcing undervalued bids on the lobstermen; if they wanted bait, they had to accept the offered price. Later, cooperatives were formed to replace retired dealers, or as means for the lobstermen to exert greater control over their activities by owning the wharfs and having independent supplies of gas and bait. The cooperatives can also, if they

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[67] Ibid., p. 23.

are aggressively managed, bypass secondary wholesalers and contract for a shipper to transport lobsters directly to the retail markets inland.[68] By doing this, the cooperatives provide a benchmark price to the rest of the industry so other lobstermen who are not involved in cooperatives can discern whether the price they are being offered is fair or not. There is a cost to joining cooperatives, however, financially as well as a commitment to attend board meetings and work through the process, often through heated discussion, of the business and policies that the cooperative will be pursuing. They may not, however, offer perks that a dealer might provide to a lobsterman, such as loans and a steady supply of bait. In a sense, the cooperatives have benefitted the lobstermen who work through dealers by forcing those dealers to improve the assortment of services offered to their clients.[69]

Territoriality of the Lobstering Communities

From the laws that have been written and formalized by the Legislature, it would appear that anyone who pays for a license would be able to enter the lobster harvesting industry. But this overlooks the long-standing communal relationships between lobstermen's families that extend back generations and form the core of how the activities of harvesting are carried out. To go lobster fishing, a person obviously needs a boat from which to set and pull traps, and

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[68] Acheson, J.M. The Lobster Gangs of Maine. (Hanover, NH: University Press of New England, 1988) p. 129.

[69] Ibid., p. 131.

in order to operate and maintain a boat for this activity, one needs a harbor from which to operate, getting supplies before heading out on the rounds to tend the traps. Each harbor consists of a group of lobstermen, called a "lobster gang," who operate boats out of that harbor and tend traps in a region of waters limited by either the traveling capabilities of their boats or by the existence of another lobster gang in an adjacent community along the coast. The territory that a lobster gang claims as its own is the result of political competition between groups of lobstermen carried out over the decades, and is now established as informal regions, with no legal recognition, along the coast which are largely recognized and accepted by the various lobster gangs operating out of coastal harbors. The formation and maintenance of these groups of lobstermen has been studied and documented by James Acheson of the Department of Anthropology at the University of Maine. His research provides many of the insights gained in this discussion of the nature and practices of these lobster gangs.

The delineation of the territorial boundaries between adjacent harbor gangs is largely accomplished by the alignment of significant landmarks on the shore. Thus, during the warm parts of the year, when lobster fishing is done close to the shore, the delineations are well established; during the winter months when fishing is done further offshore, there is more mixing of territories allowed as the boundaries cannot be as easily discerned. The concentration of lobsters in shallow waters during warm months further reinforces this sharp delineation of boundaries, while in the part of the season where lobsters move offshore, their dispersed habitation

relaxes the need to defend territory from members of neighboring harbors.

A distinction may be made of the nature of territories claimed by lobster gangs operating out of a particular harbor. This distinction generally refers to the amount of mixing allowed in a territory by the gangs of adjacent harbors. When there is a strong sense of ownership over a region near the harbor out of which the lobster gang operates, it may be classified as a "Nucleated territory." This sense of ownership grows progressively weaker as the distance from the harbor increases, until there is a good deal of mixed fishing which takes place near where the distance between two harbors is equal. While this allows lobstermen from either of the two harbors to set traps in this area, it does not necessarily allow anybody to come in and set traps; there is still a sense of ownership over the region, although now in a shared sense.[70]

In other locations along the coast, particularly in island communities, the boundaries of the regions of ownership are sharply drawn and defended with no regard to how far a location might be from the harbor. These regions may be referred to as "perimeter-defended," as there is very little mixed fishing in these areas. Even when fishing far from the shore, lobstermen will not lay traps in a region that is not recognized to be an exclusive territory of his harbor gang. In both types of territories, but particularly in perimeter-defended regions, claims over fishing rights in coastal waters may be tied to the ownership of land adjacent to those waters. In island communities, the right to fish in adjacent waters is

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[70] Acheson, J.M. "The Lobster Fiefs: Economic and Ecological Effects of Territoriality on the Maine Lobster Industry," Human Ecology 3 (1975): 187.

often tied to ownership of land on the island; if a whole island is singularly owned, the rights to fish the adjacent waters may be rented out to lobstermen from nearby mainland harbors if they are not being wholly used by the owner.[71]

This pattern of territoriality exhibited by lobster gangs has evolved since the early days of lobster fishing when the technology available, particularly wooden boats, prevented lobstermen from fishing in the winter, and when fishing was allowed, the range of their activities was quite limited. This resulted in maintenance of territory that would be akin to perimeter-defended, as the little region that a group of fishermen could harvest from was vigorously defended. This defense of territory was strongly tied to the lobsterman's ownership of adjacent land, which often has been inherited for generations. This pattern of territorial defense has been maintained in island communities, as mentioned earlier, but in regions of the coast where populations of lobstermen have become more dense, particularly regions south of the Modomak river estuary, the greater range allowed by improving technology has broken down the perimeter-defended pattern to yield the nucleated form of territorial defense. As the greater costs of obtaining new technologies became more prominent in the fisherman's budget, fishing strategies had to be adjusted to include a greater area and longer season in order to bring in larger catches.[72]

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[71] Ibid., p. 191.

[72] Ibid., p. 193.

Cooperation between Members of a Lobster Gang

Gaining membership to a lobster gang is dependent first and foremost on a person being a member of the community. Under normal circumstances, this is not accomplished by simply buying land in the community to establish residency, however; it is usually accomplished by inheritance of an elder's (usually a father's or uncle's) place in the gang through some sort of apprenticeship on the boat. If a person began fishing as an adult, or if he plans to fish only part-time, then his acceptance by the gang will most likely be quite difficult. In any case, in nucleated harbors these requirements supplement a greater emphasis on a demonstrated willingness to abide by the local fishing norms. In perimeter-defended harbors, the requirement is stronger in that a person's family must have a history of owning land on the island or on the adjacent mainland, or if this is not the case, that they pay a rental fee for the right to fish in the gang's waters.[73]

Any behavior by a member of a gang that is considered deviant of the local fishing norms, such as altering a competitor's traps, exceeding a trap limit within an area, or infringing on another member's traditional fishing area, will eventually by punished anonymously by having their own traps cut or other damage done to their boat or equipment. While this retribution is illegal and can result in a loss of person's license, there is a code of silence among the members of the community, and even by the victim himself, as there is a strong tradition within the lobstering industry to minimize the influence of state officials on their affairs.

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[73] Ibid., p. 191.

The benefits of the communal nature of lobster gangs is evident when emergency situations arise, such as if a boat has engine trouble or other distress while at sea. Since members of a gang communicate on a certain CB channel they are constantly able to get in touch with each other to request help. In addition, within a gang members develop reciprocal relationships where assistance is offered in maintaining equipment or pulling traps during an illness. These ties are often strengthened through repeated contact in social situations where gossip, jokes or trade information are swapped.

Within a gang, a hierarchy develops where the most successful lobsterman gains the respect of others by his affluence through efficient fishing effort. The efficiency of his fishing efforts is of paramount importance in gaining respect; otherwise, the lobsterman is seen as exerting unfair pressure on the lobster population within the territory. In such a case, his success would be attributed to his advantage in number of traps rather than his skill as a lobsterman. His willingness to offer assistance or other useful information to less successful members in respectful ways soothes any jealousy that may develop because of his success and creates reciprocal relationships with various members of the gang. As his time in the gang increases through the years, his seniority will enable him to have greater freedom in where he sets his traps, as well as provide him with greater influence in matters of communal deliberation, such as the first day of the season to set traps within the territory.[74]

The sharing of information is often the greatest

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[74] Acheson, J.M. The Lobster Gangs of Maine, p. 56.

assistance that one fisherman can offer to another, and this occurs largely along lines of similar hierarchy within a lobster gang. The most successful members will share information with each other, while those least successful will have difficulty in obtaining any useful information at all. This pattern holds except in relationships with a member's family; while two brothers in competition might not be open in sharing information, a younger member of the extended family would likely receive many valuable tips from an elder in order to maintain the success and social standing of the family within the community over the long run. In fact, in perimeter-defended territories, where the members of a gang are either family or long-time friends, information about the location of lobsters may be shared over the radio, in a free manner so that all members of the community may benefit. In contrast, where the membership of the gangs are less stringently controlled and thus where there are a greater number of members who may be unworthy of receiving valuable information, inaccurate reports may be circulated so as to increase competitive advantage over other members.[75]

The flow of information between lobster gangs is ordinarily quite limited, as they have little to gain from sharing information where there are no guarantees of lasting relationships and communication within gangs occurs on different frequencies on the CB. Leaders of a gang may share information with prominent members of other gangs, such as price information or experimental fishing techniques, in an effort to gain greater standing within the statewide

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[75] Palmer, C.T. "When to Bear False Witness: An Evolutionary Approach to the Social Context of Honesty and Deceit Among Commercial Fishers." Zygon. 28 (December 1993), p. 463.

industry.[76] In 1989 when the price of lobsters fell statewide, the communication between gangs enabled unified actions to be taken by the normally independent fishermen in order to protest the perceived collusion on the part of the dealers. In this case, large numbers of lobstermen over a significant portion of the coast tied-up their boats in spite of the many obstacles to their collective action, most prominently the lack of any previously existing formal communication network between harbors. Although the actions did not result in a clear victory in being offered higher prices for their catch, a significant gain by the industry was the improved network of communication between harbors along the coast. The concerted action by the lobstermen demonstrated an ability, at the very least, to put aside their competitive relationships on the water to pursue a larger goal of a more stable relationship with the dealers.[77]

Economic and Ecological Benefits of Lobster Gangs

The lobster gangs allow the members of a fishing community to become familiar with, and to develop reciprocal relationships with, other members of their trade who would otherwise be seen largely as anonymous competitors for a limited stock of lobsters. Because of the communality developed over time between members, there is accountability

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[76] Acheson, The Lobster Gangs of Maine, p. 58.

[77] Palmer, C.T. "Organizing the Coast: Information and Misinformation during the Maine Lobstermen's Tie-up of 1989," Human Organization 50 (1991), p. 199.

for a person's actions, both good and bad, that will be paid back at some time in the future. This accountability is one of the primary reasons for lobstermen's general dislike for part-time practitioners of the trade; they are relatively invulnerable to the effects of violating the local norms (trap cutting and other under-handed sanctions) because of their smaller capital investments and alternative means of employment.[78]

Between the nucleated and perimeter-defended harbors along the coast, however, there is a further difference in the practice of harvesting lobsters. Because perimeter-defended territories are more difficult to gain entry into and because there is more mixed fishing in nucleated regions, there is a greater area for each fisherman to set his traps in, on the average.[79] If the fact that the fishermen in perimeter-defended territories use the same level of capital equipment as those in nucleated regions is taken into account, there is less fishing pressure exerted per unit of area in the perimeter-defended territories. This allows a greater proportion of lobsters in the territory to reach the minimum allowable catch size and thus sexual maturity, thereby adding further to the health of the population.

Because of the stable memberships comprising the perimeter-defended territories, it is easier for the members to enact conservation measures, such as trap limits and closed seasons, within the region. The trap limits allow the individual lobstermen to limit the investments that they have

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[78] Acheson, The Lobster Gangs of Maine, p. 67.

[79] Acheson, "The Lobster Fiefs:...," p. 195.

to make in maintaining and replacing their traps, as well as the money spent for bait and fuel. Because they spend less time on the water hauling their traps, depreciation of their boat equipment is minimized as well. In addition, because they have fewer traps, they do not place traps in areas that are not productive and thus improve their yield per trap.[80]

As an ecological benefit, a fewer number of traps allows the lobsterman to tend them more often and thus release those lobsters that are of illegal size and in doing so, allow mature females to release eggs and reduce mortality of others. As a result of this greater proportion of lobsters enjoying reproductive success and growing to legal size in perimeter-defended territories, a greater percentage of the catch is of larger lobsters than those caught in nucleated areas; this results in a greater profit per trap-pull, on the average. Because lobstermen in perimeter-defended territories are able to control seasonal access to their waters, they can further increase the profitability of their catch by timing it to coincide with the peak prices offered by dealers for their catch. When all of these factors are taken together, the average gross income for lobstermen in a perimeter-defended area was more than 20 percent greater than that of lobstermen in nucleated territories at the time of Acheson's study.[81]

The regulatory structure of the lobster industry, along with the organization of relationships between participants in the industry, has allowed the volume of landings to remain remarkably level at between 15 and 22 million pounds without any major disruptions since the Depression. Both the amount

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[80] Ibid., p. 198.

[81] Ibid., p. 203.

of lobsters caught and their value have reached new records in the first years of this decade, as shown in Figure 11 below.[82]

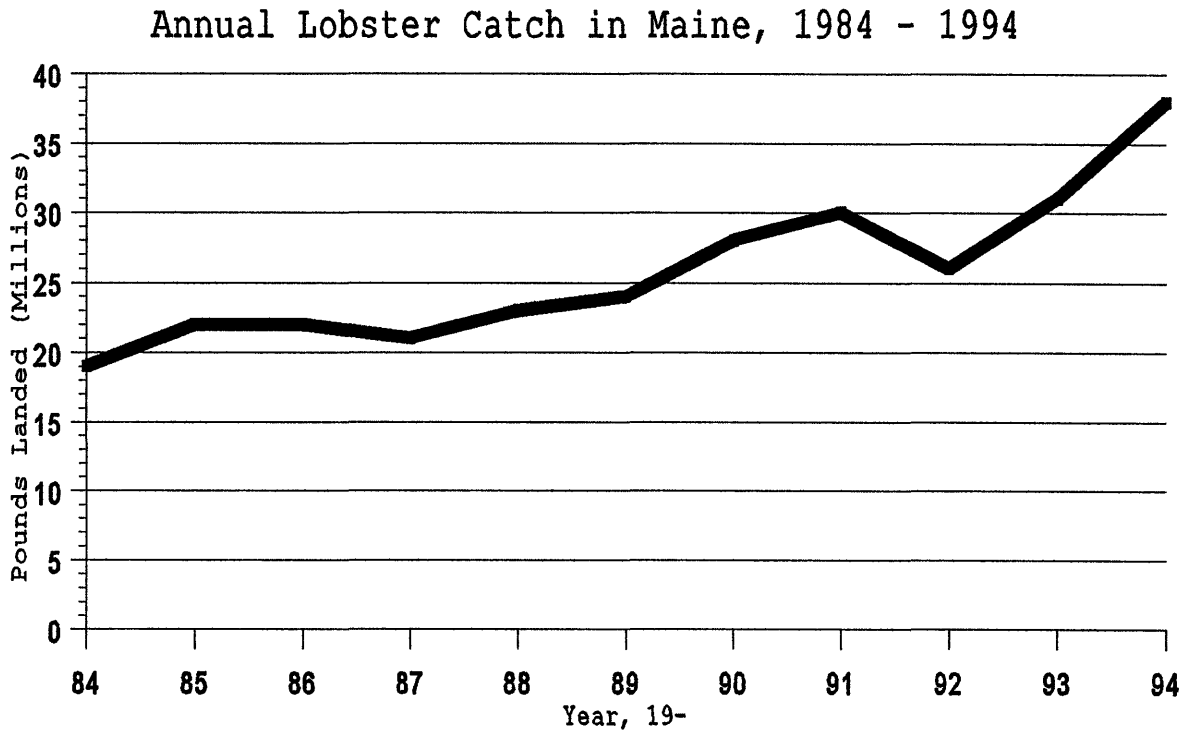

Figure 11

David Dow, executive director of the Maine Lobster Institute attributes the success to the people in the industry who "have a really strong conservation ethic." Stating further, "All these common-sense regulations that our industry agrees with and abides by is probably at least partially responsible for why we're having the success we are today."[83]

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[82] "Record Year for Lobster," Portland Press Herald, 2 March 1995, p. 9A.

[83] Ibid.

Translating Local Norms into Law

These informal rules that are applied by the members of a lobster gang cannot simply be transferred to a statewide enforcement level, because the essential accountability mechanisms could not be maintained at such a large scale without exorbitant enforcement costs incurred by the authorities. In order for the implementation of successful management tools to be accomplished, they must be formulated and enforced at a local level, where the participants of the industry have a personal, recognizable stake in their success.[84] By doing this, the state authorities demonstrate both their respect for the many years of knowledge that the fishermen have inherited and applied in the experience of their trade and their desire to integrate this understanding with the knowledge that biologists have gained from their research efforts.

The inclusion of the industry participants has been recognized by the New England Fisheries Management Council as a necessity, in the case of implementing a management plan for the industry in 1993 in order to avoid a federally imposed gauge increase. This loss of freedom to the federal level of government was accomplished by the cooperation of two traditionally opposed forces: the regional Council and the industry participants. By providing funds for the industry to prepare a first draft of the plan for review by the Council, the industry has a sense of ownership of the plan from the

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[84] Palmer, C.T. "Folk Management, 'Soft Evolutionism,' and Fishers' Motives: Implications for the Regulation of the Lobster Fisheries of Maine and Newfoundland," Human Organization 52 (1993), p. 418.

start, thereby increasing the likelihood of success in later stages of the review process.[85]

This strategy of including industry participants in the legislative process as members of a special advisory council has been adopted by the Maine Department of Marine Resources. In 1981 the Legislature authorized the formation of the Lobster Advisory Council with the intention of "fostering and promoting better methods of conserving, utilizing, processing, marketing and studying the lobster."[86] Each person serving on the 11 member council is appointed by the Governor, with one representative from each of the eight coastal counties, two primary wholesalers, and one member of the general public holding no license within the lobster industry.

Specifically, the council is authorized to advise the commissioner of the department on activities that relate to the lobster industry, including: investigating problems within the industry and reporting findings to the commissioner and Marine Resources Advisory Council; reviewing current research programs and plans for research on the lobster stock and submitting recommendations on these programs and plans; and the allocation of money from the Lobster Fund, a fund created to ensure the successful reproduction of the fishery through hatchery programs among others. While these functions are strictly advisory, the opportunity for the industry to participate constructively in the resolution of current problems and the planning of future research could serve as a spring-board to greater responsibilities for the council in

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[85] Griffin, N. "Lobstermen Work on Their Lobster Plan," National Fisherman, April 1993, p. 10.

[86] §6461, Maine State Law.

managing the resource. The most important accomplishment in this program is the active participation of industry members in the affairs of the Department of Marine Resources; this engagement provides a uninhibited path to the Department for the members of the industry to share their understanding of the lobster and its environment with their partners in the regulatory process.

Chapter VII

Conclusions and Recommendations for the Sea Urchin Industry in Maine

Conclusions of the Thesis

From the work presented above, a few conclusions may be drawn about the green sea urchin industry in Maine and the regulatory response by the managing authority to its early growth.

First, it may be concluded that, after a couple of years of largely unregulated harvesting activity following 1987, the state has enacted several measures which are first steps in controlling harvesting activities within the state's coastal waters. The most basic of these is the licensing of all people who are directly involved with the harvesting, dealing, transporting or processing of sea urchins in the state. The licensing provision serves as a basic measure to limit entry into the industry, thus allowing a limited amount of accountability within the population of license holders, limited only by the level of enforcement possible. The formation of two zones within the coastal waters is an extension of this accountability purpose, disallowing the migration of harvesters to regions that have been not been heavily harvested after they have removed the entire harvestable urchin stock from the waters near their own

communities. Finally, the establishment of a minimum harvestable size prevents the removal of the urchins that have not had a chance to breed at least once. While consideration has been given to a roe content by weight measure (10% minimum), concerns about the unenforceability of this have deterred its use; instead, a larger minimum size, phased to 2¼" in two years, has been gaining favor within the industry as an enforceable provision that will enable urchins to breed at least twice in their lives.[87]

Another conclusion that can be made is that the state is on the right path in the formation of the Sea Urchin Research Fund through money raised from the licensing of members in the industry. This provides money for the enforcement of marine laws and the creation of other programs which will study the urchin population and its functional biology within the ecosystem. It is essential that managers understand to as great an extent as possible, the interconnections with other valued species in the ecosystem, such as lobsters and groundfish; these commercially valuable species may depend on the urchins as a source of food at some point in their life-cycles. It is possible that a decrease in the urchin population could deter the restoration of the groundfish stock because of the diminished presence of food. The log book provision, while utilized successfully in many other fisheries in other states, exists only on paper in the urchin industry in Maine due to a threatened lawsuit by one member that such a measure is an undue burden on the business operation of the harvesters, dealers and processors.[88] Another research

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[87] Higgins, John. Urchin Diver. Personal Communication. 27 March, 1996.

[88] Creaser, Ted. MDMR. Personal Communication. 25 March, 1996.

provision that has yet to be implemented is the creation of reserved areas along the coast in order to determine a baseline for population studies which will discern human effects from harvesting from natural fluctuations of the population.

Third, the current investment in research will allow managers in the future to define ecologically sound limits to harvesting activities. The minimum size is only a starting point in this respect; the requirement that all urchin catches must be culled at sea ensures that those individuals that are too small to be harvested will be returned to their feeding ground where they may continue to grow and successfully reproduce with other urchins. Further research will also allow the timing of harvesting activities to coincide with the season of maximum value held by the urchins, when their roe content is at a maximum and its quality is at a level where the Japanese consumer will continue to recognize Maine urchins as a product of premium quality. This would be an efficient outcome for all members of the industry; the greatest return for a measured amount of effort. By continuing to harvest and process urchins that are of substandard quality, members of the industry in Maine are diminishing their future earning potential by damaging the reputation for quality for which Maine urchins have previously been known. Finally, research efforts may provide conclusive evidence that heavy drags currently being used to land urchins causes damage to both the harvested urchins and to the benthic environment in which they live and grow. This may enable the replacement of this type of equipment with other methods for harvesting, such as a light drag (ex., the "green drag") or bait and catch methods.

Fourth, it may be concluded that implementing the guidelines resulting from these research efforts will require coordination with and cooperation among members of the industry. In order for this to be possible, it is necessary that these findings be mutually acceptable to a majority of the members; therefore, when at all possible, research efforts should be carried out by independent scientists whose findings cannot be challenged because of allegations of a conflict of interest in the outcome. This may be more feasible if a change in attitude toward the stock of natural resources is reached where it is not the rate of removal that is to be maximized, but the value attained from the removal of that resource that is to be maximized. By doing this, option value is preserved for the resource, as well as any corresponding benefit that the ecosystem derives from the unharvested resource. This change of view necessarily involves a extension of the horizon being considered economically, and thus a lowering of the discount rate to a level where future costs and benefits carry a much more significant value in relation to immediate costs and benefits considered by many members of the industry today. In the case that many participants in the industry hold this viewpoint today, expressed in their desire for a sustainable industry, this must be openly acknowledged and translated, to as great an extent as possible, "mutual restrictions, mutually recognized by a majority of the population."

This leads to the final conclusion, that it is not feasible for the state to carry out all, or even most, of the enforcement functions required for the maintenance of a sustainable industry. At this time of fiscal austerity for

all of the state agencies, enforcement of laws and regulations not directly affecting the public welfare is of secondary importance. Therefore, these acknowledged limits on what is considered to be acceptable harvesting activities must be enforced within the community of harvesters through peaceful means of coercion. When members interact often and over an extended period of time, they recognize each other and are able to recall past behaviors, whether deviant or cooperative to the mutually recognized goal of a sustainable industry. The greater the number of members who are willing to stand up to deviant behavior, the greater the social force will be on that person by withholding useful information or denying assistance in a time of need. Of course, there is no hard-and-fast rule that can be applied for deviant behavior; each situation must be assessed and acted upon individually. The concerted action of the members will be facilitated by stable, limited, localized populations of harvesters who are accountable to the communities in which they live.

Recommendations to the Industry

In light of the conclusions provided above, the following recommendations are made to the industry as measures which will assist in the formation and maintenance of a sustainable sea urchin industry.

- The requirement that log books be kept by wholesale dealers and processors should be implemented as a necessary measure to obtain information about the effort

being expended by harvesters for the amount of urchins being landed from a particular region of the coast.

- Limited areas should be designated along the coast in order for observations to be made about the natural fluctuation of urchin populations which occur periodically and independently of the activities of urchin harvesters.

- Heavy dragging equipment should be phased out for use in the industry because of the resulting damage to urchins and their benthic environment. Subsidies in the form of a buy-back program might be useful in encouraging alternative harvesting technologies, such as baiting and trapping or airlift systems, to be explored.

- A council comprised of a geographic and functional cross-section of the industry from each zone should be formed and endowed with a special consultative designation to the Joint Standing Committee on Marine Resources in order to empower the members of the industry and thus gain greater compliance with the rules that are adopted.

- A Sea Urchin Promotion Panel should be created in order to explore other markets for the export of processed sea urchins so that the industry's dependence on the Japanese market will be marginalized should trade conditions between the two countries deteriorate.

- The concept of utilizing zones to limit the migration aggressive harvesters along the coast should be developed further to incorporate the benefits of territoriality that the lobstering communities enjoy. Zones might be formed in smaller units along the coast to promote familiarity among harvesters and encourage mutually cooperative relationships.

Summary of the Thesis

This thesis was an examination of the sea urchin industry in Maine as a example of the utilization of a finite, renewable, common property resource by agents of the public domain. The growth of the sea urchin export industry, first on the West Coast of America, followed by the expansion in Maine, was documented, as well as the resulting formation of the regulatory structure in order to manage the recently commercially-valued resource.

Because the resource is located only in the marine environment, only those persons with access to the sea can harvest the resource, yet when the density of harvesters reaches a certain level, self-imposed restrictions on activities must be enacted in order to prevent the catastrophic failure of the sea urchin population. The logical failure of competitive agents to conserve a common resource was presented through a consideration of Garrett Hardin's "Tragedy of the Commons."

The use of game theory in modeling competitive situations between agents in a closed population was explored in order to

gain any understanding of the conditions which foster cooperation between members of the population. Such cooperation may evolve if there is sufficient recognition and familiarity between members of the population and the rewards and punishments for cooperative and deviant behavior, respectively, are significant enough to coerce compliance with the mutually accepted rules.

The recognition that the resources in the environment are ultimately finite was advanced and sustainability as a goal for economic activity was proposed in light of underutilized evaluative tools for natural resources, such as option, indirect-use, and existence value. The use of the discount rate in financial analyses was presented along with the flaws of using an inflated rate along with misappropriated values of natural resources. The necessity of including the members of the industry in forming a sustainable development plan was emphasized in the conclusion of this section.

The lobster industry was then considered as an example of a community of competitive agents who cooperate amongst themselves in order to manage the quality of the resource and limit effort expended in harvesting that resource. The structure and maintenance of their territorial units was examined in order to understand what traits may be applied to the urchin industry.

Finally, conclusions of the thesis and recommendations to the industry were presented, along with a brief summary describing the structure of the thesis.

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