AN INTEGRATED FISHERIES MANAGEMENT BLUEPRINT FOR THE NEWFOUNDLAND AND LABRADOR GREEN SEA URCHIN FISHERY

JANICE MARIE RYAN

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A Major Report submitted to the

School of Graduate Studies

in partial fulfillment of the

requirements for the degree of

Master of Marine Studies

Fisheries and Marine Institute
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Abstract

Since 1997 the Government of Newfoundland and Labrador has recognised the importance of the green sea urchin resource due to growing international market demand. The purpose of this paper is to draw attention to the need for a formal Integrated Fisheries Management Plan and to present a preliminary blueprint for such a plan. A literature review was conducted of North American urchin fisheries to place this province's fishery in context. The green sea urchin is very susceptible to over-exploitation due to its life history characteristics and biology. It is very important to control fishing effort through a management plan that is based on reliable scientific data that encompasses both traditional and non-traditional management practices to promote the long-term sustainability of the stock. The most valuable lesson learned was that the timing of an IFMP is crucial to an emergent fishery and now would be the time to implement such a plan rather than later, as in reactive management which has characterized fishery management in this province.

Acknowledgements

I would like to express my sincere gratitude to the following people who offered their advice and information based on their experiences with green sea urchin fisheries throughout North America. Maggie Hunter, Biologist, Maine Department of Marine Resources and Peter Kalvass, Biologist, California Department Fish and Game, offered information and personal experiences with the collapse of their urchin resources. Doug Woodby, Biologist, Alaska Department of Fish and Game offered his perspective on how to handle a green sea urchin fishery that is in an emergent stage based on his experience in Alaska. Eric Way, Program Planning and Co-ordination, Resource Management Branch, Fisheries and Oceans, allowed me to interview him several times in my attempt to nail down exactly what management measures my own Department has put in place for the Newfoundland an Labrador green sea urchin fishery. Annemarie Russell, Statistician, Fisheries and Oceans, provided me with the resources to track the landings and landed value of green sea urchins in my own province since the start of the fishery. Glen Blackwood, Director, Centre for Sustainable Aquatic Resources, provided me with information on the Workshop held in St John's for Sea Urchin Licence Holders. Irvin Green, Owner/Operator of Green's Seafood's, Winterton, allowed me to visit his plant and gain the socio-economic perspective on the importance of the green sea urchin resource in Newfoundland and Labrador. The staff of the California Seagrant College for sending me a reproduction of a library document on sea urchin biology, enhancement, and management without charge. To my supervisor for his very thoughtful insight, critique encouragement and most importantly patience during the writing and editing stages of my paper. I would like to express my appreciation to my paper's examiners for their very constructive criticism and commentary.

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Section 1 Introduction

Historically Newfoundland and Labrador fish harvesters considered the green sea urchin a worthless, unsightly nuisance that created tangles and knots in their fishing gear. However this attitude changed when the fishing industry in this province recognised the sea urchin's export potential due to meet the growing international market demand for this culinary delicacy. Since 1997 Newfoundland and Labrador has taken advantage of this resource and came an exporter of fresh whole sea urchins as well as "uni", sea urchins whose roe sacs have undergone secondary processing (Green, 1999). The main export market for Newfoundland and Labrador green sea urchins is currently Japan, where 90 to 95% of the world's processed sea urchins are consumed (Gillingham & Penny, 1993).

There is also an emerging European market for sea urchin roe since it is an excellent substitute for high-grade sturgeon caviar at up-scale restaurants in France, Holland, Belgium, Switzerland, Germany and the UK. Another reason for the growing European market is the decline in French and Irish Sea urchin stocks (Anon, 2002a). With the decline in European domestic supply the price for this commodity has increased dramatically and it has created a market opportunity for new industry participants in Newfoundland and Labrador.

As economically promising as a sea urchin fishery may sound for Newfoundland and Labrador, the Department of Fisheries and Oceans (DFO) has yet to focus on direct scientific research or to develop a formal management plan to provide a set of guidelines for sea urchin harvesters (Way, 2001). This remains the case in 2005. This creates major problems in the sea urchin fishery where sustainability is a major consideration due to the species biological characteristics. The green sea urchin has a very slow growth rate and a spatially limited habitat (DFO, 1996), making it very susceptible to over-exploitation in a directed sea urchin fishery as well as in other fisheries that use gear (e.g. trawls) harmful to sea urchins.

The need for a management plan to ensure the long-term sustainability of the green sea urchin resources in this province is twofold. With the collapse of the groundfish industry in 1992 thousands of individuals and their dependents were left jobless. This resulted in a need to diversify the fishing sector by focusing on "emergent species" such as the green sea urchin to support the livelihood of the local population. As a result, several Newfoundland and Labrador companies developed the potential of the sea urchin fishery by using aquaculture as a way to enhance the roe quality and yield of wild sea urchins stocks (DFO, 2000a). However, culturing of brood stock in other fisheries has been known to harm the genetic biodiversity of wild stocks thus leading to ecological risks. Due to the obvious importance of diversifying the fishing industry to create employment there is a sense of urgency surrounding the formulation of a consistent and co-ordinated management plan that will allow the sea urchin fishery to be conducted in a safe, sustainable manner that does not undermine the species. This will in turn allow the fishery to develop in a way that will yield maximum benefits to the local communities by providing guidelines for the setting, allocation and harvesting of quotas.

1.1 Statement of the Research Problem

The purpose of this paper is to draw attention to the need for a formal management plan for the Newfoundland and Labrador green sea urchin fishery. To this end, the paper will present a preliminary blue print of an Integrated Fisheries Management Plan (IFMP) for the green sea urchin fishery in Newfoundland and Labrador. Specifically, my aim is to identify a set of guidelines, and to suggest potential management tools that may assist in the design of an official management plan for this interesting, and economically viable fishery.

The governing body in Canada that is responsible for the conservation and sustainability of marine resources is the DFO. Through consultation with the fishing industry, scientists, and pertinent stakeholders the DFO develops IFMP that considers the resource health, industry viability and enforcement issues (Way, 2001). The integrated management plan is a key tool in the protection and conservation of marine resources that are commercially harvested.

1.2 Methodology and Organization of the Study

To meet the objective of the paper, a review of relevant literature and experiences in sea urchin fisheries in North America will be conducted. The current status of the sea urchin fishery in Newfoundland and Labrador will be discussed to illustrate what data are necessary to create a management plan. The elements of an integrated fish management plan will then be presented including a discussion of the existing gaps in information that must be closed before an official sea urchin management plan can be designed.

This analysis is limited to the markets, biology, harvesting technology and with a view to suggesting appropriate management tools for this fishery. The processing functions of the industry are beyond the scope of this paper. Considering the limited, and only recently emerging literature on the local sea urchin fishery, it is understood that this paper can only be a first attempt at addressing the most important considerations in developing and controlling the fishery in a socially appropriate fashion.

By conducting a review of management plans and resource problems in other North American sea urchin fisheries the issues facing the Newfoundland and Labrador green sea urchin fishery can be put into context. This enables a determination of the extent to which existing information applies to Newfoundland and Labrador. Where available, economic data on markets, landings, biological data, and information from industry and other fishery participants about harvesting technologies will be used. To reiterate, this is a preliminary effort to present ideas that may be used by the DFO in the formulation of an integrated management plan.

2.0 Overview of the Fishery

This section will provide an overview on the present state of the green sea urchin fishery in Newfoundland and Labrador. Material covered includes the distribution of the resource, the biology of green sea urchins, market information, and the current state of the Newfoundland and Labrador fishery.

2.1 Green Sea Urchin Distribution

The green sea urchin (*Strongylocentrotus droebachiensis*) has one of the longest scientific names in the animal kingdom. It belongs to the class Echinoida, which is Latin for "spiny skin" (Pearce, 1998). This reflects its spherical shaped body, covered with spines, that gives the urchin a 'hedge hog' like appearance. Common local names of the sea urchin include 'urchin' and 'whore's eggs'. Its geographic distribution is vast, ranging from the Arctic south to Cape Cod in the Atlantic and from Alaska south to California in the Pacific Ocean. The sea urchin is common throughout Newfoundland and Labrador (DFO, 1996).

2.2 Biology

The sea urchin is generally most abundant just below the 'sub tidal algal fringe' at depths of 5 to 10 meters. Their preferred habitat is shallow, exposed, and rocky bottom (DFO, 1996). The movement, dispersion and aggregation of sea urchins vary spatially and temporally with food availability, predation and seabed topography. Water movement (tidal and wave action) and temperature modify their feeding behaviour and movement (Pearce, 1998). The mature sea urchin prefers a diet based on kelp (brown algae), but it will eat small molluscs and dead organisms. When food is scarce, they will even feed on other sea urchins (Pearce, 1998).

If food sources are abundant in a particular area the sea urchins will remain in that area for several months, particularly if they are in an area sheltered from predators. Sea urchins can chemosense food and predators upstream at a distance of several meters. This allows them to move towards, or away from, the stimulus as the case may be. When the only available food is drifting algae, sea urchins can live in small cryptic aggregations in topographically complex habitats, which are relatively safe from predators (Hatcher & Hatcher, 1997). If large algae are only available in the form of kelp beds and the threat of predation is low, sea urchins may form dense feeding aggregations of over 250 individuals per square meter. These aggregations are referred to as feeding fronts or "feed lines". Strong wave action can physically disperse sea urchins and move algal foods away from aggregations, preventing then from feeding effectively (Hatcher & Hatcher, 1997).

During the Spring bloom phytoplankton releases a chemical that triggers the spawning of green sea urchins. Spawning occurs in the spring and early summer months (April to July) when the water temperature and food availability are favourable for stimulation of gonads[1], external fertilization of released eggs, and embryonic and larval development (Hatcher & Hatcher, 1997). The gonads are composed of storage and sex cells. The storage cells accumulate nutrients required for the production of eggs and sperm and they make up the bulk of the gonad mass in the early stages of gonad growth. The quantity and quality of their stored nutrients are directly related to the food consumed by the sea urchin during the extended process of gonad growth (Hatcher &Hatcher, 1997). The rate and timing of the storage phase of gonad development is strongly influenced by the environment.

Sea urchins are sexually distinct, that is, they are either male or female. The development of eggs and sperm is triggered by internal chemicals and influenced by water temperature, the amount of daylight, and food availability (Hatcher & Hatcher, 1997). Green sea urchins are broadcast spawners. They release eggs and sperm into the water column where fertilization takes place. The free-swimming larvae may remain part of the mero-plankton for several months. This is the most sensitive stage when they are susceptible to physical changes in their habitat such as temperature or salinity fluctuations. Eventually the larvae will sink to the ocean bottom where they metamorphose to the post larval stage in a matter of hours. It may take 4 to 10 years for the sea urchin to reach sexual maturity. At this stage it can range in size from 15 - 75 mm in diameter.

The complex interaction of age, size, feeding behaviour, reproductive stage, food availability and quality, and its physical environment control the growth of the sea urchin's somatic and gonadal tissues. As a juvenile the urchin experiences its fastest growth of 1.1 to 1.3% per day. The growth rate of the adult slows to 0.3 to 0.5 % per day (Hatcher & Hatcher, 1997). Once the urchin reaches harvestable size (i.e. 47 mm)[2],food availability becomes the dominant determinant of growth. In situations where food is abundant individual adult green sea urchins consume kelp at rates of 0.3 to 3.4 grams per day. The feeding rate increases with size. For example, a sea urchin that ranges from 30 to 70 mm in diameter can eat five times more than an urchin less than 30 mm. Temperature is also important. A sea urchin will feed twice as much in water that is 12º C rather than 1ºC, but this changes with season, in relation to the reproductive cycle (they will feed 2- to 3-times more from winter to spring, despite steady low temperatures). Maximum growth is achieved on the highly preferred diet of kelp. The somatic growth rate decreases with age. The growth of the gonad tissues as a proportion of total energy increases with age. In sea urchins 2.5 and 3 years old the gonad starts to re-grow shortly after spawning. Between the ages of 4 and 6 years the urchin reaches an optimal balance of size and gonad production for the fishery (Hatcher & Hatcher, 1997).

Predators of the sea urchin larvae include other zoo-plankton and plankton-eating fish. Predators of juvenile and adult sea urchins include lobster, crabs and certain fish species. Sea birds are predators when sea urchins become exposed in the inter-tidal region (DFO, 1996). Humans are the most recent predator of sea urchins in Newfoundland and Labrador, as seafood processors realized the potential of sea urchins to meet the economic and social needs of their communities and markets.

2.3 Marine Protected Areas

A Marine Protected Area (MPA) is an excellent method for the study of sea urchin biology and ecology . MPAs can also be used to enhance fisheries yields benefiting commercial fisheries. MPAs, also referred to as Marine Conservation Areas, Marine Reserves and Marine Refugia, encompass a geographic area where no fishing is permitted. The area is monitored to observe the effects of no fishing and to determine if adjacent stocks are benefiting from the conservation area. MPA's can potentially compensate for recruitment over-fishing by protecting the reproductive capacity of the stock. In addition they can enhance fishery yields for some coastal stocks by providing a source of replenishment for surrounding harvesting zones (Dugan & Davis, 1993).

Benthic[3] organisms such as sea urchins are an example of a species that exist as meta-populations. A meta-population is created when there are highly fragmented populations connected by low levels of dispersal. MPAs are effective conservation mechanisms for marine meta-populations that experience Allee effects. Allee effects, also referred to as depensation, is said to be critical if net growth rate becomes negative at low populations levels; that is population levels below some minimum viable population level. A population is doomed to extinction if it ever falls below the critical population level (Clarke, 1985).

The recruitment of density dependent species such as sea urchins can be negatively affected by harvesting in ways that can cause Allee effects. Adult density and spacing is crucial to fertilization efficiency. Sea urchins reproduce by broadcasting gametes into the water column. Diffusion and turbulent mixing quickly dilute the gamete plumes of spawning urchins, so that, even in relatively calm water fertilization is unlikely over distances of a meter or two, or a time of more than about ten seconds (Denny & Shibata,1989; Levitan, 1991).

A second source of decreased recruitment with increasing fishing pressure is disruption of a refuge for juveniles under the spines of adults. In Southern California, Tegner and Dayton (1977) found 80% of juveniles of red sea urchins (up to 10-20 mm) associated with adults. This is presumably because the spine canopy protects juveniles from predators (Tegner, 1989). It is likely that the concentration of juveniles under adults represents high mortality outside the spine refuge rather then behavioural aggregations (Rowley 1989; Tegner, 1989). If this is the case, juvenile survivorship up to a size of 20-40 mm may be critically dependent on adult abundance, and areas of low adult abundance may not experience enough recruitment into intermediate sizes to offset adult mortality from fishing or natural causes (Tegner & Dayton, 1977).

Sea urchins may be susceptible to sudden, catastrophic collapse as gradually increasing habitat destruction or harvesting pressure drops populations below the densities necessary to ensure adequate recruitment (Karlson & Levitan, 1990). MPAs can provide valuable protection against catastrophic collapse of fisheries, particularly if effort is difficult to control, or the Allee effect threshold is difficult to estimate.

Once a population level has been reduced below the minimum viable population it will not respond to reductions in fishing pressure but will remain at low levels approaching extinction (Clarke, 1985). However an MPA that eliminates fishing pressure can protect "source" populations that will spill-over into adjacent harvesting areas.

While at present there is no size or spacing set for MPAs, ideally the dispersion of sea urchin larvae and settlement patterns would be important factors to consider when implementing boundaries. It has been proposed that numerous small reserves spaced closely may be desirable. The concept of one large marine reserve may not work efficiently when dealing with species that exist in meta-populations. However, a large number of tiny reserves would be difficult to administer and police (Quinn et al, 1993).

But in general, the absence of by catch and fishing gear, such as those that cause major habitat damage like trawls, can lead to increased quality of habitat and higher growth rates of target species (Quinn et al, 1993). Increased reproductive output of a population can be significantly increased through the increases in both the number and the size of reproductive animals. For species such as sea urchins that form spawning aggregations, effective reproductive output may be enhanced in MPAs because of increased densities and sizes of mature adults. During spawning, dense populations of larger reproductive animals release greater numbers of gametes.The higher concentrations of gametes in the water column increases the fertilization success and reproductive output.

MPAs may also preserve critical spawning stock biomass of exploited stocks more effectively than size limits and catch quotas for some species by preserving natural size distributions and densities. The protected spawning stocks of long-lived species within refugia can potentially stabilize fishery yields through the prevention of recruitment over-fishing during times of environmental instability, periods of low natural recruitment, natural catastrophic events, and anthropogenic disasters. Recruitment can be enhanced in refugia through the selective settlement of larvae and increased survival of juveniles in areas with dense adult populations. It has been shown that juvenile sea urchins are dependent on the spine canopy of large adults for protection at this stage.

The preservation of genetic diversity is an important consideration in the design of MPAs. When harvesting sea urchins only the larger urchins are targeted. MPAs may preserve more of the natural genetic diversity of the stock by restricting fishery-based selection of certain genotypes. Genetic tendencies that lead to larger maximum sizes, larger sizes at maturity, and fast growth in a wild stock may be conserved in protected areas.

MPAs can be economically attractive for other reasons as well. If adequate adult escapement is provided by spatial refugia, then efficiency limitations in harvesting zones may be unnecessary and the cost of harvesting could decline (Dugan & Davis, 1993).

The main problem associated with using MPAs in this province is gaining the acceptance of the public, in particular those involved in the green sea urchin industry. When Parks Canada, in affiliation with DFO, proposed a MPA on the north east coast of Newfoundland and Labrador it was met with a high level of suspicion and doubt. The harvesters in that area had the impression that they would loose control over what happened with the resources that they relied on for a livelihood (Ryan, 1999). The approach taken by government in introducing the concept of a MPA was unfortunate in this case, a circumstance recognized only after the proposal was shelved.

MPAs cannot work without the support of harvesters. The selling point is the benefits that can arise. Harvesters must realise how a marine refugia can improve and enhance sea urchin stocks. The lack of empirical scientific evidence on the benefits of marine refugia makes it more difficult to gain acceptance of MPAs (McCreery, 1999).

The size of the MPA required depends on a number of factors such as the transfer rate of species between the MPA and open fishing grounds; reproductive strategy and life history; population density; minimum viable population size; habitat attributes; trophic requirements; minimum territory sizes; mobility and migration patterns; species range;

fishing history; sources and sinks of marine larvae; metapopulation dynamics (Quinn et al, 1993).

MPAs should be experimentally tested over a long period (e.g. 10-15 years) to assess both the efficiency and the criteria for the design of the MPA. Examining the effects of MPAs on populations of experimental and non-experimental sea urchins may help separate the effects of harvesting protection from changes related to other sources, such as environmental conditions. A major problem in evaluating the effects of existing MPAs on marine populations and communities has been the lack of data collected prior to refuge establishment. Areas with a long history of scientific research and monitoring may be ideal for testing MPAs designs.

2.4 Markets

The Newfoundland and Labrador green sea urchin industry has focused on Japan as their main export market. There are two reasons for this. Firstly, Japan has become the fastest growing import market in the world. Secondly, Japan consumes 90 to 95% of the world's processed sea urchins (Gillingham & Penny, 1993). Sea urchins are economically important for their roe. Each urchin has five roe sacs that contain five segments of eggs or 'uni'. Sea urchins can be shipped live to Japan for secondary processing, or they can be processed in Newfoundland where the roe segments are removed from the sacs and shipped fresh, I know from personal experience. Urchins with a diameter of more than 50 mm are the most profitable to process. Smaller urchins are expensive to process with respect to absolute yield per unit of processing time. The two main ways the Japanese consume sea urchin roe is as sashimi, in which the roe is raw, or as sushi where the roe is decorated with rice or seaweed (Robbins & McKeever, 1990).

There is a growing demand for sea urchin roe in Japan primarily because of a growing consumer base. In the early 1970's uni was sold on traditional large wooden trays (230-250 grams each). Since then smaller plastic deli trays (70, 100, or 200 grams each) have replaced the larger wooden trays (Gillingham & Penny, 1993). This has enabled the household shopper (usually women) to purchase uni at the local supermarket. In addition, more Japanese women are working outside the home than ever before. The disposable income of household has therefore increased. Moreover, supermarket shopping is becoming more popular (Wong, 1992). Young women are consuming uni at inexpensive sushi bars as it is said to enhance their beauty. All generations are in fact eating more roe because it is believed to be effective also in obtaining better health. Once a food item of the elite social class, this delicacy has now become popular and affordable to the middle class (Anon, 1996). In part this was due to the appreciation of the yen prior to 1993, which increased the purchasing power of Japanese consumers. At the same time, the ageing population has reduced the size of the labour force, and there are fewer people working in the fishing industry to harvest and process domestic sea urchins. Japan is therefore looking to increase imports, and reduce trade barriers. These policies are favourable to firms exporting sea urchin from areas like Newfoundland and Labrador (Wong, 1992).

The sea urchin's growth-harvest cycle favour Newfoundland and Labrador exporters. Japan's sea urchins are harvestable from April to September. During the rest of the year the domestic supply is low. The Newfoundland and Labrador season starts in October and ends in May, which means that Newfoundland and Labrador exporters can supply the Japanese market when the demand for imports is high (Green, 1999). There is fierce competition from 13 other countries to win market shares in Japan during its high demand season. The most highly valued imported roe comes from the "red giant", which is harvested off the coast of California. This resource has declined along with the French and Irish sea urchin resources. Together these factors indicate that the sea urchin fishery could be very profitable for harvesters in this province.

As noted in the introduction there is also a European demand emerging for sea urchin roe in France, Holland, Belgium, Switzerland, Germany and the UK due to the collapse of French and Irish stocks. This could be a lucrative market for Newfoundland and Labrador because of the high value placed on the sea urchin roe as a replacement for sturgeon caviar (Anon, 2002a). Chile has a huge domestic market for sea urchin roe; however offshore fish species and inedible black sea urchins have invaded grounds previously occupied by edible urchins, thus limiting domestic supply. This also creates the opportunity for a sea urchin exports to Chile. In Canada, potential domestic markets may be found in larger cities like Toronto where there are large ethnic populations of Italian, Spanish, Portuguese, German, Greek, and French descent. Maine has supplied these ethnic groups in Chicago, Boston and New York City with sea urchins since the 1920's (Creaser, 2000). Newfoundland and Labrador could develop similar domestic markets in Canada.

2.5 Current State of the Newfoundland Sea Urchin Fishery

The DFO classifies the sea urchin fishery in Newfoundland and Labrador as an "emergent fishery". This term refers to species not currently exploited commercially, and to new fishing areas and methods that are not covered by management plans. The management of such a fishery differs from traditional commercial fisheries because less information is available on the emergent species, its habitat, sustainable harvesting levels and methods (DFO, 2000a).

At the provincial level the Department of Fisheries and Aquaculture (DFA) has become a key player in the diversification of the fishing industry since the moratorium on ground fish stocks in 1992. Through a memorandum of understanding between DFA and DFO, a mutual objective has been set to facilitate Federal/Provincial cooperation and coordination in the planning and implementation of the development of emerging fisheries in Newfoundland and Labrador. This memorandum states that the diversification process should "ensure the conservation of stocks and realize the optimal, sustainable and economically viable use of fisheries resources for the benefit of Newfoundland and Labrador" (DFO, 2000a).

Exploratory work is being conducted to discover more sea urchin resources, but with "absolutely no scientific involvement", by the DFO (Way, 2001). The locations, stock distribution, and breeding areas of sea urchins have therefore not been well defined (DFO, 1996). Without this information an efficient, integrated management plan for the sea urchin fishery cannot be established. According to DFO there are no significant conservation issues regarding sea urchin stocks because harvesting only takes place in water less than 18 meters in depth (Way, 2001). However, this is the main habitat of the sea urchin. Fishing effort directed in this shallow area would therefore have great effect on the stocks. Other reasons why Newfoundland and Labrador does not have management plan is that this fishery is still in the early development stage; small numbers of harvesters are involved; and the fishery is still small with respect to economic importance and labour content compared to the shellfish fisheries. But perhaps most important is that the lack of resources within DFO prevents commitment to the establishment of a management plan.

At present there are some very rudimentary measures in place to regulate the fishery. These measures are based on scant historical data and experiences in other sea urchin fisheries. Due to the emergent nature of this fishery, there is not a large historical information base. The first recorded landings of sea urchins in Newfoundland and Labrador in 1993 totalled 62 metric tonnes (Figure 2.1). This number peaked at 928 metric tonnes in 1998 and declined to 850 metric tonnes in 1999. The most recent data shows that landings have remained between 780 and 890 metric tonnes. (DFO, 2004a) Until 1996 there was a freeze on the issuance of new licences. At that time there were 170 licences in the hands of harvesters of whom only 44 were considered "active". To be considered "active" the harvester had to meet a minimum-landing requirement of 5000 kg in two of the past three years.

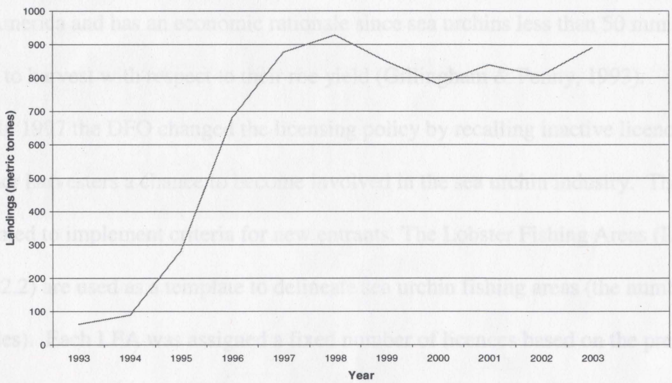

Figure 2.1 Newfoundland and Labrador Green Sea Urchin Landings 1993-2003 (DFO, 2004a).

Sea urchin harvesting areas are widespread throughout Newfoundland and Labrador. They are found in Notre Dame Bay, Trinity Bay, Bonavista Bay, Conception Bay, Fortune Bay, and Placentia Bay. There is a spatial and temporal relationship in collecting sea urchins. Notre Dame Bay urchins are the first stock ready for harvest, then Bonavista Bay, Trinity Bay, Conception Bay, and finally Placentia Bay. The harvesting season depends on the spawning season and water temperature. In Newfoundland and Labrador sea urchins are ready for harvest between the last week of September and the first week of October. They can be harvested until the start of spawning in May. Once spawning starts the roe begins to ooze, and the urchin is worthless (Green, 1999).

The only regulation used in this fishery to protect the resource is a 47 mm size limit. Sea urchins with a diameter less than 47mm (excluding spines) must not be harvested (Way, 2001). This size limit has been adopted from fisheries in other areas of North America and has an economic rationale since sea urchins less than 50 mm are not feasible to harvest with respect to their roe yield (Gillingham & Penny, 1993).

In 1997 the DFO changed the licensing policy by recalling inactive licences to give other harvesters a chance to become involved in the sea urchin industry. The DFO also wanted to implement criteria for new entrants. The Lobster Fishing Areas (LFA) (Figure 2.2) are used as a template to delineate sea urchin fishing areas (the numbers in the circles). Each LFA was assigned a fixed number of licences based on the premise that one licence would be available per 50 miles of coastline. (Available licences are in the squares and Active licences are in the triangles.) This resulted in a total of 242 sea urchin licences. In September 1999 an Industry Consultation Meeting was held with representatives from urchin licence holders, divers, Fish Food and Allied Workers Union (FFAW), Fisheries Association of Newfoundland and Labrador (FANL), Fisheries Resource Council (FRC), DFA, processors and DFO. The recommendation that resulted from this meeting was that the number of licences be set at 1 per 100 miles of coastline, or at the current active level based on harvest activity in LFA 4, 5, and 6 over the past 3 years. (i.e LFA 4 =17 licences, LFA 5 =17, and LFA 6 = 11).

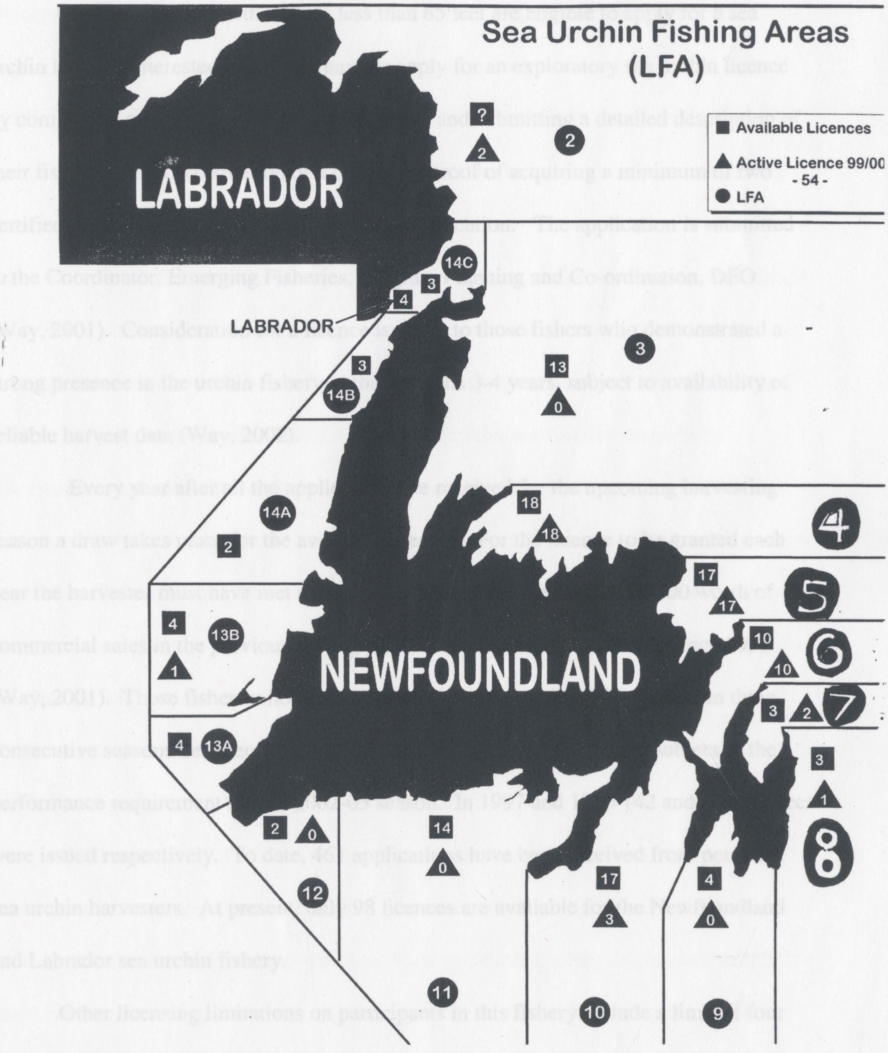

Figure 2.2 Newfoundland and Labrador Green Sea Urchin Fishing Areas
By Available Licences, Active Licences, and LFA (DFO, 2000a).

Only core fishers with vessels less than 65 feet are eligible to apply for a sea urchin licence. Interested harvesters have to apply for an exploratory sea urchin licence by completing an emerging fisheries application and submitting a detailed description of their fishing plan. Confirmation of a buyer and proof of acquiring a minimum of two certified divers have to be submitted with the application. The application is submitted to the Coordinator, Emerging Fisheries, Program Planning and Co-ordination, DFO (Way, 2001). Consideration for a licence is given to those fishers who demonstrated a strong presence in the urchin fishery in the previous 3-4 years, subject to availability of reliable harvest data (Way, 2002).

Every year after all the applications are received for the upcoming harvesting season a draw takes place for the available licences. For the licence to be granted each year the harvester must have met a minimum-landing requirement of $5,000 worth of commercial sales in the previous fishing year. This criteria has been used since 1997 (Way, 2001). Those fishers who reached sea urchin sales of $10,000 or more in three consecutive seasons between the1997-98 and 2001-02 seasons were not subject to the performance requirement for the 2002-03 season. In 1997 and 1998 142 and 129 licences were issued respectively. To date, 461 applications have been received from potential sea urchin harvesters. At present, only 98 licences are available for the Newfoundland and Labrador sea urchin fishery.

Other licensing limitations on participants in this fishery include a limit of four divers per enterprise. A minimum of two certified divers is required for a licence. Due to the specialized nature of harvesting urchins using divers, many harvesters have to turn to divers who have not historically been involved with commercial fisheries. They therefore tend to be very transient in this fishery. This may increase the risk of high grading, harvesting undersized urchins, or harming habitat due to the diver's lack of knowledge of the sea urchin fishery. Three vessels can be used under one license, and there are no limits on vessel size (Way, 2001).

Since 1997, consultation meetings with the sea urchin industry have taken place prior to the commencement of each sea urchin season. The fishery is reviewed and recommendations for the development of management plans for the coming season are made. Management measures established for each season are based on these recommendations, but there has yet to be a formal integrated management plan developed. An Industry Consultation meeting held in 1998 recommended that the harvesting cap of 100 metric tones per licence remain for 1999. In 2001, harvest caps were removed altogether. Other issues addressed included the establishment of a plant monitoring program, stricter regulations regarding the reporting of catches, renewal of licences in two of the LFA's, and the timely completion and submission of data (DFO, 2000a).

To date, no dockside monitoring program has been implemented. However, processors have agreed to provide weekly purchase data to the DFO on each fisher's landings. A small-scale pilot project to evaluate plant monitoring was considered for 2001 but was never implemented. All licence holders are required to complete and forward to DFO data sheets (i.e. logbooks) on a monthly basis.

The Newfoundland and Labrador season for the commercial green sea urchin fishery opens on October 1st and closes on May 31st with the commencement of the spawning season. In 1997 DFO delineated three exclusion areas within the harvesting areas in Notre Dame Bay, Bonavista Bay, and Trinity Bay due to conservation concerns (Way, 2001).

2.5.1 Harvesting

While there are at least six methods for harvesting sea urchins, diving is the only method permitted in Newfoundland. Diving is also the favoured method as it allows selection of appropriate specimens. The harvester employs one main vessel to store recovered sea urchins and up to two auxiliary vessels as diving platforms. The divers use scuba gear with the aid of weight belts to keep them down on the urchin grounds while hand picking specimens of appropriate size. Regular scuba gear can be used because the urchins are in shallow water less than18 meters.

The harvester must collect specimens and reach the processor within one day of harvesting. Poor weather and ocean conditions during the autumn and winter may at times prevent harvesting. Cold temperatures can cause diving gear to freeze up and ice can make harvesting unsafe (Green, 1999). The initial high costs of gearing up for harvesting sea urchins can pose a problem for harvesters who do not hold a scuba diving certification. Since most commercial fishermen are not scuba divers, this can lead to existing crew members who participate in non-diving fishing activities being displaced by certified divers (DFO, 2002).

In 1994 the Canada/Newfoundland Co-operative Agreement for Fishing Industry Development initiated a project to conduct experimental harvesting and processing of sea urchins using drags and pots. Urchin drags proved not to be size selective and worked well only in areas with good bottom conditions and low kelp populations. Long kelp blades tend to block off the drag and greatly reduce fishing efficiency. Negative environmental impacts did not appear to be significant (DFO, 2000a). However, dragging on sandy or muddy bottoms caused clouds of silt to form, which may affect the survival of some organisms incuding sea urchins. The experiments using pots proved highly because they did not catch any sea urchins or other by-catch, except for a small number of rock crab (DFO, 2000a).

In 1990 Aquametrica, a Newfoundland marine-consulting firm, carried out a pilot project to harvest sea urchins using a specially designed "ring trap". Harvesters who utilised the traps reported that they were easy to use and they allowed for easy selection of marketable urchins. To date, nothing has been done to further develop the traps to make them more suitable for harvesting marketable urchins. This harvesting technology would be beneficial for harvesters because it would reduce the high costs of harvesting urchins by diving (Gillingham & Penny, 1993). Two other harvesting methods used in other areas of the world involve collection of specimens using dip nets, and sucking urchins up from their habitat with a pump.

2.6 Why Newfoundland and Labrador Needs a Formal Management Plan.

Newfoundland and Labrador needs an Integrated Fisheries Management Plan to protect the green sea urchin stocks and to avoid the drastic stock depletion that has occurred in all sea urchin fisheries in North America. It is a major problem, therefore, that there exists no solid scientific base for the establishment of a green sea urchin IFMP in Newfoundland and Labrador. The Emergent Fisheries Coordinator with DFO has been quoted as saying there is "absolutely no scientific involvement" from DFO in this fishery and the attitude of DFO is that there are "no significant conservation issues regarding sea urchin stocks" (Way, 2001). Yet, it has been proven in green sea urchin fisheries in Maine and California that this species is easily exploited and susceptible to recruitment over-fishing. In the absence of sound scientific data managers cannot make informed decisions regarding the appropriate fishing levels for the sea urchin fishery.

Formal stock assessments and studies are normally required for major commercial fisheries. However, this has not prevented Newfoundland and Labrador's major groundfish fisheries from being placed under moratorium due to improper management. Harvesters and processors are now looking towards emergent species such as sea urchins to provide new employments opportunities. Now is the time to take measures to prevent the sea urchin fishery from becoming another victim of the tragedy of the commons. Fishing effort in the sea urchin fishery should not be permitted to continue to the point where the stock levels become insufficient to maintain a viable fishery.

3.0 Review of Other Green Sea Urchin Fisheires

This section will provide a discussion on North America's green sea urchin fisheries. The amount of information available varies depending on the history and economic importance of each individual fishery. There is more emphasis placed on areas that have a wider range of published material available due to greater involvement of science and management. The purpose is to see what lessons may be learned for the Newfoundland and Labrador sea urchin fishery.

3.1 Canada

3.1.1 Nova Scotia

Similar to its Atlantic counterparts, Nova Scotia's green sea urchin fishery is relatively new with the first commercial harvests in 1989 destined for Japan. This fishery includes all the coastline of Nova Scotia with the exception of the shore area of the Gulf of St. Lawrence. Between 1989 and 1993 sea urchin landings were less than 100 metric tonnes. There was a substantial increase in landings between 1994 and 1999, when landings ranged from 1000 to 1300 metric tonnes. The reason for the increase in landings was the doubling of price between 1993 and 1994 (DFO, 2000b).

Urchin landings dropped to 900 metric tonnes in the 1999-2000 season due to the high incidence of disease. At present disease is the biggest threat to the sea urchin resources in Nova Scotia: 270,000 metric tonnes of sea urchins died due to disease in the early 1980's. For the 1990's it is estimated that somewhere between 50,000 and 100,000 metric tonnes of urchins succumbed to disease. This was much more than the harvesting mortality in the commercial fishery. Disease threatens the biological and economical sustainability of the sea urchin resource in Nova Scotia and there are no tools available to predict the future incidence of disease (DFO, 2000b).

The only method of harvesting sea urchins in Nova Scotia is by diving. A maximum of four divers are permitted per vessel. DFO believes that this is the best method of harvesting because it does not negatively affect the stock size, and it does not risk the reproductive sustainability of the sea urchin stock. The sea urchin harvesting zones are delineated using the same geographic boundaries used for the counties of Nova Scotia. Licenses are restricted to a county in order to maintain a dispersion of effort. Once a harvester is awarded a licence they may fish competitively within that area. Only core licence holders are eligible to apply for any new licences (DFO, 2000b).

There is no formal integrated management plan protecting the Nova Scotia sea urchin fishery. However, in 1996 a Conservation Harvesting Plan (CHP) was formulated that contained provisions to control and distribute fishing effort in a manner that is believed to best utilise the resource and promote the long term stability of the sea urchin fishery. Input was used from commercial harvesters, aboriginal groups, DFO, and the Nova Scotia Department of Fisheries. The success of the CHP is dependent on a high degree of industry self-management, compliance and enforcement, because of the limited resources of the DFO to closely manage and monitor new fisheries (DFO, 1997).

The CHP states that new effort will only be considered if biological and economic factors permit, and only after full consultation with licence holders and other stakeholders. The CHP outlines regulations for the sea urchin fishery, which includes a minimum size limit (50-mm test diameter). DFO believes this to be an acceptable size limit because it allows the urchin to reproduce at least once prior to being recruited into the fishery. Green sea urchins become sexually mature at 25 mm.

There are two types of licences available to commercial fish harvesters. They are classified as either 'exploratory' or 'full time limited access licences'. The number of licences that can be supported per geographic area of coastline is determined before any licences are issued (DFO, 1997). In order to have their licences renewed, a harvester must land and sell a minimum of 2000 kilograms of sea urchins in their first licensed year. In subsequent years a minimum of 4000 kilograms must be landed and sold annually. If participation requirements are not met the licence will not be renewed. Alternatively, it may be cancelled and therefore not be available to another potential harvesters in that season (DFO, 1997).

No Total Allowable Catch (TAC) has been set for this fishery; instead there is a four metric tonne per year quota set for exploratory licences, with no minimum landing requirement for permanent licences. The harvester is required to hail (i.e. report to DFO) 100% of catches and the catch is monitored at dockside for 20% of the trips (DFO, 2000b).

Each sea urchin harvesting zone has a Restricted Harvesting Zone (RHZ). The RHZs boundaries are delineated after a detailed survey of its yield potential has been completed. Fishers who fish competitively in one or more sea urchin harvesting zones may request a permit for the RHZ within their specific harvesting zone. The permits are granted once the fisher has met specific guidelines, demonstrating that they have an in-depth understanding of the appropriate enhancement and harvesting techniques required to promote sustainable sea urchin and kelp bed resources (DFO, 2000b).

The onus is on the fisher to manage the area in a manner that sustains and enhances sea urchin and kelp production, and does not negatively impact other traditional commercial fisheries. The fisher has access to the RHZ for a four-year period. The fishing season is zone specific. Failure to meet the requirements of the permit will result in cancellation of these exclusive privileges. Part of the fisher's commitment is to provide an assessment of the RHZ in a manner prescribed by DFO. Accurate written descriptions of both existing sea urchin distribution and kelp habitat available in each zone must be provided to DFO prior to a permit being re-issued for the following season. These descriptions are subject to an audit and verification by an objective third party acceptable to DFO. Failure by the harvester to provide an accurate assessment will result in the potential loss of all or a portion of the licence holder's exclusive harvesting zone (DFO, 1997).

The main purpose of the RMZ is to provide individuals with an opportunity to directly benefit from non-competitive fishing practices, and to assess the feasibility and potential success of additional enhancement techniques. One of the main advantages of a RMZ is that it allows the fisher to better plan harvesting in location of high concentration of harvestable specimens. In addition, since there is no competition from other harvesters. The urchins can be harvested when they have reached the maximum value. The RMZ can thus be useful in enhancing kelp beds to increase sea urchin populations (DF0, 2000b).

Catch-per-unit-effort (CPUE) is not a good index of stock size or species behaviour in this fishery because the use of zones means that a reduction in the number of harvesters directing for urchins in an area can increase fishing efficiency rather than fishing effort. For example, zones where biomass has been reduced significantly by disease showed little or no reduction in daily or hourly CPUE.

A drawback is that if a RMZ is too large, highgrading can occur and the smaller urchins increase in density because the harvester selects larger urchins. Competition for food resources increases with the higher incidence of smaller urchins thus leading to a reduction in growth rate, which in turn creates an environment more susceptible to disease (since higher density populations are more prone to disease). The surviving urchins are not accessible to other fishers who do not hold a permit for this RMZ. Occasionally such large zones are not fished at all. The RHZ is surveyed every few years to assess the harvesting potential (DFO, 2000b).

3.1.2 British Columbia

The green sea urchin fishery is managed by DFO's Pacific Region through an IFMP. There are two stock assessment and three resource management personnel directly involved in this fishery. The IFMP involves the Fisheries Management Directorate, Science Branch, Shellfish Data Unit, Conservation and Protection Directorate, Pacific Fishery Licensing Unit, Treaty and Aboriginal Policy Directorate, Recreational Fisheries Division, and the Oceans Directorate. The IFMP includes evaluation criteria for the Management Plan and a Conservation & Protection Plan to ensure the Department's goals and objectives are met.

The dive fishery began in 1987 with a steady increase in effort up to 1992. Landings peaked in 1992 when 49 vessels reported 1042 metric tonnes landed valued at $4.4 million (DFO, 2001). Landings decreased after the introduction of quotas. In 1996 the lowest recorded landings were 117 metric tonnes, however an increase occurred after that year. Since 1997 landings have remained relatively constant. Figure 3.1 depicts the green sea urchin landings from 1996 to 2003 (DFO, 2004b).

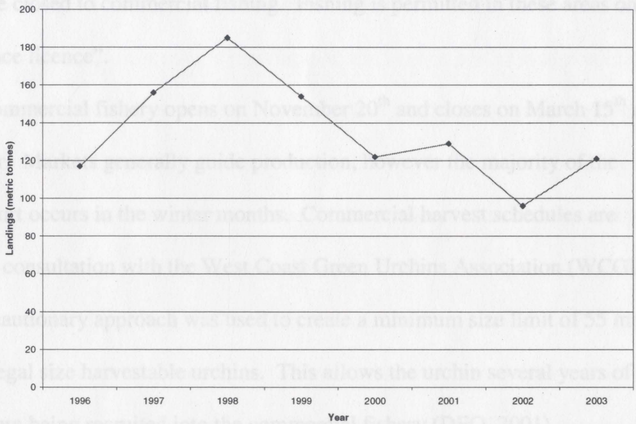

Figure 3.1 British Columbia Green Sea Urchin
Landings 1996-2003 (DFO, 2004b).

Hand-picking by divers is the only method permitted for harvesting green sea urchins in British Columbia. All diving and fishing operations must take place from the licensed vessel and all products must be brought directly onto the vessel following harvest. Vessels used to hold or transport urchins must conform to the Canadian Food and Inspection Agency's requirements for holding or transporting fish and have the appropriate licences.

The fishery is licensed regionally but occurs mainly in the south coast regions. There are seven separate quota areas. There are experimental fishery and permanent area closures that restrict commercial fishing activity only. They have no impact on the location of First Nations or recreational harvesters. Areas designated as research areas or study areas are closed to commercial fishing. Fishing is permitted in these areas only under a "science licence".

The commercial fishery opens on November 20th and closes on March 15th of the following year. Markets generally guide production, however the majority of the harvesting effort occurs in the winter months. Commercial harvest schedules are determined in consultation with the West Coast Green Urchins Association (WCGUA).

A precautionary approach was used to create a minimum size limit of 55 mm test diameter for legal size harvestable urchins. This allows the urchin several years of spawning before being recruited into the commercial fishery (DFO, 2001).

The green sea urchin is one of three urchin species fished commercially in British Columbia. The other two are purple and red sea urchins. (Both species are similar to the green sea urchin, different only in their colour and larger size.) Green sea urchins are shipped live to Japan. Product quality and perishability have restricted the fishery primarily to accessible south coast areas of British Columbia. Sea urchins are fished commercially under a "ZA" licence or a commercial communal "ZFA" licence.

The individual who designates the harvest vessel (i.e. owns or leases the vessel used in the fishery) each year holds all the licences. Licence stacking is permitted but there is a limit; a maximum of five active licenses may be designated to one harvest vessel at a time. The designated vessel must be eligible for a commercial, vessel-based licence in any of the commercial licence categories. The fee for a commercial green sea urchin licence for the 2001-02 season was $430. Fishers may redesignate their licence to another vessel during the fishing season at a Pacific Fishery Licence Unit office.

Commercial "ZA" licences are transferable; the licence holder may nominate another party as the holder of the licence. Communal commercial licences may be designated to a vessel. The Pacific Fishery Licence Unit will allow transfer of licence eligibility from one person to another when the IQ for the licence has been reached. Vessel licence length restrictions have been waived by DFO, allowing "ZA" licences designated to a vessel of any length. The licence year runs from June 1st to May 31st.

At present there are 49 licences, and a limited- entry licensing regime is in effect. Despite licence limitations effort remains high and catch per unit of effort showed a continued decline in most South Coast areas until recently. This has resulted in the establishment of an annual TAC (Table 3.1).

Table 1 Total Allowable Catch for the South Coast Region, British Columbia, 1994-2002 (DFO, 2001)

TAC South Coast Only	
Year	**Metric Tonnes**
1994	449
1995	173.4
1996	166.1
1997-99	166.1
2001-02	179

Prior to 1995 the green sea urchin fishery in British Columbia was a competitive fishery in that there was one overall TAC. Harvesters would fish for sea urchins until the TAC was caught. Some harvesters would do better than others depending on the area they were fishing and the environmental conditions. This led to processing and marketing gluts, poor quality landings and unsafe diving conditions. The management regime was therefore changed, and an Individual Quota (IQ) pilot program was initiated in 1995. A TAC for each quota area was calculated from the density estimates and range of quotas provided by the Department's stock assessment unit. Where surveys and estimates were not complete for an area, harvest area quotas were extrapolated from survey information from adjacent or near-by areas. An IQ was calculated by dividing the number of eligible licences into the coast-wide TAC. Therefore each IQ was 1/49 of the TAC or 3.65 metric tones (8,045lbs) per licence.

DFO provides opportunities for recreational fishers to harvest sea urchins for their own use, and those involved in the aquaculture industry are provided access to brood stock and seed stock for industry development and diversification. Brood stock and seed stock can be acquired through a scientific licence and is available on demand subject to conservation requirements.

Accompanying the IQ program is an industry funded catch- validation- and monitoring program, which was developed through co-management. This latter program was put in place to ensure monitoring of quotas and recovery of accurate catch data. This involves catch validation at designated landing ports, in-season collection, and compilation of harvest log data, collection of biological samples, and a year-end summary report of the fishery.

The vessel master must possess a DFO approved Catch Validation and Logbook assigned to a green sea urchin licence, and carry it on the designated vessel while fishing. All harvesters are required to report harvest time and location information to DFO. All catch must be weighed and validated at a designated landing site by a DFO certified observer. Harvesters must hail their effort and landings each day in their particular harvest area. When vessels do not hail into a harvest area there is a risk of exceeding the area quota. The vessel master must give the dockside observer 24-hour notice prior to offloading to ensure the monitoring of landed catch. Product lost due to spillage from deck to overboard, spoilage or waste due to weather delays will be applied to the catcher vessel's IQ and the applicable area quota.

The logbook remains on the vessel. One copy accompanies the product to destination, and another copy is handed to the observer at time of validation, along with harvest charts. The observer checks the information for consistency. The original copy is sent to the DFO Shellfish Data Unit within 28 days following the end of the month in which harvesting took place. The vessel master must confirm remaining vessel quota from the validation and harvest logbook. Harvesters are required to allow dockside observers to measure a random sample of 25 urchins from every off-loading. In the green sea urchin fishery compliance with regulations and licence conditions is said to be good. This is largely due to dockside validation and mandatory harvest and validation logs.

Since 1996 this fishery has been restricted to areas with a known catch history. To encourage development of this fishery on a scientific basis, DFO, in consultation with the WCGUA have developed an exploratory fishing protocol. This allows for an expanded commercial harvest while collecting data to improve the DFO's understanding of the resource (DFO, 2001).

Ongoing research by DFO, WCGUA, and First Nations includes joint stock assessments, biomass transects surveys, and the determination of experimental harvest sites and study sites. Survey goals include gaining a better understanding of the growth and recruitment parameters of green sea urchins, investigating size limits and effects of various harvesting strategies on resident stocks. This allows DFO to adjust quotas accordingly. Scientific research and stock assessment surveys are of vital importance to this fishery as it moves from a precautionary management regime towards a science based fishery. This process allows DFO to make better management decisions (DFO, 2001).

With respect to stock status there is no indication of concern for green sea urchin stocks in British Columbia at present. The fishery is managed conservatively with area closures and reductions in quotas in areas where populations have declined. The DFO considers the stocks healthy, but plans to continue with a precautionary approach to management. This ensures that conservation goals are met, which in turn ensures sustainable harvests in all areas. The long-term goal is to develop a science- based management regime. This can be accomplished through a collaborative process between DFO, industry, First Nations organizations, and other stakeholders (DFO, 2001).

3.2 United States

3.2.1 Maine

The green sea urchin is the second most valuable species harvested in the commercial fishery in Maine, second only to lobsters (MDMR, 2002). Sea urchins were first utilised by Maine's aboriginal population as a part of their daily diet according to local folklore. The first actual recorded landings of sea urchins in Maine date from 1929. Between 1937 and 2003 sea urchin landings ranged from $US 219 to $US 2,179 per metric tonne in nominal terms. Prior to 1987 Maine only shipped sea urchins to Chicago, Boston, and New York City, where Italian, Spanish, Portuguese, German, Greek, and French ethnic communities provided a market (Creaser & Hunter, 2000).

As indicated earlier, in the mid 1970's Japan expressed a growing interest in North American sea urchins after they witnessed a domestic decrease in local supply. By 1986 the value of sea urchins was increasing rapidly due to this new Asian demand. During 1987, Maine became one of North America's dominant exporters to Japan (Creaser & Hunter, 2000). In 1987, 635 metric tonnes of sea urchins were harvested. Landings increased to a peak in 1993 when 17,826 metric tonnes were harvested (MDMR, 2000b) (Figure 3.2).

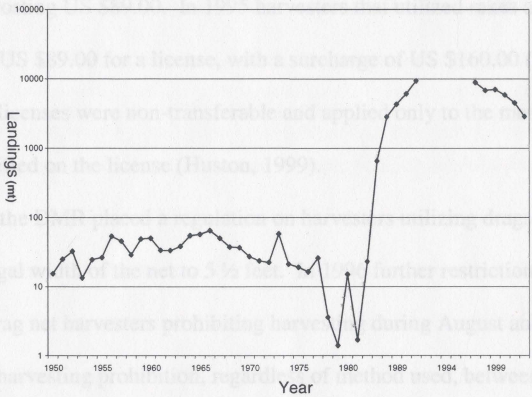

Figure 3.2 Maine Green Sea Urchin Landings 1950-1991, 1997-2002 (NMFS, 2004a).

Landings had declined to less than 3,000 metric tonnes in 2002 fishing season. It is believed this decline resulted from over-fishing, heavy exploitation of virgin stocks, size restrictions within the fishery, and a shortened harvesting season. An indication of over expansion is evident in 1994 when the number of licensed harvesters increased by 37%, while landings fell by 10% (Huston, 1999).

The Maine sea urchin fishery is managed by a combination of general conservation laws and specific regulations. The laws are established by the Maine State legislature and the regulations by the Department of Marine Resources (DMR) (Hunter, 2000). The present sea urchin fishery in Maine is prosecuted by hand picking by divers, dragging, hand raking, and trapping (Huston, 1999). Prior to 1992 sea urchin harvesters were only required to hold a commercial annual fishing license, costing US $33.00. After 1992 harvesters who hand picked and used dragnets required a gear- specific annual license costing US $89.00. In 1995 harvesters that utilized rakes and traps were required to pay US $89.00 for a license, with a surcharge of US $160.00 (MDMR, 2000b). These licenses were non-transferable and applied only to the method of harvesting specified on the license (Huston, 1999).

In 1993 the DMR placed a regulation on harvesters utilizing drags nets that restricted the legal width of the net to 5 ½ feet. In 1996 further restrictions were placed on sea urchin drag net harvesters prohibiting harvesting during August and September. There is now a harvesting prohibition, regardless of method used, between sunset and sunrise (MDMR, 2000a).

In 1994 two sea urchin fishing zones were established to control sea urchin harvesting effort and to establish harvesting seasons that are based upon the urchin reproductive cycle. Between 1987 and 1992 sea urchins were harvested all year round. Beginning in 1993 the fishing season was gradually reduced to its present length of 120 days. The selection of harvesting days is a joint decision between the DMR and members of the Sea Urchin Zone Council, which is an industry stakeholders group consisting of harvesters, processors, and two scientists (MDMR, 2000a). Factors to be considered when selecting fishing days include the harvest method, fishing zone, market conditions, statute holidays, demand, and spawning conditions (Creaser & Hunter, 2000). Since 1999 a law calls for a mandatory license suspension for any person violating season or zone restrictions (MDMR, 2000a).

The minimum size limit on sea urchins has been 51mm since 1994. In 2000 a maximum size limit of 89mm was established. This maximum size limit was reduced to 76mm in 2001, and to 83mm in 2002 (MDMR, 2000a).

Current license holders are automatically renewed for the following year, subject to license fee payment (Huston, 1999). Licenses are issued on an exit ratio basis: for every five individuals leaving the sea urchin fishery one new person will be awarded a license. Licenses that become available are issued on a lottery basis and harvesters interested in receiving a sea urchin license must submit a written application to the DMR prior to the start of the new harvesting season (MDMR, 2000a).

In the 1994-1995 fishing season the DMR initiated a "Commercial Sea Urchins Port Sampling" program that resembles the Dock Side Monitoring Program in Newfoundland. Initially, attention was given to locating buyer stations, acquainting DMR staff with buyers, refining interview questions, fine tuning measuring and weighing techniques, and developing sampling strategies (Creaser & Hunter, 2000). The information collected included catch per unit effort, size, and sex determination. Through this program a grading system was established. A difficulty was the constantly changing location of buying stations during the season. This made it difficult to know how many active buyers there were in each county at any given time (Creaser & Hunter, 2000).

The logbook data used in sea urchin fishery management includes landings in pounds, and value in dollars per month, by county and harvest method; urchin roe content by month; location (zone) and harvest method; daily price fluctuations; numbers of harvester-fishing days, and number of active harvesters; and average harvester catch size (Creaser & Hunter, 2000).

The management methods in Maine correspond to those used in other sea urchin fisheries within North America. However, in 1999 Maine introduced a new concept by closing six specific fishing areas. These areas are now used in an underwater survey for urchins to create a formal stock assessment. In addition they may aid in replenishing the over-exploited sea urchin stock in Maine's coastal waters.

3.2.2 California

California's largest commercial fishery targets the red sea urchin. The main harvest area for this species is in Northern California. Populations south of this region are inadequate to support a commercial fishery due to the high presence of its main predator, the sea otter (Kato & Schroeter, 1995). In 1971, the first exploratory fishery for sea urchins commenced. The first significant harvest of red sea urchins occurred in 1973 with an annual landing of 1,632 metric tonnes (Figure 3.3.). The fishery peaked in 1988 at 23,586 metric tonnes as a result of a growing demand for roe in Japan. Since 1988 the fishery has decreased steadily. Landings increased slightly between 1998 and 2002. In 2003 landings dropped to a historical low of 4,431 metric tonnes.

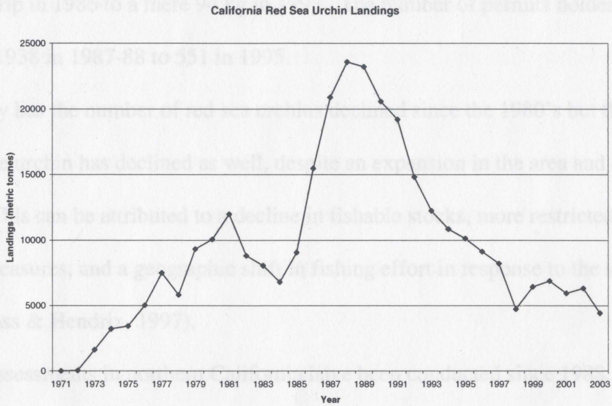

Figure 3.3 California Red Sea Urchin Landings 1971-2003 (NMFS, 2004b)

Between 1971 to the late 1980's there was no formal management measures in place to promote a sustainable, economically efficient fishery. The only requirement was a commercial fishing licence. The use of logbooks was voluntary. This "laissez-faire" approach to management was to some extent a result of the popular view that sea urchins were "valueless pests" responsible for the depletion of the kelp forests along the coastline of California (Kalvass & Hendrix, 1997). No harvesting quotas have been established for this fishery since and there is no underlying scientific mandate for a management plan for the northern California red sea urchin fishery. To date management has been reactive; only when a concern or issue is raised is it addressed (Kalvass & Hendrix, 1997).

Scientists who are studying the dramatic decline in landings in the northern California red sea urchin fishery are now wondering whether conservative management could have avoided the collapse of this fishery. It is known that since 1985 harvesting has been directed towards virgin stocks, and the CPUE has declined from 1,901 kilograms per trip in 1986 to a mere 94 kg in 1993. The number of permits holders decreased from 938 in 1987-88 to 551 in 1995.

Not only has the number of red sea urchins declined since the 1980's but the mean size of the urchin has declined as well, despite an expansion in the area and depth range fished. This can be attributed to a decline in fishable stocks, more restricted management measures, and a geographic shift in fishing effort in response to the stock collapse (Kalvass & Hendrix, 1997).

Stock assessments in northern California have been conducted since 1988. Sea urchins are considered to be a long-lived organism that are easily fished down when the initial harvests of the stock come from an accumulation of old and unproductive subpopulations (Ricker, 1973; Hilborn et. al., 1995). In addition, they are very susceptible to recruitment over- fishing. This happens as the large size classes are removed and a greater reliance is placed on the smallest size interval in the harvestable stock. Stock depletion model estimates and population survey data suggest that Northern California stocks are below 50% of pre-fishery levels (Kalvass & Hendrix, 1997).

Harvesting of sea urchins in California takes place in the low inter-tidal zone at depths up to 22 meters. In most areas this zone can be found within 300 meters of the shoreline (Kalvass & Hendrix, 1997). Harvesters use surface-supplied air for diving rather than scuba gear, which is commonly used on the East Coast of the US. Using a short handled rake, the divers scoop sea urchins into a mesh bag and deposit them on a collection vessel. Most vessels employ one or two divers and a line tender.

The management authority of the sea urchin fishery lies with the California legislature. A Commission of five representatives from the California Department of Fish and Game (CDFG) levies landing taxes and establishes licensing, and Individual Transferable Quotas. Since 1985 a specific permit has been required for divers harvesting urchins, and an additional permit was required for crew members tending the vessels used. In 1987 a moratorium was placed on the issuance of new permits and remains in effect at present.

The legislature established the Director's Sea Urchin Advisory Committee in 1987. This committee include representatives from the harvesting and processing sectors, the California Sea Grant, and the CDFG. This committee is used as a forum for consensus based management of the resource. Since 1987 all management measures for the sea urchin fishery have emerged from this forum.

At present only three management measures are in place for this fishery. They are: limited entry; a minimum size limit; and season closures (i.e. monthly one week closure between May and September) (Kalvass, 2000). The CDFG has recently proposed three interim management measures for the red sea urchin fishery. They include establishing and monitoring a maximum size limit to accelerate recovery of fished areas; establishing regional management zones for northern and southern California; and establishing annual harvest quotas based on 5 year annual harvest catches (Anon, 2002b).

In the early 1990's scientific research findings determined that California's marine environment was in serious decline. In response to the research findings the California Legislature brought forward the 1999 Marine Life Protection Act (MLPA), a major purpose of this Act was the power to establish a network of MPAs to protect the states marine natural heritage, the diversity and abundance of marine life and the integrity of marine ecosystems. The red sea urchin is one of the target species that would benefit directly from the establishment of the MPAs. To date the MLPA has not been implemented however the CDFG is submitting the "Master Plan" framework of the MLPA for proposed adoption by the Commission in August 2005. This will provide a state wide framework for the design and implementation of the MPAs.

This is an urgent measure since survey data suggest that under the fishing levels of the past decade the population densities now common on the California north coast may be insufficient for stock maintenance. There is still optimism that this fishery can be salvaged. In 2002 the CDFG submitted a "Master Plan" for a Fishery Management Plan (FMP) to the Fish and Game Commission recommending a high priority for a sea urchin FMP. Although a formal FMP has not yet been implemented, the CDFG established an invertebrate team in 2003 to create a more effective focus on the collection of scientific data of benthic invertebrates, including sea urchins. This increased scientific effort includes fishery sampling, logbook data, and database management on both the southern and northern California sea urchin stocks (CDFG, 2003).

In 2003 the monthly week long closures were eliminated. The original purpose of these closures was to reduce fishing effort during the period when the sea urchins were at their lowest value and the opportunity for harvest was at its highest. The sea urchin Industry argued that the closures made it difficult to maintain a consistent market presence during the summer months and that overall effort has decreased. In addition the

July closure of the northern Californian sea urchin fishery was eliminated to create a state-wide season.

The most recent change in the management of the sea urchin fishery was the repeal of minimum landing requirements for permit renewal. It was deemed ineffective as a tool to reduce the number of fishery participants because some permit holders would fish at times when they otherwise would not have in order to meet the minimum landing requirement. This became a safety issue in addition to a management issue. (CDFG, 2003)

3.2.3 Alaska

In 1981 a red sea urchin fishery was developed on the Alaska's southern panhandle. A commercial fishery for green sea urchins started in 1984. While red urchins are the primary species harvested in Alaska only the green urchin fishery will be discussed here for the sake of comparison purposes with Newfoundland's green sea urchin. Due to the low participation level in this fishery there has not been much effort put into scientific research.

In 1980 a test fishery was held in Alaska to determine the marketability of green sea urchins (ADFG, 2002). By 1986 urchins were being harvested in Dutch Harbour, and in Cook Inlet by 1987 (Woodby & Hebert, 2000). At present the green sea urchin is harvested only around Kodiak in Registration Area J.

The recorded landings of green sea urchins have fluctuated greatly. Landings rose to a peak of 100 metric tonnes in 1988 but dropped dramatically to 28 metric tonnes in 1989. By 1996 landings had dropped to 16 metric tonnes (Woodby & Hebert, 2000).

Inconsistency of fishing effort and subsequent harvest has made inferences on abundance, distribution, and recruitment difficult (ADFG, 2002).

Green sea urchins are shipped live to Alaska's main market in Japan. The harvesting season for Alaska green sea urchins is from October 1st to January 31st. A closure period from February 1st through September 30th ensures optimal roe content.

Since the green sea urchin fishery is not one of the main commercial fisheries in Alaska, the Alaska Department of Fish and Game (ADFG) has not budgeted for research. To allow for a commercial harvest with limited scientific information ADFG has created Guideline Harvest Levels (GHLs) to limit the effort. Areas with a historical commercial harvest have GHLs that do not exceed 10,000 pounds. Those areas without historical catch data have GHLs that do not exceed 5,000 pounds. The management is based on a pre-cautionary approach. The following table contains the GHLs for the 2002-2003 fishing season.

Table 2 Alaska Green Sea Urchin Guideline Harvest Levels, 2002- 03(ADFG, 2002)

Section or Area	**GHL (lbs)**
Northeast Section	10,000
Eastside Section	10,000
Southeast Section	10,000
Southwest Section	10,000
Westside Section	10,000
North mainland Section	5,000
South mainland Section	5,000
Semidi Island Section	5,000
Kodiak Area Total	**65,000**
Chignik District	5,000
Alaska Peninsula District	5,000
Aleutian Islands District	5,000
Bering Sea District	5,000

When setting the GHLs, ADFG made provisions for further exploration and development of the commercial sea urchin fishery by setting the GHL low enough so that further allocations are available on demand but with a view to distributing fishing effort throughout the region (ADFG, 2002).

Sea urchins may be taken only by hand picking, which may be aided by diving gear, and rakes. All divers must obtain a Commercial Fisheries Entry Commission Interim Use Permit. Divers may register for only one dive species at a time. The boundary lines used to delineate management sections for the urchin fishery and to distribute effort are the same as for the tanner crab and sea cucumber fisheries.

Under the Commercial Fisheries Entry Commission permit there is no requirement for harvesters to carry onboard observers. Vessels may be periodically asked to carry an observer on a voluntary basis for data collection. Divers and dive tenders are asked to allow ADFG dockside sampling staff access to their catch. Fish tickets are required of processors, buyers and fishermen. A completed dive/harvest logbook, which includes the co-ordinates of the dive location, is required for all sea urchin fishing activities. Completed logbook pages must be submitted to ADFG or the processor at the time the fish ticket is completed and signed at the processing facility (ADFG, 2002).

Conditions in the permits allow ADFG to gather additional information on green sea urchin stocks in the region. For example, catch per unit effort will be compared to historical averages to ensure that indications of localized depletion or decreases in stock size are not occurring. ADFG also reserves the right to close sections or areas to fishing before the GHLs are reached if indications from commercial data suggest long term harm may occur.

3.2.4 Oregon

Oregon's sea urchin fishery started in 1986, coinciding with the decline in Southern California's red sea urchin fishery (Phu, 1990). The Oregon commercial sea urchin fishery directs for both red and purple sea urchins, with red being the main species caught. Landings in the first year totalled 25 metric tonnes and increased to a peak of 4218 metric tonnes in 1990 (McCrae, 1992; Phu, 1990).

Prior to 1988 there were no formal management measures in place to protect the sea urchin stocks. The Oregon Department of Fish and Wildlife introduced the first set of management restrictions in 1988. This management regime has now developed into a detailed limited entry system. Anyone interested in harvesting sea urchins in Oregon must hold a commercial fishing licence, at a fee of US $50. In addition, the harvester must possess a restricted fishery permit for sea urchins. A special harvesting permit is required for purple urchins (McCrae, 1992).

Although red sea urchins must be 3 ½ inches or larger in shell diameter (this excludes the spines), each diver may possess up to 50 red urchins less then the minimum size in diameter. Purple urchins must be 2'' or larger in shell diameter. The red sea urchin fishery is open year round. Urchins may not be harvested in water depths less than 10 feet (McCrae, 1992).

When the fishery commenced there were 46 restricted fishery permits available. There is now a freeze on the issuance of new permits. Permits are transferable, but a harvester must first purchase three valid permits from existing permit holders. The three permits are then combined into a single permit. This method is used to reduce the number of active sea urchin permits. The most recent data available to me indicate that in 1998 only 26 active permits were eligible for renewal the following year. Sea urchin harvesters must land a minimum of 5,000 pounds in one permit year to be eligible for permit renewal the following year[4] (McCrae, 1992).

4.0 A Blueprint for Newfoundland and Labrador

This paper will argue that an Integrated Fisheries Management Plan is necessary in order to ensure the long-term sustainability of a commercial green sea urchin fishery in Newfoundland and Labrador due to serious depletion of all green sea urchin fisheries in North America. This section presents a blueprint for the key elements of such a plan.

Management tools used in the North American sea urchin industry range from the traditional styles that focuses mainly on reducing fishing effort to the non-traditional where the focus is placed on enhancement experiments and co-management. This section will look at the various management tools and techniques that might be incorporated into an IFMP for the green sea urchin commercial fishery in Newfoundland and Labrador. Each management measure will be defined with an analysis of its positives and negative aspects, with a final comment on implementation.

4.1 Management Tools

4.1.1 Collection of Scientific Data

An efficient IFMP has to be based on valid scientific data. Scientific assessments are important in order to understand sea urchin biology and the impact of commercial fishing on relatively unexploited stocks. There are different methods available for collecting independent fishery information on sea urchin stocks. They include formal stock assessments, coast-wide biomass transect surveys, experimental harvesting sites and selected study sites that are closed to commercial harvesting. The aim should be an improved understanding of growth and recruitment, impacts of size limits, and the effects of various harvest strategies on resident stocks.

To make scientific assessments and studies feasible, the sea urchin industry, which includes harvesters and processors should be involved and bear a proportion of the costs. It is important to give industry a vested interest in sustaining a healthy stock. One way to support scientific studies on the green sea urchin stocks in this province is to levy a landing tax on sea urchin catches.

By collaborating with Memorial University's Department of Biology, the Marine Institute and the Canadian Centre for Fisheries Innovation, ideas, resources, and discussions on the sea urchin resource can be shared and used to make informed management decisions. The collection of scientific data and information is without a doubt necessary for DFO to move from a management style based on the precautionary approach (which in reality is not used here) towards an economically viable and science based management regime. The importance of this point cannot be overstated.

4.1.2 Harvesting Methods

The biology of the green sea urchin dictates when the season starts and ends because the urchin is only suitable for market when it is not in the spawning state. However, because the target of this fishery is the gonads of the urchin, the overall fecundity of the stock is inevitably affected. The fishing season starts when the roe sacs of the urchins have become firm at the beginning of October, thus ensuring maximal roe content. It ends in May when spawning commences.

The best method for harvesting sea urchins is by scuba diving and hand- picking. Hand picking allows for appropriate size selection of specimens and negligible damage is done to the benthic community. This is the most commonly used method worldwide, and it is the only method currently permitted by DFO in Newfoundland and Labrador.

There is a very transient participation of divers in this industry. This may have undesirable consequences if divers collect undersize urchins, or have a tendency to pick only the largest specimens, which leads to highgrading. Similarly, insufficient care may be taken when moving around within the sea urchin habitat. This may have negative environmental effects.

However, the Fisheries and Marine Institute of Memorial University offers professional diving certification courses for recreational divers interested in harvesting sea urchins. The course provides information to participants on how to first harvest urchins in a sustainable manner. But the cost of the course is not insignificant. Furthermore, DFO does not currently require this certification of sea urchin harvesters. If DFO made it mandatory for sea urchin harvesters to hold a professional diving certification then the problems associated with the use of inexperienced harvesters could be substantially reduced.

In response to the interest of harvesters to increase the CPUE, the DFO is supporting experimental fisheries that utilise urchin drags. This method is not size selective and is very harmful to kelp beds, which is the urchin's main food source. More environmentally sensitive management would not tolerate such harvesting methods. Nor would it support fishing with drags. By contrast, experimental fisheries utilising urchin traps have proven to be size selective, easy to use, and less harmful to the urchin's habitat. If the demand exists for alternative harvesting methods, urchin traps may be ecologically preferrable.

4.1.3 Size Restrictions

Size restriction is one of the most common management tools used in commercial fisheries in North America. However economic considerations are influencing minimum size restriction in the green sea urchin fishery. Urchins less than 50 mm are not economically feasible to harvest because of the combination of longer processing time and smaller roe yield, rendering the ratio of yield to processing time unprofitable.

In Newfoundland and Labrador urchins less then 47 mm are illegal to harvest. This minimum size allows the urchin to reproduce at least once prior to recruitment into the fishery. It is believed that urchins sexually mature at a test diameter of approximately 25 mm (DFO, 1996). This size restriction may reduce the likelihood recruitment over-fishing by preserving reproduction potential and spawning stock biomass. Harvesters have not contested it since the market demands urchins larger than 47 mm. In addition imposing a maximum size limit on sea urchins could further protect the spawning stock. The larger the urchin the greater the number of gametes[5] it will produce (Hatcher and Hatcher, 1997), thus producing more potential offspring. Moreover, protecting the individuals with the higher fecundity in the stock would mean that over-fished areas should also recover quicker.

Before a maximum size limit is introduced, further scientific assessment and studies would have to be conducted to ensure that the test diameter chosen would indeed enhance the spawning stock. Fishermen would also have to be convinced that leaving the larger, more profitable urchins in the water is a good thing for the long-term.

4.1.4 Licensing Policy

The design of an effective and enforceable licensing policy is a complex task in any commercial fishery. Great care must be taken to make such a policy appropriately fishery-specific, including the criteria and restrictions that govern those who can participate. One of the most important aspects of controlling effort by means of licensing is an appropriate definition of what constitutes over-exploitation. In this province we still have the opportunity to limit effort while the fishery is still in the early stages of development. This presents an opportunity to manage effort prudently at the outset, and thereby avoid crisis management strategies.

Sound scientific data on the stock combined with accurate harvester's data are required to estimate the number of licences that can be safely issued. A scientific assessment should be made in each sea urchin fishing zone to determine how much effort the stock can support in that area prior to the issuance or renewal of licences for each season. Currently the number of licences is based on a rule of one licence per 100 miles of coastline, or 98 licences in total. This rule was based on a recommendation that was made at an Industry consultation meeting. The rule has no scientific basis, and it is not known if this number of licences is too high or if more participants could be included in this fishery.

There is a protocol in place for those participating in this fishery. Only core harvesters with vessels less than 65' may apply for a licence to fish sea urchins. In order to obtain a special "Emerging Fisheries" permit, applicants must show proof that they have a buyer for the resource, and that they have secured a minimum of two certified divers for harvesting purposes. A lottery style draw is then used to determine which applicants will be awarded the available licences. The lottery restricts effort and prevents the pre-determined number of licences from being exceeded.

In Newfoundland and Labrador the green sea urchin fishing areas (see figure 2.2) coincide with the LFAs, with each area having a specific number of sea urchin licences available. An individual harvester who holds a sea urchins licence should be restricted to the specific fishing area listed in the licence conditions. This is in order to maintain dispersion of effort. The licence should not be transferable between areas and it should be gear specific. This would be beneficial if the DFO decides to permit other types of harvesting methods in the future. Each fisher would then fish competitively within the designated area (Way, 2002).

Licence conditions should also specify the vessels that are associated with the license. The harvester must ensure that the vessels used are registered and within the size limit (i.e. less than 65 feet). The licence conditions should specify the minimum (two) and maximum (four) number of certified divers to be used at any given time. If necessary, effort in this fishery can be reduced subsequently using an exit ratio to award new licences. For example, a new licence may be awarded only after five licences have been retired.

4.1.5 Quota Allocation

A common element in North America's sea urchin fisheries is the absence of a formal TAC. In 1998 Newfoundland and Labrador set a harvest cap of 100 metric tonnes per licence. In 2001 this cap was removed. Currently, the sea urchin fishery is competitive, with no limitation on the amount of urchins harvesters are permitted to land. It is safe to say that the potential for over-exploitation and depletion of sea urchin stocks is therefore very high. This is because the green sea urchin fishery in this province is extremely data poor regarding stock abundance and the amount of fishable biomass. It is unclear how much fishing effort these stocks can sustain before they become over-fished, as has been the case for all other such stocks. Imposing a competitive quota on sea urchin harvesters is not necessarily the best solution. There are more negatives than positives associated with using a competitive quota to manage this fishery, especially since scientific information on the stocks is so limited. A competitive quota can lead to processing and marketing gluts, poor quality landings, and fishers may venture out in unsafe harvesting conditions to get a share of the quota.

In such a data poor fishery it is best to use a pre-cautionary approach, i.e. to err on the side of caution. A 'Guideline Harvest Level' (GHL), which is a quota set very conservatively in the absence of concrete scientific studies can do this. A GHL should be set for each sea urchin fishing area based on the fishing history in each zone. Areas with a longer history of fishing may be given a higher GHL than those that are considered to be "virgin stocks" (stocks for which there is a lack of data on the population). This system would create an equitable distribution of fishing effort. The GHL should also be set low to permit scientific research so that once the commercial quota is allocated there is sufficient resource left in the water to sustain a scientific quota.

Normally a TAC becomes the centre of attention because everyone ponders the question of "who is going to get what?" In this province quota allocation has become the centre post of IFMP's. To avoid the 'race to harvest' and to establish an equitable distribution of the resource, the use of IQ's is now highly favoured. If a TAC is set at 500 metric tonnes, and there are 100 harvesters in the sea urchin fishery then each harvester could be awarded, say, five metric tonnes of sea urchins per season. The IQ would be part of the individual licence conditions.

The benefits to implementing an IQ system include a more efficient distribution of the quota. Once the market price for sea urchins becomes available the harvester can estimate his profit prior to the start of the season. This allows proper business planning of the sea urchin enterprise. Finally, but most importantly, IQ's should lead to a safer fishery because harvesters are not competing for 'their share of the quota', and are therefore not compelled to go out in weather that is unsuitable for diving.

4.1.6 Documenting Data

Information from logbooks, interviews, and fishery observers and dockside monitors are vitally important in the management of commercial fisheries. The Science Branch of DFO has been subject to major budget cutbacks in recent years, which has limited the ability of scientists to collect solid scientific data on major commercial fisheries. Emergent fisheries such as the green sea urchin fishery have not been given any priority in this regard. This has resulted in very little scientific data being collected for this fishery.

The effects of fishing effort on growth, distribution, reproduction, and total mortality of the sea urchin stocks must be considered so that informed management decisions can be made. Management decisions can only be as good as the data they are based on. The data that the DFO compiles must therefore be accurate and consistent and harvesters must be compelled to submit accurate records in a timely manner. Data collected by DFO can be used to observe trends in the fishery with respect to increases or decreases in landings in relation to CPUE. This will give an indication of the sea urchin response to fishing effort.

DFO Catch Validation and Logbooks are the most common types of data recording in Canadian fisheries. A logbook should be assigned free of charge to every green sea urchin licence and carried at all times by the licence holder. Clearly defined objectives and instructions should be listed in the logbook so the harvester/licence holder knows exactly what is required for compliance. The need for good, accurate data should be made known. By including a logbook with every sea urchin licence it is easy for harvesters to supply the required data. All personal information provided should, of course, be kept confidential by the DFO.

The harvester must fill out the logbook immediately after harvesting has ended for the day so that the information recorded is accurate and consistent. Information that the harvester should provide includes the sea urchin fishing area, the total amount of time of harvesting activity, the gear used, and the amount of catch. In many fisheries the harvester is required to "hail in" their catch, which simply means that the harvester must report their total catch for the day via VHF radio, cell phone or fax to the local DFO office. Hails are especially important when the quota is near completion in a sea urchin fishing areas because it reduces the risk of exceeding harvest quotas.

The use of logbooks in a fishery should be the first phase in the Catch Validation and Monitoring program. The second phase should involve DFO-certified Dock Side Monitors. Prior to harvesting urchins the harvester would give the local dockside monitor 24-hour notice so that they can be available at the designated landing port once the urchin harvester has landed with the catch. The dockside monitor would record the information provided in the fisher's logbook for that harvest day and then weigh all catch on a government certified scale to validate the harvester's logbook. This validation of the logbook ensures that quotas are monitored and the recovery of accurate catch data. This method also allows for the recording of harvest time before and after the fishing activity.

The dockside monitor should also be instructed to collect specimens for biological sampling purposes from the fisher's catch. The specimens collected would not come off the fisher's seasonal quota. However, any spillage or wastage observed by the dockside monitor would come off the harvester's quota. The in-season collection of data may be further supplemented by a year-end summary report by the harvester, which would include personal observations on abundance of sea urchins, changes in the fishable stock, environmental changes, and any changes in fishing effort to maintain catch rates.

Other sources of fishery dependent data include the record of sale, as well as personal interviews with fishers. The record of sale is the most common piece of documented information in commercial fisheries. It includes the amount of catch landed and its value, the name of the vessel, type of gear used, and area where catch was taken. The agency responsible for the processing sector in commercial fisheries, the provincial DFA, can collect these data. This is the best source of data on catches, but it needs to be routinely validated.

Interviews are useful where many fishers land in the same area. This method also allows the interviewer a chance to sample catch for quality, collect weight and measurements, and to collect specimens. Data collected can be used for validation purposes, and to supplement records of catches from logs or sales slips.

In the past twenty years DFO has contracted out to the private sector the task of obtaining data on catch, vessels, and fishing effort. Seawatch Incorporated is the provincial observer company that deploys observers to commercial fishing vessels for the duration of the fishing trips. Observers would be very beneficial in the sea urchin fishery because they could obtain unbiased information on a fishery, which is currently badly lacking in scientific data. Observers collect information on fishing area, fishing effort, size and sex composition of catch, quality of catch, and specimens for further scientific scrutiny. All information collected is kept strictly confidential and submitted to DFO in a timely fashion.

4.1.7 Restricted Harvesting Zones

The goal of traditional management practices is to harvest the "excess" (or surplus) population production (i.e. the sustainable yield) while leaving the reproductive capacity of the stock intact. This type of management assumes that the excess population is not required for long-term population survival or to maintain a stable ecosystem. Unfortunately it does not consider the problem of ecosystem over-fishing where the natural balance has been altered by the removal of key species. Nor does it consider the complex web of multi-species biological interaction. Management is based on the biology of individual species. Fisheries that target long lived, late maturing species such as sea urchins, need to incorporate a management strategy that enhances reproduction per parent, as well as yield per recruit (Dugan & Davis, 1993).

The previous sections have discussed the types of traditional management practices that have been used in the North American green sea urchin fisheries. While the goal of any sound management practice is to maintain a sustainable commercial fishery, there is ample evidence that traditional practices do not prevent over-exploitation of the resource. In some areas governments, industry, academia, and interest groups have turned to non-traditional management practices to find means to enhance populations that have been over-fished, and to monitor stocks more closely.

The following sections will focus on the non-traditional management tools and styles that have been used in sea urchin fisheries elsewhere, and which can be potentially used to great advantage in Newfoundland and Labrador as well.

Restricted Harvesting Zones (RHZs) are areas that are set aside from the rest of the competitive fishing zone. Only one harvester is granted a special permit to fish the RHZ. That harvester becomes the steward of that RHZ and must therefore demonstrate an in-depth understanding of the appropriate enhancement and harvesting techniques required to promote sustainable sea urchin and kelp bed resources.

The harvester fishes in the assigned RHZ for four years, but each year prior to being reassigned the permit the fisher must provide a written assessment of the RHZ. The assessment includes a written description of sea urchin distribution and/or kelp habitat. The descriptions are necessarily subjective because they come from the harvester. The descriptions should therefore be subject to audit and verification by an objective third party acceptable to DFO. This would be costly, but probably very effective.

The sea urchin harvesters in Newfoundland and Labrador would benefit from the RHZ by fishing an exclusive area. They would be given the opportunity to assess the feasibility and potential success of additional enhancement techniques. The harvester could plan harvests so as to take advantage of high concentrations of harvestable specimens that are of higher value than specimens from competitively fished areas. Fishers are thus given the opportunity to self-manage and reap the benefits from protective fishing practices. This gives the harvesters limited control over a resource that they benefit from, and permits them to see first hand how good management practices benefit the resource.

If RHZs were implemented in Newfoundland and Labrador, where the only method of harvesting is hand picking by divers, harvesters may want to leave older larger urchins in the water to increase fecundity of the population. The stocks benefit by being protected from competitive fishing practices. This permits the resource to rebound from over-fishing. The harvester fishing in the RHZ is mindful of being the steward of this resource. They will therefore have an incentive to fish responsibly.

The RHZ allows the DFO to get some indication of what is going on in each fishing zone. Using harvesters rather than DFO personnel to monitor stock abundance and status saves the taxpayer money. An objective third party must assess the information collected by harvesters to ensure that the data are valid and useful to DFO. This might be implemented on a trial basis to determine whether it is cost effective. (I understand that trials of this kind are currently undertaken in Nova Scoti.a) Finally, the information collected can be used in stock status reports.

There are however negatives associated with RHZs. For instance, high grading may occur in areas where the RHZ is too large. If too many small urchins are left in the RHZ the higher density of undersized urchins creates an environment more susceptible to disease. The unused urchins in this zone are not accessible to fishers who do not hold a permit for the RHZ. There have been instances where such areas were not fished at all (DFO, 2000b).

Interestingly, when the DFO's representative for emerging fisheries in Newfoundland and Labrador was approached about the concept of RHZs his opinion was that it would not work here. The reason given was that within the sea urchin harvesting zones rezoning would have to occur. This could create problems with fishers who have been fishing in the areas for some time. It is believed that the fishers would not be agreeable to the idea of creating an area in their zone where they were not permitted to fish, while rewarding another fisher the exclusive opportunity to harvest in that area (Way, 2001). But by rejecting the idea without consulting harvesters, the merits of RHZ as a management tool cannot be determined. This would be most unfortunate.

4.1.8 Co-management

The theory of co-management is a relatively new phenomenon in fisheries management. The

> "argument behind co-management is that to achieve more effective and equitable systems of common-property resource management, representatives of user groups, the scientific community, and government agencies should share knowledge, power, and responsibility" (McKay, 1988).

However, it is difficult to create a co-management program for a common property resource that is equitable to all user groups, and is based on reliable data.

For co-management to be successful (enforceable) harvesters must be a part of the management process. Involvement of the harvesters in the management process can reduce the political problems that often arise from resource management efforts. If users are more involved in management, they are more likely to perceive the management system as legitimate and hence comply with the rules and regulations developed.

Industry funded catch-validation-monitoring programs are examples where co-management comes into practice. Exploratory fishing protocols have been developed in British Columbia to encourage development of the sea urchin fishery in a scientific manner through a collaborative process between DFO, commercial industry, First Nations and other stakeholders. The same groups are also involved in joint stock assessment, coast- wide biomass transect surveys, experimental harvest sites, and selected study sites.

In Maine and California industry stakeholders, scientists, and government officials have created the Sea Urchin Zone Council and the Sea Urchin Advisory Committee that are a forum for consensus based management. Recommendations and management measures emerge from these forums and are put into practice by the governing bodies. In this province co-management could also be used to create marine refugia, restricted harvesting zones, or enhancement programs for the sea urchin resource. Prior to an IFMP being implemented a green sea urchin advisory committee meeting should be held with representatives from industry, aboriginal communities, the scientific community, DFO, and other stakeholders. Such a meeting would allow all stakeholders to voice their opinions and concerns regarding the sea urchins fishery in this province. Recommendations should then be presented for consideration prior to the implementation of the IFMP.

In a science poor fishery such as the green sea urchin fishery in Newfoundland and Labrador the decision-making is often seen as "muddling through" (Lindblom, 1979) A lack of funding, time, and resources required for rational planning leads to an "action now, science later" approach. This is common in fisheries like the sea urchin fisheries where little is known about the resource, and priority is given to seemingly more important (i.e. valuable) commercial fisheries. In a situation like this it often takes action at the grassroots level (i.e the harvesters) to pressure the government into paying more attention to the management of the resource.

If the objective is easy to understand for the stakeholders, positive action and political support will follow. The danger is that the initial enthusiasm on both sides can very quickly dissipate when difficulties arise. There is also the fear by fishers that government will be "taking over", leaving management decisions one-sided and the harvesters shut out of the management process. If the scientists involved consider a project a waste of time and resources then the outcome of the project will be compromised from the start. But even when co-management does not work entirely as intended, such a mechanism can stimulate discussion and an exchange of experience, which can in turn lend to a more rational approach or at least better informed incrementalism (i.e. enlightened "muddling through").

5.0 Conclusion

The Newfoundland and Labrador green sea urchin fishery is considered an "emergent" fishery for which only limited information is available on the biology, sustainable harvesting levels and methods. There has been exploratory work conducted to discover new sea urchin resources by industry, however the DFO has had no scientific involvement with this resource and the fishery is not protected by a formal management plan. Compared to sea urchin fisheries throughout North America this province's fishery is still in the development stage. There are a small number of harvesters involved as opposed to the number of harvesters involved with the larger commercially more important fisheries. The perception is that the economics of this fishery do not permit the DFO's resources to commit to scientific exploration or study that is required to formulate an IFMP.

In the sea urchin fisheries throughout North America management styles range from the pre-cautionary approach to formalized fishery management plans and conservation laws based on government scientific research and industry involvement. The pre-cautionary approach has been used in Nova Scotia and Alaska where there is limited scientific information and historical catch data available to make sound management decisions. In areas where there is an abundance of historical data such as Maine and California, conservation laws, regulations and direct scientific research have been used in a reactive response to drastic stock decline due to over-exploitation. The best example of a management style that is working to promote long- term sustainability is that in British Columbia. In Canada, British Columbia has the only formal IFMP in place to protect the resource and there is no fear of over-exploitation or threat of catch decline at the present time.

The literature review clearly indicates the need for a sound management plan for the Newfoundland and Labrador green sea urchin fishery. It can be argued that the green sea urchin is very important to the diversification of this province's fishing industry as it provides new economic opportunities to rural areas hit hard by the 1992 cod moratorium.

There is also strong biological evidence supporting the need for a green sea urchin IFMP. Sea urchins are very susceptible to recruitment over fishing. When large size classes are removed a greater reliance is placed on the remaining smaller size classes in the harvestable stock. By nature sea urchins are very slow in reaching sexual maturity. If over-exploitation occurs before the urchins are allowed to reproduce, the recruitment rate into the fishery falls along with the catch rate. Fishing pressure is then likely to increase, which can result in drastic stock decline.

In Maine, the green sea urchin fishery is the second most valuable fishery next to lobsters. A sharp decline in landings between 1993 and 2000 resulted from over-fishing and heavy exploitation of virgin stocks that contain large aggregations of old and un-reproductive subpopulations due to over expansion in the fishery. California's largest fishery targets the red sea urchin. Landings there peaked in 1988 at 23, 586 metric tones and plunged to a historical low in 2003. To blame was a "laissez-faire" approach to management with no harvesting quotas set due to a lack of a management plan. California's approach is a prime example of "reactive" management; only when a concern or issue was raised was it addressed. There appears to have been no realization that a formal fishery management plans based on science is required to salvage the fishery.

The aim of the paper has been to identify a set of guidelines and to suggest potential management tools that may assist in the design of an official management plan for this interesting, and economically promising fishery. A review of the existing sea urchin fisheries throughout North America casts light on issues also relevant to the Newfoundland and Labrador green sea urchin fishery. This process helps identify the areas lacking in the information needed to formulate a sound management plan.

There are several lessons regarding the management of sea urchins examined in the literature review. The sea urchin's life cycle characteristics make this species very susceptible to over-exploitation. It has been shown that heavy exploitation of virgin stocks, recruitment over-fishing and over-expansion in fishing effort can lead to stock collapse. It is very important to control fishing effort through a formal IFMP to promote the long-term sustainability of the stock. Sound scientific information from a variety of sources that include traditional knowledge is vital to developing a successful management plan. This is especially the case in new fisheries that move from a pre-cautionary management regime to a science based fishery.

When there is limited or no information available about the resource it make sense to use the "pre-cautionary" approach based management and to implement management tools such as size limitations, Guideline Harvest Levels, Total Allowable Catch, and Individual Harvesting Quotas that are conservative. Co-management is very important in fisheries that are data poor and do not have the financial resources to engage in scientific research, and monitor compliance or enforcement. This management style places responsibility on the user, which requires the fisher to manage the resource in a manner that sustains and enhances the resource in order to ensure long term economic benefits.

It has been shown that non-competitive fishing practices work best in this fishery. In competitive fisheries the harvesters will compete for their share of the TAC by fishing until it is all caught. There is an unequal balance of prosperity because some fishers will do better than others depending not only on their skills but also upon the abundance of resource in their fishing area. This fishery style leads to processing and marketing gluts, poor quality landings and more importantly, serious safety considerations due to weather factors. Thus an IQ licensing policy works best in this fishery.

Sound scientific information is essential to the development of a successful IFMP. This includes harvester's logbooks, biological samples from commercial catches, and catch validation at landing ports, stock assessments and exploratory work. However, one quickly learns that a science-based management regime is dependent on industry involvement and co-operation from all stakeholders in order to obtain the biological and traditional ecological knowledge, which is important to the development process.

The most important lesson learned here is the importance of the timing of the implementation of a management plan for the green sea urchin. In Newfoundland and Labrador, now is a good time to implement an IFMP in order to avoid the reactive management style that has all too often characterized fisheries management in this province. The best example is, of course, the Northern Cod disaster. Reactive management usually equals failure.

This research suggests that the key elements that should be contained in any future green sea urchin IFMP in Newfoundland and Labrador are:

1. Collection of Scientific Data
    - Stock assessments
    - Biomass transect surveys
    - Experimental harvesting sites
    - Closed study sites
2. Harvesting Methods
    - Species-specific certified scuba divers
    - Hand picking
    - Urchin traps
3. Size restrictions
    - Minimum
    - Maximum
4. Licensing Policy
    - Fishery specific
    - Sea Urchin Zones
    - License Cap
    - Lottery draw for new licenses
    - Non-transferable licenses
    - Vessel limitations
5. Quota Allocation
    - Guideline Harvest Levels
    - Individual Quota's
6. Documenting Data
    - Logbooks
    - Interviews
    - Fishery Observer data collection
    - Dockside monitors
7. Restricted Harvesting Zones

8. Co-management
   - Industry funded catch validation program.
   - Exploratory fishing protocols.
   - Joint stock assessment, coast-wide biomass transect surveys, experimental harvest sites, and selected study sites.
   - Advisory committees and individual zone councils.

The first step to the development of a green sea urchin IFMP is to convince the stakeholders of the potential economic importance of this resource. In this province fisheries diversification and the introduction of new employment opportunities is key to the sustainability of rural areas. Once the fishing industry treats the green sea urchin as a valuable commercial resource the DFO may allocate resources to the science and management of this fishery.

Currently the DFO is lacking the essential information required to formulate a green sea urchin IFMP. But by focusing on a co-management the DFO can collaborate with industry and other research agencies to obtain the information required. By involving harvesters in management a vested interest in the long-term sustainability of the species are developed, and this safeguards the success of the management plan. Co-management can pave the way for other important management tools such as GHL's, RHZ's, marine refugia, and enhancement programs that would otherwise likely be turned down by harvesters.

In an emergent fishery such as the Newfoundland and Labrador green sea urchin fishery a pre-cautionary based management style is best until such time that the science and traditional ecological knowledge can support an IFMP. Action at the grassroots level with the fish harvesters may be the key to influencing the DFO and allowing them to realize the crucial need for an Integrated Fisheries Management Plan rather than subject the resource and those who depend on it to the vagaries of the muddling through approach.

Footnotes

[1] Somatic and gonadal tissues refers to the organisms body and reproductive tissues, respectively.

[2] See section 2.5 Current State of the Newfoundland Fishery.

[3] Benthic refers to the community of organisms that inhabit the ocean floor.

[4] Short-term permit transfers are permitted for medical reasons.

[5] Gametes refer to the sex cells of the urchins that are fertilized in the reproduction stage.

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