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DISCUSSION PAPER SERIES

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Modeling Disaster: The Failure of Management of the New England Groundfish Industry

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Abstract:

Most of the worlds' marine fisheries are overexploited or endangered, including the New England groundfishery, once one of the world's most prolific. After 35 years of management, stock sizes and catches are lower now than ever. We argue that New England groundfishermen are caught in a prisoner's dilemma, from which they have failed to escape. We then suggest a set of policies to get these groudnfishermen out of their dilemma.

Introduction

The 21st century is opening on the specter of massive fisheries failure. Fully 69% of the world's marine fisheries are exploited at a level at or beyond the level corresponding to maximum sustainable yield (MSY) (Garcia and Newton 1997). One of those is the groundfisheries of the Gulf of Maine, once one of the world's most prolific fisheries. Groundfishing was the New World's earliest industry. Although this fishery has been under management for decades, the size of the stocks now is far smaller than it was when management began. What we are witnessing is both stock failure and management failure. In this paper, we will focus on answering the question: Why has groundfish management failed? As we shall see, groundfishermen are caught in a prisoner's dilemma, from which that have failed to escape. Until they do escape, this fishery will continue its downward spiral.

The Fishermen's Dilemma

Conservation lies at the heart of any fishery management scheme. To present the starkest choice imaginable, consider just two conservation rules. Conservation rule I stand for the status quo. For the New England groundfishery, think of this as the traditional overexploitation of the fishery. Conservation rule II represents a better management scheme—of the sort that has been sought since the 1970s, a story we tell below.

Consider a set of n fishermen. We normalize their payoffs from following conservation rule I to be zero. By contrast, if every fisherman follows conservation rule II, the benefit is b and the cost is c. Since conservation rule II represents better management, we have

$$b - c > 0 \qquad (1)$$

It pays if every fisherman follows conservation rule II.

If things were this simple, then the fishermen would just adopt conservation rule II and there would be no downward spiral. This is where the dilemma comes in.

Let x(i) be fisherman i's strategy, which takes on two values: x(i) = 1 if fisherman i follows conservation rule II, and x(i) = 0 if i follows conservation rule I. Finally, let X be the sum of the x(i). This notation suffices to track the strategies employed in the game.

Let u(i) be fisherman i's payoff function.

$$u(i) = (X/n)b - c \quad \text{if } x(i) = 1 \qquad (2)$$

$= (X/n)b$ if $x(i) = 0$.

The idea here is that the full benefit b of following conservation rule II is only achieved if everyone in the fishery follows that rule. Otherwise, the benefit is proportional to the number following the rule. If everyone follows conservation rule I, then $X = 0$ and the payoff for each fisherman is 0. There are two cases to consider, depending on whether $b/n > c$ or $b/n < c$.

When $b/n > c$, fisherman I has an incentive to follow conservation rule II even if no one else does. His payoff is $(1/n)b - c > 0$, which is better than conservation rule I pays. This inequality applies to every player, and the result is a Nash equilibrium x* of the game with $x^*(i) = 1$ for every fisherman. The benefit to conservation rule II is so great that every fisherman adopts it on his own. Unfortunately for the New English fishery, this is not the case that applies.

Now suppose $b/n < c$. Fisherman I has no incentive to follow conservation rule II if no one else does. since $(1/n)b - c < 0$, which he would get from following conservation rule I. So there is a Nash equilibrium x* with $x^*(i) = 0$ for all i. Plus, the same algebra applies to values of X greater than 0. So the Nash equilibrium we have identified is unique. This is the Prisoner's Dilemma the fishermen face: $x^*(i) = 0$ for all I is a strictly dominant strategy that leads to an inefficient outcome.

It is hard to get out of a prisoner's dilemma, as the experience of these fishermen will show. The most popular way theoretically is to let the players play the game repeatedly forever. In this case, if they are sufficiently patient, then there exists a Nash equilibrium supporting conservation rule II. Unfortunately, these fishermen don't have the luxury of infinity---the fish won't last that long. A way that often works experimentally is to let the subjects communicate with each other; they talk their way out of the dilemma. As we shall see, there has been no dearth of communication among all involved in this fishery, the dilemma persists. At the end of the paper, we propose a quite different maneuver from infinite play or communication, namely social preferences, which have proved promising in other contexts and might help the fishermen escape their dilemma here. We now take a detailed look at this fishery and its recent management history.

The Groundfishery and its Management

The groundfishery is very heterogenous. Not only are different types of gear used (trawls, gill nets, long lines), but the size of boats varies from 40-footers that go to sea for a day or two to

120-footers that remain at sea for weeks at a time. Electronic gear, fish-cooling apparatus, crew size, and vessel configuration also vary. Ground-fishing vessels are highly mobile and sell their catches in a number of ports. Some of the smaller boats concentrate on inshore grounds within 50 miles of their home harbors; the larger vessels roam widely over the Gulf of Maine and beyond. Crews of groundfishing vessels are part of a social network, but people in the network do not all interact, and many vessels fishing on the same grounds are from different harbors and have crews that scarcely know each other. Although biologists know that factors such as water temperature, salinity, and predation by mammals have played a role in the decline of groundfish stocks, there is a consensus among them that the major problem has been overexploitation by human beings (Sinclair and Murawski 1997).

Groundfishing was the New World's earliest industry, and what is present day New England played a prominent role in that industry (Lear 1998). In New England, catches reached their peak about 1860 (O'Leary 1996). Since that time, catches have varied, but the general trend has been downward (Ackerman 1941). Now, the entire Gulf of Maine only produces 6% of the fish that were produced in Blue Hill Bay of Maine in the 1860s (Alexander et. al. 2009).

Despite the long-term decline, throughout most of the history of the United States fisheries were managed by the states, which typically had few regulations on the groundfishery. There was no management at all of the offshore groundfishery in the northwest Atlantic until 1947 when the International Commission for the North Atlantic Fisheries (ICNAF) was formed. The commission had 11 signatories, including the United States, Canada, Great Britain, the USSR, and other European nations. Although ICNAF attempted to manage by allocating quotas, ICNAF regulations were not stringent enough, nor were they well enough enforced, to prevent over exploitation of the stocks (Acheson 1984).

In the 1960s , the Gulf of Maine was invaded by a large fleet of trawlers and factory ships that quickly overexploited stocks of herring, cod, haddock, hake, whiting, and flounder (Playfair 2003). By 1972, the groundfish stocks in the Gulf of Maine were so depleted that the foreign fleets left the Gulf of Maine (Acheson 1984).

The federal government of the United States began to manage the groundfisheries after the Fisheries Conservation and Management Act [FCMA] was passed by the U.S. Congress in 1976. This law gave the federal government authority to manage all fish species from the 3-mile line to 200 miles; the states retained the right to manage the waters from the beach to the 3-mile

line (Maine Commercial Fisheries 1973). The passage of this act was initially greeted with enthusiasm by fishermen, who believed it would end competition by the foreign fleets in the Gulf of Maine, and by conservationists and managers, who believed it would end overexploitation of badly depleted fish stocks. Within weeks of its passage, industry support for the law began to erode when fishermen discovered that the law gave the federal government power to regulate them. Implementation of this law went forward with increasing disillusionment and extreme resistance.

Under the FCMA, the United States and its territories are divided into eight coastal zones. Each zone has a regional council composed the heads of the state fisheries agencies from the states, a representative of the National Marine Fisheries Service (NMFS), a representative of the U.S. Coast Guard, and of representatives of the states, usually from the fishing industry, appointed by the governors of the states involved. The FCMA was designed to include fishermen in the councils so that the councils would have the benefit of their local level knowledge about the complex fisheries in each council zone.

The regional councils propose management plans for each species of fish to the Secretary of Commerce, who, with the advice of the NMFS, rejects or accepts these plans. Accepted plans are published in the Federal Register and are enforced by federal agencies, including the Coast Guard.

The policy of the federal government was to accomplish three goals. First, the establishment of the exclusive economic zone (EEZ), popularly known as the 200-mile-limit law, was designed to keep most foreign boats out of U.S. waters. Second, the federal government aimed to expand and modernize the fishing fleet, which resulted in the establishing the capital construction fund and the Fishing Vessel Obligation Guarantee Program (Apollonio and Dykstra 2008). Third, the federal government wanted to conserve fish stocks in the EEZ and passed the FCMA with this goal in mind. As we shall see, the policy was successful in removing the foreign fleets from U.S. waters and in building up the U.S. fishing fleet. Attempts to conserve the fish stocks, however, have been an abject failure.

Groundfish management has been enormously complicated. Many plans have been tried, involving virtually every kind of management tool from quotas and gear restrictions to seasons and closed areas. The management plans have been modified in several ways. In addition, the U.S. Congress has updated the enabling legislation twice. The political process of changing these

various plans involved different combinations of groups and organizations with different interests. The New England Regional Council, the NMFS, factions of fishermen, conservation groups, members of the U.S. Congress, local politicians, scientists, and the courts all played a role in devising and changing those plans. Unfortunately nothing seems to have worked. Groundfish stocks are in worse shape today than they were when management began.

It would take several volumes to discuss every facet of groundfish management in detail. In this section, we will cover only the most important groundfish management plans, the political pressures bringing them about, the management tools employed, and the results.

Three-Month Quota Plan (TMQ): 1977-1979

Under the FCMA, the first management plan on the most important species of groundfish (i.e., cod, haddock, and yellowtail flounder) went into effect in March 1987. The TMQ plan was drafted by the NMFS with no input from the council, a highhanded action that presaged trouble between the two (Dewar 1983). The management tools employed were seasonal quotas and trip quotas. A catch quota was established for each species for a three-month period, and when the quota was reached, fishing was halted. No limited-entry system was imposed; anyone who wanted a license got one.

The TMQ plan created a good deal of opposition in the industry, due in great part to the fact that the regional council used its closure powers repeatedly so that one day it would be legal to catch fish, the next day it would not. Rules changed so rapidly that a crisis atmosphere was created, and fishermen had a hard time keeping up with them (Barlow 1978). The fishermen not only lobbied against the TMQ plan, but also cheated massively (Acheson 1984). By the summer of 1979, many fishermen and council members had to admit they did not know how many fish were being caught; the TMQ was a failure.

After several months of discussion, the council decided to impose an “interim plan,” which was intended to last only for a short time until a permanent plan could be put in place. Its main features were mesh size regulations, minimum fish sizes, and closed areas on spawning grounds (Barlow 1980; Morrison 1980). The interim plan was put into effect in 1982 and lasted until 1986.

Development of the Atlantic Demersal Fisheries Plan Plan

In 1980, even while the interim plan was in effect, the regional council began to develop a radically different plan that they hoped would be more effective. The plan abandoned the idea of using quotas, which had proven to be impossible to enforce, and proposed rules that promised to be more acceptable to the industry.

1n 1985 the Atlantic Demersal Fisheries Plan (ADF) was proposed by the council. It included mesh sizes, closed areas, and seasonal limits—the kinds of rules that had the most support in the industry (see section on attitudes below) (Stevens 1985). It was the result of years of discussion in which council members were heavily lobbied by various industry groups.

In March 1986, the NMFS "completely disapproved" of the plan and directed the New England Regional Council to develop a new plan giving "serious consideration to a quota system, limited entry, and a larger minimum fish and mesh sizes" (Stevens 1986a:1A). The industry was outraged. The council stuck to its guns and insisted that its plan was a good one, and after a few months the NMFS gave partial approval of the council's plan for a year (Stevens 1986b). At that point the NMFS and the Secretary of Commerce began to develop their own groundfish plan (Stevens 1987). NMFS officials stated that their plan would not be put into effect if the council could develop a plan that would conserve groundfish.

This situation posed a jurisdictional dispute. The council assumed that it had the authority to manage the fishery; the NMFS assumed it had ultimate authority, including the right to promulgate plans when it deemed council action inadequate. Politicians, particularly the congressional delegations from Massachusetts and Rhode Island, sided with the council and the industry and requested that the NMFS cease development of any secretarial plan (Studds and Young 1987). The NMFS complied, but the resulting plan was, in the words of one NMFS official, "very watered down."

In 1988, within two years after the ADF plan was put into effect, a new stock assessment showed that the cod stock was in serious trouble due to high fishing effort (New England Fishery Management Council 1988). The technical monitoring group "recommended slashing effort by more than 50%" (Stevens 1989:46). At this point, the council began to appreciate the seriousness of the situation, but it still acquiesced to the demands of industry for lenient rules (Stevens 1988).

The ADF in the Last 20 Years

Since the ADF plan was put into place in 1986, it has been extended by 16 amendments (major changes) and 44 frameworks (minor changes). Each amendment put new restrictions on fishing in response to evidence of stock failure. The most important amendments are described in Table 1.

226 Table 1. Atlantic Demersal Finfish Plan, Key Amendments

Amendment	Date Passed	Management Mechanism Used	Impetus for Passage
5	1993	Moratorium on new vessel permits; changes in mesh sizes; two large closed areas on Georges Bank; established a days-at-sea program (to limit the number of fishing days each vessel was allowed to fish) (New England Fishery Management Council 1992).	Conservation Law Foundation 1991 lawsuit (New England Fishery Management Council 1992).
7	1996	Objective was to cut fishing effort for cod, haddock, and yellowtail flounder by reducing total allowable catches, setting trip limits, and reducing days at sea.	Stock assessment showed need to cut effort by 80% from 1993 levels (Apollonio and Dykstra 2008: Plante 1996a)
9	1998	Established a new definition of overfishing; set new management goals for 12 groundfish species.	Cut effort to bring plan into compliance with the Sustainable Fisheries Act of 1996 (Plante 1998c)
13	2003	Habitat protection; new stock rebuilding timetables; days-at-sea program, with A, B, and C days.	Conservation Law Foundation 2002 lawsuit (Hall-Arber 2006; Commercial Fishery News 2003).
16	2010	Sectors (plan would allow groups of fishermen to get an allocation of fish and promulgate their own rules to allocate it among themselves) and annual catch limits	Widespread recognition that Amendment 13 was not working

Increasing Fishing Effort and Declining Catches

The job of the council and NMFS was made more difficult by actions of the federal government, which increased the number of boats and vessel tonnage in the Gulf of Maine. (Apollonio and Dykstra 2008). In 1977, 1,200 licenses were issued, whereas in 1979, the number was increased to 2,191—an 83% increase (Acheson 1984). Federal loan programs facilitated the entry of new vessels.

Changes in the international boundary also increased fishing pressure. In 1984, the International Court in The Hague drew a new international boundary between the U.S. and Canada in the Gulf of Maine that excluded American fishermen from waters they had used for centuries, including the Grand Banks, the Gulf of Saint Lawrence, Labrador, and even parts of the Gulf of Maine. American vessels crowded into the in-shore waters of the Gulf of Maine, where, by 1986, they considerably reduced the stocks of groundfish (Lannin 1988). While the NMFS and the council were attempting to limit fishing effort, the actions of the international court and the loan agencies had the opposite effect (Acheson 1984).

From 1984 to 1988 severe reductions in total catches were experienced as stocks became overfished (Figure 1). The catches of many species declined 30% to 50% between 1982 and 1988 (Lannin 1988). Stocks reached their lowest point in 1994, explained population dynamicist Vaughn Anthony, because “the spawning stock has collapsed” (Plante 1994:11A). Stocks have remained low ever since despite all attempts by the council and NMFS to revive them. As stricter regulations have gone into effect, effort has declined also. In 1960, there was no limit on the number of days that a vessel could fish; by 1994 boats were restricted to 88 days at sea, and by 2009, some boats were restricted to 20 days fishing per year (Bangor Daily News 2009). Declining catches and ever more stringent effort restrictions have produced a precipitous decline in the number of boats in the New England groundfish fleet, from 343 in 1978 to 50 in 2009 (Acheson et al. 1980; Mack 2010).

Lately, management efforts may be bearing fruit. In 2007, NMFS scientists announced that “cod were no longer overfished” (Plante 2008:8A).

Political and Other Factors

A number of political factors have affected groundfish management.

Industry Opposition

The industry lobbied the council continuously to get rules it could live with, but failed. As a result, every action of the council, the NMFS, or the Secretary of Commerce met with political agitation: heated hearings, visits from congressmen, letters to newspapers and public officials (Miller and van Maanan 1979). Members of the council admitted to feeling threatened—particularly in the late 1990s when council meetings became especially ugly. Every amendment was challenged by lawsuits by fishermen against officers of the NMFS or the Secretary of Commerce (Plante 1996b, 1999). Sometimes these pressure tactics worked to reverse council and NMFS management decisions.

Industry Factions

The groundfishing industry is divided into a number of factions that rarely can attain consensus. One group would work for management goals that would benefit it at the expense of other types of groundfishermen (Plante 1998a, 1998b). The conflict between small and large boat owners over Amendments 13 and 16 was especially bitter. As a result, the industry as a whole could rarely unite to promote or oppose any management measure.

Cheating and Enforcement Problems

There has always been as good deal of cheating. The TMQ plan (1978-1980) failed in great part because of massive law enforcement problems, and widespread cheating continues today. King and Sutinen (2010:7) estimate that "from 12 to 24% of the total harvest is taken illegally." This has an adverse effect on the health of the stock. King and Sutinen (2010) report many fishermen believe illegal fishing will prevent them from ever benefiting from stock-rebuilding programs.

Long-Delayed Action

Management plans developed slowly. One factor was extreme bureaucratic complexity—a "paperwork nightmare" according to Apollonio and Dykstra (2008:73), which required years to complete all legal and federal bureaucratic procedures. In addition, the jurisdictional conflict between the council and the NMFS delayed the development of the interim plan and the ADF plan for several years. Industry opposition and lawsuits also contributed to

delay. Council members who were fishermen were especially susceptible to industry pressure to move slowly. John Williamson, a fishermen member of the New England Regional Council, said: "There was often a coalition for taking it easy. Keep things moving in the right direction, but go slow" was their motto. After 1992, much of the council's ability to set its own timetable was reduced by the two Conservation Law Foundation lawsuits, which meant that the development of Amendments 5 and 13 was set by the court (Plante 1991). The reauthorizations of the FCMA, which gave greater power to the NMFS, added further delay (Stevens 1995, 1996). Even between 1977 and 1994, when management decisions were primarily in the hands of the council, effective rules to reduce fishing effort were slow in coming. It was in this period that stocks fell precipitously (see Figure 1). One NMFS scientist said that delay permitted stocks to fall far more than they would have had stricter rules been imposed earlier.

Summary of Council Politics

In reality, the New England Regioanl Council was pushed in many different directions by groups ranging from industry factions and scientists to NMFS administrators and the courts. Self interest, loyalty to friends in the industry, scientific data, court orders, the wishes of bureaucratic and political superiors, and genuine concern for the common good, all played a role in influencing the decisions of New England Regional Council members. Sometimes the council responded to an organization or coalition from below, while at other times it responded to pressures from above.

However, a number of observers have argued that the composition of the New England Regional Council doomed it to failure. Eagle et al. (2003) argue that council members who are fishermen stand to gain financially from council decisions and have significant conflicts of interest (Weber 2002). This type of organization puts the fox in charge of the hen house. On the whole, the council system has not worked well in New England. However, it is difficult to make the case that having fishermen on the councils is the reason for that failure. The majority of people on the New England Regional Council are not fishermen, and the fishermen do not vote as a block, nor do they always vote with their own self interests in mind (Apollonio and Dykstra 2008). If the council had been captured by the industry, then the industry should have gotten the rules it wanted from the council. This did not happen. Indeed, some rules passed by the council

were exactly those that the industry opposed (e.g., quotas and the days-at-sea program of Amendments 5 and 13).

While many of the factors leading to management failure in the New England groundfishery are political, there were other important factors that played a role.

Technical and Biological Characteristics of the Fishery

Some resources are easier to manage than others (Schlager et al. 1999; Ostrom 2000a). The combination of fishing technology and biology of the species involved make groundfish particularly difficult to manage. Groundfishing gear is highly unselective. Ottar trawls take all sizes of fish, including juveniles and those with eggs. When groundfish are hauled to the surface from any depth, their swim bladders break and they die. A high percentage of all fish caught in ottar trawls and gillnets, the most commonly used techniques, come aboard dead.

Science and the Views of Fishermen

Groundfishermen have little faith in the quality of science behind fisheries management plans. In our 2009 survey of people who had held groundfishing licenses in the 1970s, we asked them to respond to the statement: "I have faith in the quality of federal science." Of the 96 people who responded, only seven (7%) agreed, whereas 67 (68%) disagreed. There are two reasons for lack of faith.

First, the fishermen view the ocean differently from scientists. Groundfishermen see the ocean as a chaotic environment, in which fish stocks change rapidly and unpredictably in response to a variety of factors. Fishing effort is only one factor affecting the size of stocks, and in the view of fishermen, it may not be the most important one. From the fishermen's perspective, the goal of management should be to protect fish in vulnerable parts of their life cycle, (i.e., to protect small fish, gravid fish, and essential spawning and nursery grounds) by enacting mesh-size regulations and/or closures (Acheson and Wilson 1996). Scientists, by contrast, view management in terms of stock-recruitment models, which posit a mathematical relationship between fishing effort, the size of the breeding stock and recruitment. The size of the stock can be managed by controlling fishing pressure by human beings. Thus, they favor management by quotas, days at sea, license limits, and other strategies to limit the number of fish caught. From the perspective of fishermen, this approach is doomed to failure.

Second, fishermen do not believe that scientists know how many fish there are. Because fishermen often come upon large concentrations of fish, they base their judgment on those and assume that there are far more fish available than scientists say. Fishermen also distrust the methods scientists use to collect fish population data (Commercial Fisheries News 2002). Despite their skepticism, however, the stock assessments behind groundfish management were reasonably good. To be sure, modeling fish stocks is difficult, but an independent peer-review panel said that the work of the NMFS's laboratory at Woods Hole was "scientifically sound" (Plante 2003a). With rare exceptions, the scientists have said that most groundfish stocks have been overfished. They were almost certainly correct.

There are serious questions about the management rules that have been imposed. Some analysts argue that the conservation of the groundfish stocks would be better served if the rules focused on conserving the fish in vulnerable parts of their life cycle (e.g., breeding stock) rather than just cutting effort on all fish (Acheson and Wilson 1996). Others argue that groundfish are concentrated in local stocks so that management efforts need to be at a smaller scale. Rules designed to manage stocks in the entire Gulf of Maine set up the wrong incentives (Steneck and Wilson in press).

In a 1978 survey of fishermen, we asked "What kinds of regulations would you approve for your section of the industry?" We received a total of 72 different answers. These answers are coded and summarized in Table 2.

Table 2. Regulations Preferred by New England Groundfishermen in 1978

Regulation	Maine and N.H.	Mass and R.I.	Total
No regulation	22 (11.5%)	41 (32.0%)	63(19.8%)
Limited entry	8 (4.2%)	11 (8.5%)	19 (5.9%)
Closed area or season	20 (10.5%)	4 (3.1%)	24 (7.5%)
Mesh size rules	18 (9.4%)	10 (7.8%)	28 (8.8%)
Import quotas	17 (8.5%)	0 (0%)	17 (5.4%)
Ban efficient gear	9 (4.7%)	2 (1.5%)	11 (3.4%)
Help marketing	9 (4.7%)	0 (0%)	9 (2.8%)
Ban foreign boats	7 (3.6%)	6 (4.7%)	13 (4.0%)
Less government	2 (1.0%)	6 (4.7%)	8 (2.2%)
Quotas	2 (1.0%)	7 (5.4%)	9 (2.8%)
Lobster regulations[a]	23 (12%)	18 (14%)	41 (12.8)
Gov't loans and aid	35 (18.4%)	13 (10.1%)	48 (15.0%)
No information	18 (9.4%)	10 (7.8%)	28 (8.8%)
Total	190	128	318

[a]Some of these skippers were engaged in both groundfishing and lobstering during the annual round. These people were more concerned with lobster regulations than groundfishing rules; virtually all favored lobster trap limits or a change in the lobster size regulations. Source: Acheson 1984.

We can draw several conclusions about the attitudes of groundfishermen from these data, conclusions that give insight into the difficulty the council faced in crafting a plan acceptable to the industry.

First, many fishermen wanted no regulations and said they did not believe any were needed. Fully 20% said they wanted "no regulations."

Second, although the majority admitted that some kinds of rules were needed, there was no consensus on what regulations should be devised. Moreover, there was a good deal of variation on the kinds of regulations preferred in different parts of New England. The rules that were favored by the largest percentage of fishermen in New England as a whole were mesh sizes and closed areas and seasons, followed by limited entry and rules to limit the efficiency of fishing gear.

Third, there was no support for the kinds of regulations that the regional council and NMFS had put in place in the first plan. Only 1% said they wanted a quota. More fishermen preferred rules on how fishing was done rather than how much fishing could be done.

A large number of the fishermen interviewed recognized that the stocks were in difficulty, but they had serious doubts about the ability of the government and political system to solve the problems faced by the industry. They were pessimistic about the future of their industry and the ability of the government to address its problems.

Although this study was done more than 30 years ago, the conclusions drawn from it apply today. A 2009 study by Acheson of 102 people who were in the groundfishery in the 1970s gives additional insights into the attitudes of groundfishermen. The majority of these people had left the industry; only seven of those in groundfishing in the 1970s were still in the fishery at the time of the survey. When asked about why they left groundfishing, 68% answered that they could not earn an adequate income in groundfishing. Some said "no fish"; others said "poor income in groundfishing"; and still others blamed "the management system," which prevented them from catching what fish they could.

When asked whether they would like their children to enter groundfishing, only 17% said "yes," whereas 51% said "no." When asked whether they agreed with the statement "I have faith in the quality of federal science," only 7% agreed or strongly agreed, and 68% did not agree or strongly disagreed. Sixty-one percent agreed or strongly agreed with the statement "the state of the groundfishery is bad" and only 20% disagreed or strongly disagreed with the statement. In short, these fishermen were pessimistic about the fishery, and the state of federal science. Most did not want their children to enter the business even though many of them come from families that have been in groundfishing for generations.

Not surprisingly, advocates for the large boat fleet tell a different story. In testimony before the Marine Resources Committee of the Maine Legislature, a lobbyist stated, "groundfish populations today are more robust than they have been in decades.… The New England groundfish industry is losing its economic viability because restrictions do not permit the full harvesting of the total allowable catch" (Raymond 2007). Despite decades of scientific evidence of severe stock decline, and hundreds of boats leaving the fishery, big boat owners want to harvest groundfish stocks more heavily than regulations allow. Such groundfishermen do not care about fish stocks in the long run. They want to harvest enough fish to stay in business as

long as possible, and they hope the stocks of fish will last. Some fishermen have a more predatory attitude. One said in an interview, "I want to take them [the fish] now. They are not going to be here in the future."

The Downward Spiral

A number of different management plans, ranging from quotas and gear restrictions to seasons, closed areas, days at sea, and sectors, have been tried on the groundfishery. Unfortunately, nothing seems to have succeeded.

When management began in 1977, the stocks were already at low levels and fishing pressure was high. Stocks were further devastated by the invasion of large boats after imposition of the Hague Line in 1984. Fishing pressure on the stocks was increased further by the federal loan programs designed to build up the U.S. fleet, and the unselective fishing technology along with the biology of the fish leads to high mortality on all fish caught. Since the rules governing the groundfishery were not those that fishermen would have chosen, and fishermen were convinced these rules were costly, unenforceable, ineffective, and based on a false scientific model of how the ocean works, they responded to the rules with opposition, lawsuits, and a massive amount of illegal activity. This opposition, combined with bureaucratic complexity and jurisdictional disputes with the NMFS, caused the council to stall in imposing effective rules (Apollonio and Dykstra 2008). This delay was probably deadly.

Groundfishermen have a short-term perspective. Faced with falling stocks and ineffective management, they are not inclined to invest in conservation rules that have no assurance of working. Rather, they focus on staying in business in the short run and hope stocks will not be unduly damaged by fishing. Some have a gold rush mentality, with all that implies for a high discount rate strategy. The widespread cheating further undermines conservation efforts: those who conserve fish are sacrificing, while the rewards are being taken by the "free riders."

Groundfish management follows a familiar pattern. Scientists issue a stock assessment indicating that the stocks have fallen and tighter regulations are needed. The New England Regional Council and the NMFS, after years of deliberations and negotiations, put out new regulations. These are strongly opposed by the industry. After a time, the regulations prove ineffective, stocks decline further, and the pattern is repeated. The failure reinforces the ideas

that groundfishermen have about the poor quality of science and the ineffectiveness of the rules. A gold rush mentality, political opposition, ineffective regulations, and stock decline follow each other in an ever more desperate downward spiral.

Escape from the Fisherman's Dilemma

We remain optimistic that the downward spiral of the New England fishery can be stopped. To that end, the fishermen need to escape from their dilemma and choose a better conservation rule than the status quo. What would accomplish that is a thorough makeover of their attitudes to conservation. The technical term for that is "social preferences," where a player's payoff no longer depends just on his or her economic result, but more broadly on the overall outcome.

To see the effect that social preferences can have on the fisherman's dilemma, consider the amended payoff function:

$$u(i) = x(i)[\ (X/n)b - c\ ] \qquad (3)$$

If $x(i) = 1$, this is the same as equation (2), but if $x(i) = 0$, it is different.

One way to express the difference is in equation (2) a fisherman gets full credit for free riding on the conservation efforts of the rest. In equation (3), by contrast, a fisherman gets no credit for free riding on the conservation efforts of the rest. Another way to express the difference is, "We are all in this together. Either we adopt conservation rule II and get the full benefit, or we don't. And those who don't get excluded from that benefit." In that way, (3) expresses a form of solidarity.

Let's look at the Nash equilibrium of (3), in the case when $b/n < c$. We still have the prisoner's dilemma equilibrium $x^*(i) = 0$, where every fisherman chooses the conservation rule I, the status quo. However, one now has a good Nash equilibrium also, namely $x^*(i) = 1$. This pays $b - c > 0$ to everyone. If player 1 deviates to $x(1) = 0$, he gets payoff 0 which is less. Hence, we have the good Nash equilibrium.

What about between these two Nash equilibriums, one with $X = n$ and the other with $X = 0$?

One can show that there exists a unique integer m, such that:

For $X > m$, deviation from $x(i) = 1$ does not pay and so best response dynamics leads to the good Nash equilibrium.

For $X < m$, deviation from $x(i) = 0$ does not pay and so best response dynamics leads to the bad Nash equilibrium.

The New England groundfishermen have not escaped from their dilemma. Their situation stands in stark contrast to that of New England lobstermen, whose fishery is well managed and sustainable—no downward spiral there. A conservation ethic has played a key role in that fishery, as we argue elsewhere (Acheson and Gardner 2009).

The groundfishery and the governance structure used to manage it have many of the characteristics that rational choice theory predicts will lead to an inability to devise effective rules to solve collective action problems.

First, it is axiomatic among rational choice theorists that characteristics of the community involved play an important role in the development of norms and rules. People will be more likely to provide themselves with rules leading to joint benefits if they know each other's past performance, if the game is played repeatedly, and if the rules can be enforced (Elster 1989; North 1990; Ostrom 1990; Taylor 1990; Knight 1992; Ostrom 2000a, 2000b). Under these circumstances, people know who is likely to cooperate, can monitor behavior, and can sanction shirkers. For this reason, norms and rules are more likely to be produced by people in small, homogenous communities with a long history and a sense of community. Yet the groundfish industry has virtually none of these characteristics. Fishermen are scattered throughout New England and comprise a loose social network. Most do not know many other people in the industry, and they certainly do not form a community with a long history. Groundfishermen are heterogeneous. They fish for different species with different types of gear from different sizes of boats that stay at sea different lengths of time. There is also ethnic heterogeneity. As a result, it is virtually impossible to frame rules that everyone considers fair. Different factions have lobbied the regional council to get rules that benefit them at the expense of other factions of groundfishermen. There is nothing unusual in this situation (see Knight 1992), but these factional disputes have made it impossible for the industry to present a united front and has caused a good deal of conflict, particularly in the development of Amendments 13 and 16.

Second, rational choice theorists have considerable evidence that effective resource management rules are likely to arise if local-level communities have a hand in developing the rules (Ostrom 2000b). People who are allowed to play a role in developing resource management rules will promulgate rules they consider effective in conserving the resource when they do not

impose undue costs. Such rules can be self-enforcing. The rules put in place to manage the groundfishery were put in place by the regional council, which was pushed in many different directions by the NMFS, judges, the U.S. Congress, scientists, conservationists, and industry factions. This is the antithesis of local participation.

Third, the discount rate reflects people's assessment of probable future gains. If individuals do not gain the benefit of norms, they will not support efforts to generate them (Knight 1992). This means that if effective resource management rules are to be established, they must allow those who make the investment in the resource to benefit from that investment. If it is unlikely that resources will be there in the future or if efforts to invest in resources are likely to fail, there is little incentive to sacrifice current harvests for future rewards. Eric Alden Smith (2003: 421) neatly phrases the dynamics of this situation: "higher payoffs from cooperative production mean a greater incentive to solve collective action problems, to ensure any needed coordination, and counter free riding."

In the groundfishery, catches had been falling for decades, and fishermen were sure that the managers were using strategies that would be ineffective so that stocks would not likely increase. Under these circumstances, fishermen have every incentive to take the fish stocks now.

What Rational Choice Theory Does Not Explain

There are several factors that play a role in the failure to effectively manage the New England groundfish industry that have not been adequately studied by the rational choice theorists or other social scientists interested in institutional failure. Among the most prominent of those are delay and timing problems, technical and biological factors, and the scale at which management is attempted. Moreover, much of the literature on devising rules is devoted to understanding the conditions under which user groups will develop rules at the local level (i.e., self regulation) (see Ostrom 1990). Less attention has been devoted to the role of government, bureaucracy and jurisdictional infighting. Last but not least, are ideational issues. The rational choice literature recognizes that values, cultural models, and ideology play a critical role in the development of norms and institutions (North 1990). Recently a growing body of literature is developing on this subject (e.g., Fehr and Gachter 2000; Henrich and Henrich 2007), which suggests that if the groundfishery is going to develop norms and institutions to manage the resource, it will have to undergo a change in culture. Congruently, in resource management

546 circles there is a growing conviction that successful management depends, in great part on
547 fostering a sense of stewardship or a "conservation ethic." How such conservation ethics develop
548 is a complicated matter, involving the interaction of a variety of variables over time (see
549 Acheson and Gardner n.d). Certainly no such ethic has developed in the groundfish industry.
550 This suggests that rational choice theory may need to be extended and modified to take such
551 factors into account if it is going to succeed in explaining the development of rules and
552 institutions to manage resources.
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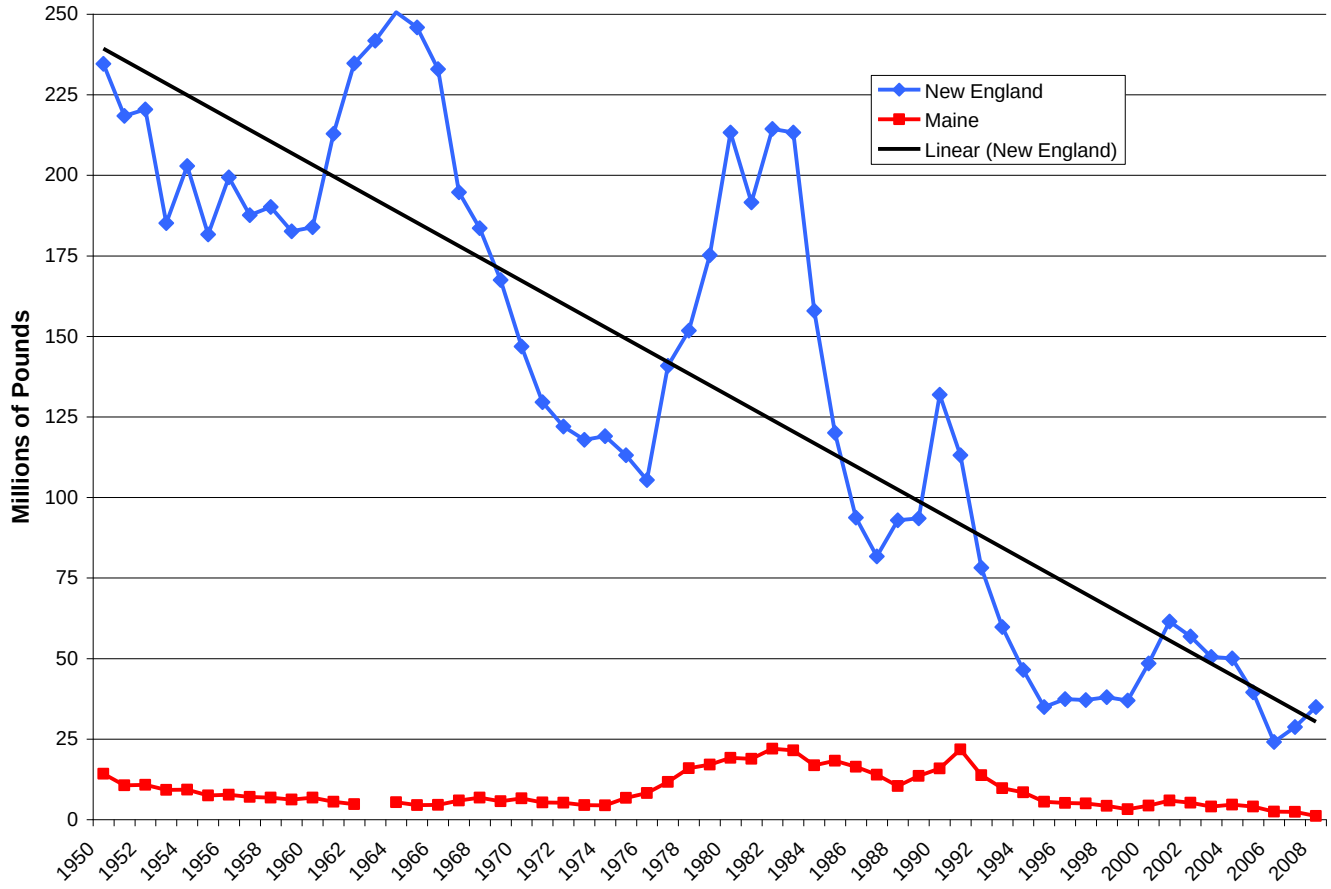
Figure 1. Catches of Cod, Haddock, and Yellowtail Flounder, Maine and New England, 1950-2008 (millions of pounds)



Source: Author's chart, landings information generated from www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html