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Marine Protected Areas in the Gulf of Maine: Policy for a Common Resource

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MARINE PROTECTED AREAS IN THE GULF OF MAINE:

POLICY FOR A COMMON RESOURCE

By

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In the wake of 25 years of unsuccessful single-fisheries management in the Gulf of Maine, there has been growing support for reform. Ecosystem management has been proposed as one alternative, but the information needed to manage whole ecosystems is greatly lacking. Implementing fully-protected marine protected areas (MPAs) is one way to preserve habitat while at the same time acquiring data for future ecosystem management. Under the current institutional arrangement in the Gulf, engineering agreement for MPAs is difficult due to the differing goals of varied user groups. The situation is reflective of a common property resource problem in that there are many individual users with no property rights reaping benefits from a shared resource, the Gulf of Maine. The result is overexploitation of the resource, in this case fish and associated biota and habitat. Common property resource dilemmas have been well studied by political scientists such as Elinor Ostrom. Ostrom has discovered there are common criteria for successful common property regimes.

The questions this thesis poses are; 1) how does the common property resource regime of fisheries management in the Gulf of Maine compare to Ostrom's criteria and; 2) what needs to be done to further meet these criteria for successful MPA implementation in the Gulf of Maine?

This thesis is comprised of five chapters which address both policy issues and scientific questions pertaining to the implementation of fully-protected MPAs in the Gulf of Maine. Chapter 1 examines how fisheries in the Gulf of Maine reached its present state; Chapter 2 examines fishing industry attitudes towards historical fisheries management practices and the use of MPAs as a current fisheries management tool; Chapter 3 reports the overall benefits of MPAs obtained

from national and international studies; and Chapter 4 is an analyzes of benthic invertebrate communities in the Gulf of Maine whose results are related to the MPA discussion. The concluding chapter incorporates the viewpoints of industry and MPA proponents into Ostrom's 8 criteria for successful common property resource management of MPAs in the Gulf of Maine.

Results show that although there is movement towards ecosystem-based fisheries management and MPAs on the part of both fishermen and MPA advocates, efforts are not coordinated and are inconsistent. Recommendations are to address the political hurdles of boundary clarification and establishment of an MPA forum before advancing MPA efforts.

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INTRODUCTION

Marine protected areas (MPAs) are now considered as an important tool for fisheries management. In the Gulf of Maine, several forms of MPAs have been implemented or proposed over the last seven years. Temporary groundfish closures in the Gulf of Maine and Georges Bank have been in place since 1994. Future plans for the Gulf of Maine have included such proposals as rotational closures for scalloping on Georges Bank, a no-take preserve along the US and Canadian sides of the Hague Line, and inshore zoning. These proposals are driven by two goals: to preserve groundfish stocks and/or to preserve marine habitat and biodiversity.

To meet either of these goals, fishing behavior must change via the institutions under which humans operate. Policing an area as vast as the ocean is costly and impractical. Effective enforcement of fisheries laws at sea, therefore, is largely dependent upon self-regulation. Many policy-makers believe that self-regulation occurs when the stakeholders have input into decision-making and there is incentive for self-regulation. "If incentives of economic goals are melded with those of social goals, they may lead to sustainable resources" (Scott, 1993, p 45).

Presently in the Gulf of Maine, there are several groups of stakeholders with varying and oftentimes conflicting interests in the ocean's resources (i.e. recreational fishermen versus commercial, fixed gear fishermen versus mobile gear fishermen, inshore versus offshore fishers, ecosystem and habitat management versus managing for fish stocks only). To reach consensus amongst these groups, communication barriers must be removed and common ground sought after. It is a difficult task, but policy-makers and managers world-wide believe this to be the most effective way to increase the chances for timely implementation and success of major regulation changes like no-take MPAs. In the Northeast, talks of MPAs as a fisheries management tool have begun, but science, industry and fisheries management have yet to collaborate and reach any kind of consensus on the topic.

There are several ways to design MPAs, defined here as a no-take reserve, depending upon the goal. Two of the five goals of MPAs listed by the World Conservation Union (IUCN) are to conserve biodiversity, and to protect and restore habitat. Scientists who adopt the precautionary approach, the belief that ecosystems and their inhabitants should be understood before being exploited, assume biodiversity and habitat are important to fisheries sustainability. The stakeholders who have the most to lose from ineffectual MPA assignments based on the precautionary approach are fishermen. Therefore, reasons for MPAs need to be robust. There is a difference of opinion amongst fishermen as to the merits of the goals for maintaining biodiversity and habitat, especially by mobile gear fishermen. While gillnet fishermen and long-liners depend on knowing how to interpret habitat for their livelihood, mobile gear fishermen rely more heavily on knowledge of bottom topography and other physical features of the ocean. Therefore, groundfishermen do not pay as much attention to nor assign as much benefit to offshore habitat, (Hall-Arber and Pederson, 1999). For this reason and others, it is oftentimes more difficult to convince mobile gear fishermen of the importance of habitat and biodiversity, and why it is worthy of protection in the form of MPAs.

In the interests of seeking commonalities between groups, this thesis uses the insight of the groundfishing community as a springboard for comparing attitudes of two main stakeholders involved in the MPA discussion, groundfishermen and scientists advocating MPAs. It is comprised of five sections. The first section examines the history of fisheries management in the Gulf of Maine. The second section takes a look at industry attitudes of historical fisheries management practices and the use of MPAs as a current fisheries management tool. The third and forth sections examine the scientific rationale behind MPAs, including the author's analysis of benthic invertebrate communities in the GOM and its relatedness to the MPA discussion. The fifth and last section examines MPAs as a Common Property problem and includes the information gathered from previous chapters to ascertain what future steps need to be taken to ensure successful MPA implementation.

Chapter 1

HISTORY OF FISHERIES MANAGEMENT

Introduction to the history of fisheries management

As a result of several failed attempts by federal and regional agencies to manage the collapsed state of fisheries in the Gulf of Maine, fishermen, management and scientists are struggling to understand the factors needed for sustainable fisheries. Marine protected areas (MPAs), Sustainable Fisheries Act (SFA) and its associated Essential Fish Habitat (EFH), and co-management have become familiar terms as various stakeholders convene to examine novel approaches in attempts to rebuild fish stocks and create a long-term plan for sustainable fisheries in the Gulf of Maine.

Designating EFH and/or MPAs is a complicated assignment, however, evident when one watches fisheries managers, scientists and industry try to define and recommend the placement of restricted areas inside the GOM. Decisions on what needs to be protected and how is up for debate, dependent upon the importance one places on the economic value of commercial fish, aesthetic value, recreational value and/or the value of conservation for conservation's sake. While EFH is sculpted to cater to the economic gain of the commercial fishing industry, fully-protected MPAs are designed with conservation of the ecosystem in mind. Differing goals and the chance for successfully attaining them depends upon best available science.

Data used to assist in decision-making for fisheries management comes from NMFS trawling surveys, studies conducted by benthic marine ecologists, and to a limited extent, traditional ecological knowledge. Despite this, many claim there is not enough quantitative science to merit well-founded decisions. The fishing industry distrusts annual stock assessment numbers compared to what they witness firsthand, and scientists who focus on biodiversity preservation and ecosystem management differ in opinion with those who believe in historical single-species management. Ecosystem management theory adopts a long-term, pro-active "precautionary approach" towards regaining sustainable fisheries, which is oftentimes a threat to those who economically have much to lose in the short-term.

In spite of this, the National Marine Fisheries Service (NMFS) has put pressure on fisheries managers nationwide to develop viable strategies for sustainable fisheries management by re-evaluating past failures and adopting new measures for future success. No-take MPAs is one of these measures. To understand how to implement MPAs in combination with other measures, one must first understand the history of fishing and fisheries in the Gulf of Maine.

Historical overview of the state of fisheries in the Gulf of Maine

The Gulf of Maine has been fished by U.S. and European fishermen since the 16th century. One of the first written documents to describe the commercial fishing grounds of the Gulf of Maine and Georges Bank stated, "...no other fishing area equaling this in size or in productivity exists anywhere else in the world..." (Rich, 1929). By the mid 1900s, change in fishing gear coupled with advances in technology and insufficient management contributed towards a significant decline in commercial fisheries.

Over time, gear changes and technology revolutionized fisheries, but fish populations could not keep up. The traditional method of handlining used in the 1800s was all but replaced by the otter trawl by 1918. Refrigeration cars on trains, ice production and diesel powered trawl vessels heavily impacted the fisheries by 1928. By the 1940s, several fish populations were classified as "depleted" (Sinclair and Murawski, 1997). By 1977, another steep decline in groundfish populations due to large international factory ships fishing inside the Gulf of Maine became so problematic that extended economic zones (EEZ) were established. The purpose of the EEZ was to keep international fleets outside the 200-mile boundary of all US coasts (the Fisheries Conservation and Management Act, or the Magnuson Act, of 1976). Under this act the US could exclude foreign vessels only if the US fleet had the capacity to fully exploit the resource. Consequently, the Federal Government implemented several programs designed to build up the US fleet (Johnson, 1999). By the 1990s, the resulting build-up of regional fleets depleted stocks once again. By 1997, nearly all wild fish stocks world-wide were classified as fully or overexploited (FAO, 1997).

Overcapacity of the harvesting industry was not to fully take the blame, however. Habitat loss, and open-access fishing policies in the Gulf of Maine helped to substantially decrease many wild fish stocks. In addition, environmental factors such as temperature shifts and pollution were being examined for their effect on population structure (Graham, 1970).

The end result for fishing communities over the last 70 years has been a loss of the top trophic level of fish, a decreased size of predatory finfish, decreased biomass of commercial fish, and a dramatic shift in species composition (Pauly, 1998; Sinclair and Murawski, 1997; Cohen and Langton, 1992; Steneck, 1996). Extent of resulting alteration in the Gulf of Maine ecosystem was brought into question. There was an overall 65% decrease in groundfish populations between 1977-1987 (Anthony, 1990). From 1963 to 1986, the percentage of gadoids caught off Georges Bank shifted from 55% to 11 %, while dogfish shark accounted for 2 % in 1963 to 41% of commercial fish caught in 1986 (Cohen and Langton, 1992). By 1992, the lowest groundfish landings in history were recorded and the National Marine Fisheries Service and the New England Council were once again put under scrutiny for the devastated condition of New England's fish populations.

<u>The evolution of fisheries science and management in the Northeast (1870-1970)</u>

In 1870, only five years after the Civil War, scientists and citizens in the northeast states started taking notice of depleted inland fisheries. Fish commissions had been established in some states, but there was no federal involvement in fisheries at this time. Shared concern over population declines in certain commercially valuable species such as salmon and trout arose from pollution, soil erosion, construction of dams and habitat destruction (Benson, 1970).

In 1871, under President Ulysses S. Grant, Congress authorized creation of the Commission on Fish and Fisheries. Since that time, the Commission has gone through several changes. By 1903, the Fish Commission was moved to the Department of Commerce and Labor, and was renamed the Bureau of Fisheries. In 1970, the Bureau of Fisheries was made a part of NOAA and renamed National Marine and Fisheries Service (NEFSC website, 2001b). The transformation of names came with a shift in the definition and direction of fisheries management as well.

The father of fisheries science in the United States was the first US Commissioner of Fisheries, Spencer F. Baird. In 1874, Baird called attention to the fact that the decrease in cod was correlated with the installment of power damns in Northeast rivers which interrupted the migrations of the fish on which cod fed (Graham, 1970; Benson, 1970). The solution to the decrease in inland fish stocks was " to introduce and multiply shad, salmon, or other valuable fish throughout the country, especially in waters under federal jurisdiction or in interstate and boundary waters" (Benson, 1970, p. 2).

To fulfill this mission, Baird and his contemporaries began serious investigations into fisheries science in Woods Hole in 1871. A permanent station at Woods Hole was not established until 1885. By 1920, some states and Canada followed suit by building their own laboratories. In the early 1900s, research at Woods Hole mainly concentrated on fresh water and anadromous fish species. Closed fresh-water systems were easier to understand and manipulate, and aquaculture proved successful. Fishery science could be best applied to fresh water fish management versus that of oceanic systems. For both fresh and salt-water systems, Baird recognized the importance of understanding fisheries science through a combination of disciplines such as oceanography, climatology, biology, ecology and even population dynamics, but the ocean was still too little understood (McHugh, 1970).

Management efforts for oceanic fish were geared towards controlling efforts of the fishermen in lieu of trying to influence fish populations. From 1925 to 1935, the emphasis on oceanic fish studies brought forth attempts to quantify population variations in order to explain these variations. There was a great desire to know why catches fluctuated and how to control these fluctuations. In 1930, the fishermen themselves asked the federal government to conduct a study on the substantial decrease in haddock landings. To address this, studies were conducted in analysis of catches, abundance of year classes, growth and death rates, migration and movement and measures of fishing effort. This marked the beginnings of the evolution of fisheries population dynamics (McHugh, 1970).

After World War II, an interest in mathematical models developed as well as recognition of the fact that "if fisheries management was to succeed, it must understand the dynamic relationships of total communities, rather than the individual species or stocks of fish" (McHugh, 1970 p. 28). Despite this early ecological approach, single-species management ensued.

In 1949, the International Convention for the Northwest Atlantic Fisheries (ICNAF) was ratified. It included the U.S., European nations and Newfoundland. By 1951, a statistical system for catch of participating countries was created. The North American Council on Fisheries Investigations developed the design into five sub areas further divided into 26 statistical divisions on which each country submitted a monthly report. Reports included; 1) species caught, 2) catch per unit effort and 3) gear type. Species of highest interest at the time were cod, haddock, redfish and halibut. Growth and mortality rates were measured in addition to catch structure and age structure. In 1953, the Commission developed programs in biological-oceanographic research to study environmental factors and gear selection studies. For the first time, as a result of studies done by William Herrington, mesh regulations were implemented for haddock to increase efficiency of catch and to eliminate by-catch of juvenile haddock (Graham, 1970). To many, these achievements concluded the first era of success for ICNAF.

The second era of the ICNAF focused on dealing with the unforeseen increase in effort by new European countries. Russia, Poland, and Germany and Romania quickly entered the Convention area from 1956 into the 70s. By 1970, ten countries were fishing Georges Bank compared to the US only in 1949. Apprehension of over fishing was soon justified. As stocks were fished down, new stocks were exploited resulting in matching or exceeding maximum sustainable yield (MSY)[1] of the whole of the Northwest Atlantic fisheries by 1967. Mesh regulations and good year classes couldn't compensate for increased effort (Graham, 1970).

Control of fishing effort was introduced in 1962, but was difficult to implement between 14 nations. Use of MSY to measure fishing effectiveness was also in question. Some governments

[1] MSY is the highest average yield over time that does not result in a continuing reduction in stock abundance, taking into account fluctuations in abundance and environmental variability (NEFSC website, 2001a).

believed fishing to the maximum economic yield (MEY) [2] was a far better solution. The effort and landings rates are usually always lower at the MEY than at the MSY, thus decreasing the chance for overexploitation of fish populations. Although MEY was considered, it did not and has not to this day gained the acceptance of MSY as the driving force behind fisheries management. Assuming there was adequate understanding of the biology behind commercially fished stocks, the difficulty of setting and agreeing upon national quotas to attain MEY would be thwarted due to economic and social factors (Graham, 1970).

Trend towards fisheries dynamics

The trend towards fisheries dynamics may have started with detailed studies on the Pacific Halibut for the fisheries of British Colombia (Thompson, 1970), as well as studies by F.I. Baranov on the biological basis for fisheries management in Russia (McHugh, 1970). Years later, Thompson and Bell published the first American application of population dynamics in 1934. From this point on, the study of population dynamics grew to relatively more sophisticated levels by W.E. Ricker and others in Canada, R.J.H. Beaverton, S.J. Holt, and others from the United Kingdom, and Milner B. Schaefer and others from the United States (McHugh, 1970).

Although many scientists believed population dynamics to be at the heart of fisheries research, others did not. Dr. Kasahara in his 1961 lecture series at the University of British Columbia stated,

> ...the role of population dynamics seems to have been overemphasized. Even for the question of conservation, there are so many cases in which the present methods of population dynamics are not useful, either because basic ecological characteristics of the species involved are not sufficiently known, or because the abundance of the population changes tremendously by unknown environmental factors (McHugh, 1970 p. 39)

This theory of fishing according to the population scientists of the day assumed that each stock of fish is resilient to fishing mortality so that, up to a certain limit, the stock adjusts by increased survival and growth. The stock reaches a new equilibrium with its environment as it

[2] MEY is where marginal cost = marginal revenue: if effort is increased the additional revenue is less than the additional cost (NEFSC website, 2001a).

does so. As a stock is fished, the equilibrium catch rises to a maximum and then falls until the stock can no longer remain in equilibrium. To identify the level of fishing intensity that will produce the MSY is the job of the fisheries population dynamicist.

To accurately predict MSY is more easily said than done, however. It requires knowledge of landings (amount of fish caught), effort, recruitment, growth and mortality from fishing and natural causes. The challenge is to capture the knowns and guess the unknowns with "best available science." Landings and effort are measurable variables since managers can collect this data directly from vessels and buyers, but predictability of what the catch will be like the next year is not. Fish quantity varies seasonally and yearly due to numerous environmental, ecosystem and habitat factors, and recruitment of a stock is only known years after the MSY has been established (Townsend, pers. comm., 2000.). Because of this, MSY has been criticized for not only its inaccuracy but for its emphasis on single species management in lieu of the effect of ecosystem processes and habitat (Wilson, in press).

Solutions: legislation and the creation of boundaries (1970s-present)

By 1966, the increase in foreign ships on Georges Bank caused significant crashes in commercial fish stocks, and the Magnuson Act of 1976 was passed by the US and Canada to keep foreign fleets outside the 200 mile Exclusive Economic Zone (EEZ). Since Georges Bank was located within 200 miles of both the US and Canadian coasts, this led to a dispute between US and Canada over access rights to the productive fishing grounds of the Bank. To rectify the situation, the International Court of Justice was called in to settle the dispute in 1981, and by 1984 the Hague Line dividing US and Canadian waters was created. The line closed off much of Canadian waters as well as the northeast peak of Georges Bank to US fishermen. The Hague Line ruling did not take traditional fishing grounds into consideration, and the US fleets were forced out of areas where haddock and cod landings were highest. As a result, the US fleet was forced to shift fishing efforts towards the Gulf of Maine and southern Georges Bank (Johnson, 1999).

Meanwhile, the Magnuson Act of 1976 was beginning to take on a life of its own. One outcome of the act was the New England Fishery Management Council (NEFMC). The NEFMC implemented the first of several groundfish fishery management plans (FMP) one year later. The 1977 FMP introduced catch quotas, minimum fish and mesh sizes, and spawning area closures for cod, haddock and yellowtail flounder. The second Interim Groundfish FMP in 1982 replaced the quota system with minimum fish sizes and net mesh regulations. Due to lack of enforcement in part, both failed.

In 1986, NMFS was faced with approving NEFMC's Northeast Multispecies Fishery Management Plan, a plan that included 15 groundfish species. In January of 1986, NMFS disapproved of the plan due to the threat of over fishing. When the unchanged FMP was re-submitted by the Council, NMFS approved the regulation for one year, in which time the Council had time to adopt suitable amendments. One year later, the Council made ineffectual changes and NMFS once again approved the plan under overwhelming pressure from the New England congressional delegation (Shelley *et al.*, 1996).

In 1989, the Goundfish FMP underwent a second change in the form of an amendment. It failed, however, to address the steady decline in groundfish stocks observed by NMFS scientists since the early 1980s. The plan also canceled a scheduled increase in mesh size. In the same year, in accordance with NMFS revision to the fishery management plan guidelines developed under the Magnuson Act, "overfishing" was to be defined by the New England Council along with recovery plans for stocks found to be overfished based on those definitions. The council used the same definition developed for the Groundfish FMP, twenty percent of the maximum spawning potential for most groundfish stocks. (Shelley *et al.*, 1996).

In 1990, the Council completed development of Amendment 4, which admitted that overfishing thresholds had been surpassed for all stocks of cod, haddock and yellowtail flounder. However, the amendment contained no provisions to eliminate the overfishing of these stocks or to initiate rebuilding. This was to be addressed in a future amendment. At this point, the Conservation Law Foundation (CLF) advised the New England Council and NMFS that Amendment 4 was in violation of FCMA's national standards. NMFS approved most of Amendment 4 and CLF and the

Massachusetts Audubon Society sued the Secretary of Commerce, the Director of NMFS, and the Regional NMFS Director in June 1991 for failure to prevent the overfishing of cod, haddock, and yellowtail flounder (Shelley *et al.*, 1996).

Results of the lawsuit were obtained by August of the same year. A consent decree was signed by the plaintiffs and the US Department of Commerce which ordered the Council to come up with a plan to stop overfishing rates on cod and yellowtail flounder within five years, and within ten years for haddock. If the Council did not develop the plan by Sept. 1992, the Secretary was to develop the plan instead. Established on March 18, 1992, Amendment 5 to the Groundfish FMP met the terms of the consent decree.

Closures in the Gulf of Maine and Georges Bank

In further response to the 1991 lawsuit, Amendment 5 was approved in January 1994, more than four years after the Council had acknowledged that cod, haddock, and yellowtail flounder were overfished. The Amendment was to decrease fishing effort by 50% over 5-7 years. The beginning of many new regulations to be endured by the groundfish industry, Amendment 5 placed a moratorium on new entrants, required permits, restricted the number of days at sea (DAS) for vessels over 45 feet in length, increased mesh size restrictions, set minimum fish sizes, and established mandatory reporting. For the first time, seasonal and area closures were established as an emergency response to the collapsed status of Georges Bank haddock (haddock spawning grounds in Closed Area I and Closed Area II)

After only 8 months of implementation, NMFS scientists realized rebuilding goals for Amendment 5 were set too low for the critical nature of cod and haddock stocks, and Amendment 7 was born. The amendment was responsible for decreased days at sea, increased the area closed to fishing in Closed Areas I and II, and further limited access to the fishery.

Meanwhile, the Sustainable Fisheries Act of 1996, an amendment to the original Magnuson Steven Act, was created. In 1999, additional closures to the Gulf were imposed by Frameworks 26 and 27, both designed to reduce cod catch. Framework 27 was responsible for the inshore Western GOM Closure (Figure 1.1)

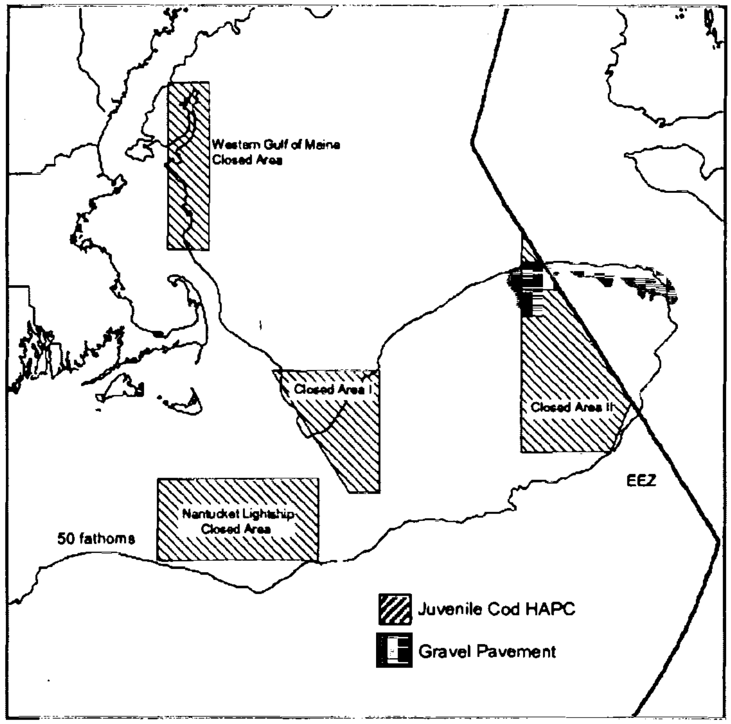

Figure 1.1. Gulf of Maine Area Closures (NEFMC, 2000a)

Since 1994, and again in 1996 and 1999, groundfish species have been managed by time/area closures, gear restrictions, minimum size limits, and, for cod species, direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5 and 7 to the FMP. Amendment 9 established biomass rebuilding targets, and defined rules which specified target fishing mortality rates and corresponding rebuilding timelines.

Closures placed in the Gulf of Maine since 1994 by the Atlantic States Management Fisheries Council (ASMFC) are not considered to be Marine Protected Areas, defined in this thesis as fully-protected from fishing and other extractive activities. Partially decided on historically closed areas (Table 1.1), Areas I and II on Georges Bank were closed to redistribute effort in two very densely used fishing areas. Gulf of Maine inshore rolling closures were mapped according to best guesses at spatial and temporal factors of fish spawning behavior of cod.

Table 1.1. Abbreviated History of Groundfish Year Round Closures
(Gilford, pers. comm, 2001)

Abbreviated History of Groundfish Year Round Closures		
Year	Area	Comments
1969	Closed areas I and II	Established by ICNAF to protect spawning (ICNAF only allowed closures for spawning protection)
1977	Closed Areas I and II	Incorporated into Atlantic Demersal Finfish Plan *to provide haddock spawning protection*, but recognizing some protection given to cod and yellowtail flounder. Seasonal.
1982	Closed Areas I and II	Incorporated into Interim Groundfish Plan *to protect haddock spawning*. Some changes made to area boundaries. Seasonal.
1986	Closed Areas I and II, Southern New England Yellowtail Flounder closure	CA I and II incorporated into Northeast Multispecies FMP *to protect haddock spawning*. SNE Yellowtail Flounder closure (west of current Nantucket Lightship Closure) adopted *to reduce mortality and enhance spawning potential. Seasonal.*
1988	Closed Areas I and II, Southern New England Yellowtail Flounder closure	Council's Technical Monitoring Group (TMG) provides evaluation of closures. Recommends moving CAI south and east. Concluded SNE closure was too short in duration, or in the wrong season. (Boundaries of CA I were changed, apparently in response to this suggestion, but not sure when that occurred).
1994	Closed Areas I and II, Nantucket Lightship Closure	Amendment 5 suspends Closed Area I, expands Closed Area II. Nantucket Lightship Closure defined, *closure to take effect when juvenile flounder are found at a defined level in the spring bottom trawl survey.*
1994	Closed Areas I and II	At the request of the Council, NMFS implements expansion of CA II, suspends opening of CA I through an emergency rule *to protect cod and haddock stocks.*
1994	Closed Areas I and II, Nantucket Lightship Closed Area	NMFS implements closures year round through emergency action.
1995	Closed Areas I and II, Nantucket Lightship Closed Area	Framework 9 adopts year round basis of closures previously implemented through emergency action.
1998	Western Gulf of Maine Closure	Framework 25 adopted WGOM closure to *reduce mortality of Gulf of Maine cod.*

There were many uncertainties in the outcome of the placement of these areas due to the speed (and limited information) on which the closure decisions were made. Both temporal and spatial considerations for these areas are presently up for reconsideration by the NEFMC (NEFMC website, 2001).

The Sustainable Fisheries Act - the evolution of single species management to ecosystem management

The Magnuson-Stevens Fishery Conservation Act of 1976 under NMFS was responsible for the establishment of 8 regional fisheries management councils through the creation of fisheries management plans (FMPs). The goal of these plans was to prevent overfishing while attaining optimum yields[3] However, no authorization was given to halt actions that might adversely impact a fishery. Although science and industry suspected the importance of habitat, habitat was not seriously considered by management until the late 1980s when the attention was drawn to the large portion of overfishing of highly prized species. National and international parties began insisting that habitat degradation become a higher priority issue. Local scientists around the Gulf of Maine were seriously questioning the impact of mobile gear on the sea floor (Watling, pers. comm., 2001). Amendments drawn up in 1986 required habitat assessments to be included in the Federal Management Plans and they gave the Councils the right to comment on activity adversely affecting the habitat of a fishery within their jurisdictions. NMFS was given 45 days to respond to the recommendation (Fletcher and O'Shea, 2000).

Amendments made in 1990 to address the concerns of California salmon fishers stated that a Council could make comment and recommendations regarding state or federal actions likely to impact the anadromous fishery under their jurisdiction. (Fletcher and O'Shea, 2000).

One further amendment to the Magnuson Act, The Sustainable Fisheries Act (SFA) was passed in 1996. Among its provisions were mandatory overfishing elimination and stock

[3] Optimum yield: (1) the amount of fish which will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems; (2) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and (3) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery. (NEFSC website, 2001a)

rebuilding, the establishment of a program to protect essential fish habitat, and the establishment of a new national standard for bycatch reduction. This was given top priority by the 8 Councils whose job was to identify habitat essential for managing fish stocks as well as to encourage the conservation and enhancement of the habitat. In response to federal agencies, once the essential fish habitat (EFH) was identified, Councils were to comment on federal activities that might adversely affect this habitat. Congress called for compliance within two years of the enactment of the SFA (Fletcher and O'Shea, 2000).

Like the 1986 amendment, the 1996 amendment failed to take the additional step to require habitat preservation, conservation or mitigation, and did not give the citizens the right to challenge federal agency decisions to move ahead with a project (Fletcher and O'Shea, 2000). However, it did for the first time clearly identify the prevention of overfishing as a need under the Act. This had a large impact on litigation cases filed against NMFS from 1996 to present. The language on which to argue overexploitation was created. Prior to 1986, the vagueness of the overfishing definitions in the 1976 Magnuson Act made it difficult to debate overfishing on clear grounds. Councils acting under their own self-interests were (and are) not held accountable for their actions nor could they be sued under the current management scheme. NMFS however, can. Concerned stakeholders saw NMFS as the conduit to make Councils abide by the Sustainable Fisheries Act. To date, there have been approximately 133 lawsuits against NMFS since 1996 (NFCC, 2001).

Oceans Act and MPA Executive Order 13158

In the summer of 2000, President Clinton and Congress passed into law the Oceans Act of 2000, which paved the way for the establishment of a federal Oceans Commission. The purpose of the Act is to protect life and property, promote responsible stewardship of ocean and coastal resources, including fisheries, protect the marine environment and prevent marine pollution, enhance marine-related commerce and transportation and reduce conflicts among users, and increase our knowledge and understanding of ocean and coastal processes and their role in climate variation. A 16-member oceans commission was appointed on April 20, 2001 to begin work on January 20, 2001. The Commission was given 18 months to submit a final report to Congress and the White House of findings and recommendations for U.S. ocean policy. (USM website, 2000.)

In May 26, 2000, the National Marine Protected Areas initiative was passed, Executive Order 13158. The purpose of the Order was to strengthen the protection of US and coastal resources by expanding a national system of MPAs by working closely with state, territorial, local, tribal and other stakeholders. In order to reverse the continuing loss of ocean habitats, the mission of the executive order is to protect and preserve "representative" samples of important coastal ecosystems. The Department of Commerce, Department of Interior, and other federal agencies are responsible for implementation. Two evaluation steps were included:

1) To evaluate the adequacy of existing levels of protection for important marine resources and recommend new MPAs and/or strengthening old ones to establish a comprehensive and representative system and
2) Using natural and social science to develop objective information, technical tools and management needed to support a national MPA system. (USM website, 2000).

In addition to directing the establishment of an MPA Federal Advisory Committee, the Order called for the creation and maintenance of a national website to disseminate information on MPAs, identification of a national list of MPAs, and the establishment of a National MPA Center. The Executive Order provided the following direction to Federal Agencies:

> To the extent permitted by law and subject to the availability of appropriations, the Department of Commerce and the Department of the Interior, in consultation with the Department of Defense, the Department of State, the United States Agency for International Development, the Department of Transportation, the Environmental Protection Agency, the National Science Foundation, and other pertinent Federal agencies shall develop a national system of MPAs (Executive Order 13158).

The order did not create federal authority for MPAs nor did it focus on no-take MPAs. It does, however, raise the visibility of MPAs, encourage research and education, and establish a dialogue (Kurkhill, pers. comm., 2001). On June 4, 2001, Secretary of Commerce Donald Evans released a statement announcing President Bush's endorsement of and intent to retain the

Executive Order and continue the processes begun by the Clinton Administration. Three million dollars appropriated for the Executive Order was approved in December, 2001

Government support for the re-examination and implementation of MPAs is a first step towards improvement of our oceanic natural resources, but there are many other aspects to consider in order for such a change to occur. Public opinion and the current state of science in the Gulf of Maine must be seriously taken into account.

In the next chapter, industry viewpoints of past fisheries management practices and the use of MPAs as a current fisheries management tool are examined. In Chapter 3, the scientific rationale behind MPAs is reviewed, and in Chapter 4 a preliminary study by the author on megabenthic fauna of the Gulf of Maine is related to this rationale. The last chapter compares the Common Property Theory to the information gathered in the previous chapters to determine what future steps need to be taken to ensure the success of the intent of Executive Order 13158.

Chapter 2

INDUSTRY PERSPECTIVE

Introduction

Currently in the Gulf of Maine, the only fully-protected MPA is the Habitat of Particular Concern (HAPC) on Georges Bank. The rest of the closures in the GOM were implemented as an emergency response to mandates resulting from the lawsuit of 1991. These closures are not considered "MPAs" according to the NEFMC since they are designed to protect commercial fish only, allow for selected gear types, and/or allow for seasonal fishing (NEFMC, 2000b). In addition, there are plans underway by the NEFMC to change the spatial and temporal parameters of these closures as more information is collected. Unfortunately, only a very small portion of these areas has been monitored to determine changes pre- and post- closure time, and success of these closures (by industry) is measured according to the increase in commercial fish populations only. MPA advocates and those seeking multi-species fisheries management believe that success should be measured by the preservation of biodiversity and habitat as well as the restoration of commercial fish stocks. There is increasing pressure for the implementation of fully-protected MPAs both nation-wide and in the Gulf of Maine.

Many fisheries political scientists and managers believe that the major stakeholders of oceanic resources, such as fish, must be involved in the decision-making process to ensure the success of MPA implementation and enforcement (Agardy, 1997). The increasing gap in communication and mistrust between fishermen and fisheries managers over the last decade has caused concern amongst fisheries managers. Attempts to bridge this communication gap have begun by involving industry in research and management. Gathering traditional ecological knowledge to map historical cod spawning grounds, developing industry-science collaborative research programs, and creating dialogue between scientists and fishermen around groundfish research priorities have all been attempts to improve relationships between industry and management. In the last two years, the PEW Oceans Commission and special NOAA offices have been formed to reassess the state of our oceans and to investigate MPAs nation-wide. However, there has been little attempt to understand and include the opinions of those who use the Gulf of Maine most and perhaps who know its waters and bottom type best, groundfishermen. These fishermen have much to contribute to the MPA discussion, and management has much to gain with their cooperation.

In the interests of assimilating industry opinion into the MPA discussion as well as to compare it to the opinions of other stakeholders, the following anecdotal information has been collected to represent the viewpoints from members of Maine's groundfish industry. Three topics are addressed in this chapter: 1) the effects of the past 10 years of fisheries management practices on industry, 2) recommendations for future management and research by the industry and, 3) how marine protected areas fit into future fisheries management plans. This information is derived from four different sources:

1. New England Fisheries Management Council (NEFMC) meetings on the socioeconomic impacts of amendments 5 and 7 address the effects of the past 10 years of management on industry (NEFMC, 2001).
2. Results of interviews with 10 experienced groundfishermen address the impact of historical management, recommendations for future fisheries management, and how MPAs fit into future fisheries management.
3. Gulf of Maine Aquarium research priority meetings for groundfish (Gulf of Maine Aquarium, 2000).address recommendations for fisheries research by groundfishermen.
4. Northwest Atlantic Marine Alliance (NAMA) and Stonington Fisheries Alliance mission statements contained recommendations for the improvement of fisheries management in the future (NAMA website, 2001; Ames, pers. comm., 2001).

<u>**New England Fisheries Management Council socioeconomic impact meeting results**</u>

Closures, shifts in fishing pressure and decreasing groundfish populations affected fishermen according to the size and rigging of their boats. Small boat owners with boats 45 feet or under historically fished inshore and changed gear according to the seasonal changes in fish species. Small and medium sized vessels, 50-69 feet, increased their fishing concentration in the Gulf of Maine, and large vessels 70 feet and over relied more heavily on Georges Bank for groundfish and scallops (Johnson, 1999).

From 1994 to 1998, the number of small vessels reporting Maine landings declined from 110 vessels to 75. The number of medium vessels dropped between 1993 and 1998 from 77 to 48, and the number of large vessels from 1993 to 1998 decreased from 50 to only 25 vessels. These adjustments led to a reconfiguration of the Maine Fleet, with a greater concentration of vessels in the small and medium class sizes. The decrease in boats meant decrease in support businesses and as a result the service infrastructure was seriously affected. To exemplify the economic trickle-down effect, when the city of Portland, Maine lost 5 fishermen during the year 2000, one fisherman's life was estimated to be worth $1,600,000.00 to its community (Johnson, 1999).

Socially and economically, there were heavy ramifications for the overall fleet reduction throughout the 1990s. Fishermen who survived trip limits, reduction in days-at-sea and area closures (especially those inshore) compensated in other ways, many switching over to lobstering. In addition, many small and medium boats increased their capacity. Other groundfishers found they benefited due to less competition. Many harvesters who were able to stay in the fishery claimed that conditions remained good in spite of reports of declining stock abundance during the late 1990s (Johnson, 1999).

The Report from the Groundfish Social Impact Informal Meetings (NEFMC, 2001) echoed similar sentiments about social impact throughout New England. Two of these meetings were held in Maine. Common complaints from fishing community members are listed below.

Safety

Decreased days at sea (DAS) affected the safety of large boat fleets (Portland's large boat fleets were decreased by 50%) as the boats tried to increase efficiency by maximizing their days at sea causing them to fish in places, seasons, and weather not normally fished. (i.e. market prices are better at certain times of the year, and when that time is winter, the chances of running into bad weather greatly increase). Boats will also stay out at sea for extended periods since they didn't want to waste time steaming home and then back out again.

The small boat industry has been affected most by inshore rolling and marine mammal closures. This caused fishers to work further offshore outside of the closures, endangering themselves in the process.

Many boat owners complained about the inability to get stern men (experienced or not). When the fishing business is not stable, the job of a stern man does not pay as well as others. This causes many fishers to go out to sea alone, again jeopardizing their own safety.

Inequity

Who can fish where and how much they can fish has created a divide in the fishing industry between large and small boats, fleet DAS and individual DAS, and recreational fishermen and commercial fishermen. For instance, where inshore rolling and marine mammal closures occur, large boats can go further offshore to fish but small boats can't. Fishermen also felt closures shifted the fish allocation from Downeast communities to western communities.

Flexibility

Fishermen used to be able to fish different species throughout the year. Due to regulations from Amendments 5 and 7, fishing between species was no longer profitable and many switched over to lobstering as their main fishery. When fishers were made to focus their efforts on single species due to decreased days at sea, they felt that concentrating all effort on an already strained stock instead of spreading out effort over several fisheries did not make good management sense. In addition, people with limited access permits (latent permits) are afraid of losing them and fear that when the stocks do recover, they won't have permits with which to fish. Lastly, the number of fishermen who switched over to lobstering has been high as well as the highest trap numbers seen so far. This has created new tensions between fishers.

Economy/infrastructure

Fleet downsizing and loss of shoreside infrastructure such as cutting houses, ice plants and other support services has damaged the economy. Some boats had to land at other ports (i.e. Port Clyde) due to the loss. Many people left the fishing business altogether.

A good crew is hard to find on a year round basis since the DAS are so low, it isn't worth their while when the crew member could be doing something else. The shoreside labor pool is also leaving to better paying jobs in the city.

Retirement security became a big concern as fishers could no longer sell their boats like they used to upon leaving the industry, which helped provide retirement funding. In addition, boats are worth nothing without a permit to fish and the ability to keep these permits was questionable. The Stonington town clerk estimated that 65% of the town was dependent upon its fisheries and saw the demise of the town when its participants could no longer fish (NEFMC, 2001).

Mental health/self-esteem

Loss of self-esteem from both being out of work and the low public opinion of groundfishing resulted in increased substance and child abuse and divorce. Communities like Portland lost their blessing of the fleet ceremony as a direct impact of Amendments 5, 7 and 9. Historically, this ceremony represented the spirit and pride of the fishing community.

Future of fishing

"No one wants to take up fishing anymore" was echoed by many fishermen. The future was thought to be too uncertain in fisheries, and the publicity too negative. Fishermen felt the heat from bad press from government and environmental organizations caused the next generation to avoid a career in fishing. In addition, resident fishermen are finding it exceedingly difficult to be able to afford to stay in their home ports due to increasing property taxes from out-of-state buyers.

Regulations and lack of industry representation

Low cod trip limits in year 2000 of 30 pounds infuriated fishermen. Because cod limits were so low, and by-catch was not allowed, fishermen threw thousands of pounds of marketable, dead cod overboard. Enforcement of trip limits was poor and honest fishermen suffered. It depressed and angered fishermen to know the council (NEFMC) allowed high-grading and discard.

Like many fishermen in Maine, those from Downeast felt especially disconnected with the management process. They did not feel represented, and council meetings were always too far away and costly to attend. A fishermen from Maine must typically give up 1 to 2 days of fishing to travel to a meeting in Massachusetts only to arrive and not be heard. Enforcement was thought to be a problem according to two offshore fishermen. The Coast Guard was thought to be inadequately trained in fish enforcement, and so much escaped them.

Data

Quality and the timing of dispersal of fisheries information by NMFS had been weak in the past. Fishermen complained of receiving landings data 2-3 years after it had been collected, and that rules made with this information were inadequate. At the same time, inaccurate data is turned into NMFS by industry members based on a deep mistrust for how that information will be used by NMFS' scientists. Fishermen fear that truthful data reporting will be used against them as it has in the past. In addition, traditional ecological data is ignored by management in lieu of historical data collected by NMFS.

Biological results of amendments 5 and 7

The complex of 15 commercially and recreationally exploited groundfish species managed under the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan (FMP) are cod, *Gadus morhua*, haddock, *Melanogrammus aeglefinus* redfish, *Sebastes faciatus,* silver hake, *Merluccius bilinearis*, red hake, *Urophycis chuss*, pollock, goosefish, *Lophius americanus,* scup, *Stenotomus chrysops*, black sea bass, *Centropristis philadelphica*, ocean pout, *Macrozoarces americanus*, cusk, *Brosme brosme,* wolfish, *Anarhichas lupus*, white hake, *Urophycis tenuis,* yellowtail flounder, *Limanda ferruginea*, and windowpane flounder, *Scophthalmus aquosus* (NMFS, 2001).

As a result of closures and other management actions taken in 1994, only 4 out of 15 species included in the groundfish plan are of rebuilding or are of healthy status (NMFS, 2001) Amendment 7 only managed for 5 of these stocks. The rest are over-exploited or overfished according to results from NMFS winter and fall surveys in the Gulf of Maine. Some species, like cod, are taking much longer to respond to the new laws instated by amendments 5, 7 and 9. Meanwhile, sea scallops, *Placopectin magellanicus*, have taken advantage of the respite from mobile gear in closed areas of Georges Bank, to the point of allowing limited numbers of fishermen back into the area to fish the abundance.

Overall, many fishermen have been advocates of some closures in the Gulf of Maine. Others became believers after witnessing the scallop population increase on Georges Bank. Not all closures have had equal success, however. Georges bank haddock and Georges Bank yellowtail are rebuilding well, but cod and Southern New England yellowtail are not (NMFS, 2001).

Timing and placement of closures are being reconsidered by the NEFMC. Closures are open seasonally and to limited gear types but are not considered MPAs according to the no-take definition. Clinton's executive order 13158 is now bringing the question of MPAs to the forefront, and concerns are being raised by industry members as to the future of fishing in the Gulf of Maine.

Interview methods

Personal interviews were conducted with 10 fishermen from Maine with 22 to 45 years experience in the groundfish industry in the Gulf of Maine. Questions were directed at:

1) problems in past fisheries management in the GOM,
2) effects of gear (including their own) on the bottom of GOM,
3) interpretations and thoughts on MPAs in the Gulf, and
4) solutions to overfishing and management problems.

Nine interviews were conducted in person and one interview was conducted over the phone, on average for 2 hours in length.

Summary from interviews

What factors are responsible to the fisheries downfall in New England?

There are many opinions amongst industry as to why the New England fisheries collapsed involving both inshore and offshore factors. Physical factors mentioned were water temperature, acid rain, and pollution. Inadequate management structure and laws that "made no sense" (when cod bycatch had to be thrown overboard due to a 30 lb. Limit on cod); poorly trained enforcement (coast guard enforcers not being trained properly); dated data; lack of education; advancement of technology, trawling frequency too high, overfishing by factory trawlers, and decreased area in which to fish after the 200 mile EZ line and the Hague Line were instated. Bureaucratic management that views the GOM as a uniform body versus a complex set of systems was also blamed for the decrease in health of the GOM fisheries.

Gear damage debate

Answers to questions regarding gear damage to the ocean bottom have historically depended on the type of gear used by the interviewe. Fixed gear fishermen have found fault with the use of mobile gear and mobile gear users have found fault with the use of fixed gear in past studies (Hall-Arber and Pederson, 1999).

One offshore groundfisherman interviewed for this chapter charged that: trap movement may influence fish settlement and paths fish migrate through, bait causes "souring of bottom" since live fish stay out of the area, and lobstering can be a dirty industry due to traps and other garbage left in the water. There was a generally held belief by those whose used trawls that dredging was more destructive than trawling since dredging digs more deeply and their nets are too efficient (landing too much by-catch), horse power is too high and boats are too big for the area and amount of fish being caught. One groundfisherman observed that bottom trawls change the structure of the bottom as rocks and sediment are moved around. Fish are also acoustically sensitive. According to 2 fishermen, fish have been scared by noise made by otter trawls and were thought to swim away.

All groundfishermen interviewed believed that trawling certain bottom made the area more productive for targeted species like scallops, and fish populations could be found in the same places repeatedly over time. It was stated by 2 interviewees that one could trawl "too much" (i.e. when catching most of the fish in areas where different stocks congregate simultaneously). It was commonly believed that there are areas that are more "trawlable" than others (hard, complex bottom that harbors juvenile fish is not as desirable to trawl as soft bottom). Jeffries Ledge was identified by 2 interviewees as major nursery habitat that should be kept off-limits to all fishing activity.

What do benthic invertebrates represent?

Many environmentalists associate the apathy of the conservation effort in our oceans with an "out of sight-out of mind" phenomenon. The idea of association is one that leads to connection, and not many have the chance to see the bottom of the GOM first-hand or what comes up from the bottom. Fishermen, however, do. Because of this exposure, fishermen have made specific associations with benthic fauna. Invertebrate fauna can be an asset or a hinderence, depending upon the type of gear used. Cerianthids and other tubes have been viewed as a nuisance to trawlers since they pull down the net. To a gillnetter or hook fishermen, invertebrates are associated with bottom-type, shelter and type of fish attached to that habitat (Hall-Arber and Pederson, 1999).

According to two mobile gear fishermen interviewed, all the animals in benthic pictures of the GOM had been dumped out of the cod end at some point of their career and all habitats explored in the GOM are home to some fish at one time of the year or the other.

There is a common opinion amongst groundfishermen that habitats matter more in inshore breeding and spawning areas than in offshore areas. At the same time, all admitted that the parameters of sunken ships and pipelines are trawled because of their high productivity. One reason given as to why that was was because of the difference in habitat.

Reactions to a no-take MPA, the Hague Line proposal

The first no-take MPA proposed for the Gulf of Maine was in 1994. Proposed by Martin Willison, a Canadian biologist, and Rick McGarvey, a bioeconomic fishery modeller, the International Peace Park was proposed to be placed on both sides of Hague Line, to start 12 miles offshore and extend to the end of the Exclusive Economic Zone of 200 miles, encompassing ten miles on each side of the US and Canadian borders. Proponents of the plan say that it is an excellent opportunity to establish the data needed to understand the role of biodiversity, unaltered habitat, fish behavior, processes, fishing practices and to alleviate the problem of Canadians and Americans straying over the borderline. Reasons for the MPA's placement: the area represents all habitats found in the GOM; the area is already enforced since it's on the border of two countries; it is thought to benefit scallop, cod and haddock stocks, and it includes the Georges Bank Gyre which is thought to enhance egg and larval dispersal (Hickson *et al.*, 1998)

Responses from industry were not supportive of the proposal, the largest reasons being that the plan did not make (economic) sense and it was not understood who the GOM would be saved 'for'. Economically, fishing along the Hague Line productive and not in trouble.

Offshore fishers offered other reasons for opposing the International Peace Park; the area was one of the last areas they could fish, the Canadian side was not as heavily fished as the US side, and therefore US had more to lose (the equity issue); and fishermen did not believe in evidence for the proposed boundary spill-over effect and how this action would benefit them. Other industry members emphasized that there were other areas more important to protect. Designation of the Hague Line area as an MPA was thought to lessen the chances of MPA placement in these more important areas.

What is commonly thought of MPAs in the Gulf of Maine?

At the time this question was posed, the four closures in the GOM had been set in place and started showing positive results of increased stocks of scallop and some groundfish. The fishermen questioned had fought for these closures and agreed that closures were important to bringing back fish, but opinions on how and where future closures were to be placed differed. All considered present GOM closures to be MPAs of one type or the other, and believed certain places could be no-take areas due to their importance as prime fish habitat (Jeffries Bank) or juvenile habitat (Jeffries Ledge).

All interviewees agreed that there were alternatives to total closures and offered other ideas: seasonal closures, selectively closed areas to gear types that create too much damage to habitat, and closures to re-build an area in order for it to be selectively re-opened. The formation of fishing cooperatives was also mentioned, as they have been successful in Alaska and other parts of the country.

The concept of equity was emphasized: if an area was to be closed, it should be kept closed to all to make it fair. When sections of Georges bank opened up to scallopers but not to groundfishermen after scallops rebounded, groundfishers were outraged. Groundfishermen did not benefit from this and a select group of scallopers did, which increased tension between user groups.

All interviewees agreed that a system of closures, no matter what type, needed to be flexible to change as knowledge and needs changed. Fishermen have watched and been involved in the process of placing the 4 GOM closures, but the appropriateness of the placement of these areas to meeting rebuilding goals is questionable. Aside from the Georges Bank scallop story, there has not been enough monitoring to determine other types of "success" of the closures. The concern for flexibility in closures is a large one as long as the success of these closures remains unknown.

What are the common threats underlying MPA proposals/ under what criteria would you consider an MPA in Gulf of Maine?

The largest threat unanimously voiced by fishermen interviewed was having no say in the placement and type of MPAs implemented. This comment was geared towards groups such as environmental and "MPA groups" viewed as being more concerned for the environment than they were for fishermen's livelihoods, and who were not as well acquainted with the GOM as the fishermen. At the same time, it was voiced by fishermen that amongst industry, there were too many special interests in the NEFMC placing MPAs in a way that would benefit their own self-interests to the exclusion of conservation.

MPA definitions and goals were not well defined and were thought to be very confusing. There are at least two definitions currently being used:

1) the World Conservation Union (IUCN website, 2001) defines MPAs as:

> any area of intertidal or subtidal terrain, together with its overlying waters and associated flora, fauna, and historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment.

2) according to NOAA, Executive Order 13158 defines marine protected areas as:

> any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide *lasting* protection for part or all of the natural and cultural resources therein (MPA website, 2001).

The overall MPA order currently being used in the U.S. by NOAA and the Department of the Interior stated in Presidential Executive Order 13158 directs NOAA and the Department of the Interior to strengthen and expand existing MPAs, establish new MPAs, and create a national system of MPAs for various conservation purposes.

One of the key words to note in definition #2 is the word 'lasting.' The groundfish closed areas on Georges Bank, which are subject to change, do not provide lasting protection. Therefore, while they may be considered MPAs under the IUCN definition, they might not be considered so under the US Executive Order. (Luttenberg, pers. comm., 2001)

The controversy over MPAs according to interviewees stemmed from the translation of definitions used and whether an MPA was considered to be a totally closed area or a partially closed area, the former for ecologic reasons and the latter for economic.

Inflexibility was again mentioned as a concern for MPA implementation. It was believed that MPA parameters needed to be changed with new data, and therefore closing an area was useless unless it could be closely monitored.

The idea of "boundary over-flow" touted by successful MPAs worldwide was not believed since it had not yet been witnessed pertaining to groundfish in the area. At the same time, groundfishermen commonly spoke of towing around shipwrecks, the edge of closed areas and along above-ground pipes due to increased productivity in these areas.

Displacement of effort once an area was closed, especially permanently, was a real concern by ½ of the interviewees. Displacement of effort was thought to result in increase in gear conflict and competition for the resource as had been witnessed as a result of Amendments 5 and 7.

Research priorities of fishermen: results from Gulf of Maine Aquarium priority discussions for groundfishing group, 2000

The culmination of groundfish priority needs came from a group of scientists and industry members who studied and fished both inshore and offshore with different methodology and gear types. Mobile-gear fishermen cover up to 18-20 miles in a single tow and learn to read and interpret bottom topography, physical measurements and fish movements. Hook fishermen and gillnetters must develop a more intimate understanding of benthic habitats, and fixed-gear fishermen focus on the characteristics of specific locations (Ames, per comm., 2001). Due to all these factors, prioritized research agenda reflected type of gear and species fished, in addition to the specialty fields of attending scientists.

Research priorities were split into 11 headings: oceanography, assessment, historical research, stock differentiation, spawning areas, species specific questions, habitat, pollution, gear research, socioeconomic research, and how to improve fisheries management. For the purposes of this comparison, I will look at the categories of oceanography, assessments, habitat, and management.

Physical oceanography and biological oceanography were the most important research needs mentioned. The connection between currents and temperature to the success and distribution of groundfish stocks was evident (source and sink areas, larval settlement), as well as habitat needs of fish at all stages. Inshore priorities centered on preservation of spawning and nursery habitat via pollution and coastal development abatement, (Gulf of Maine Aquarium, 2000).

It was agreed upon by all attendees that groundfish assessments needed improvement. Inshore trawl surveys were needed to fill the gap of missing inshore data. NMFS has conducted offshore surveys only. Juvenile trap surveys, expanding the observer program, electronic data collection in the form of vessel monitoring (VMS) systems, study fleets to replace log books, and development of multi-species assessment models were needs in this category (inshore trawl surveys did finally begin in 2001).

The understanding of habitat's relationship to fish involves a multi-disciplinary approach using biological, oceanographic, and behavioral information. Habitat was recognized as being species specific, and that what influences a fish can occur at fine spatial and temporal scales (type or shape of bottom substrate and change in behavior with the seasons). Due to constant disturbance of bottom habitat both inshore and offshore, many species presently in the Gulf of Maine are opportunistic. Areas identified for further study were places that already had been partially researched (i.e. Jeffries Ledge, Outer Falls, Fippenies Ledge, and Wilkinson Basin). Research questions focused on habitat mapping, using existing data from NURP and the Navy, and increasing information on settlement areas, juvenile areas, and key predator/prey/location relationships. The concept of zoning was discussed as a way to create a safe environment for fishermen to share information about certain fishing areas in the GOM.

Lastly, fishery management was discussed. It was unanimously agreed that something had to change in management and suggestions focused on: restoring flexibility in fisheries, researching alternative management techniques (ITQs and zoning), re- examination of the applicability of MSY, improving the relationship between fishers and scientists in order to increase data sharing, and holding management accountable for decisions made.

Multispecies management, a revolutionary topic in fisheries management, was briefly addressed in this document. Although the need for multi-species or ecosystem management was unanimously recognized, how to put it into practice was not. The point was made that:

> ...ecosystem theory has not yet been distilled down to a practical application for fisheries management, and that, most approaches are so data-hungry that they are dismissed as hopelessly idealistic (Gulf of Maine Aquarium, 2000, p. 15).

There was optimism that multi-species management might be addressed via the decentralization of decision-making, management, and scientific work (Gulf of Maine Aquarium, 2000).

What is needed to improve the state of Gulf of Maine fisheries: "alternative solutions"

To address the communication gap between fishers and scientists, research collaboration between fishermen and scientists and other stakeholders was deemed necessary and began in the Northeast in 1999 with monies from the Northeast Consortium and in 2001, from monies from NMFS and NEFMC. According to fishermen involved in this research, these efforts have so far been well-received and are a positive step towards both regaining trust amongst stakeholder groups and answering questions often asked and not answered regarding fisheries in the GOM.

Responsible fishing means paying close attention to gear impact and by-catch rate. Much can be and has been done to lower the rate of both in careful gear match to the type of bottom towed. It was also thought that we could learn from what other countries are doing with modified gear and management techniques.

Many do not see MPAs as the cure-all but as one part of a management package, to be used in conjunction with zoning and restricted access and fishermen's cooperatives. There are many good ideas with regards to how to better extract our ocean's resources from local fishermen with insight and experience. The following are examples of two approaches formed from groups in Midcoast Maine and Downeast Maine.

There is a belief by some members of the Northwest Atlantic Marine Alliance (NAMA), that MPAs will only turn the GOM into a giant aquarium with no benefit to fishermen. It is therefore up to the fishing industry to devise a well-executed management plan, starting from the local level. This would mean fisheries must become organized enough to implement incremental measures while at the same time changing the structure of management drastically. Politically, NAMA would like to see:

- Shifting the commercial fishing industry oversight from the Department of Commerce into the Department of Agriculture since agriculture offers an avenue of understanding of natural resource-based activities.
- Organizing groups on a membership basis in order to nurture responsibility and accountability

- Designate a portion of the Gulf of Maine from the shore to 25 miles as an inshore management area where fishers would have to agree to fish exclusively in the inshore area for a specified period of years with a process determined by inshore participants to implement changes after this initial period.
- Form local community alliances to outline the details of managing the inshore area, similar to what the lobster zone councils do. The challenge here is to identify management measures appropriate and effective in dealing with complex diversity of resource problems being experienced. The idea here is to keep the small boat fleet operational by having its members identify fishing methods that will allow them to continue for other species besides cod (NAMA web site, 2001).

Stonington Fisheries Alliance, like NAMA, believes in improving fisheries by implanting ideas and incentives for fishing communities towards development of stewardship of the resources fished. In order to accomplish this, marine and fisheries education must be emphasized, gear-friendly methods used, life stage bottleneck management practiced, loss of permits/access for destructive practices acted upon, and stewardship incentives of preserving latent permits as permits with limited access rights which would enable small boats inside 40 miles to comply (Ames, pers. comm., 2001).

Summary of Chapter 2

In summary, there have been overriding themes in the viewpoints from industry regarding both past and present fisheries management practices. Many comments were equity-oriented and involved comment on the process with which management decisions were made. Having input into fisheries management, and currently MPA decisions, was of great importance to industry. Fear of misrepresentation and/or no representation commonly voiced stemed from other concerns. There was large concern that decisions will be made by people who do not have proper knowledge of the GOM. According to many fishermen, "environmentalists " were thought to belong to this category. Even those who did have historical knowledge of the GOM (i.e. fellow fishermen who belong to the Council) had been known to make decisions thought to be based on economically driven self-interests.

There are currently many stakeholders who feel they should have an equal voice in decision-making regarding the ocean's health and resources. Industry members interviewed and meeting participants expressed the pressure felt from these other groups and again voiced that they felt left out of the decision-making process. Fishers interviewed felt they have not only been left out of management decisions made in the past, but have been made out to be the "bad guys" by environmentalists which in turn influenced public opinion. This lack of support, many fisherment claimed, further drove a wedge between industry and other stakeholders. On the other hand, collaborative research between industry and science had helped to bridge this gap.

Other viewpoints led to differing opinions on how MPAs will affect fisheries. These opinions were based on "traditional ecological knowledge" formed from years of experience fishing, combined with the uncertainty of the state of present knowledge of the GOM. This was reflected in the strong need expressed to have present closures and future MPAs monitored, and doubt of the "spill-over" effect so often touted as the largest economic benefit of MPAs. Fear of economic loss was also reflected in non-support of no-take MPAs (i.e. the Hague Line Peace Park proposal) and the common sentiment amongst interviewees to ensure flexibility in the future placement of MPAs

Uncertainty of fisheries science was also expressed by industry as they discussed fisheries science with other marine scientists. Beliefs of how ocean processes worked, relatedness of fauna and habitat to fish life histories (especially offshore), and how gear affected the bottom differed according to differing experiences with gear type and location of the fishery (i.e. offshore versus onshore). Scientists and industry members agreed that fisheries knowledge was patchy and that there was historical data that might prove helpful if it was collated and integrated with existing data. For example, traditional ecological knowledge had rarely been used as a tool for historical understanding of fisheries life histories after they collapsed. Logbooks turned into NMFS could have invaluable information in which to make sound fisheries management decisions, but the mistrust was so high between fishermen and government scientists that complete, correct information was rarely reported.

It was commonly believed between scientists and industry members that MPAs were to be used as a tool to fisheries management, along with other types of management, and were not to be of no-take status except in the case of areas strongly proven to be nursery or breeding grounds. There were varying theories as to how MPAs should be used, but inclusion in the management process, equity in economic gain, proof of attaining the goal of the MPA and MPA monitoring were overriding answers by industry to the question "under what circumstances would MPAs be accepted?"

Industry priorities did not entirely embrace the precautionary principle that MPA advocates use to support the preservation of biodiversity argument used in favor of no-take MPAs. In the next section, I will present the lessons established MPAs in other parts of the country and the world have shown us, and discuss the precautionary principle used by advocates of MPAs for both fisheries and ecosystem management.

Chapter 3

SCIENTIFIC RATIONALE FOR FULLY-PROTECTED MARINE PROTECTED AREAS

Biodiversity and habitat defined

Biodiversity is defined by National Research Council as "the collection of genomes, species and ecosystems occurring in a geographically defined region" (N.R.C., 1995).

There are several different types of biodiversity, applied at varying scales. Although these definitions interrelate, it is important to consider the appropriate scale when discussing biodiversity preservation Starting with the smallest to the larger measurable components, there is genetic, phyletic, species, and functional diversity. Endemism, whereby an animal is found in a specified area, is also to be taken into account in the diversity discussion. At a more comprehensive level, diversity is observed as an ecosystem made up of community assemblages, between and within habitats, and at the largest scale, as a mosaic of habitats encompassing 100s of kilometers. These are referred to as seascapes.

Gray (1997) recently reviewed all concepts associated with measuring biodiversity at a variety of scales. Gray settled on a modification of Whittaker's definitions of diversity, which account for levels of diversity observed at increasingly larger scales. These include: *point species richness*, the number of species in several sampling units taken within a defined area, with *habitat species richness* being the number of species in all samples taken in a specific habitat; *large –area species richness*, total number of species in a larger area which includes a variety of habitats and assemblages: and biogeographical-province species richness, the total number of species in a biogeographical province.

Habitat, the area a plant or animal naturally lives, is oftentimes included in discussions of biodiversity. Habitat is more easily studied, mapped, and understood by multiple resource users. Habitat implies clear boundaries based on substrate and depth. Habitats are used as the "templates of ecology" (Southwood, 1977). Similar to the results of deforestation on land, many marine scientists believe that the loss of ocean habitats leads to loss of both genetic and species diversity. Gray (1997, p. 154) argues that, "biodiversity assessments need to be made at the community, habitat, and landscape levels if we are to predict changes over time."

Importance of biodiversity in marine systems

There is a growing body of knowledge of the biotic and abiotic effects which contribute towards the health of the global system. The beginning of the oceanic food web which supports the more complex marine life that humans consume and use in pharmaceuticals also provides at least one-half of the oxygen in the earth's atmosphere (Agardy, 1997), is involved in biochemical cycles that influence global climate, and is responsible for oil and diatomaceous earth. The ocean has also served as a feedback mechanism for pollution from onshore and offshore activity.

Admittedly, questions exist as to the specific mechanisms that effect ocean's ecosystems as biodiversity decreases, but the large scale results of pollution, eutrophication, overfishing, loss of habitat, invasive species, and global warming are beginning to be become quite evident. Results include such things as decreased disease resistance, dominance of one species overtaking many, decreased food availability, decreased habitat structure, and increased intraspecies spacing leading to decreased reproductive success. There are still many unknowns as to the role of ocean biodiversity, but lessons of the past strongly support using the precautionary principle for future decision-making.

What is threatening oceanic biodiversity?

Results of overfishing

Nearly all the world's fish resources are overexploited, resulting in smaller size distribution which has lead to decreased reproduction and loss in genetic diversity (FAO, 1997). Of all groundfish stocks managed by NMFS in the Gulf of Maine, approximately 67% are overfished, and another 25% are fully exploited (Atkinson *et al.*, 2000). Extinction rates have increased, and in some cases, there have been trophic alterations that have worked their way dangerously down the food web (Pauly, 1997).

Results of anthropogenic disturbance

There are many kinds of physical and biological disturbances that naturally occur in the ocean. (disturbance defined here as "physical or biological processes that create space suitable for colonization" (Grime, 1977)). Marine communities are impacted by storms, hurricanes, landslides, ice scour, low salinity excursions, and unusually large temperature changes (Dayton, 1971; Paine and Levin, 1981). Anthropogenic sources include mobile gear that drags or dredges the bottom.

There has been much concern over the impact of mobile gear on benthic habitats and ecosystems, beginning in the US in 1914 and again in the 1930s when otter trawls started to dominate longlining and seining methods (Commonwealth of MA, 1964; Steneck, 1996). Early studies on the effects of trawling were limited by ill-suited equipment and methods for analysis. Studies conducted in 1914 concluded that otter trawls did not "seriously disturb the bottom on which they fished" (Dorsey and Pederson, 1998, p. 53). Today, advanced visual and mapping technology allow us to re-examine and redesign these studies with a higher quality of results. These studies have become more crucial since trawling effort has increased greatly since 1976. Results from these studies have shown gear has smoothed bottom (rid it off vertical structure), resuspended sediment, removed vegetation (inshore), and smoothed and altered soft and hard bottom. Results also showed habitat destruction and removal of vertical structures such as sponge, coral, cerianthids, sea pens, and other structural fauna (Agardy, 1995). In addition, non-targeted commercial species have been killed and thrown back dead or dying by the ton, affecting the ecosystem at large.

The argument has been made by some fishermen that storms in shallow areas and gray whale feeding methods generate similar results to that of trawling (Stevenson, pers. comm., 2001; Oliver and Kvitek, 1984), but physical disturbance in the GOM is uncommon at depths of 30 meters or more (Witman, 1998), and most of the Gulf of Maine is at least 70 meters deep. Frequency of disturbance between a storm and daily trawling differ greatly as well. It has been estimated that on average, every square inch of the sea floor was contacted by mobile fishing once a year in the GOM and three to four times per year on Georges Bank. The towing is concentrated in areas that are more productive and physically suited for trawling (Dorsey and Pederson, 1998, p. 2). Lastly, the effects of a storm at depth to the substrate and fauna do not parallel that of the effects of a trawl.

Recovery of a disturbed area is therefore dependent upon substrate, depth, and frequency of disturbance. The intermediate disturbance hypothesis states that disturbance creates space for newcomers, but spatial and temporal scales of disturbance determine whether diversity increases or decreases (Connell, 1978). Species within a given habitat are adapted to natural disturbance scales. This oftentimes differs with man-made disturbances. If the animals do not adapt, diversity is not increased. In the case of excessive trawling on hard bottom, especially at depth below 30 meters, diversity may be decreased (Collie, 2000)

Once an area has been trawled, the surviving species become indicators of the newly disturbed habitat. Once the transformation has occurred, further trawling causes little additional change, making assessments of impacts meaningless (Roberts and Hawkins, 2000). Types of animals to survive this kind of treatment are seastars and other scavenging species (Kaiser and DeGroot, 2000). Some commercial species such as shrimp, flatfish, and scallop are positively influenced by dragging. These animals take advantage of the new space freed up from trawling and/or the food that has been made more accessible from the trawling activity (Roberts and Hawkins, 2000).

It is believed amongst fishermen and scientists alike that there are better and worse places in which to trawl. Deep water slow growing organisms will be effected most, "depending on gear size and configuration, frequency and trawling on the specific site, the bottom type and benthic community" (Carr, 1999). Direct impacts will be the major destruction of the community. Indirect impact will be that some species and age groups, such as small groundfish, will not have niches to hide from predators (Carr, 1999).

As the debate continues, monitoring both the inside and outside of MPAs is essential towards ending the argument over cause and effect of bottom gear.

Precautionary approach

> Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. (Bergen, 1990)

There are numerous factors that regulate wild commercial species of fish, but as previously mentioned, these are not well understood. Because of this, precautionary strategies can serve as a hedge against uncertainties in predicting sustainable levels of exploitation (Clark, 1996). Opponents of the precautionary approach will oftentimes argue against management regulations based on lack of evidence, and/or when economic cost outweighs regulation benefits. Oftentimes management's lack of will to act in a precautionary fashion prevents the best available data from being fully explored such as gear impacts, spatial patterns of fishing effort, habitat linkages to exploited populations, and patterns in diversity of marine taxa (Auster, pers. comm., 2001).

To delay actions based on lack of "perfect information" is costly, however. The dangers of ignoring the precautionary approach have been well documented. A considerable number of marine species have exhibited severe declines, have been extirpated from large parts of their range, or have become extinct (Roberts and Hawkins, 2000). Assessment of life history characteristics that could lead to severe population declines in marine species has revealed that many species may be at risk of extinction (Musick *et al.*, 2000). Questionably reversible regime shifts have occurred in the Gulf of Maine and in other parts of the world (Steneck, 1996).

Actions under the precautionary approach should be used to avoid potential high costs when full reversibility is not insured, or recovery of environmental damage is predicted to occur over long time periods (i.e. decades). Some recovery from actions is highly likely, as in the protection of long-lived and sensitive marine species. The precautionary principle should be used when uncertainty is very high (i.e. approaching ignorance related to important issues) and the costs of errors may produce irreversible damage. For instance, management actions to reduce the probability of endangering populations of species not assessed or sampled (Musick *et al.* 2000) (Figure 3.1).

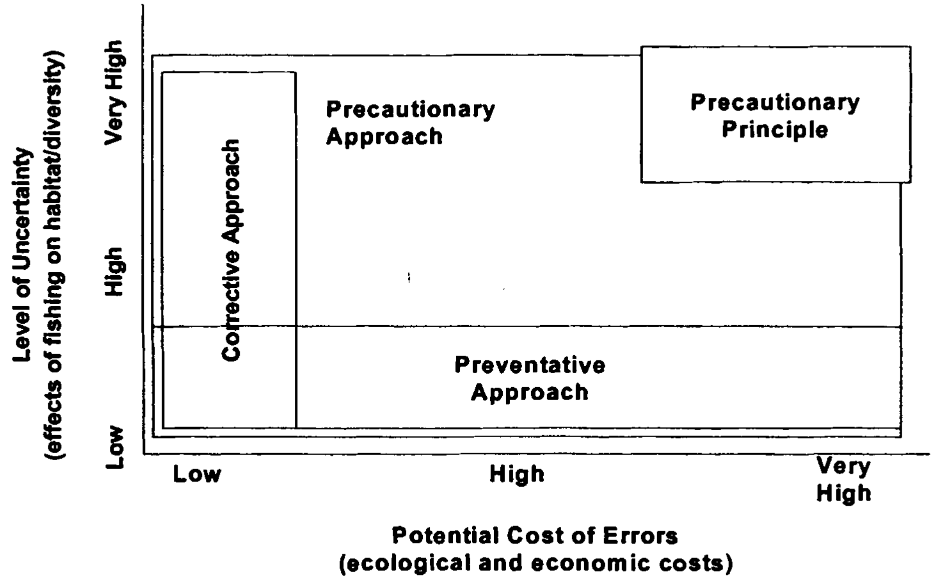

Figure 3.1. Precautionary Approach

A comparison of management approaches based on level of uncertainty and the potential cost of errors (modified from Garcia, 1996 in Auster, 2001). Costs should be considered in both ecological and economic terms (e.g. lost opportunities when the ecological functions of habitat are damaged or regulatory actions limit fishing due to the endangerment of particular taxa). The level of uncertainty is based on our understanding of the effects of fishing practices on both habitat metrics and biological diversity (Auster, 2001).

Preventative approach = Avoid occurrence of unwanted consequences with low level of uncertainty.
Corrective approach = Correct for unintended consequences of previous actions.
Precautionary approach = Avoid potential high costs when full reversibility is not insured.
Precautionary principle = Avoid irreversible damage in cases of very high uncertainty.

Precautionary actions further reduce the risk of unintentionally producing a threatened species. Incentives are created for the fishing industry to provide more refined data which benefits the users of the public resources (Dayton, 1998). As new knowledge is accumulated, the precautionary approach can be reduced to preventative and corrective measures with the hopeful outcome of more diverse fishing opportunities (Auster, 2001).

Until this happens, the use of no-take MPAs within representative habitats and assemblages would protect both exploited and unexploited populations. No-take MPAs would also provide the backdrop for maintaining the age structure and genetic diversity of populations, an area where habitat is protected from human impact and areas where juveniles could recruit to the sea floor where other organisms provide cover for them. Animals may then emigrate or swim out of the protected area causing a spillover effect where larger animals leaving the protected area can be harvested. These benefits have been demonstrated from other fully-protected MPAs worldwide (Roberts and Polunin, 1991; Roberts and Hawkins, 2000).

Solutions to biodiversity preservation in the oceans: multispecies management

Although relatively little is known and/or agreed upon regarding the specifics of what drives life in the sea, much is known of the results of overexploitation of its resources. When the ocean was viewed as having a limitless supply of fish and fishing was open to anyone with a hook or net, no one had reason to seriously examine limit and boundary constraints. As a result, the scientific data we could have been collecting all along to predict and assist us in understanding processes today does not exist (except for that of traditional ecological knowledge). Today, when scientists and managers are asked to make reactionary decisions designed to save the future health of the ocean, there is virtually no baseline data on which to make these decisions. This, in combination with our single-species view of fisheries management, results in limited understanding of the nature of how fish live and interact with their environment.

In the Gulf of Maine, there have been numerous triage efforts to bring back the resource. Temporary closures, limited entry, and gear improvement are a few examples of this. These are only temporary solutions geared towards single-species management, and there is no guarantee that history will not repeat itself once stocks are rebuilt and fishing restrictions are loosened.

There is a call for drastic change in the focus of fisheries management, and many are now rallying around ecosystem-based management as an alternative to single species management. The definition of ecosystem-based management defined by Al Gore (1993):

> a goal driven approach to restoring and sustaining healthy ecosystems and their functions and values. It is based on a collaboratively developed vision of desired future ecosystem conditions that integrates ecological, economic, and social factors affecting a management unit *defined by ecological*, not political, boundaries.

"Ecosystem" in this quote is defined as "an interconnected community of living things, including humans, and the physical environment with which they interact" (Gore, 1993). One of the goals of multi-species management, then, is to preserve the habitat in which a species lives (NRC, 1995).

Implementation of ecosystem management

How does one implement ecosystem management strategy, especially in a reactive setting? By setting aside habitat that supports biodiversity. There are three main goals for doing so:

1. conservation of biological diversity,
2. sustainability of resource use and maintenance of ecosystem integrity, and
3. assessing effects of environmental change through research and monitoring (Agardy, 1995).

Further considerations are to:

1. reach sustainable fishing levels,
2. focus on highly threatened species or processes,
3. protect critical areas for targeted ecosystem through a zoning system, and
4. focus on indirect degradation causes like point-source pollution, etc.(Agardy, 1995).

However, as in any new strategy, there is risk of failure, and one can only decrease the risk by decreasing the unknowns and raising the chance of success and predictability. Monitoring programs in protected habitats is one way of accomplishing this. Scientists in the US and Canada have been rallying around the idea of no-take marine protected areas (MPAs) since the 1980s (Watling, pers. comm., 2001). Other countries are way ahead of us. New Zealand and Australia established MPA systems in 1971 and 1975. With the passage of Clinton's executive order 13158, MPAs are finally being seriously considered in the US as a tool for fisheries management. How to implement these is a challenging task.

Reasons for ocean preserves/MPAs

The data on overexploitation (i.e. decrease in fish size, decrease in biomass of fish populations, decreased biodiversity of ecosystems, loss of habitat and spawning grounds, total regime shifts in the species make up of ecosystems over time) come from areas that have kept track of documented landings of relatively few of the species of fish and invertebrates that exist in the ocean. Science cannot account for the damage done with catches and bycatch of the hundreds of undocumented species, and at an ecological level, the resulting cascading effects and trophic shifts. Of more than 800 species exploited in US waters, the status of over 60% was unknown to the National Marine Fisheries Service in 1998 (Roberts and Hawkins, 2000, p, 12). There used to be natural de facto refugia for mobile gear in the form of complex hard bottom. Rockhopper gear allowed for entry to places previously inaccessible. MPAs act as a way to put these refugia back. In addition, harvested fish stocks, unlike in farming, do not get replanted. The management techniques compensating for the uncertainty of future fish are limited and single-species oriented. Many fish have not come back. MPAs properly placed would ensure species preservation.

Twenty years ago, the first fully protected reserves were established (Roberts and Hawkins, 2000). Since that time, the interest and momentum has picked up for application elsewhere. Reports from no-take zones established worldwide claim their species diversity increased, size increased, there was spill over effect at the borders of the MPAs. Despite this evidence and longevity of experience of the MPA, the idea of no-take MPAs are more difficult on which to achieve consensus and implement. Presently, MPAs cover less than .5% of the worlds oceans and 71% of those have no active management (Kelleher *et al.*, 1995). Many marine parks in the US actually encourage fishing (McArdle, 1997).

Types of MPAs

The controversy over MPAs begins with the manner in which they are defined. As mentioned in section II, definitions currently being used come from either IUCN, NOAA, or from Executive Order 13158. There are closed areas to certain gear or types of use as in Australia's zoning of the Great Barrier Reef and the National Marine Sanctuaries of the U.S., seasonally closed areas as in the rolling closures in the GOM, and fully-closed or no-take areas. We currently have national sanctuaries, state parks, and marine preserves, and yet what defines each of these can be totally different. To add to the confusion, goals that dictate the type of MPA desired oftentimes are not well developed.

Challenges of MPA selection and definition of "success"

Before oceanic exploration began in earnest in the Gulf of Maine by Henry Bigelow in the early 1900s, ecological principles were largely defined by terrestrial biologists. Although we still have a long way to go towards understanding ocean systems as well as we do terrestrial systems, we also know that ocean and terrestrial systems differ. Variables such as space and time scales, physical processes, trophic position, and pressure effects of marine systems differ substantially from land (Day and Roff, 2000). Recognizing these differences are important as we choose management strategies that further affect the health of our oceans. Rotational scallop fishing, currently under consideration on Georges Bank, has been compared to crop rotation practiced on land without adequate research to prove its effects on the ecosystem.

One of the largest challenges in ocean ecosystem research is in how to begin to define ecosystems spatially and temporally, incorporated with the understanding of patterns, processes and consequences of natural and human induced disturbances on those ecosystems. Although placement of MPAs relies on imperfect scientific information in many cases, monitoring for processes and effects can be conducted while the MPA is in place at the same time criteria for success is established.

What defines success is synonymous with the goals of the MPA. In most cases, success is measured by the increase in biomass and/or diversity and/or size of commercially utilized fish. Basically speaking, any sign of a species' chance to increase its reproductive potential (Roberts and Hawkins, 2000). Benefits of MPAs measured thus far are thought to satisfy the major goals for both fisheries and conservation science.

Benefits of MPAs

Results in both topical and temperate MPAs studies have shown:

1. bigger fish produced more eggs,
2. no-take reserves allowed spillover of adults and juveniles into fishing grounds, and
3. number and biomass of individuals within reserves increased.

Halpern (in press) examined 76 studies of reserves and found commonalities no matter where the reserve was, temperate or tropical, from full to partial protection from fishing. The studies showed increase in size of fish, increase in abundance, increase in species diversity, increase in biomass, and habitat recovery. Density (abundance) almost doubled, biomass increased to 2 ½ times that in fished areas, average body size increased by 1/3. (Other examples to be found in Roberts and Polunin 1991, Dugan and Davis 1993). Scallops in closed areas on Georges Bank rebounded in only 4 years as well as their recruitment to adjacent fishing areas (Murawski pers comm., 2001). One scallop model found that egg production/female on Grand Banks could increase by 15 times in protected reserves (McGarvey and Willison, 1995).

In addition, MPAs can:

1. Provide a refuge for vulnerable species like the barn door skate (Casey and Myers, 1998). Even though not targeted, *Dipturus laevis* have been caught as bycatch off NE US and Canada to the brink of extinction. The same applies to other species who are too slow to avoid being caught and who have low reproductive rates. During the world wars, the North Sea became a de facto reserve to fish due to the danger of entering those waters. Stocks tripled in the five years of World War II. (Roberts and Hawkins, 2000, p.35).
2. Prevent habitat damage and facilitate increase in diversity at the seascape level important for animals that need some kind of structure in which to hide, breed and eat.
3. Facilitate recovery from catastrophic human and natural disturbances. This has been well documented with reefs under stress. Reefs with multiple stresses did not recover as well as those with low amounts of stress (Connell, 1997).

Implications for migratory species in temperate waters

Numbers of MPA studies in temperate waters are not as numerous as those of tropical waters, but there are several similarities in the benefits reaped from MPAs (mentioned in the previous section), especially related to invertebrate species. Benefits of MPAs for migratory fish have been harder to sell to the fishing industry in New England. In temperate waters of the Gulf of Maine, reserve proposals such as the Hague Line have been dismissed as "not making sense." Fish were known to cross the Hague Line during migration, and so the benefits of MPA placement were questionable according to fishermen interviewed (see interview responses, Chapter 2).

However, there is evidence that the behaviors of migratory fish are complex. Studies have shown that migratory temperate species occur in large aggregations at specific locations for part of their lives, and have the potential to bottleneck on migration routes. Juveniles of the species may hang out in an area before moving on. There are definitive spawning sites many migratory species return to year after year. Some migratory species have been known to loiter in reserves and off oil platforms and pipelines which act as refugia (Roberts and Hawkins, 2000).

Behaviors contributing to reproduction and interrupted by certain fishing techniques might benefit from MPAs as well. Studies in Canada showed it can take an hour for a spawning fishing aggregation to regroup after a trawl passed through the aggregation. Research has shown that artificially stressed fish produce greater numbers of abnormal offspring than unstressed fish (Auster, 2000). Some migratory species include fish of reproductive age that do not migrate (Roberts and Hawkins, 2000). Lastly, it has been speculated that some migratory species teach migration routes to their young. Large cod have been seen leading smaller ones across the Canadian continental shelf on their migration routes to spawning grounds. There is concern over the fate of the species if the largest fish are annihilated (Rose, 1993).

Of all variables known to effect aggregation sites of fish populations (juvenile sites, migrating/feeding adult stop-over sites, and areas of population source or sink), spawning areas should be put at the top of the priority list. Fishing in these areas during spawning is the surest way to wipe out a species, as has been demonstrated with turbot (*Scopthalmus maximus*) along the south coast of England before the turn of the 20th century (Roberts and Hawkins, 2000). In the Gulf of Maine, a similar fate has occurred with inshore cod and haddock (Ames, 1997). Life histories of fish and associated biota need to be understood in order to place fully-protected reserves that meet the goals of that reserve. In addition, other variable need to be considered before designing an MPA system.

Length of time a reserve has to be in place before one sees results

The time required to produce results depends upon the processes of recruitment, reproduction, growth, and migration. It is important to note that the biomass of reproductive animals must first increase within the reserve. At this point, the recruitment to surrounding areas will improve and spillover will eventually, hopefully result in increased biomass and population densities. Whether an animal is long-lived (later maturity age) or short-lived (early maturity age) is another factor in considering time constraints. Long-lived species are easiest to wipe out since the recovery rate is so slow. Habitats tend to recover slower than the exploited species since structures build on top of one another and this takes time. Processes of habitat recovery may take decades (Roberts and Hawkins, 2000).

Criteria for success

Spillover effect

The most economically beneficial argument to industry for MPAs is that of the spillover effect. Experience from other MPAs and models has shown that where protection is complete, populations build up more rapidly than in places where protection is incomplete. The longer the preserve is established, the closer animals will establish carrying capacity. The higher the fishing intensity outside the reserve, the lower will be the population densities of organisms present. This can encourage rapid spillover, but it is also possible that disturbance outside the boundary could act as a constraint on movements of organisms inhibited by disturbed area or habitat damage. Animals must be mobile to leave reserves. If stationary, offspring can spill over, but intermediate mobile creatures do the best since they will gain greater protection than highly mobile fish that go in and out of their boundary and increase their chances of getting caught.

Length

The longer the length of the boundary, the more opportunity there is for movement out of the reserve, to a point. The largest enhancement to fisheries is the intermediate level since the greater the edge to area ratio of a reserve, the faster the net movement rates across boundaries. Large edge to area ratio reserves, as in a small or thin reserve, will offer less protection to animals inside than those with less edge, such as a large or circular reserve. Spillover is easiest where reserve boundaries include areas of continuous habitat. The effects are inhibited if boundaries coincide with habitat breaks (Hawkins and Roberts, 2000).

Size

Most MPAs started small due to experimental conditions and economic sacrifices. The MPA does not have to be huge to be effective, as shown by Halpern's study (in press) and mentioned in Roberts and Hawkins (2000). It is the number of MPAs that is important. It is better to have a series of small MPAs than one large one (large reserves are more disruptive to fishing activity.) It would spread the benefits from spillover and export of offspring over a management area rather than concentrating it in one place (Day and Roff, 2000). Rates of spillover would be greater from larger edge to area ratios. It also makes more sense economically. Washington state has 3 reserves for razor clams (*Siliqua patula*), to increase the chances for overall success. When one reserve was wiped out, the rest survived (Roberts and Hawkins, 2000).

Habitat redundancy

Coverage of different habitats is also important. Coverage is needed for diversity sake, but the reserve must be big enough to protect viable populations of organisms (Halpern, in press) Dr. Bill Ballantine from New Zealand believes that the network of many fully protected small sites better meets the needs of marine organisms than large multi-use reserves. Reasons being:

1. single, few reserves can never be made large enough to protect the amount of area covered by both planktonic and growth stages common to many marine species.

2. linked system of many small reserves can be built one site at a time, especially if precise location of these sites is left to democratic process while biological constraints guiding the selection is determined by scientists (Atkinson *et al*, 2000).

On the other hand, there is also a threat of habitats being divided into fragments too small. Small habitat islands remote from the main pool of species have increased rates of species extinctions and decreased immigration rates more than larger 'habitat islands' or those nearer the main pool of species (Roberts and Hawkins, 2000).

Spacing

It is not advisable to leave large gaps in MPA networks. MPA sites need to be closely spaced versus isolated, especially in temperate waters. Species that disperse poorly need be closely spaced in order for populations of the species to interact (Roberts and Hawkins, 2000).

Economics

Economically speaking, the success of a fishery is dependent upon the placement of MPAs since fishermen are dependent on location according to boat size (small boats must stay nearshore), gear type, and the seasons commercial species are targeted according to market price and abundance. Jurisdiction also must be considered. State waters extend from shore to 3 miles offshore and federal waters from 3 to 200 miles offshore.

How does one prioritize the considerations and placement of MPAs? Should one be protecting spawning habitat, juvenile habitat, or bottleneck areas where adults rest? By doing so, do the laws favor offshore fishermen over inshore fishermen? In the interest of the ecosystem management approach, is it possible to locate and protect areas that support the highest biodiversity or biomass of life, commercially valued or otherwise?

Challenges of measuring complex marine systems

Single-species fisheries management has been practiced since WWII, and the tools used to measure it have evolved in this period of time. The primary goal of fisheries management has been to determine and predict the effect of fishing effort on fish populations, and thereby set up appropriate regulations to maintain fish stocks at a predetermined maximum sustainable yield (MSY). The relationship between fishing landings and spawning stock size is measurable. It is the theorized relationship between the spawning stock and *recruitment* that is generally unknown. At best, the relationship is only claimed to exist for a few stocks and then only at very low population sizes (Myers *et al.*, 1995; Hall, 1988). In spite of the absence of confirming evidence, fisheries scientists are convinced that sustainability of each population depends upon the maintenance of an adequate spawning stock biomass. Consequently, in lieu of predicting recruitment, it is simply hoped, or assumed, that recruitment will proceed at a rate that is close to the average for some recent time period– one or two decades (Wilson, in press).

Models have been constructed accordingly, with MSY as the targeted goal. These models have historically been limited and unreliable for determining accurate stock assessments and predictability of future fish stocks. Since there is so much uncertainty regarding cause and effect of interactions within a complex oceanic system, a model designed to reflect these various constraints would be untenable (Wilson, in press).

> No model forecast the rapid decline of the Peruvian anchovy in the early 1970s; nor did a fisheries model forecast the resurgence of this fishery to 11 million tonnes in 1994 - this was not for a lack of complexity in fisheries models, but because basic data and understanding of the marine ecosystem were lacking" (Parsons, 1996, p. 225).

Until we reach this integrated level of understanding we can, at the very least, recognize patterns. Successful fishermen have been doing this for hundreds of years, but at relatively smaller scales or time periods. To be able to apply small-scale patterns to the big picture takes time, but this is what is needed for effective management at the ecosystem level. This is one argument for designating MPAs as fully-protected areas. MPAs can be used as method for determining and modeling uninterrupted natural processes over varying long term spatial and temporal scales.

Percentage recommendation for MPAs worldwide

Species that fluctuate widely need a bigger space than those who don't due to the dependence on recolonization of habitat patches from which they have disappeared. What amount should be saved? More than 1,600 scientists and conservationists have supported a call for 20% of the seas to be protected by the year 2020. Modeling a figure of at least 20-40% ensures long-term yields of over-exploited species which will greatly reduce overexploitation and collapse. MPA advocates also stress the importance of protecting the full range of species and habitats (Roberts and Hawkins, 2000).

Difficulty establishing MPAs

Regime shifts

Alterations of many environments in the form of regime-shifts have been severe. One cannot expect a total comeback when the present community is totally different from what existed in the past. More data and monitoring schemes need to be set up for scientists to learn about how ecosystem principles like succession work in the ocean. Until this happens, it is hard to predict if effects from regime shifts will and can reverse.

Temporal and spatial considerations

Temporal expectations of what an MPA can do must coincide with whether the species under consideration is long-lived or short-lived. Expectations may be unrealistic when a long-lived species that lived in a complex ecosystem is expected to rebound over night. Spatial considerations of an MPA must be considered at the same time.

How large an MPA must be to be effective is not well understood. There is increasing understanding that many small closely spaced MPAs are better than one large site, but placement and size of MPAs is a complicated process with present limited knowledge.

Animals have a limited range due to geographic and physical barriers. One in 10 reef fish have a range of 50,000 km2 (Roberts, in press). Inshore cod have not yet returned to spawning grounds in the GOM (Ames, 1997). This may be due to the combination of low survivorship and late maturation age. Spatially, proximity of invertebrates, like urchin, need to be close enough to spawn successfully. Also, recruitment of fish with complex maturation history, like wrasses (born female and change to male when mature) need to be considered. If caught too young, these fish don't change to males and reproduction is jeopardized.

If an animal is a spatially short disperser, then the reserve must be close to source populations. Unless high densities already exist within reserves or very close by, the chance of recovery is very low for the species at hand. Conch populations in the Florida Keys have not rebounded despite a 10 year closure, and tiger grouper (a long-lived species) have not recovered in Saba Marine Park after a 10 year closure (Roberts and Hawkins, 2000).

Interestingly enough, not all species will thrive in a closed area. There may be a reversal or a succession of different sorts as those that survive well in disturbed areas will not in a preserve (Roberts and Hawkins, 2000).

Economic–ecological congruence

Physical ocean boundaries have been historically placed for political and economic reasons (economic value of the resource, number of people employed by that resource, state or country boundaries) and these are oftentimes unrelated to the ecological parameters and variables that dictate the conditions of a given habitat and its occupants. Establishing MPAs that protect ecosystem health as well as fisheries enhancement will require crossing political lines.

Shift in effort

Depending upon the area or areas closed, there is bound to be a shift in fishing pressure from one area to the next. Maps of fishing effort in the Gulf of Maine after the 1994 closures showed effort piling up on the edges of the closed areas (Murawski, 2001). Studies reviewed in Roberts and Hawkins (2000) did not support harmful effects of redirected effort, independent of the fishery being limited-entry or open-access. To date, there have been no studies to confirm or deny negative effects on stocks in the Gulf of Maine.

Management in the single species era

At a recent meeting of 105 conservation and fishing organizations in Washington DC the president of the National Coalition for Marine Conservation warned,

> Fishery management decisions, such as setting catch limits, currently only consider the impacts on single species, without regard for interactions between predator and prey species, or the effects of fishing on the food web. Current single-species management has contributed to the overfishing of more than 100 stocks, endangerment of some, and destruction of the habitats they depend on. (Hinman, pers. comm., 2001)

The change from single-species to multi-species management requires fishery management councils to address the ecological interdependence and interactions of marine species before setting catch levels. Although there is increased talk of multi-species management and/or ecosystem management, it has yet to be put into practice. It is difficult to study and measure lost species and ecosystems of the past when there is no historical baseline for comparison. MPAs are a type of 'short cut' to the preservation of possibly several species while concurrently discovering what combination of variables determine their success. Lessons can be learned from recent studies in the GOM as well as from successful MPA systems worldwide.

Case studies in temperate waters

US temperate MPA studies: Maine

A study conducted on the northern edge of Georges Bank (in coarse gravel and sand) compared invertebrate species in dredged sites and undredged sites. Results showed undredged sites had higher numbers of organisms, biomass, species richness and species diversity (Collie *et al.*, 1997).

Undisturbed sites were compared to disturbed areas in Swan's Island conservation area (Swans Island, Maine). Substrate consisted of cobble –shell and sand-shell bottoms. Results showed a statistical difference in both areas with an increase in epifaunal abundance in the preserve versus outside the preserve. The cause was most likely attributed to trawling (*Auster et al.*, 1996).

US temperate MPA study: Washington

In Shady Cove, San Juan Islands, Washington, a temperate rocky reef was protected for 7 years. After this period, it was discovered that lingcod (*Ophiodon elongatus*) was nearly three times more abundant in the reserve than outside of the preserve (Roberts and Hawkins, 2000).

Edmonds Underwater Park, an artificial reef inside a rocky reef, after 27 years of protection, the number of rockfish eggs and larvae originating from within the park was 55 times greater than that outside and 20 times greater for lingcod (Roberts and Hawkins, 2000).

International temperate MPA study: Japan

Japan, Kyoto Prefecture, sand and muddy bottom, was sampled after being closed for 4 years. After that time, the proportion of large male snow crabs had increased by 32% in the closed area (Roberts and Hawkins, 2000).

Maria Island Reserve, Tasmania, closed its temperate rocky reef for 6 years. After this time, the density of rock lobster and bastard trumpeter fish had increased by 1 and 2 orders of magnitude within the reserve. Numbers of species also increased for fish, invertebrates and algae, as did the densities of fish larger than 33 cm (Roberts and Hawkins, 2000).

After 14 years of protection in Tawharanui marine Park in New Zealand, (a temperate rocky reef area), the most common predatory fish *Pagrus auratus* was found to be 9 times more common in the reserve than outside. In the same area, the spiny lobster *Jasus edwardsii* was 3.7 times more abundant, with a carapace about 16 mm bigger (Babcock *et al.*, 1999).

Mechanisms of successful MPA programs

New Zealand

New Zealand has the largest area of no-take reserves worldwide. Encompassing 600 islands from 2.9 to 2,887 square miles, the Marine Reserves Act was incorporated in 1971, allowing for the addition of area to the park's modest beginning of one reserve surrounding a marine lab. Once other locals became educated about the reserve, support grew to the point of formal acceptance.

Sites were selected based on three major criteria: 1) representativeness, 2) replication of habitats within a system, and 3) zero-take to allow research on non-disturbed sites. (Atkinson *et al.*, 2000)

Australia

Officially approved in 1975, Australia Great Barrier Reef Marine Park (GBRMP) was the first of its kind. The park set aside 135,000 square miles of multi-use zoned areas as a result of huge outpour of public concern over increased exploitation of resources of the reef system.

Currently, the three major uses of the park are for private recreation, commercial fishing, and the fastest growing commercial activity, commercial tourism. Areas are zoned accordingly: 1) general use (almost anything permitted but blasting and mining) 2) National Park (recreational activities allowed, but not commercial and 3) preservation and scientific research (both recreational and commercial use prohibited). The zones are reviewed every 5 years and public input is encouraged (Agardy, 1995).

Interestingly, the large public support may be due to the fact that 98.1% if the area (as of 1990) is open to recreational of commercial fishing. On the other hand, government and nongovernment organizations are involved in cooperative research and monitoring (Atkinson *et al.*, 2000).

San Salvador Island

In addition to setting aside an MPA system, San Salvador made an ordinance that incorporated education and enforcement via elected officials. For this program, the recipe for success was:

1. high community involvement and local support
2. the MPA was not highly controversial
3. clear cause and effect (i.e. high predictability)
4. results were seen in only 2 years time
5. benefits were witnessed in increased catch and income (Atkinson *et al.*, 2000)

Recently implemented MPAs in the United States

Florida

The Tortugas Ecological Reserve in Florida became the nation's largest permanent marine reserve on July 12, 2001. Located more than 70 miles west of Key West, Florida, the new reserve is part of the Florida Keys National Marine Sanctuary and encompasses more than 150 square nautical miles of deepwater corals and critical fish spawning sites. The Tortugas reserve joins the sanctuary's network of 23 areas set aside for special protection in 1997. In a consensus process that has become a model for other efforts worldwide, a 25-member working group that included commercial and recreational fishermen, divers, conservationists, researchers, government representatives and other concerned citizens designed the reserve after studying ecological and socioeconomic data for the region and agreeing on goals. Florida's governor and cabinet gave their unanimous approval to include state waters in the reserve on April 24, 2001 (Causey, 2001).

Southern California

Southern California's northern Channel Islands MPA proposal was not as successful as Florida's. After two years of carefully planned meetings involving all stakeholders, consensus could not be reached between sport anglers, commercial fishermen and environmentalists. As a result, the final decision is being made by California's Department of Fish and Game under the Fish and Game Commission, including public comment (Becher, 2001).

Dealing with uncertainty and industry compliance

The largest commonality of successful MPA systems mentioned above is that of public support and compliance. Compliance is related to the incentives for supporting an MPA plan, and much of this support from fishermen comes from certainty of future economical outcomes.

Fishermen in the Gulf of Maine have historically compensated for lack of economic certainty with the flexibility of switching between fisheries throughout the year. Amount of flexibility was related to rights or allocation of resources via regulations. Rights differed according to whether one fished offshore or onshore in an open access or limited entry fishery, with mobile or fixed gear. Since 1994, flexibility in fishing has been taken away and inequity of rights amplified, resulting in distrust of governing institutions and a break down in communication between management and industry (NEFMC, 2001).

The creation of an environment was needed to allow for and encourage the collective pursuit of useful knowledge. Ideally, management organization and resource right designation should be prepared to encourage the type of learning that would lead to collaboration in the form of social networks resulting in the reduction of communication problems and the encouragement of individual and collective learning (Wilson, in press).

Three of the most common needs stated by interviewed fishermen were 1) non-representation in the management process, 2) receiving dated biological fisheries data, and 3) the absence of monitoring of current GOM closures.

Industry's non-representation in the management process was the most common complaint by interviewees (9/10) and they desired an improved system for inclusion into the management process. In the typical top-down administrative approach to management, individuals or groups rarely find it in their interests to share their personal knowledge, and this has increasingly occurred between industry members and the NEFMC. The danger in not being heard is that non-compliant behaviors result. Local or bottom-up management has been advocated by many practitioners in marine policy and political science as part of the solution to this common complaint (Wilson, in press).

Receiving dated biological fisheries data was another common complaint of industry members. "The timeliness of receiving the information which gives us feedback of the natural system and human influence on that system will determine efficacy of reduced information costs, possibilities for learning and adaptation, and ability to cope with uncertainty" (Wilson, in press). For this reason, the importance of monitoring currently closed areas in the GOM was also very important to the fishermen interviewed and heard at meetings.

While there were/are several common concerns voiced by industry members, there was also agreement between industry and MPA proponents. The need for multi-species and ecosystem management was expressed by both industry members and MPA proponents. However, the evolution from single-species management to multi-species and ecosystem management is in its infancy. Tools exist to measure biology, geology, and oceanography of our fishing grounds, but there is much needed information to fill in the gaps of overall understanding of how an ecosystem functions. One of these gaps is that of the benthic habitat and biota.

Status of science in the Gulf of Maine

Scientific exploration of the ocean and its inhabitants did not begin until the late 1800s. Globally, oceanographic research aboard the HMS Challenger.made its mark in 1872. Around the same time and nearer to home, Henry Bigelow began studies in the Gulf of Maine (GOM). Bigelow's first published work on fish in the Gulf of Maine in 1911 was followed by publications in oceanography and plankton of the area. In the century to follow, studies continued in oceanography, geology, ichthyology, fish population dynamics, plankton, marine birds and mammals, and deep-water benthic ecology. Unfortunately, these areas were not uniformly supported, and as a result, have varying degrees of knowledge associated with them.

Economic and government interests have strongly supported oceanography and fisheries science due to interests in weather and global atmospheric changes, naval navigation, and commercial fisheries. Benthic exploration was largely ignored early on. It did not receive any serious attention until the 1980s. The value of benthic information was finally realized when the revised Magnuson Act of 1996 included the Essential Fish Habitat and Habitats of Particular

Concern mandates. Unfortunately, the data needed to address habitat management concerns is largely unknown due to scanty historical information and a lack of untrawled control areas to study in the GOM. (most areas had been trawled by the mid 1980s with the introduction of rock-hopper gear). In addition, marine research has not focused on the interconnectedness of oceanic processes to biological ecosystems, especially that related to the benthos of the GOM.

Since 1984, the National Underwater Research Program (NURP) funded by NOAA has taken an active role in benthic research in the Gulf of Maine. Through NURP, videotapes and slides have been taken of the benthos in well over a hundred dives around the GOM. The purpose of these trips was to collect geological and/or biological data from the bottom.

To increase the understanding of megafaunal benthic communities and their role in the GOM, a subsample of the NURP dives were qualitatively analyzed for species assemblage make-up as related to benthic substrate and depth. The description and results of this study are given in Chapter 4.

Chapter 4

INVESTIGATION OF MEGABENTHOS ASSEMBLAGES IN THE GULF OF MAINE FOR APPLICATION TO MPAs

Abstract

The Gulf of Maine megabenthos remained little known until submersibles and remotely operated vehicles became routinely available. Utilizing videotape and still photos, patterns of megabenthos were analyzed from dives made at 20 locations in water depths of 40 to 232 meters. All identifiable taxa were assigned to one of three abundance classes and the values used for multivariate analysis. Results suggest that: (1) there is zonation of megabenthos assemblages with depth, possibly corresponding with the three water masses in the Gulf of Maine; (2) species composition of the assemblages varies with substrate type; and (3) each assemblage is characterized by a few dominant species. Megabenthos composition appears to reflect major habitat characteristics and is used to substantiate a subtidal habitat classification system.

Introduction

Until recently, habitat classification of the benthos was limited to the intertidal and the shallow subtidal (<30m), areas sampled via SCUBA and video surveys (Greene *et al.*, 1999). Assessing benthic habitats deeper than 30 meters requires the use of more costly techniques such as side-scan sonar, swath bathymetry, and seismic reflection. While these techniques are invaluable for large-scale substrate mapping, sampling and identification of biota to overlay onto a habitat classification is much more difficult. Video and photographs of the ocean bottom taken from manned submersibles and remotely operated vehicles (ROVs) is useful for this purpose. In the Monterey Canyon area, for example, a classification scheme was devised for deep-water habitats using a combination of remote sensor systems and in situ geological and biological observations taken from videotape (Greene *et al.*, 1999). On the northern edge of Georges Bank, photographic transects were used to determine and quantify sediment types and organism abundance in trawled and untrawled areas (Collie *et al.*, 2000).

To date, there has been relatively little research on the distribution and species diversity of benthic assemblages in the Gulf of Maine. Since 1984, NOAA's National Undersea Research Program (NURP) has funded well over one hundred submersible dives in and around the Gulf of Maine. Video from these dives was used for the specific objectives of the funded research and then archived. We retrieved videotape and 35mm photographs from several of these dives to analyze broad-scale megabenthos species distributions in relation to physical features such as substrate type and overlying water mass characteristics.

Methods

Information from submersible dives

Videotapes from thirty-eight dives at 20 locations visited between 1984 and 1998 in the Gulf of Maine were used in this analysis (Figure 4.1, Table 4.1). The locations chosen were divided according to large physiographic features, viz., muddy basins, mid-Gulf and offshore moraines, sandy offshore banks, and deep basins. Depths of dives ranged from 39 to 247 meters. Each videotape lasted approximately 40 minutes and average submersible speed was ½ knot (25 cm/second). Tapes were viewed in their entirety. Invertebrate epifauna and benthic dwelling fish were identified to lowest possible taxon level. Abundance ranks of 0, 1, 2, or 3 were assigned for each of 35 taxa recorded. Ones were given to animals seen only one or two times during the dive survey, twos were assigned to animals appearing 3 to 10 times, and threes were assigned to animals that were ubiquitous throughout the tape.

Table 4.1. Gulf of Maine Dive Site Information

dive location	tape #	lat	long	date	substrate	depth	trawl
1. Cashes Basin	CLE 340	42 53.1	69 01.0	7/5/95	m	151 m	no
2. Cashes Basin	CLE 341	42 50.8	68 58.5	7/6/95	m s g b	122 m	yes
3. Jordon Basin	D 753	43 23 00	68 07 26	7/4/87	m	213 m	yes
4. Platts Basin	D 760	43 21.25	69 22.49	7/6/87	m	175 m	yes
5. Wilkinsons Basin N.	D 1542	43 04.1	69 52.3	9/21/89	m	188 m	yes
6. S Truxton S. to Crow.	CLE 256	42 54.283	67 29.605	7/25/94	s g	182 m	no
7. Crowell Basin	Recon 5	42 48.85	67 29.25	8/15/84	m g	217 m	no
8. Stout Swell	CLE 263	42 20.07	68 00.50	7/27/94	m s g b	168 m	yes
9. Truxton Swell	CLE 255	43 02.64	67 46.89	7/24/94	m g	198 m	yes
10. Truxton Swell E.	CLE 257	43 03.07	67 25.82	7/25/94	m s g	192 m	yes
11. Wildcat Knoll	JSL 3894	42 26 21.42	69 59 19.32	7/6/95	m	202 m	yes
12. Wildcat Knoll	JSL 3895	42 24 26.64	69 59 39.48	7/6/95	m s	206 m	yes
13. Wright Swell	CLE 262	42 33.04	67 52.94	7/27/94	m s g	213 m	yes
14. Wright Swell	CLE 138	42 30.01	68 09.97	8/11/93	s g b	152 m	yes
15. Franklin Basin	D 747	42 16 08	67 46 72	7/3/87	m s g	232 m	no
16. Lindenkohl Basin	D 748	42 30 .92	67 47.75	7/3/87	m s	231 m	yes
17. Fippenies Ledge	97 PS 2 06 A14	42 46 01	69 15 61	8/14/97	s g b	73 m	yes
18. Fippenies Ledge	97 PS 2 06 A18	42 43 60	69 12 71	8/15/97	s g	73 m	yes
19. Fippenies SE	D 743	42 43 87	68 14 97	7/2/87	s g	74 m	no
20. Fippenies SE	D 744	42 43.88	69 15.27	7/2/87	s g b	75 m	yes
22. Fippenies Ledge SE	D 745	42 43 07	69 15 48	7/2/87	m s g	79 m	yes
23. Jeffries Ledge	D 1543	43 04 0	70 00.6	9/21/89	m s g	143 m	yes
24. Jeffries Ledge	D 1544	43 04 .0	70 02 .2	9/21/89	m s g b	88 m	yes
25. Jeffries Ledge N.	D 1545	43 04.2	70 03.5	9/21/89	s g b	55 m	no
26. Platts Bank W	D 1547	43 12.4	69 40.9	9/22/89	g b	56 m	yes
27. Platts Bank W	D 1548	43 11.6	69 42 .0	9/22/89	s g	73 m	yes
28. Jeffries Bank	CLE 142	43 18 34	68 49 89	8/11/93	m	122 m	old
29. Jeffries Bank	97 04 A 02	43 21 43	68 44 49	8/10/97	s g	73 m	no
30. Jeffries Bank	D 757	43 13 07	68 55 05	7/5/87	m	168 m	yes
31. Jeffries Bank	D 756	43 22.50	68 44.53	7/5/87	s g	88 m	old
32. Jeffries Bank SW	Recon 2	43 21 19	68 52 35	7/30/84	m s g	110 m	yes
33. Outer Fall or Jeffries	CLE 136	43 22 47	68 44 54	8/10/93	s g b	88 m	no
34. Outer Fall	CLE 143	43 27 .48	68 41.03	8/13/93	m s	113 m	no
35. Outer Fall	D 755	43 27.52	68 41.06	7/5/87	m s g	122 m	no
36. Stellwagon B. NE	CLE A-13 (8/529)	42 20 .77	70 14.643	9/4/98	s g	40 m	yes
37. Stellwagon B. NE	CLE B-11 (7/528)	42 21.630	70 12.974	9/4/98	s g	56 m	yes
38. Three Dory Ridge	D 759	43 13.53	69 19.45	7/6/87	s g	126 m	no

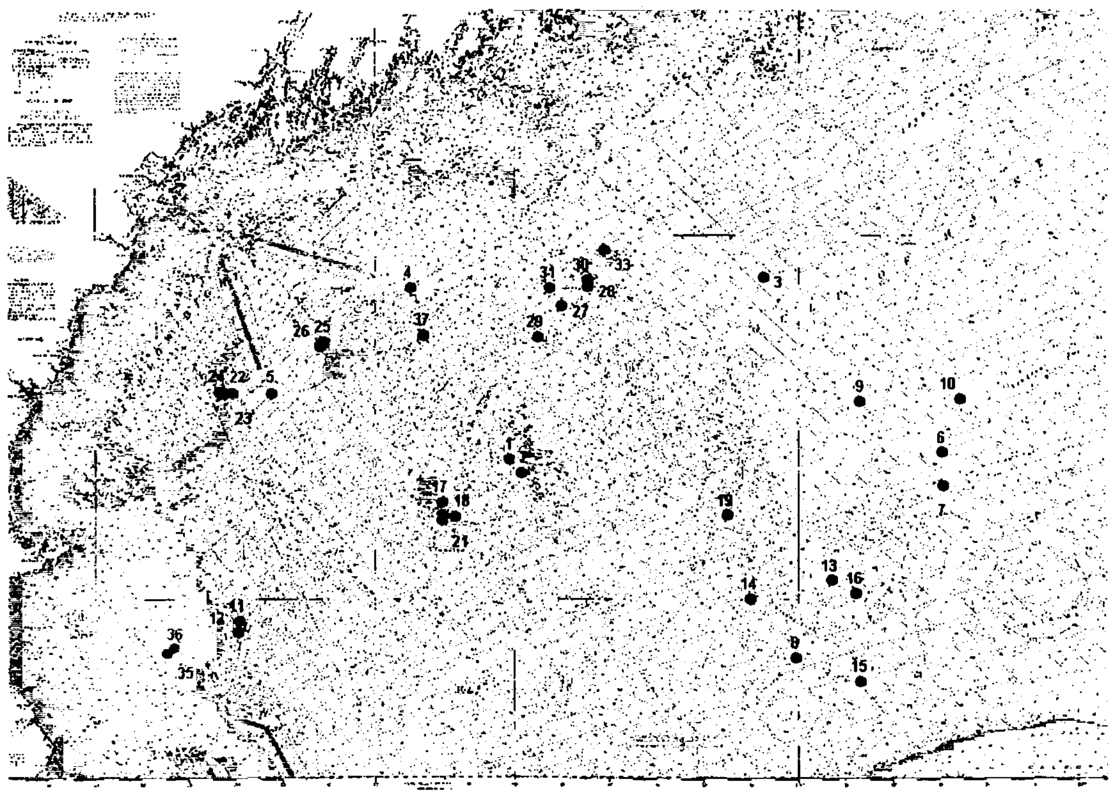

Figure 4.1. Gulf of Maine Dive Sites

Other factors recorded for each dive included depth, substrate type, year, and indications of trawling. Depth values were assigned linearly at 30 m intervals, as follows: group 1 = 30-60 m, group 2 = 61-91 m, group 3 = 91-121m, group 4 = 122-151 m, group 5 = 152-182 m, group 6 = 183-212 m, and group 7 = 213-243 m. Number of dives per group: Four in group 1, ten in group 2, two in group 3, six in group 4, five in group 5, five in group 6, and five in group 7. Substrate composition was taken from field notes, and substantiated using substrate maps of the Gulf of Maine (USGS, 2000). Substrate categories used were mud, sand, gravel, boulder, and combinations thereof.

Statistical methods

Four major questions were asked for this analysis: 1) how does depth effect megabenthos assemblages, 2) how does substrate effect megabenthos assemblages, 3) for said effects of depth and/or substrate on assemblages, what organisms represent these effects, and 4) how do the numbers of species types correspond to depth and substrate changes? To answer these questions, a statistical program developed to analyze marine communities, Plymouth Routines in Multivariate Ecological Research (PRIMER), was used (Clarke and Warwick, 1994).

To analyze for depth effects, species rankings on a spreadsheet were squared to 1,4, and 9, to better reflect true abundances, and a Bray-Curtis similarity index was run to compare dives according to depth across all dives and species (Bray and Curtis, 1957). To construct a plot to graphically represent the biological relationships among samples from the similarity index results, non-metric multi-dimensional scaling (MDS) was used (Kruskal and Wish, 1978; Clarke and Green, 1988). Stress, reported on the MDS plot, shows the distortion between rankings of Bray Curtis Similarity index and corresponding distance rankings (<.05 is excellent, <.1 is good, ≈2 is limit of acceptance).

Analysis of similarity matrix (ANOSIM) was conducted to test for significant differences between groups according to depth (Clarke and Green, 1988). Global r, used in univariate tests to test for differences between groups of samples, is also reported. A global (r) test of the null hypothesis (Ho), that there are no differences between groups, involves computing a particular ratio of variability in the group means to variability among replicates within each group. The resulting F statistic takes values near 1 if the null hypothesis is true, larger values indicating that Ho is false. Standard tables of the F distribution yield a significance level (p) for the observed F statistic, p, interpreted as the probability that the group means observed could have occurred if the null hypothesis is true (Clark and Warwick, 1994).

To determine dissimilarity between depth groups, a similarity percentages (SIMPER) test was conducted. SIMPER results reported the breakdown of contributions from each species per group as well as the dissimilarity percentage between each group with every other group (Clarke, 1993). Group one represented 4 dives; group two, 10 dives; group three, 2 dives; group four, 6 dives;

group five, 5 dives; group six, 5 dives; and group seven, 5 dives. SIMPER was run with squared rankings, and only species that accounted for 10% or more of the overall invertebrate assemblage were included. The results are seen in average dissimilarity between groups as compared to temperature depth gradients in the Gulf of Maine.

To analyze for substrate effects, MDS plots of substrate types were analyzed in the same manner as they were for depth. Species rankings were squared, Bray-Curtis similarity index was run, and MDS plots of each substrate type were printed.

To analyze average abundance of species per dive in mud-only, mixed, and sand/gravel-only habitats, Sigma Plot was used to report averages and standard deviations (SPSS, 1997). The same information was used to construct pie graphs reporting species assemblage composition in mud-only substrate and sand/gravel-only substrate.

Results

There were 35 megabenthos invertebrate taxa used in this analysis (Table 4.2).

Table 4.2. Megabenthos Invertebrate Categories

Anthozoa spp.	*Myxicola indundibulum*
Asterias sp.?	*Ophiomyxa sp.*
Asteroidea sp.	*Ophiura sarsi*
Bathysiphon sp.	*Ophiura sp.*
Boltenia sp.	*Pagurus spp.*
Buccinum sp.	*Pandalus borealis*
Cancer spp.	*Pennatula aculeata*
Cerianthus borealis 1	*Placopecten magellanicus*
Cerianthus borealis 2	*Polymastia sp.*
Cerianthus borealis 3	*Porania pulvillus insignis*
Crinoidea sp.	Porifera (cup)
Ctenodiscus crispatus	Porifera (encrusting)
Hippasteria phrygiana	Porifera (other)
Hydrozoa spp.	Porifera (stalked)
Idmonea Atlantica	*Solaster sp.*
Iophon sp.	*Terebratulina septentrionalis*
Lithodes sp.	*Urticina sp.*
Mogulidae spp.	

Notes: *Asterias sp.*? = where *Asterias sp.* was difficult to distinguish from *Henricia sp. Cerianthus borealis* was divided into subcategories 1, 2 and 3, representing small, medium and large sizes (Shepard, 1986). *Ophiura sp.* category was used for brittlestars of unknown species. Porifera; cup, encrusting, stalked and other were grouped according to shape since many benthic sponges have yet to be identified.

Depth effects

An MDS plot derived from the Bray-Curtis similarity index of the seven depth groups and their megabenthos assemblages demonstrate a gradation according to depth (Figure. 4.2). When an analysis of similarities test was run to determine differences between these seven depth groups (Table 4.3), significant differences (p =<.05) were found between group 1 and groups 2,3,4,5,6,and 7, and between group 2 and groups 3,4,5,6,and 7. Group 3 did not differ significantly from groups 4,5,6 and 7. Group 4 did differ significantly from groups 6 and 7. Group 5 did not differ significantly from 6 and 7, and group 6 did not differ significantly from group 7. Global r was .37 and p-value was .001, verifying the significance of these results.

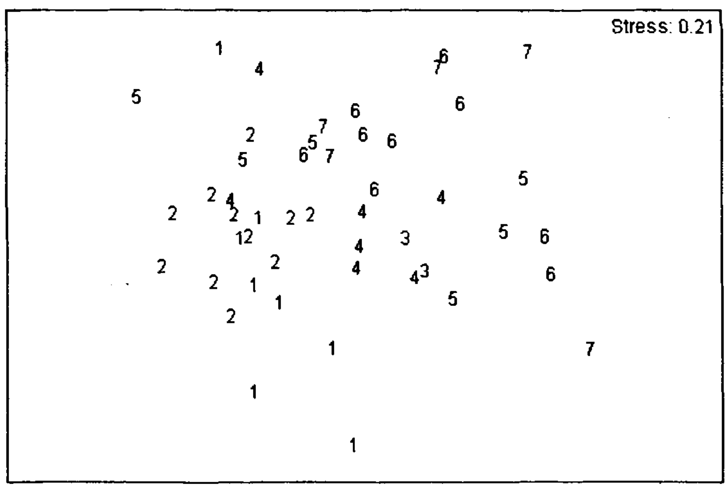

Figure 4.2. MDS Plot of Megabenthos Communities with Depth

Table 4.3. ANOSIM Similarity Comparisons of Depth Groups 1-7

Global Test
Sample statistic (Global R): 0.368
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
1, 2	0.305	0.2	75582	999	1
1, 3	0.608	4.4	45	45	2
1, 4	0.321	0.1	6435	999	0
1, 5	0.435	0.8	3003	999	7
1, 6	0.422	0.2	24310	999	1
1, 7	0.663	0.2	1287	999	1
2, 3	0.603	1.3	78	78	1
2, 4	0.382	0.1	31824	999	0
2, 5	0.6	0.1	12376	999	0
2, 6	0.639	0.1	167960	999	0
2, 7	0.655	0.1	4368	999	0
3, 4	-0.279	91.7	36	36	33
3, 5	-0.255	85.7	28	28	24
3, 6	0.231	10.9	55	55	6
3, 7	0.091	38.1	21	21	8
4, 5	-0.019	47.3	1716	999	472
4, 6	0.244	1.1	11440	999	10
4, 7	0.268	2.4	792	792	19
5, 6	0.138	11.2	5005	999	111
5, 7	0.013	41.8	462	462	193
6, 7	0.075	24.	2002	999	239

The megabenthos taxa, therefore, can be segregated by depth into three groups: Group 1, 30-60 m, Group 2, 61-90 m, and Groups 3-7, 91-243 m. From SIMPER output, the average dissimilarity between group 1 and groups 2,3,4,5,6,and 7 is .84, the average dissimilarity between group 2 and groups 1,3,4,5,6, and 7 is .78; and the dissimilarity between groups 1 and 2 is .72. As delimited by Mountain and Jessen (1987), depth Group 1 is within Gulf of Maine surface water (1-60 m), Group 2 is within the core of Maine Intermediate Water (60-100 m), and Groups 3-7 are mostly below what has been arbitrarily defined as the upper limit of Maine Bottom water (>100m).

Substrate effects

MDS plots of dive per substrate-types were created to determine possible differentiation of assemblage structure based on substrate-type. A slight differentiation was found in dives containing mud versus dives not containing mud (Figure 4.3), but more differentiation was seen in the MDS plot of dives containing mud-only versus other substrate mixes (Figure 4.4).

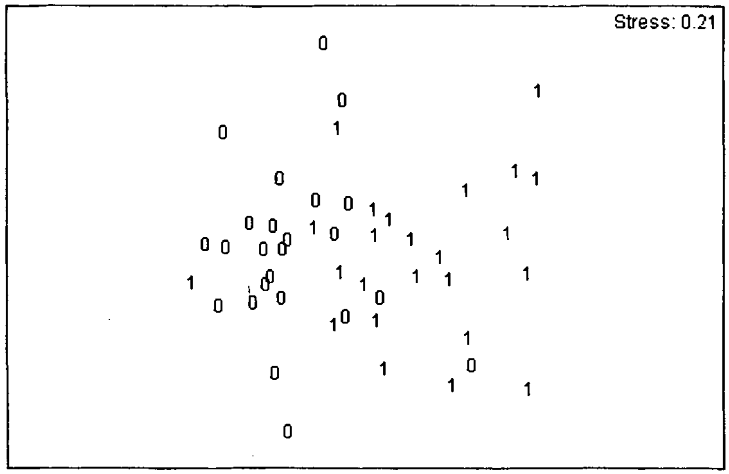

Figure 4.3. MDS Plot of Dives Containing Mud (1) and Dives Not Containing Mud (0)

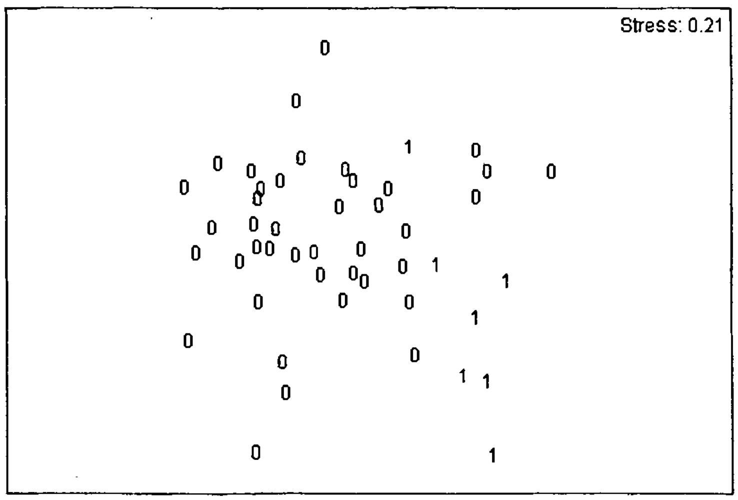

Figure 4.4. MDS Plot of Dives Containing Mud-only (1) and Dives Not Containing Mud-only (0)

Dives containing gravel versus those not containing gravel (Figure 4.5) are less segregated than in the groups containing mud (Figure. 4.3). Groups containing sand and gravel-only (Figure 4. 6) are less segregated than in the mud-only plot, but are more segregated compared to the MDS plot containing gravel (Figure 4.5).

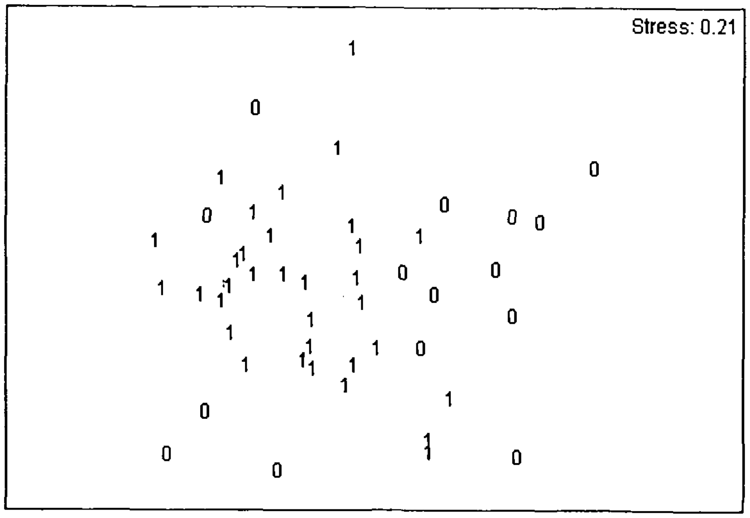

Figure 4.5. MDS Plot of Dives with Gravel (1) and with No Gravel (0)

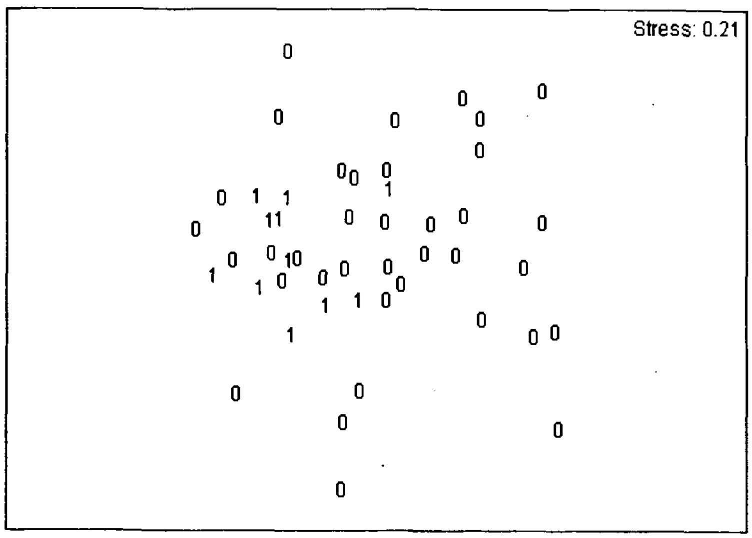

Figure 4.6. MDS Plot of Dives with Sand-Gravel only (1) and Not Sand-Gravel-only (0)

Species contribution (Dominant species responsible for composition of mud-only and sand/gravel-only assemblages)

Epifauna responsible for 74% of the composition of mud-only groups are *Ophiura spp.*(combined) (34%), *Pennatula aculeata* (20%), and *Pandalus borealis* (20%)(Figure 4.7).

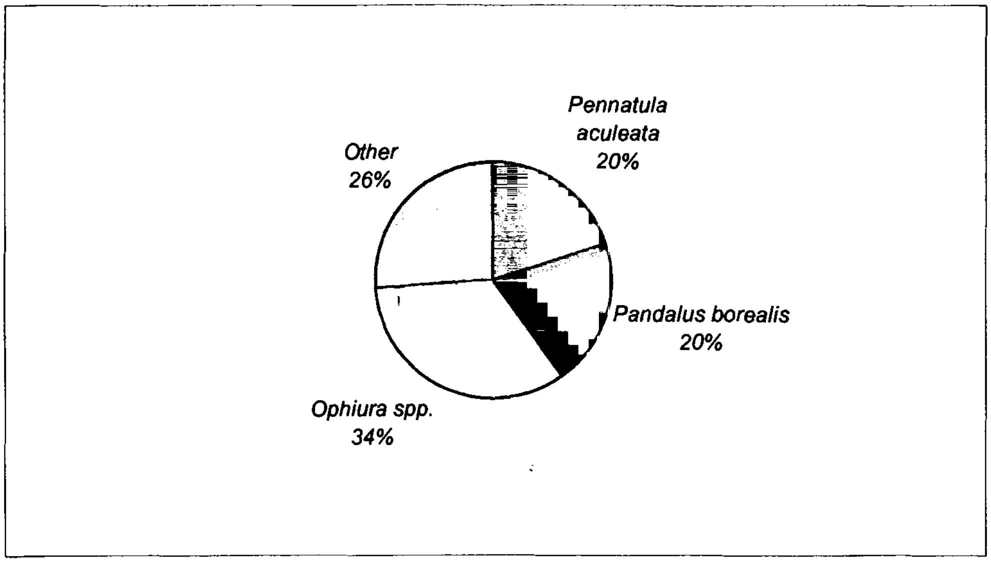

Figure 4.7. Megabenthos Assemblage Species in Mud-only Sites

Epifauna responsible for 72% of the composition of sand/gravel-only groups are *Asteroidea spp.* (17%), Porifera other than *Iophon sp.* (14%), *Cerianthus spp.* (12%), *Urticina sp.* (10%), *Iophon sp.* (9%), *Terebratulina septentrionalis* (6%), and *Pagurus sp.* (4%) (Figure 4.8).

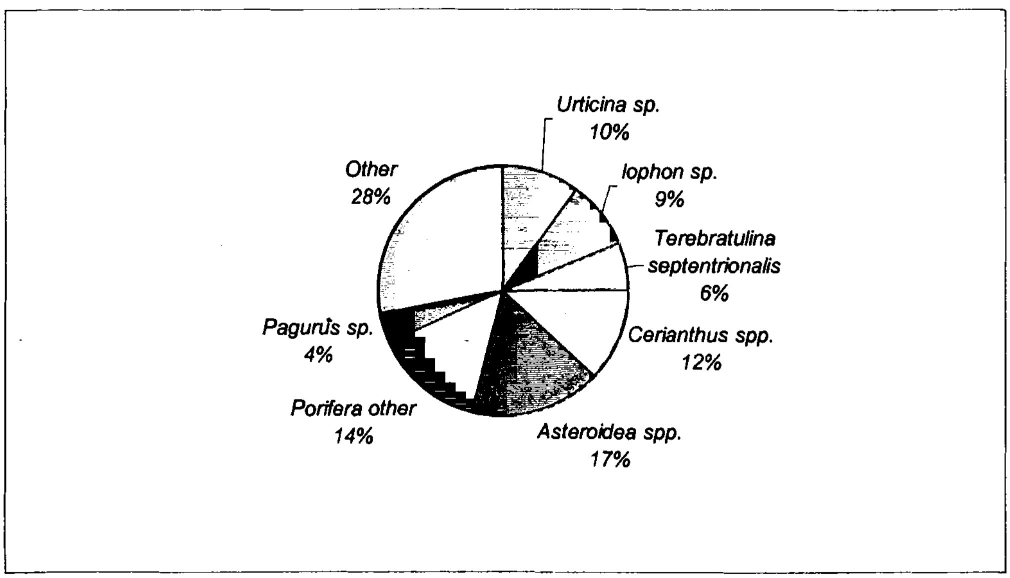

Figure 4.8. Megabenthos Assemblage Species in Sand/Gravel-only Sites

Abundance and presence of megabenthos species shifted with substrate type. Upon examination and comparison of the ranks of 20 epifauna, 9 taxa present in sand/gravel-only sites were absent in mud-only sites (i.e. *Terebratulina septentrionalis*, all sponges, *Asteroidea sp.*), and 2 taxa present in mud-only sites were absent in sand/gravel only sites (i.e. *Ophiura sarsi* and *Ophiomyxa sp.*). All taxa were represented in mixed sediment groups, but fluctuated in average numbers between mud-only and sand/gravel-only groups (Figure 4.9).

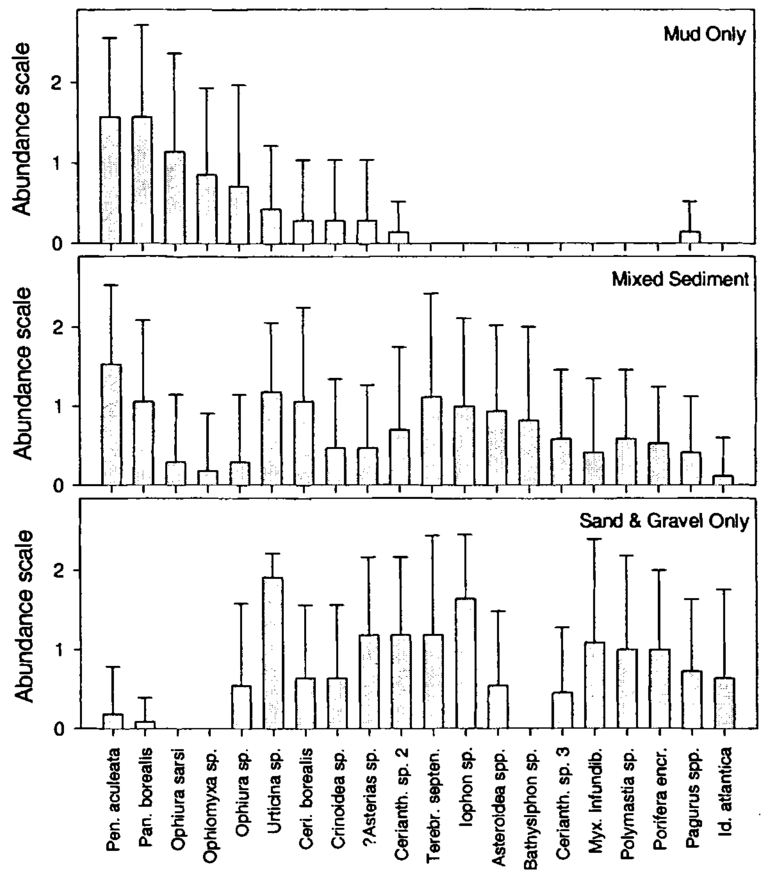

Figure 4.9. Average Abundances of Species in Mud-only, Mixed Sediment, and Sand and Gravel-only Sites

Pennatula aculeata and *Pandalus borealis* were dominant in mud-only sites and sites containing mud, but were not dominant in sand/gravel-only sites. Dominant epifauna in sand/gravel-only sites, *Urticina sp.* and *Iophon sp.* existed in rare to absent numbers in mud-only sites (Figure 4.9 above).

Upon reviewing all 35 species across all substrate types, the number of megabenthos species in mud-only sites was 14, mixed substrate 31, and sand/gravel-only, 28. Species missing in mud-only groups but present in mixed and sand/gravel-only groups were Mogulidae spp., Asteroidea sp., *Bathysiphon sp.*, *Boltenia sp.*, *Ceranthus borealis 1*, *Hippasteria phyrygiana*, Hydrozoa spp., *Idmonea atlantica*, *Myxicola infundibulum*, *Placopecten magellanicus*, *Porania p.*, *Solaster sp.* *Buccinum sp.*, Anthozoa spp., and all sponge groups. Mixed substrate did not have *Buccinum spp.* or porifera (cup). The following species were missing from sand/gravel only; *Bathysiphon sp., Boltenia sp., Cancer sp.*, porifera (cup), *Ophiura sarsi* and *ophiura myxa*.

Discussion

Differences seen from analysis in megabenthos assemblage structure are apparently governed by depth, and the apparent zonation of depth with communities in groups 1-7 roughly corresponds with the boundaries of the three water masses of the Gulf of Maine (Figure 4.10).

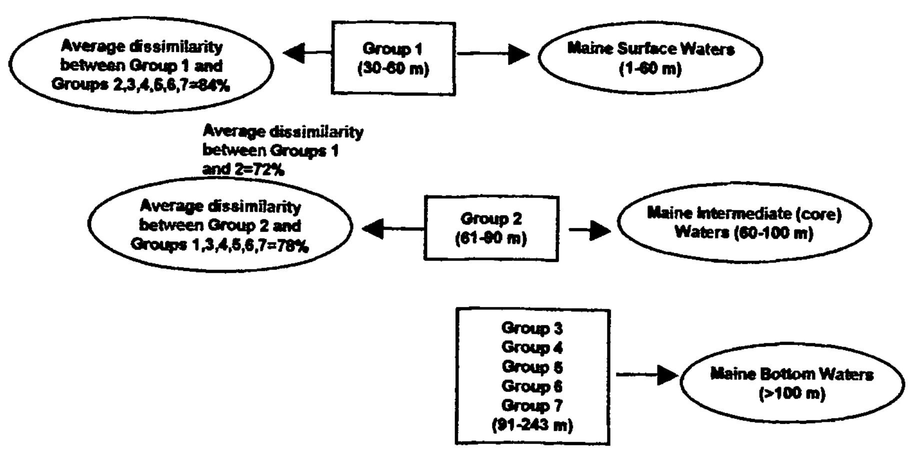

Figure 4.10. ANOSIM Results with 3 Subgroup Delineations Compared to the Three Water Masses in the Gulf of Maine

These water masses, defined by temperature and salinity, have boundaries at approximately 60 m (GOM Surface Water), 61-90 m (core of GOM Intermediate Water), and greater than 100 m (GOM Bottom Water). Surface Water (SW) seasonally varies in temperature from near 0 to 12-16 C, and forms a thermocline in the summer but is isopycnal with the Intermediate Water in the late winter. Intermediate Water (IW) is derived from the Labrador current and flows into the GOM via the Scotia Shelf varying over 4-7 C with salinity near 32 psu. Bottom Water (BW) flows into the Northeast Channel and reaches 8-11 C and close to 35 psu. There is apparently some influence on the Intermediate Waters from the North Atlantic Oscillation, and in years when the Labrador Current flow is decreased, much more Bottom Water flows into the GOM, reaching depths as shallow as 100 m. Changes in properties of the bottom waters of different basins result in changes of deep waters inflowing through Northeast Channel, and from changes in the surface waters entering the Gulf as well. (Hopkins and Garfield, 1979; Mountain and Jessen, 1987).

The deep channels also allow nutrient-rich waters into the Gulf. Upwelling near the Bay of Fundy result in large plankton blooms.These blooms are responsible for the high productivity and historical fish catches in the GOM. Satellite images show that most of the primary productivity is restricted to a zone about 100 km along the western edge of the GOM (Yentsch *et al.*, 1995). Some of this high productivity is distributed along the northern edge of Georges Bank out to the Northeast Channel, but the vast central area of the GOM is overlain by locally oligotrophic waters.

Additional influences of depth such as variations in light, pressure, dissolved oxygen content, organic matter, current and physical disturbances were not measured in this study, but have important effects on the life histories of the organisms analyzed.

Substrate acts as a secondary influence in the structuring of species composition on the ocean floor. Many species found in gravel and sand were not found in mud-only sites. Although this is a factor of depth. (sandy-gravel areas tend to be in shallower areas, while muddy areas are more common in deeper basins), animals are also adapted for living in these different habitat types. Cerianthid anemones need sand and gravel to construct their burrow tubes. Urticina anemones, brachiopods, and sponges need the hard attachment site that gravel and rocks provide. In contrast, mud-dwellers such as sea pens (*Pennatula borealis*) and brittle stars have adapted to burial, locomotion, and feeding in the mud. Transition areas from sand and gravel to mud are easily detectable via their megabenthic inhabitants (Belknap, per comm., 2001).

Megabenthos species assemblages differed in number from those in mud-only areas to sand and gravel areas. There was less epifauna seen in mud compared to sand and gravel (complex bottom) perhaps due to the fact there are more infaunal species in mud than epifaunal. There are also dominant organisms which represent substrate types in this analysis. Shrimp, sea pens and brittlestars in mud-only areas, and sea stars, sponges, and borrowing anemones in sand and gravel areas. Several bottom habitats within the GOM are inhabited by high densities of epifaunal species such as shrimp, *Pandalus borealis*, the brittle star *Ophiura sarsi*, the cerianthid, *Cerianthus borealis*, and the brachiopod, *Terebratulina septentrionalis*. *P. borealis* and *O. sarsi* can occur in very high numbers (Watling, pers. comm., 2001). Because they are general predators, they may control the settlement of new recruits into the areas which they inhabit. The phenomenon has been noted before in the marine world (Bertness, 1999) where predation by large epibenthic consumers has occasionally been shown to control infaunal abundances in shallow water (Olafsson *et al.*, 1994). Whether this is a natural phenomena or one induced by anthropogenic factors is in question. Habitat in these tapes had been modified by mobile fishing gear, as noted where rocks and boulders were turned, dragged and/or scrapped and/or trawl marks were present in the tapes.

It is postulated that there are four major factors that act to determine local habitat levels of biodiversity which will ultimately determine the large-area species richness of the Gulf of Maine. Those are: substrate composition, water mass type, dominant benthic taxa, and surface-water primary productivity. The epifauna analyzed in these tapes may also be representative survivors of anthropogenic disturbance. Frequency and rate of trawling has been known to be high in some areas of the Gulf of Maine. Almost all 10' squares in the U.S. part of the Gulf show nearly 100% coverage by mobile fishing gear (Pilskaln *et al.*, 1998). While the coverage is not uniform, high percent coverage values generally indicate that most of the trawlable bottom was disturbed. Bottom gear has been shown to smooth bottom (i.e. rid it of vertical structure), resuspend sediment, remove vegetation inshore, and smooth and alter soft and hard bottom and destroy habitat where removal of vertical structures such as sponge, coral cerianthids, sea pens and other structural fauna (Agardy, 1995). Studies conducted in European and U.S. waters have shown that heavily fished areas show reductions in species richness approaching 50% (see chapters in Kaiser and DeGroot, 2000).

In the videos analyzed, about 50% of the dives had trawl marks (older dives pre-dated rock-hopper gear). How recently these sites were trawled could not be assessed, as marks in the deeper, undisturbed muddy bottom may stay for longer periods of time than do marks in more disturbed, shallow areas (above 30 meters). In accordance with work done on Georges Bank (Collie *et al.*, 2000), there was a trend noted in this study with the animals seen on hard substrate in trawled and untrawled areas. Presence of sponges of all types was markedly decreased in trawled sites of the same depth and substrate type. More tapes would have to be analyzed to attain significance.

The applicability of this study lies within current efforts to understand deep-water benthic ecosystems. Currently in the Gulf of Maine there is heavy emphasis on increasing groundfish populations by decreasing fishing effort, yet the role of habitat and food webs is not understood. To date, the relationship of invertebrate habitat and fish habitat has barely been examined. Commercial fish species are known to live, eat, spawn and migrate through all depths and substrate types that exist in the tapes and in the GOM. Migrant fish may depend on invertebrate prey taxa whose distributions may be coincident with the distribution of fish migrants in the GOM (Auster and Shackell, 2000). The diet of most commercial fish is comprised of invertebrates at some time in their life stage (Bowman *et al.*, 2000). The brittle star *Ophiura sarsi* makes up a substantial part of the diet of the American plaice in the Gulf of Maine (Packer *et al.*, 1994). Association of some demersal fish species with certain habitats is a critical factor affecting survival of post-larval and juvenile size classes due to habitat influence in both easily finding food and hiding from predators (Tupper and Boutilier, 1995; Gotceitas *et al.*, 1993). Epifaunal and infaunal invertebrate communities are also influenced by sediment type and overlying productivity in that the full range of sedimentary regimes within the local area contain the greatest number of species and communities. There is general spatial concordance of assemblages of fishes and benthic fauna in areas in the Gulf of Maine, even though certain benthic assemblages occur in areas occupied by multiple fish assemblages (Auster and Shackell, 2000).

Marine Protected Areas (MPAs) are currently being proposed to address the efforts of fish and habitat restoration in the Gulf of Maine. Criteria listed for MPAs generally include the maintenance of biodiversity which can be best incorporated by preserving habitat, yet for almost all of the US EEZ, benthic data do not exist at the level or scale necessary to effectively utilize this criteria. World Wildlife Canada published a "seascape" map for the Scotian Shelf and the Canadian waters of the GOM (Day and Roff, 2000). The Conservation Law Foundation of Boston is working on a similar project for the US waters of the GOM (Atkinson *et al.*, 2000). These seascape maps utilize such data sources as depth, surficial geology, and water characteristics (i.e. temperature) yet they are missing data which incorporate benthic organisms. Video analysis of megabenthos could partially address this gap.

Chapter 5

MPA IMPLEMENTATION IN THE GULF OF MAINE

Introduction

Thus far, single-species fisheries management in the GOM has not worked. Commercial fish stocks and non-commercial fauna and their habitat have been greatly decreased and/or altered by poor extraction practices. Ecosystem management is one proposed solution, yet we currently do not have the understanding required to put ecosystem management in place. In accordance with the precautionary principle, marine protected areas are being advocated as a method to increase the kind of understanding needed (while increasing commercial stocks at the same time). Under our current institutional structure, coming to consensus over the MPA issue is extremely difficult due, in part, to the different beliefs of many stakeholders. To address marine protected areas is to address a classic common property problem (where there are no property rights and many users benefiting from it). Studies of common property management schemes (successful and unsuccessful) have led to criteria that appear necessary for successful common property institutional arrangements. If circumstances in the GOM are to meet these criteria, we have a long way to go. Establishing boundaries and developing a forum for users to discuss MPAs may be the first steps towards meeting these criteria.

The chapter is comprised of four sections: 1) summary of anecdotal data from fishermen and MPA advocates; 2) MPAs as a common property resource; 3) recent institutional theory that might inform MPA implementation and; 4) recommendations for future steps towards MPAs.

Anecdotal summary of fishermen and scientist opinion

Pertinent viewpoints voiced by scientists (MPA advocates) and fishermen in this thesis can be divided into three major areas; a) observations of the current fisheries management process, b) perceptions of science in the GOM, and c) socio-economic concerns towards fisheries management as related to the implementation of MPAs. Depending on one's position, one might emphasize the importance of any one of these categories over the other. The decision-making process is what drives operational rule-making (i.e. where to fish) for biological and economic reasons. Historically, economics has had a highly influential role in rule-making in fisheries management, but biological processes drive the resource on which fisheries economics is based. In the end, the system of governance is what determines the fate of the resource. Thus far, attempts to improve this system of fisheries management (by the NEFMC and other institutions) have not worked well, due largely to the lack of sound institutional structure, a point that will be elaborated over the course of this chapter. The following three sections are listed in order of the amount of conflict each presents.

Observations of the current fisheries management process

Process, "the method for doing something involving a number of steps" (Webster Dictionary, 1979), is directly related to collective-choice arrangements, the right of users to participate in the operational rules which govern them. The following comments by fishermen and scientists interviewed reflect the state of the collective choice arrangement in fisheries management in the GOM, (an important component in devising successful fisheries management to be discussed later). It is broken up into 3 parts: 1) the language problems between fishermen, scientists and fisheries bureaucrats; 2) time and transactions costs necessary for fishermen to participate in the process; and 3) the lack of accountability of management.

Inclusion/language problems that exist between fishermen, scientists, and fisheries bureaucrats

- Lack of representation in the fisheries management process was repeatedly voiced from fishermen and scientists interviewed and in meetings. Many fishermen interviewed did not feel represented by the Council, and several scientists interviewed who served on the Council did not feel their expert advice was heeded. Both scientists and fishermen criticized the Council's lack of practices to support ecosystem management. Lack of representation appears to have fueled wary reactions to fully protected MPAs as well. Having a say in the process and designation of MPAs was an overriding concern of fishermen interviewed, and also of several scientists who have tried to work with the Council in the past. (The Council refers to NEFMC, an 18 member management council set up to help create sustainable fisheries under the Magnuson-Stevens Fishery Conservation Act of 1976).

- Poor definition in MPA language and lack of leadership in work around MPAs presents a major hurdle in the attempt to commence dialogue amongst stakeholders. Interviewees, meeting attendees at NEFMC habitat meetings, Ocean Life Institute MPA symposium (OLI, 2001), and the Fishermen's Forum MPA meeting in 2001 (Rockland, ME) felt that there are currently too many definitions of what an MPA is and that this should be remedied before continuing MPA discussions.

Lack of accountability by management

- Litigation against NMFS for not adhering to the Magnuson Act in the lawsuit of 1991 (Shelley *et al*, 1996) is further evidence that even the process 'on-the-books' is not followed.
- Generally, interviewees and attendees of socioeconomic meetings felt that closures in the GOM related to amendments 5, 7 and 9 increased economic hardships on the fishing industry and quickly widened the trust gap between fishermen and government scientists.
- Fishermen interviewed questioned the credibility of the Council due to the passage of wasteful regulations (i.e. a low cod limit resulting in cod as illegal bycatch forced the discard of thousands of pounds of dead cod), and nonrepresentative stock data (i.e. NMFS information from trawl surveys was dated, and offshore surveys did not represent inshore or offshore fisheries according to fishermen interviewed and at meetings).
- Offshore fishermen noted that regulation enforcement was poor due to ill-prepared coast guard officials and lack of observers.

Time and transactions costs necessary for fishermen to participate in the process

- Interviewees who fished inshore felt equity of access to fishery locations and resource allocation became an issue as closures in the GOM favored offshore fishermen over inshore fishermen. This also seemed to be reflected in fishermen's attitudes in MPA designation (i.e. if an area closed, it should be closed to all).
- Flexibility in fishing was also lost due to Amendments 5, 7 and 9. Fishermen were no longer able to switch between gear-types and lobstering became a catch-all fishery. There was concern by both fishermen interviewed and scientists who attended Ocean Life Institute's MPA symposium (2001), that MPA assignments remain flexible to compensate for the uncertainty associated with limited information. Because of this, fishermen and scientists stressed a need for MPA monitoring which would influence future placement of MPAs

Perceptions of science in the Gulf of Maine

Most differing opinions expressed between fishermen and scientists (in fishermen interviews and at groundfish research priority meetings) was in perceptions of science and reasons for fisheries decline in the GOM. Differences and similarity in viewpoints between these two stakeholders is important to note as we gear up towards ecosystem management for the future.

- Reasons groundfishermen gave for the demise in stocks (besides overfishing) were: pollution, temperature, increased effort and technology, lack of good enforcement and lack of real time fisheries data.
- MPA advocates tended to stress overfishing as the main reason for the depletion problem. In addition, trawling effects on the bottom were also given as a reason for demise of habitat and fish stocks by scientists. Fishermen believed that although trawling could be overdone (i.e. when aggregations of fish from different stocks in one area were trawled until gone), there was positive impact from trawling in some areas (i.e. scallopers claim trawling makes an area more productive). Lastly, the belief that there are more and less desirable sites on which to trawl was voiced by both fishermen

and benthic biologists (depending upon habitat complexity, juvenile fish and spawning ground location, and occurrence of natural disturbance).

- Groundfish research priorities listed by groundfishers emphasized more research in inshore and offshore oceanography, inshore habitat, and fish life histories. Less attention was given to offshore habitat.
- Attitudes over partial-take versus no-take MPAs were varied. All groundfishermen interviewed agreed to partial-take MPAs, as a part of and in conjunction with other fisheries management tools such as TACs, DAS, gear modifications, etc. Partial no-take MPAs, like the present closures in GOM, served to replenish depleted stocks, (some fishermen questioned their placement). The thought of no-take MPAs was threatening to most fishermen interviewed when "no-take" was perceived as being an area inflexible to change. No-take MPAs were only deemed acceptable by fishermen interviewees in areas or parts of areas of well-proven nursery grounds (like Jeffries Ledge).
- Scientific proponents for MPAs strongly believed in biodiversity preservation and therefore pushed for a precautionary approach in support of MPAs and curtailment of ongoing destruction to the ocean ecosystem. Biodiversity preservation and ecosystem management was rarely discussed as a priority by groundfishermen interviewed. It was mentioned in the Maine Groundfish Research Priority Report (NEFMC, p. 15, 2001) that,

  > ...it is widely acknowledged that the fishery should be managed on either a multi-species , or better, ecosystem basis, but ecosystem theory has not yet been distilled down to a practical application for fishery management. Most approaches as so data-hungry that they are dismissed as hopelessly idealistic. At the same time, some view a promising approach to be decentralization of decision-making, management, and scientific work.

- The spill-over effect, the most economically compelling selling point of MPAs, has varied acceptance from industry. Many were convinced of the spill-over effect from watching Georges Bank (GB) scallops, GB haddock and GB yellowtail flounder increase with closures on Georges Bank. All interviewed

> trawled around bottom shipwrecks and pipelines due to the increase in fish found in these mini-refuges. Yet many were still doubtful no-take MPAs could work towards increasing fisheries on a large scale. A no-take MPA system was thought to displace effort and increase gear conflict, creating more tension amongst fishermen. MPA advocates and modelers have so far not seen evidence for the displacement factor and agree in the need for flexibility in the placement of MPAs.

Under the right conditions (i.e. correct spatial and temporal considerations and with proper support), no-take MPA studies have shown that MPAs can and have resulted in restoration of commercial and non-commercial species, increased biomass and species size, spillover effects of these species into fishing areas, habitat restoration, and a place to study effects of undisturbed areas.

Although positive results have been seen first-hand by fishermen who fish the closures in the Gulf of Maine, no-take MPAs are still hard to sell to many fishermen (Raymond, pers. comm., 2001). In addition, positive results of MPA systems cited repeatedly by MPA analysts has yet to be proven to industry. Some fishermen interviewed claimed that many of these studies take place in tropical climes that do not fully represent temperate waters (i.e. GOM waters). Secondly, some fishermen interviewees stated that due to lack of monitoring in GOM closed areas, there is little information to presently help determine space and size criteria for MPAs in the Gulf.

Economy

The decline in the fishing economy and culture in Maine is a serious concern as it affects the future of the industry and its users. There have been major downsizing of fleets, decrease in infrastructure, and boats previously saleable for retirement income are not marketable in the aftermath of Amendments 5, 6, and 7. Coastal property is being bought up by wealthier buyers, often from out-of-state, at an increasing rate. The resulting increased land values caused many native inhabitants to move out, eroding Maine's fishing community and culture in the process.

Closures, shifts in fishing pressure and plummeting groundfish populations affected fishermen according to the size of their boat and how they were rigged. Small boat owners (boats 45 ft. or under) historically fished inshore and changed gear according to the seasonal changes in fish species. Small and medium sized vessels (50-69 feet) increased their fishing concentration in the Gulf of Maine whereas large vessels (70+ feet) relied more on Georges Bank for groundfish and scallops (Johnson, 1999).

From 1994 to 1998, the number of small vessels reporting Maine landings declined from 110 vessels to 75. The number of medium vessels dropped between 1993 and 1998 from 77 to 48, and the number of large vessels from 1993 to 1998 decreased from 50 to only 25 vessels. These adjustments led to a reconfiguration of the Maine Fleet, with a greater concentration of vessels in the small and medium class sizes (Johnson, 1999). The decrease in boats meant decrease in support businesses and as a result service infrastructure was seriously affected. To exemplify the economic trickle-down effect, when the city of Portland, Maine lost 5 fishermen during the year 2000, one fisherman's life was estimated to be worth $1,600,000.00 to its community (NEFMC, 2001).

The perception and fear of many in the fishing industry is that MPAs will bring additional stress onto a highly stressed system. Fish are considered a common property resource, and whatever is done to manage the Gulf's boundaries has potentially high impact on its appropriators (i.e. fishermen). Common Property Theory is discussed in the next section as applied to fisheries management.

Common property theory

The decline of the Gulf of Maine fisheries is sometimes attributed to a classic tragedy of the commons. Whenever a common pool resource [4] is used in an unlimited manner, there are unowned benefits/incentives for doing so on the part of the appropriators (i.e. in this case, fishermen). In fisheries, benefits lie in the supply of resource units, the fish, without the cost of

[4] common pool resource (or common property resource): a natural or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use (i.e. fish, oil, aquifers, ecosystems) (Ostrom, 1996).

restocking the resource system. Similarly, in an irrigation scheme, benefits lie in obtaining a steady flow of water for crops without having to resupply the water source. The resource units are individually used, but the resource system is openly shared by the appropriators to the detriment of the resource. Herein lie the problems of open access[5]. Garrett Hardin's Tragedy of the Commons (1968) used the example of cattle grazing in a public commons to illustrate the problems with using a limited resource in an unlimited manner. When a resource is used in this manner, the care of the resource itself is overlooked or ignored.

> There appears then, to be some truth in the conservative dictum that everybody's property is nobody's property. Wealth that is free for all is valued by no one because he who is foolhardy enough to wait for its proper time of use will only find that it has been taken by another...The fish in the sea are valueless to the fisherman, because there is no assurance that they will be there for him tomorrow if they are left behind today. (Gordon, 1954, p. 124)

The result of such extraction practices is the substitution of long-term sustainability with short-term economic gain

MPAs are subject to this dilemma as well. In many ways they are similar to the flow of water that comes from one irrigation source to farmland; or to the stock of fish that provides a 'surplus yield' year after year. In the case of the MPA the flow of resources is the fish (and other ecologically valuable biota) that leave the MPA and become available to fishermen and the flow of ecosystem services broadly available to society. Like water flow and fish stocks the only way to avoid depleting the flow of public resources[6] (or dissipating their benefits) is to develop rules restraining and allocating harvesting. When those rules are developed (or it becomes apparent that it is possible to develop such rules) it will be possible to reach agreement for the establishment of MPAs.

The difficulty of establishing an MPA stems from the fact that it (the MPA) is essentially a collective tool that can be applied to the common property area however its boundaries are defined. Resolving the problems of an MPA requires resolving the commons problem.

[5] open access: regardless of who technically owns a resource, the accessibility of that resource to virtually anyone who wishes to access it (Acheson, in press).

[6] public resources: compared to a private resource, anything not privately owned but owned by a society as a whole (Acheson, in press).

In the following sections I will outline the theory of common property resource and apply it to the implementation of MPAs.

Criteria for success of common pool resources

Elinor Ostrom and others (Evelyn Pinkerton, Tundi Agardy, Jack Knight) argue on the basis of theory and experience that there are circumstances that make it possible to resolve the commons dilemma. After studying a large number of successful and unsuccessful CPR (common pool resource) arrangements, Ostrom (1996) constructed 8 criteria or rules that serve as a core for successful common pool resource management. These are stated below.

1. Clearly defined boundaries. Individuals or households who have rights to withdraw (harvest) resource units from the common pool resource (CPR) must be clearly defined, as must the boundaries of the CPR itself. Not any boundaries work; good boundaries should have the effect of containing the costs and benefits of restraining rules – for incentives and for learning.
2. Congruence between appropriation and provision rules and local conditions. Appropriation of rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, material, and/or money.
3. Collective-choice arrangements. Most individuals affected by the operational rules can participate in modifying the operational rules.
4. Monitoring. Monitors, who actively audit CPR conditions and appropriator behavior, are accountable to the appropriators or are the appropriators.
5. Graduated sanctions. Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both.

6. Conflict-resolution mechanisms. Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.

7. Minimal recognition of rights to organize. The rights of the appropriators to devise their own institutions are not challenged by external government authorities.

8. (for CPRs that are parts of larger systems) Nested enterprises. Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

Ostrom's 8 common pool resource rules applied to MPA situation in the Gulf of Maine

If Ostrom's 8 criteria are indeed guidance for successful democratic management of public resources for fisheries in the Gulf of Maine, how far are we from meeting these criteria with current fisheries management practices, including MPAs, in the Gulf? Below is a list, in prioritized order, of how our current management system compares with Ostrom's 8 CPR rules.

Boundaries

The most important criterion for planning of MPAs in the Gulf of Maine is in defining clear boundaries of both the CPR (geographic) and the CPR users (i.e., stakeholders). . This is the foundation upon which all management/implementation is built, and it is the first step towards collective action. Were we to recreate boundaries based on the ecological needs of the ocean (including its fish stocks), we could finally begin to manage for the whole health of the Gulf. In this way, the resource would be allocated to users (in a regulated fashion) according to its biological and ecological limitations. Historically, physical boundaries of the Gulf have been drawn according to the economic needs of the users. Both physical boundaries and user group boundaries are discussed below.

Physical boundaries The Gulf of Maine has several administrative divisions: state waters from 0-3 miles, federal waters from 3-200 miles, and international waters over the Hague Line (discussed in chapter 1). Maine's state waters are divided into 7 lobster zones, 2 urchin zones, and various aquaculture lease sites and 2 state marine reserves (Monhegan and Swan's Island). There is one national marine reserve, Stellwagen reserve, which allows fishing but not oil and mineral extraction. The most recent boundaries in national waters are in the form of fishing closures in 4 areas in the Gulf and Georges Bank. Within these areas is one habitat of particular concern (HAPC) area. The future of the boundaries of these closures and HAPCs are currently being reconsidered by the New England Council. MPAs as defined by the Executive Order 13158 are only beginning to be addressed.

Fishing by the commercial industry outside these closures has resulted in an informal zoning by limited entry of most fisheries, gear type, and boat size paired with total allowable catch (TAC) limits and days at sea (DAS).

Fishing the edges of closures, initially thought to result in depletion of resources inside the closure (and MPAs) has not yet been proven to have a detrimental effect on fishing stocks inside the closure. In a comprehensive study of MPAs around the world, negative effects from displaced effort outside MPAs has not been proven either (Roberts, 2000).

Current boundaries conditionally conform with ecological boundaries, depending upon the scale of governance and goal of boundary setting. When boundaries are determined politically, as in international boundaries like the Hague Line, lines are fixed and there is less likelihood of conformity due to the heterogeneity of the seascape in the Gulf of Maine. At the local level, however, fishermen create informal boundaries that conform to the ecology by fishing on a specific species in a specific habitat type. Lobstermen and fishermen who use long-lines are examples of fishermen who pay close attention to ecological boundaries. Trawlers pay attention to bottom type but not in as detailed a manner as fixed gear fishermen. Trawlers will fish on highest fish populations within the constraints of political boundaries like the Hague Line, closure boundaries, or physical boundaries like that of sunken ships. The area in between formal boundaries is informally zoned according to substrate type and fish present.

User group boundaries There are many user groups utilizing resources in the GOM. The primary users of the GOM's resources are commercial fishermen, followed by other commercial enterprises such as oil and mineral extraction, transportation (shipping, ferry service), and garbage dumping, followed by those who use the GOM recreationally (i.e. recreational fishermen, boaters, and sight-seers). Each of these groups has a unique investment in the CPR of the GOM and must abide by different physical boundaries and resource allocation. Consequentially, political power within and between these groups differs as well. One of the biggest users with the most highly regulated resource is that of the fisherman. The fishing industry covers the whole Gulf, and is strongly affected by the boundaries of state, federal and international waters, boat size and gear type. A no-take system of MPAs would affect this group the most. Existing MPAs have already affected this group significantly.

Current GOM closures are temporary, however, and there are many fishermen with latent permits (i.e. permits that would allow future use of saved fishing days) waiting to reap the rewards of rebuilt stocks. What will happen to these stocks once the closed areas open with increased effort in the form of latent permits? As stocks continue to rebuild in the Gulf of Maine, the latent permit issue is at the top of the Council's priority list as they struggle to meet the goals of Amendment 13. Amendment 13 requires the councils to address the 1996 Sustainable Fisheries Act (SFA) Multispecies Fisheries Plan to build biomass. The Council's goal is to place significant reductions in fishing mortality for mid-Atlantic yellowtail, Georges Bank haddock, white hake and dab. The Council is also contemplating assignment of different regulations to different areas in the Gulf of Maine in the form of sector allocations or "to apportion available resources according to permit category, vessel size, gear type, or a combination of the above" (Howard, 2001).
The risk in the current user boundary regime is the NEFMC's continuing support of single species management in lieu of ecological management.

To avoid destruction of the fisheries resource in the GOM, one must apply rules limiting appropriation and /or mandating provisions. Ostrom's next criteria as they apply to the fisheries system in the GOM are all important in a successful management scheme.

The collective choice arrangement

The collective choice arrangement (i.e. that those affected by the operational rules can participate in modifying these rules) is weak in fisheries management. As already mentioned, the inclusion of the industry in management decisions is key for monitoring and compliance, which would hopefully help attain the goal of stewardship and eventually, long-term sustainable fisheries management.

Although the intent of the creation of the Councils was to fill the need for collective choice on the part of the local fishing industries, it has not succeeded. There is an advisory process, but no requirement for listening. Having no say in management is still a major complaint amongst fishermen (and non-governmental scientists). Fishermen are most affected by the operational rules, but feel meetings are held in inconvenient places (i.e. especially those from Maine), they don't feel heard when they do attend, and many fishermen don't feel the council represents them. Scientists assigned to technical committees of the Council have had similar complaints. Both industry and science complain there is too much self-interest on the part of industry representatives to make sound decisions for long-term fisheries sustainability. Those who have observed the growing pains of the Council over the past 25 years say it has improved, but still has a long way to go before meeting the original intent of the Magnuson Act.

Thus far, MPA meetings have largely been held by the science community to the exclusion of the fishing industry. Several shared viewpoints on MPAs by scientists and industry have been expressed in private interviews, but these may not be voiced in public meeting unless trust between scientists and industry is re-established.

Nested enterprises

The remaining criteria in Ostrom's list are dependent upon the multiple layers of nested enterprises present in any given CPR. Before going forward, it makes sense to mention what enterprises are involved in the extraction of natural resources in the Gulf of Maine. Without understanding this nested system, we cannot begin to rationally address MPAs.

As has been previously mentioned, there are several nested enterprises in the GOM, from state to federal and international waters. Appropriations, provision, monitoring, enforcement, conflict resolution, and governance activities are all organized in multiple layers of nested enterprises in the Gulf of Maine. The Department of Marine Resources (DMR) is given responsibility over state waters (fisheries resource management and development). At the federal level, the Army Corps of Engineers (AEOC) is responsible for channel dredging, Environmental Protection Agency (EPA) for ocean dumping, and the Minerals Management Service (MMS) is responsible for oil, gas and mineral exploration. NMFS, under NOAA, is responsible for fisheries management only. New England Fisheries Management Council answers to NMFS. Atlantic States Marine Fishery Commission, comprised of 15 Atlantic Coast states, collaborates with NMFS and NEFMC.

There is no one organization mandated to take charge of MPAs, and several organizations are currently gearing up in anticipation of the implementation of Executive Order 13158. Among these groups are the NEFMC, CLF, and a newly formed group called Gulf of Maine Marine Protected Areas Collaborative (GOMMPAC). Despite their shared interest in MPAs, there is no effective nesting within these organizations.

Congruence

Congruence between appropriation and provision rules and local conditions helps to account for the perseverance and continuance of the GOM's overall health and resources. If congruence existed between the human made boundaries of an area to which the rules apply and the natural boundaries, then the perseverance of the ecosystem and commercial fish stocks in the GOM would endure. Hence the purpose of an ecologically based MPA system.

The question for the Gulf is, with so many types of governance systems responsible for the rules, mentioned in 'nested enterprises' section, how can one ever make the rules match the ecosystem spatially and temporally? Multiple layers of top-down fisheries management combined with incomplete information of fisheries-related processes (i.e. physical and biological factors and habitat) in the GOM make congruence between provisional rules and local conditions a real challenge.

Fish migrate north and south, inshore and offshore, vertically in the water column, and seasonally according to life history phase and physical and biological conditions (i.e. temperature, current, water quality, food availability). Hence, fish continuously cross human-made boundaries in a multi-dimensional world making them nearly impossible to manage in accordance with these boundaries. To compensate, we attempt to manage species by species by limiting appropriators via effort and landing restrictions based upon results of models that do not account for ecosystem components/variables. Of the four agencies responsible for regulating these species, DMR, NEFMC, ASMFC, and NMFS, ASMFC views species from a trans-boundary perspective. This is a start. Understanding commercial fish species is important towards solving part of our understanding of oceanic ecosystem, but there is much left to understand until an ecosystem approach can be practiced. Until we can start to understand the ecosystem components, there will continue to be lack of congruence between the management decisions and the resources of the Gulf. Marine Protected Area advocates support ecosystem-based management while at the same time enhancing commercial fish stocks. The expectation of effective monitoring is key.

Monitoring and graduated sanctions

Monitoring and graduated sanctions (rule compliance) are grouped together here since one cannot successfully monitor without compliance. Those in the GOM who actively audit CPR conditions and fishermen's behavior are accountable to the fishing industry or are the industry. At the same time, appropriators/fishermen who violate operational rules are likely to be assessed graduated sanctions by other fishermen, by officials accountable to the fishermen, or by both. If there were constant monitoring and appropriate rule compliance by the fishermen in the GOM, there would be accountability and a larger sense of responsibility for the resource. This is imperative for the survival sustainable fisheries and an MPA system.

Monitoring of fishing ground closures in the GOM is practiced via enforcement by airplanes, helicopters, the coast guard, and electronic monitoring boxes on experimental fishery scallop boats. However, there is still room for non-compliance on the part of the fisherman, especially offshore where it is harder to monitor larger areas. Common offshore enforcement complaints by users are that the coast guard is under-trained for enforcement, there are not enough observers on boats, there has been illegal night time dragging, fishing within the boundary lines, and other short-cut practices by appropriators.

The exception to the above is the in-house monitoring, a quasi-voluntary compliance contingent upon the compliance rate of others. In the GOM, this is practiced by inshore fixed gear fisheries such as lobstering. Maine's lobster industry has evolved over time and is largely monitored, with sanctions, by informal laws (Acheson, 1988). There is incentive to adhere to the laws since the industry had a large hand in making them and believed in the sensibility of these laws through the positive results of resource landings. The fishery is mostly inshore, and additional boundaries were set in place with the establishment of 7 lobster zone councils. Participants were accountable to the industry and to themselves for the continuance of a sustainable industry. Historically, industry had fought for laws that made economic and ecological sense and saw the success in the outcome. Over time, the lobster industry viewed themselves as stewards of the resource, the results of which are thought to have contributed to an increase in landings over the last 20 years.

It is much more difficult to develop successful monitoring and graduated sanctions in federal waters with mobile gear. Accountability is in question at different levels. It is difficult to instill stewardship in the fishermen when the NEFMC is not held accountable for fishing management decisions under the existing fisheries management regime. Many fishermen do not have the incentives necessary for a high rate of quasi-voluntary compliance. In the beginning of the GOM closures, disincentives for rule compliance such as distrust, resentment, and an increase in gear conflict resulted from issues of inequity created by Amendments 5, 7 and 9 (i.e. post-closure practices of closing off Georges Bank to rebuild groundfish stocks only to later allow in scallopers). This kind of action undermines stewardship and incentives for compliance on the part of all fishermen. Currently, much effort is spent trying to heal these wounds (i.e. boat buy-back programs, consortium funding for industry-science collaboration, etc.) and go forward.

A potential MPA system would incorporate state and federal waters. Self-enforcement of MPAs would require strong buy-in by the industry and this would require, at the very least, inclusion of fishermen in the process of MPA selection. It would also include clear boundaries and a scheme developed to reward the actions of those protecting the MPA. Although many groundfishermen are now convinced of the benefits to closing areas temporarily, "many have a hard time with the idea of permanent closures" (Raymond, 2001, p.1). The Habitat of Particular Concern area on the northern edge of Georges Bank is the only no-take area in the GOM. The permanence of the words "no-take" is the largest obstacle to setting up a system of MPAs. On the other hand, those who do agree that we need an MPA system stress the importance of scientific monitoring and flexibility in the design of MPAs. Many in the industry are disappointed in the lack of attempts to comprehensively monitor existing closures for biological purposes. The key to appropriator compliance, once again, is to include these ideas and others from fishermen in on the decision-making process of no-take MPA assignment. This brings us to collective-choice arrangement in fishery and potential MPA management.

Conflict resolution mechanisms

Having rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials is paramount to the maintenance of rules within a management system. If rules are to become established over the long-term, there must be a mechanism for discussing and resolving what constitutes an infraction.This is particularly important to an MPA system in its experimental phase where initial rules will be highly subject to interpretation.

Conflict resolution in the form of representation at the local and national levels takes the form of public comment meetings, informal conflict resolution amongst industry members (i.e. lobster gangs, offshore trawlers gear avoidance), and litigation. How well these work depends upon the system and level at which they are being addressed. The DMR or a lobster zone may be able to resolve conflict at the local level, but there are more hoops to jump through at the national level, along with an apparent discontentment in the way fisheries management is managing. The increase in litigation against NMFS over the last 5 years is worthy of analysis. The lawsuits represent the discontentment and heightened awareness by various stakeholders over fisheries management practices. Winning these suits in support of sustainable fisheries may be one way to improve the state of the Gulf, but many lawyers would agree that there are better solutions than filing law suits to improving fisheries management.

The type of conflict resolution involving MPAs would depend upon whose jurisdiction the MPA system would fall, and how much flexibility was build into MPAs. If NEFMC were to rule under the current system (from federal mandate), it is hard to imagine equal stakeholder representation. There is currently a healthy amount of conflict between different fishing industries (i.e. hook fishermen versus groundfishermen, groundfishermen versus fixed gear), on the topic of MPAs, and scientific advice has largely been ignored regarding habitat and ecosystem management. For MPAs to work, the NEFMC process must change drastically or an independent MPA organization must be formed (like that of Australia or New Zealand).

Rights of appropriators

The rights of the appropriators to devise their own institutions supported by external government authorities instead of thwarted, is important for the maintenance of informal, local rule-making. These rules are important to external government since they do not have the added responsibility of enforcing such rules. Locally, this encourages stewardship and accountability, which is paramount for upholding rules in an MPA system.

Fisheries management in New England has yet to give minimal recognition of rights for fishermen to devise their own institutions, supported by external government authorities. The lobster industry of Maine is the closest example to a fishery that is devising its own institution, but it is a work in progress. Seven lobster zone councils created as a result of the 1995 passage of the Lobster Zone Management law empowered each council to pass management rules for the zones with a 2/3 vote on the number of traps that can be used, the times that fishing can be done, and the number of traps that can be used on a single line (Acheson and Brewer, in press). Despite the intent of bottom-up management of lobster zone councils, the DMR is careful too not relinquish too much power to the Lobster Zone Councils. (The one exception to this is the lobster management on Monhegan Island. Monhegan Island established an Exclusive Lobster Fishing Zone in 1998 which only allows residents to fish the island's waters.)

Other organizations in Maine have formed independently as a reaction to a history of poor fisheries management and minimal recognition of rights to organize. They think they can do a better job at the local level. NAMA and Stonington Fisheries Alliance are local organizations collecting support to gain a voice in fisheries management, but they have not yet been recognized formally. If such organizations were given rights to devise their own rules without the creation of outside government in the context of MPAs (including industry's desire to monitor and keep MPAs flexible), MPAs might fare better in the long run.

Institutional history: institutions involved with MPAs in the Gulf of Maine

There are currently several organizations involved with the future execution of Executive Order 13158. In addition to NEFMC, CLF and GOMMPAC have organized around the possible implementation of an MPA system in the GOM. There are differing goals amongst these groups over what MPAs should represent and how to go about implementing them.

> NEFMC maintains that they have been implementing MPAs since 1969 as is their right. "The use of closed areas at the sole discretion of the Council is consistent with the integrated and coordinated approach for the implementation and management of MPAs suggested in the Executive Order, but ensures that the authority for managing our Nation's fisheries remains with the Council as was intended by Congress. (Howard, pers. comm., 2001).

To prevent confusing and contradictory management protocols in different places, Mr. Howard has proposed the creation of a special MPA advisory board consisting of Council members, NMFS and the other national agencies involved with ocean resources in the GOM.

Currently the Council has no formal policy, strategy, or official position on the use of MPAs as a management tool. However, because the council perceives their involvement in the MPA initiative as being backed by the Executive Order, and MPAs are receiving increased attention at the National level, the Council plans to increase their involvement in these processes. The Council has since formed an MPA committee responsible for developing an official Council policy and strategy on MPAs, as well as keeping the Council informed of recent MPA developments and implementation of the Executive Order.

There are other Council committees potentially related to MPAs, such as the Habitat Committee and Species Committees. Depending on the exact nature of the Council's MPA Policy and Strategy, the MPA Committee may work with the species committees making changes to Council FMPs to make them more consistent with the intent of the Executive Order. NEFMC is currently working on reassigning closed areas in GOM and there is talk of possible no-take MPAs to include HAPC areas (NEFMC website, 2001).

For the same reasons there have been problems with fisheries management, there are problems with this system for the establishment of MPAs. The Council represents the fishing industry yet would be making decisions that would impact the commons of the rest of the stakeholders of the GOM. The Council has a history of voting according to the self-interests of its members who are not seen as truly representing their constituents. The Council has emphasized increasing commercial stocks to the detriment of protection of habitat, invertebrates and non-commercial fish that surely hold the key to the health of the ecosystem.

MPAs in the form of closures have been set up as discrete unrelated places in which to bring back individual species of fish versus a system of incorporated no-take MPAs designed to increase the overall health of the resource and its ecosystem. In addition, the governance under the Council is not conducive to successfully implementing MPAs under a democratic system. Locally managed sites of MPAs in New Zealand, the UK and the Philippines have a much higher success rate than government MPAs. (Largely due to a history of education and informal compliance built into support for a formal institution). Of 160 sites that have been designated under national parks and other programs, site regulations are not enforced and according to the World Conservation Union, management levels are generally low (Kelleher *et al.*, 1995).

Under our current fisheries management system largely influenced by the NEFMC, the original intent of an ecologically based MPA system stands the risk of becoming diluted and/or a tool to further the interests of a few stakeholders at the expense of the common.

Conservation Law Foundation's involvement in MPAs

The Conservation Law Foundation believes there currently is no coherent, comprehensive goal-oriented state, federal or regional policy for MPA development. There is no one group with authority and jurisdiction over the GOM that has volunteered to establish MPAs with the goal of fostering the region's biodiversity. The Conservation Law Foundation (CLF) has been working hard to fill what they see as a policy gap that "has been the stumbling block for a comprehensive approach for marine protection." (Atkinson *et al.*, 2000, p. 65). CLF has called on NGOs, political leaders, government agencies and other interested parties to join the CLF in a concerted effort to secure legislation at federal and state levels for no-take MPAs in the GOM (Atkinson *et al.*, 2000).

Gulf of Maine Protected Areas Collaborative

Over 40 self-identified supporters of MPAs in New England have begun to meet and share ideas for the last 2 years. They call themselves Gulf of Maine Marine Protected Areas Collaborative (GOMMPAC), and include environmental advocates, marine biologists and ecologists, educators, and government planners.

Recommendations for the future

Given what we know about the status of the Gulf of Maine's biology, fisheries management, and the stakeholders interested in designing MPAs in the common property of the Gulf of Maine, what might be done to begin moving in a direction towards the circumstances in Ostrom outlines to begin the evolution of a process that might lead to an MPA?

One of the most important criteria of the eight on Ostrom's list is that of boundaries. To address boundaries is to examine the users of the Gulf's resources as well as the physical and political boundaries that define the Gulf of Maine. Secondly, a collective forum must be designed to allow these stakeholders to meet.

Users

Proponents invested in devising a system of no-take MPAs consist of marine scientists, educators, economists, and litigators who believe that no-take MPAs are a needed tool to improve the overall health of the GOM. After watching repeated mismanagement of the ocean's resources, these stakeholders are invested in taking measures to stop the negative cycle of mismanagement. They see themselves as stewards of the ocean and come from various levels of understanding, expertise and power.

Many of the primary users of the resource, the groundfishermen, are proponents of temporary or conditional MPAs as well as some no-take MPAs. Collectively, industry holds the most knowledge about the Gulf of Maine. They are its police force, and are most directly effected economically from the ramifications of MPA placement. Fishermen have much invested in the resource and it is to their benefit to work in a system that promotes sustainable fisheries.

There are many complexities and uncertainties in the planning of a successful MPA system. Planning for success requires knowledge of marine law, ecology, oceanography, fish life history, oceanic food webs, modeling, and economics. Scientists who advocate MPAs have been studying MPAs worldwide and modeling the effectiveness of MPAs in the GOM. Experienced fishermen know the Gulf of Maine as well as what oceanographic, geologic and biological cues commercial fish follow.

The input of these various user groups is vital to intelligent planning for the commons of the Gulf of Maine, but we need a forum that takes advantage of the various expertise while at the same time avoiding power struggles between stakeholders. Thus far, most of the dialogue around MPAs has been between scientists, managers, politicians and economists with no to little industry participation. Before examining what kind of forum might be designed, physical and political boundaries should be analyzed.

<u>Physical boundaries of MPAs-challenges</u>

For MPAs to be established in the GOM, physical objectives dictate designing a network of replicated habitats taking into consideration an ecosystem-based management plan that preserves both commercial fish species and biodiversity.

At best, our more permanent ocean preserves are a fragmented patchwork of sites set up for specific independent resource management: Stellwagen Bank National Marine Sanctuary (which prohibits sand and gravel mining only), Manomet National Wildlife Refuge, and the offshore juvenile cod Habitat Area of Particular Concern (HAPC) are examples of this.

Ecosystem management, a revolutionary topic in fisheries management, was briefly addressed in a groundfish meeting for scientific priority needs. Although the need for ecosystem management was unanimously recognized, how to put it into practice was not. The point was made that "...ecosystem theory has not yet been distilled down to a practical application for fisheries." This is an important point. To begin to reach such a place, a tool is needed to consolidate the vast sum of information we have on the biological and physical information of GOM, in a way that visually layers the information.

Recognizing this, World Wildlife Canada created a map of seascapes on the Canadian side of the GOM. Seascaping with the use of GIS and an involved computer program incorporated variables such as depth, water temperature, light, and substrate. The variables can be overlain on top of one another to create a more comprehensive picture of how they affect overall ecosystem processes. This combined with data of fish and benthic faunal inhabitants (chapter 4) would help solve the ecosystem puzzle and set physical boundaries in the Gulf.

CLF is currently finishing seascaping the US side of the GOM using the same program and protocol as WWF Canada. In addition, detailed mapping of the GOM benthos using more advanced bathymetry methods used to map Brown's Bank is being considered by geologists in both the US and Canada to map the entire Gulf of Maine. Such a project is thought to greatly assist with the future placement of marine reserves and/or with zoning practices.

Zoning and forum development

If MPAs are to be used as a part of a fisheries management package, zoning may prove to be a good bedfellow. There is growing support for zoning. At the local level, fisheries organizations (Stonington Fish Alliance, NAMA and Cobscook Bay Marine Research Project) agree that zoning is one way to incorporate stewardship into commercial fishing since one will be forced to work with limitations in resources and space. Zoning has even been proposed by the NEFMC.

There have been several suggestions for locally based zoning systems. NAMA has proposed a council system that would form community alliances to outline details of managing the inshore area as lobster zone councils do. This would include representatives from each zone who truly represent industry members. Since there are three organizations in the southern, middle, and Downeast sections of the state who are currently working on problems related to inshore zoning and stewardship, perhaps they could be incorporated into such a system. Zones could radiate out from shore like lobster zones or the GOM could be zoned similar to the Australia Great Barrier Reef Program where certain areas are designated for certain uses (the Council has suggested this as well). NAMA proposes yet another plan that designates a portion of the Gulf of Maine from the shore to 25 miles as an inshore management area where fishers would have to agree to fish exclusively in the inshore area for a specified period of years with a process determined by inshore participants to implement changes after this initial period.

My own proposal would involve the design of a collective forum separate from that of the Council. It would include groups of representatives of the scientific community working in the GOM (i.e. marine ecologists, fisheries biologists, geologists, oceanographers, and fisheries anthropologists), inshore and offshore fishermen with multi-gear experience or who equally represent multi-gears, organized fishing groups already formed in the Gulf, environmental organizations, people involved in the organization of other MPAs, and litigators. There would need to be a checks and balance system devised to keep people honest and focused, as well someone to answer to for actions taken (higher tier here who enters only in case of stalemates and abuse of power). Power would have to be appropriated in such a way as to be fair to stakeholder groups.

Zoning benefits

The zoning management system proposed would begin moving toward Ostrom's conditions in that they would give stakeholders a public forum and assign clear boundaries physically and politically. From here they could move forward into rule-making that would encourage stewardship and self-regulation. Such a system would more successfully incorporate and excercise collective choice arrangements, monitoring, graduated sanctions, conflict resolution mechanisms, minimal recognition of rights to organize. Nested enterprises would have to be taken into consideration. In addition to state and federal limits, there are other pre-existing zones in the Gulf (i.e. 7 lobster zones, 2 urchin zones, and a multitude of aquaculture lease sites).

Zoning costs

There are projected costs to the creation of such boundaries. Costs would depend upon diversity of commercial fish stocks and flexibility afforded to industry to jump to different fisheries throughout the year. If zones are fixed then should flexibility be built into fishing different stocks? If a fisherman uses fixed gear, they do not need the same physical flexibility since their stocks are in one area and are non-migratory within their season. A disproportionate loss of property rights between onshore and offshore fishermen has already been experienced with W. GOM closure by inshore fishermen. How does one make for equity in zonation? Many claim the GOM is informally zoned due to the way people fish. If there is a way to legalize some of these zones, would it reap any better rewards in combination with MPAs?

Overfishing outside boundaries due to redistribution is a common concern on the part of industry. Results in MPAs and models of MPAs thus far have not supported this concern (Roberts and Hawkins, 2000). Modeling has shown limited success of MPAs under open-access and sole ownership regimes when the MPA is small (10% of the fishing ground) (Gilbert, pers.comm., 2001). Size may prove to be a crucial factor if combining MPAs with zoning.

Another concern of MPAs is that of increased gear conflict. If MPAs were combined or included with zoning, this should minimize the problem of gear conflict since zoning would be in accordance with gear use.

Incentive-building

Developing incentives that lead to self-enforcement and stewardship is a challenge, and the process for doing so takes time. Trust (or reestablishment of trust) and communication must be fostered within and between stakeholder groups. One must then identify management measures appropriate and effective in dealing with complex diversity of resource problems being experienced, in combination with ecological problems. (I strongly advocate incorporating both objectives.) Allocation of rights will also be a key obstacle. To work with any of these challenges requires a common, clear vocabulary to work with, and this has yet to be established (i.e. multi-definitions for MPAs, confusing language of Magnuson Act, interdepartmental language of state and federal organizations.) Another obvious challenge is that of public support.

To address the trust issue, Organizing groups on a membership basis might nurture accountability and responsibility. In response to interview comments on how to better management, several efforts would need to take place at various levels at the same time. Marine and fisheries education must be promoted, gear-friendly methods used, and inshore fishery built up.

How latent permits are used when the stocks reuild and closed areas open up is a serious concern for the near future. One could use permits as an incentive by taking away permits/access for destructive practices. Latent permits might also be preserved as permits with limited access rights to encourage stewardship.

Circumstances to assist evolution towards a change in governance

There are signs of change presently taking place in the Gulf of Maine at the local level. People are tired of the current management regime and are ready for a change in fisheries governance. No-take MPAs are being considered as a tool for improving the health of the Gulf. The following is a list the represents forward movement and change towards an increase in the voice of local fisheries organizations (away from centralized government) and MPA acceptance;

- In interviews, groundfishermen unanimously agreed that fisheries management practices needed improvement towards multispecies management.
- Benefits of MPAs have been witnessed first hand by the fishing industry from positive results of some of the closed areas.
- Local organization of groundfishing industry is improving. NAMA, stationed in Southern Maine, has grown to over 1,000 members, Stonington Fishermen Alliance is still active, in the Midcoast area and organizations have formed in Cobscook Bay area Downeast.
- In support of the establishment of boundaries and limits; there is limited entry into most fisheries, and there is increased talk of inshore zoning.
- To increase communication and trust between scientists and industry, both parties have been pairing up to conduct research in the GOM (with monies from the Northeast Consortium since 1999, the Council, and NMFS).
- Improvement in technology has made tracking fishing effort much easier and faster, and cuts down enforcement costs. The scallop industry in the GOM has been using vessel monitoring systems (VMS). VMS use is thought by many to be the way of the future.
- The is an increase in effort to modify gear and reduce bycatch rates
- Education of the GOM is spreading. Ocean resource concerns are being televised and aired on the radio. In general, the public is better informed than it was 10 years ago, and there is more public involvement with MPA issues.
- There is more data to answer GOM ecosystem questions. Aside from consortium projects, GLOBEC, GOMOOSE, seascaping, and increased mapping efforts, there is an attempt to conduct a marine census for the whole Gulf of Maine (run by Woods Hole Oceanographic Institute)
- Currently an organization to investigate success of the Council process has been set in place.

Summary

New England's history of fisheries collapses and closures in 1966 and again in 1986 did not result in improved fisheries management despite the harsh lessons learned. One year after Clinton's executive order and 10 years after the lawsuit against NMFS, many managers, fisheries scientists, and industry members are beginning to agree that MPAs (no-take and partial take) can be a useful tool in fisheries management. Under the right conditions (i.e. correct spatial and temporal considerations with full support), no-take MPAs can and have resulted in restoration of commercial species, increased biomass and species size, spillover effects of commercial species into fishing areas, habitat restoration, and a place to study effects of undisturbed areas.

Industry has a lot to say about management and MPAs. If industry is to be included in this process as many agree they should, then there is much catching-up to do. To convince industry that no-take MPAs are a good idea, one needs to listen and integrate what industry is saying with what scientists have discussed. In some cases, the ideas are not that different. (i.e. from interviews and meetings attended, many fishermen are convinced we need to leave certain areas in the GOM alone and have pushed for the closures we now have.)

Under the right conditions, correct spatial and temporal considerations and with proper support), no-take MPAs can and have resulted in restoration of commercial and non-commercial species, increased biomass and species size, spillover effects of these species into fishing areas, habitat restoration, and a place to study effects of undisturbed areas.

In the Gulf of Maine, Marine Protected Areas (MPAs) are currently being proposed to address the efforts of fish and habitat restoration. Criteria listed for MPAs generally include the maintenance of biodiversity which can be best incorporated by preserving habitat, yet for almost all of the US EEZ, benthic data do not exist at the level or scale necessary to effectively utilize this criteria. World Wildlife Canada published a "seascape" map for the Scotian Shelf and the Canadian waters of the GOM (Day and Roff, 2000). The Conservation Law Foundation of Boston has a similar project nearing completion for the US waters of the GOM (Atkinson *et al.*, 2000). These seascape maps utilize such data sources as depth, surficial geology, and physical water properties like temperature, yet they are missing data which incorporate benthic organisms into their seascapes. Video analysis of megabenthos could partially address this gap.

The largest obstacle to making MPAs work in the Gulf is that of addressing the classic common property problem. Fisheries management in the GOM has a long way to go before meeting Ostom's criteria for successful governance of fisheries and MPAs

There have been some positive changes in the way people think and experience the marine resource realm. A shift in perception by the public as equal users in the CPR of the GOM has occurred only in the last 6-10 years. Consequentially, awareness and involvement in maintenance of the public resource of the ocean has greatly increased. Local organizations have formed around the idea of MPAs to counter the single-species/non-ecological management of the past. Modelers, economists, and scientists have held many MPA meetings to discuss the rationality of using MPAs to partially fill the ecosystem management requirement. Fishermen who initially fought MPAs of any kind have changed their minds after witnessing increasing population of commercial stocks due to the GOM closures. Although the focus for these closures was solely for fishery recovery and habitat preservation for spawning grounds, industry at least witnessed the spillover affect first hand, the argument for establishing a more permanent MPA system.

At the same time, there is momentum by local fishermen in Maine and the NEFMC to manage fisheries using local boundaries and incentives. Zoning is being discussed more frequently as a way to manage people along with the resources. Unfortunately, zoning may not be the answer to ecosystem-based management unless it proceeds the establishment of MPAs and the goals of ecosystem management

The challenge comes back to satisfying ecosystem-based management goals (preservation of ecosystems, fish and their habitats) versus single-species commercial fish goals (preserving commercial fish species to the exclusion of all else). Organizations like CLF and GOMMPAC are looking at the former, while NMFS is concerned with the latter. Meanwhile, independent organizations like Stonington Fisheries Alliance and NAMA have agenda that incorporates a little of both.

Organizations are thinking in a forward direction with regards to establishing clear boundaries, compliance incentives, and ecosystem management. However, groups are not working with each other to create a solution. Management is especially lacking in consistency at the moment. Groups are forming due to discontent over past fisheries management practices but they are not working together. A forum is badly needed for group process involving all stakeholders, with a governing group who can provide focus and support and a system of checks and balances to hold people accountable.

REFERENCES

Acheson, J. M. 1988. *The Lobster Gangs of Maine.* University Press of New England, Hanover, NH, 131 pp.

Acheson, J. M. and Brewer, J. F. (in press) Changes in Territoriality in the Maine Lobster Fishery. In: Dolsak, Nives and Elinor Ostrom, eds. *The Commons in the New Millenium: Challenges and Adaptation.* MIT Press, Cambridge, MA.

Agardy, T. 1995. The science of conservation in the coastal zone: new insights on how to design, implement, and monitor marine protected areas. *Proceedings of the World Parks Congress 8-21 Feb. 1992, Caracas, Venezuela.* IUCN, Gland, Switzerland.

Agardy, T. 1997. *Marine Protected Areas and Ocean Conservation.* Academic Press, Washington, DC, 240 pp.

Ames, E. 1997. *Cod and Haddock Spawning Grounds in the Gulf of Maine; from Grand Manan Channel to Ipswich Bay,* Report for Island Institute, Rockland, ME.

Ames, E. 2001. personal communication.

Anthony, V. C. 1990. The New England groundfish fishery after 10 years under the Magnuson Fishery Conservation and Management Act. *North American Journal of Fisheries Management* 10: 175-184.

Atkinson, J.P., Brooks, P.M, Chatwin, A.C., and Shelley, P. 2000. *The Wild Sea: Saving Our Heritage.* Conservation Law Foundation, Boston, MA. 120 pp.

Auster, P.J. 2000. Representation of biological diversity of the Gulf of Maine region at Stellwagon Bank National Marine Sanctuary. *Northwest Atlantic; Patterns of Fish Diversity and Assemblage Composition. Managing Protected Areas in a Changing World.*

Auster, P.J. 2001. Defining thresholds for precautionary habitat management actions in a fisheries context. *North American Journal of Fisheries Management* 21:1-9.

Auster, P.J. and Shackell, N.L. 2000. Marine protected areas for the temperate and boreal Northwest Atlantic; the potential for sustainable fisheries and conservation of biodiversity. *Northeastern Naturalist* 7(4): 419-434.

Auster, P.J., Malatesta, R.J., Langton, L., Watling, L., Valentine, P.C., Donaldson, C.L.S., Langton, E.W., Shepard, A.N., and Babb, I.G. 1996. The impacts of mobile fishing gear on sea floor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. *Review of Fisheries Science* 4: 185-202.

Auster, P.J. 2001. personal communication.

Babcock, R.C., Kelley, S., Shears, N.T., Walker, J.W., and Willis, T.J. 1999. Changes in community structure in temperate marine reserves. *Marine Ecology Progress Series* 189: 125-134.

Becher, B. 2001. Channel Islands Plan Delayed. *Sports Daily News*, Dec. 6 *www.dailynews.com/sports/articles/1201/06/spo13.asp.*

Benson, N.G. 1970. The American Fisheries Society, 1920-1970, pp. 13-24. In: Benson, N.G., ed. *A Century of Fisheries in North America.* American Fisheries Society, Washington, DC.

Bergen Declaration on Sustainable Development; the precautionary principle.1990 In: Appendix 4, Selected Statements of the precautionary principle/approach *www.aph.gov.au/senate/committee/clac_ctte/gene/e04app.doc.*

Bertness, M.D. 1999. *The Ecology of the Atlantic Shorelines*, Sinauer Associates, Sunderland, MA. 417 pp.

Bowman, R.E., Stillwell, C.E., Michaels, W.L., and Grosslein, M.D. 2000. Food of Northwest Atlantic fishes and two common species of squid. *NOAA Technical Memorandum NMFS-NE* 155:138.

Bray, J.R. and Curtis, J.T. 1957. An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographs*, 27: 325-349.

Carr, A. 1999. Trawl impacts vary depending on the bottom. *Commercial Fisheries News*, February, 10b-11b.

Casey, J.M. and Myers, R.A. 1998. Near extinction of a large, widely distributed fish. *Science*, 281:690-692.

Causey, B. 2001. The Hidden Gem of the Florida Keys. *Blue Planet Quarterly*; The Ocean Conservancy: 22-29.

Clark, C.W. 1996. Marine reserves and the precautionary management of fisheries. *Ecological Applications* 6:369-370.

Clarke, K.R. 1993. Non-parametric multivariate analysis of changes in community structure. *Australian Journal of Ecology* 18: 117-143.

Clarke, K. R. and Green, R. 1988. Statistical design and analysis for a "biological effects" study. *Marine Ecology Progress Series* 46: 213-226.

Clarke, K.R. and Warwick, R.M. 1994. *Change in marine communities: an approach to statistical analysis and interpretation.* Natural Environment Research Council, United Kingdom, 144 pp.

Cohen, E.B. and Langton, R.W. 1992. The ecological consequences of fishing in the Gulf of Maine. In: Townsend, D.W. and Larsen, P.F., eds. *The Gulf of Maine. NOAA Coastal Ocean Program regional synthesis series no. 1 Washington, DC*: NOAA Coastal Ocean Program. pp. 45-69.

Collie, J. S., Escanero, G.A., and Valentine, P.C. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. *Marine Ecological Progress Series* 155: 159-172.

Collie, J.S., Escanero, G.A., and Valentine, P.C. 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. *ICES Journal of Marine Science* 57: 987-1001.

Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs. *Science* 199: 1304-1310.

Connell, J.H. 1997. Disturbance and recovery of coral assemblages. *Proceedings of the 8th International Coral Reef Symposium, Panama* 1: 9-22.

Day, J. and Roff, R. 2000. *Planning for Representative Marine Protected Areas: A Framework for Canada's Oceans. World Wildlife Fund Canada,* Toronto, Canada,147 pp.

Dayton, P.K. 1971. Competition, disturbance and community organization: the provision and subsequent utilization of space in a rocky intertidal community. *Ecological Monographs* 41: 351-389.

Dayton, P.K. 1998. Reversal of burden of proof in fisheries management. *Science* 279: 821-822.

Dorsey, E. M. and Pederson, J., eds. 1998. *Effects of Fishing Gear on the Sea Floor of New England.* Conservation Law Foundation and the Massachusetts Institute of Technology Sea Grant College Program, 160 pp.

Dugan, J.E. and Davis, G.E. 1993. Applications of fishery refugia to coastal fishery management, *Canadian Journal of Fisheries and Aquatic Science* 50: 2029-2042.

Executive Order 13158, 2000. Marine Protected Areas Federal Register, Vol. 65, No. 105, May 31, 2000 *Presidential Documents, Executive Order 13158* of May 26, 2000.

Fletcher, K. M. and O'Shea S.E. 2000. *Essential Fish Habitat- Does Calling it Essential Make It So?* Environmental Law (Northwestern School of Law of Lewis and Clark College, Portland, Oregon): 51-98.

[FAO] Food and Agriculture Organization. 1997. *FAO Fisheries Department Review of the State of the World 1997a.*

Gilbert, D. 2001. personal communication.

Gilford, J. 2001. personal communication.

Gotceitas, V., Brown J.A., and Mercer, S. 1993. Substrate selection by Juvenile Atlantic Cod (*Gadus morhua*): effects of predation risk. *Oecologia* 93:31-37.

Gordon, H.S. 1954. The economic theory of a common property resource; the fishery. *Journal of Political Economy* 62:124-142.

Gore, A. 1993. *Reinventing Environmental Management: Accompanying Report of the National Performance Review.* U.S. Government Printing Office, Washington, DC.

Graham, H. W. 1970. Management of the Groundfish Fisheries of the Northwest Atlantic, pp. 249-262. In: Benson, N.G., ed. *A Century of Fisheries in North America*, American Fisheries Society, Washington, DC.

Gray, J.S. 1997. Marine biodiversity: patterns, threats and conservation needs. *Biodiversity and Conservation* 6:153-175.

Greene, G.H., Yoklavich, M.M., Starr, R. M., O'Connell, V. M., Wakefield, W.W., Sullivan, D.E., McRea, J.E. Jr. and Cailliet, G. M. 1999. A classification scheme for deep seafloor habitats. *Oceanologica Acta* 22 (6): 663-678.

Grime J.P. 1977. Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. *American Naturalist* 111: 1169-1194.

Gulf of Maine Aquarium. 2000. *Maine Groundfish Research Priority Discussions.* Gulf of Maine Aquarium, Portland, ME, 17 pp.

Hall, C.A.S. 1988. An assessment of several of the historically most influential theoretical models used in ecology and the data provided in their support. *Ecological Modeling* 43 (1-2): 5-31.

Hall-Arber, M. and Pederson, J. 1999. Habitat observed from the decks of fishing vessels. *Fisheries* 24 (6): 6-13.

Halpern, B. (in press). The impact of marine reserves: does size matter? *Ecological Applications.*

Hardin, G. 1968. Tragedy of the commons. *Science* 162: 1243-1248.

Hickson, T.J., Huston, Y., Lucero-O'Brien, and Rogers, D. 1998. *Evaluation of a Proposed Marine Protected Area along the Hague Line,* College of the Atlantic, Bar Harbor, ME, pp. 1-24.

Hinman, K. 2001. personal communication.

Hopkins, T.S. and Garfield, N. 1979. Gulf of Maine intermediate water. *Journal of Marine Research* 37(1): 103-109.

Howard, P. 2001. In: Walking the Plank. Molyneaux, P., *Fishermen's Voice* , 6(4) April 2001.

[IUCN] World Conservation Union website 2001, World commission on protected areas. *wcpa.iucn.org/.*

Johnson, T. 1999. *The 1999 Groundfish Report.* Maine Department of Marine Resources, Boothbay Harbor, ME, 63 pp.

Kaiser, M. and DeGroot, S.J. 2000. *The effects of fishing on non-target species and habitats, biological, conservation, and socio-economic issues.* Blackwell Science Ltd., Oxford, 399 pp.

Kelleher G. C., Bleakley and Wells, S. (eds.) 1995. *A Global Representative System of Marine Protected Areas. Volume I.* The Great Barrier Reef Marine Authority, the World Bank, and the World Conservation Union, Environment Department, the World Bank, Washington, DC, USA.

Kurkhill, P. 2001. personal communication.

Kruskal, J.B. and Wish, M. 1978. *Multidimensional Scaling.* Sage Publications, Beverly Hills, CA.

Massachusetts, Commonwealth of, 1964. *Special Report of the Department of Natural Resources relative to restricting use of beam or otter trawls, the appointment, powers and duties of shellfish constables, the control and eradication of dogfish, the taking of lobsters and the enforcement of certain laws relative to fish by local police.* Under chapter 43 of the resolves of 1963. No. 3703, Wright and Potter Printing Co., Boston, pp. 5-95.

McArdle, D.A., ed. 1997. *California Marine Protected Areas.* University of California, La Jolla, U.S.A.

(MPA) Marine Protected Area website, 2001. *www.mpa.gov/mpadescriptive/whatis.html.*

McGarvey, R. and Willison, M. 1995. *Rationale for a marine protected area along the international boundary between U.S. and Canadian waters in the Gulf of Maine. www.atlantisforce.org/willisn01.html.*

McHugh, J. L. 1970. Trends in Fishery Research. pp. 25-56 In: Benson, N.G., ed. *A Century of Fisheries in North America.* American Fisheries Society, Washington, DC.

Mountain, D.G. and Jessen, P.F. 1987. Bottom waters of the Gulf of Maine, 1978-1983. *Journal of Marine Research* 45: 319-345.

Murawski, S. 2001. Quantitative methods for MPA design, with application to the NE USA. In: Ocean Life Institute of the Woods Hole Oceanographic Institution, 2001. *The second symposium on Fisheries, Oceanography and Society: Marine Protected Areas: Design and Implementation for Conservation and Fisheries Restoration,* Aug. 27-29, Woods Hole, MA.

Musick, J.A., Harbin, M.M., Berkeley, S.A., Burgess, G.H., Eklund, A.M., Findley, L., Gilmore, R.G., Golden, J.T., Ha, D.S., Huntsman, G.R., McGovern, J.C., Parker, S.J., Poss, S.G., Sala, E., Schmidt, T.W., Sedberry, G.R., Weeks, H., and Wright, S.G. 2000. Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). *Fisheries* 25 (11): 6-30.

Myers, R. A., Barrowman, N.J., and K. R. Thompson. 1995. Synchrony of recruitment across the North Atlantic: an update. (Or, "now you see it, now you don't!"). *ICES Journal of Marine Science* 52: 103-110.

[NAMA] Northwest Atlantic Marine Alliance website, 2001. *http://www.namanet.org/press.htm*

[NEFMC] New England Fisheries Management Council, 2000a. *Essential Fish Habitat; The Designation of Essential Fish Habitat in New England,* Newburyport, MA. *www.nefmc.org*

[NEFMC] New England Fisheries Management Council, 2000b. *Summary of Current Multispecies Closed Areas and Exemptions, Amendment 13 options,* July 24, 2000.

[NEFMC] New England Fisheries Management Council website, 2001: *reconsideration of closed areas. www.fishresearch.org/RP_NEFisheries.asp.*

[NEFMC] New England Fisheries Management Council. 2001. *Report from the Groundfish Social Impact Informational Meetings.* pp. 1-63.

[NEFSC] Northeast Fisheries Science Center website, 2001a. Definition of fisheries technical terms. *www.nefsc.nmfs.gov/techniques/tech_terms.html#msy.*

[NEFSC] Northeast Fisheries Science Center website, 2001b. *Fisheries historical time line. www.nefsc.nmfs.gov/125th/timeline/1950.html.*

[NFCC] National Fisheries Conservation Center, 2001. You win some, you lose some: the costs and benefits of litigation in fishery management, *131st annual meeting of the American Fisheries Society,* Phoenix, AZ, 37 pp.

[NMFC] New England Fisheries Management Council. 1994, 1996. *Amendments 5 and 7 to the Northeast Multispecies Fisheries Management.* New England Fishery Management Council, Saugus, MA.

[NMFS] National Marine Fisheries Service website, 2001. *Status of Fisheries Resources off Northeastern US. www.nefsc.nmfs.gov/sos/spsn/species.html.*

[NRC] Natural Research Council. 1995. *Understanding Marine Biodiversity.* National Academy Press, Washington, DC.

[OLI] Ocean Life Institute of the Woods Hole Oceanographic Institution, 2001. *The second symposium on Fisheries, Oceanography and Society: Marine Protected Areas: Design and Implementation for Conservation and Fisheries Restoration*, Aug. 27-29, Woods Hole, MA.

Olafsson, E.B., Peterson, C.H., and Ambrose, W.G. 1994. Does recruitment limitation structure populations and communities of macro-invertebrates in marine soft sediments: the relative significance of pre- and post-settlement processes. *Oceanography and Marine Biology Annual Review* 32: 65-109.

Oliver, J.S. and Kvitek, R.G. 1984. Side scan sonar and diver observation of gray whale feeding grounds. *Biological Bulletin* 167: 264-269.

Ostrom, E. 1996. *Governing the Commons; The Evolution of Institutions for Collective Action.* Cambridge University Press, USA, 280 pp.

Packer, D. B., Watling, L., and Langton, R.W. 1994. The population structure of the brittle star *Ophiura sarsi* Lutken in the Gulf of Maine and its trophic relationship to American plaice (*Hippoglossoides platessoides* Fabricius). *Journal of Experimental Marine Biology and Ecology* 179: 207-222.

Paine, R.T. and Levin, S.A. 1981. Intertidal landscapes: disturbance and the dynamics of pattern. *Ecological Monographs* 51:145-178.

Parsons, T. 1996. Taking Stock of Fisheries Management. *Fisheries Oceanography* 5: 224-226.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., and Torres, F. Jr. 1998. Fishing Down Marine Food Webs. *Science* 279: 860-863.

Pilskaln, C.H., Churchill, J.H., and Mayer, L.M. 1998. Resuspension of sediment of bottom trawling in the Gulf of Maine and potential geochemical consequences. *Conservation Biology* 12: 1223-1229.

Raymond, M. 2001. In: Walking the Plank, Molyneaux, P. *Fishermen's Voice*, 6 (4) April 2001.

Rich, W. H. 1929. *Fishing Grounds of the Gulf of Maine.* Appendix III to the Report of US Commissioner of fisheries from 1929 BB Doc 1059, pp. 51-104.

Roberts, C.M., (in press). Benefits of fully-protected marine reserves for migratory species. *Reviews in Fish Biology and Fisheries.*

Roberts, C.M., and Hawkins, J.P., 2000. *Fully Protected Marine Reserves: a Guide.* World Wildlife Fund Endangered Seas Campaign, Washington, DC.

Roberts, C.M. and Polunin, N.V.C. 1991. Are marine reserves effective in management of reef fisheries? *Reviews in Fish Biology and Fisheries* 1: 65-91.

Rose, G.A. 1993. Cod spawning on a migration highway in the north-west Atlantic. *Nature* 366: 458-461.

Scott, A. 1993. Obstacles to fishery self-government. *Marine Resource Economics* 8: 187-199.

Shelley, P., Atkinson J., Dorsey, E., and Brooks, P. 1996. The New England fisheries crisis: what we have learned. *Tulane Environmental Law Journal* 9: 221-244.

Sinclair, A. F. and Murawski, S.A., 1997. Why have groundfish stocks declined? pp. 71-93. In: Boreman, J., Nakashima, B.S., Wilson, J.A., and Kendall, R.L. (eds). *Northwest Atlantic groundfish: Perspectives on a fisheries Collapse.* American Fishery Society, Bethesda, MD.

Southwood, T.R.E. 1977. Habitat; the template for ecological strategies presidential address to the British ecological society, *Journal of Animal Ecology* 46(2): 337-365.

SPSS Inc. 1997. *Sigma Plot 4.0 for Windows* [Computer Software]. Jandel Scientific, United States.

Steneck, R.S. 1996. Fisheries-induced biological changes to the structure and function of the Gulf of Maine ecosystem. *Proceedings of the Gulf of Maine Ecosystem Dynamics Scientific Symposium and Workshop,* pp. 151-165.

Thompson, P.E. 1970. The First Fifty Years-The Exciting Ones pp. 1-12 In: Benson, N.G. (ed). *A Century of Fisheries in North America,* American Fisheries Society, Washington, DC.

Townsend, D. 2000. personal communication.

Tupper, M. and Boutilier, R.G. 1995. Effects of habitat on settlement, growth, and postsettlement survival of Atlantic cod (*Gadus morhua*). *Canadian Journal of Fisheries and Aquatic Sciences* 52: 1834-1841.

[USGS] United States Geological Survey. 2000. *Open File Report 00-358 USGS East-Coast Sediment Analysis: Procedures, Database and Georeferenced Displays,* Woods Hole, MA.

[USM] University of Southern Maine, 2000. Website; Oceans Act 106th Congress 2nd Session S. 2327. *www.mli.usm.maine.edu.*

Watling, L. 2001. personal communication.

Webster's Deluxe Unabridged Dictionary, 1979. Simon and Schuster, New York, New York.

Wilson, J. (in press), In: Stern, P., Ostrom, E., Dietz, T. and Dolsak, N., eds. *Scientific Uncertainty, Complex Systems and the Design of Common Pool Institutions, in the Drama of the Commons.* National Research Council, Committee on Human Dimensions of Global Climate Change.

Witman, J. D. 1998. Natural disturbance and colonization on subtidal hard substrates in the Gulf of Maine. pp. 30-37 In: Dorsey and Pederson (eds). *Effects of fishing gear on the sea floor of New England.* Puritan Press, Hollis, NH.

Yentsch C.S, Campbell, J.W., and Apollino, S. 1995. The garden in the sea. pp. 61-76 In: Conkling, P.W., ed. *Cape Cod to the Bay of Fundy: an Environmental Atlas of the Gulf of Maine.* MIT Press, Cambridge, MA.

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Carolyn Skinder hails from Andover, Massachusetts. She attended the University of Massachusetts and the University of Oregon where she earned a B.S. in Psychology and Zoology and a Masters in Secondary Education in Biology.

Carolyn has spent her adult life on the West Coast, where she alternated between her passions for marine research and teaching. She left a career as Education Director on Santa Catalina Island to to pursue a Masters degree in Marine Policy in the Marine Science program at University of Maine, Orono, and at the Darling Marine Center, Walpole, Maine.

This thesis represents Carolyn's attempt to address the communication gap that exists between scientists, managers and the fishing industry over fisheries management practices in the Gulf of Maine. After receiving her degree, Carolyn intends to pursue work in marine outreach and cooperative extension programs to improve resource protection, education, and stewardship of our oceans. Carolyn is a candidate for the Master of Science degree in Marine Policy from The University of Maine in May, 2002.