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Discussion paper

An Overview of Empirical Analysis of Behavior of Fishermen Facing New Regulations

BY

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An Overview of Empirical Analysis of Behavior of Fishermen Facing New Regulations

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> The biological resources of the sea have long fascinated man. The mystery of what lies beneath the surface has stimulated his imagination and nurtured hope that in this vast area there are resources capable of feeding a growing and a still hungry population for centuries to come. But, at the same time, realization of this hope is impeded by the opacity, instability, and sheer magnitude of the medium itself–by man's inability to see and hold. Fishing–one of man's earliest callings–is still haphazard and subject to the vagaries of weather, ocean currents, and mysterious migrations (Christy and Scott, 1965, p. v).

1 Introduction

In a broad sense, the topic of this lecture covers much of empirical research in fisheries economics. What happens in a fishery upon a change in regulation? When regulations change in fisheries, the changes depend on an array of factors, from environmental and biological factors to economics and social factors. Fishermen's response to changes in regulations are thus intimately connected to all relevant factors, and changes in regulations should be interdependent with fishermen's response. Upon such reflections, the topic is clearly connected to the fundamental, empirical question What happens in fisheries upon changes? So, everything is connected, and in order to understand the empirics of fisheries economics, I need to establish what has become known, among other things, as the Fisheries Problem. From there, I will discuss evidence of rent dissipation and inefficiency in fisheries, before I move on to rights-based management and related evidence. I will also discuss more recent ideas on self-governance and spatial behavior.

The title of the lecture uses the word 'behavior' and its presence requires some discussion. It makes me think about behavioral economics. Behavioral economics relies heavily on experiments, but has recently broadened its methodological scope to use most common methods in modern economics (Camerer and Loewenstein, 2004, p. 7). Behavioral economics concerned with fishermen is quite limited, but some fishermen experiments have been carried out. The experiments are mostly concerned with risk preferences, perhaps as a reaction to the seemingly popular idea of risk loving fishermen.

In a limited discussion like this, I cannot address all aspects of the question What happens in in fisheries upon changes? The main focus will be on fishers responses to regulations in change, but in places I have found it necessary to discuss responses more generally.

2 The Fisheries Problem

The fundamental problem in fisheries was recognized already in 1911 by the Danish economist Jens Warming (see Warming, 1911). He wrote in Danish, however, and his ideas remained unknown for many years; his seminal 1911 paper was first translated into English in the nineteen eighties (Andersen, 1983).

Not until 1954, with Gordon's 'The Economic Theory of a Common-Property Resource: The Fishery' (Gordon, 1954), did economic analysis of fisheries really begin (Squires, 2009, p. 638). Gordon established a model of rent dissipation under open access which made it clear that the fundamental reason for overfishing and overcapacity in fisheries is the lack of property rights (Gordon, 1954, pp. 130 - 131). The idea is simple; as long as there is a positive rent in a fishery with open access, new fishermen will enter until the rent is dissipated. Put into the economist's language, excess effort enters until average rather than marginal product equals opportunity costs (Wilen, 2000, p. 308). The allocation of inputs would be inefficient; each fisherman has an incentive to catch as much fish as possible as fast possible, before anybody else catches it.

Gordon also pointed out that the maximum physical yield as a management objective promoted by biologists overlooks the fundamental issue in common properties (1954, p. 136). Economists are still working to convince biologists and marine scientists of the true nature of the Fisheries Problem; unwanted incentives from incomplete property rights. (See Wilen (2006) for a recent attempt.) Notwithstanding, Squires (2009) claims that Gordon's insight about incentives

> . . . has been the central contribution of fisheries economics to fish-

> eries management, and its concepts and ideas have widely diffused to other social sciences, fisheries science, conservation biology and ecology, industry, governments, and international organizations, and are even starting to make inroads into the thinking of conservationists (p. 638).

A perhaps more well-known description of the commons problem is Hardin's 1968 article 'The Tragedy of the Commons,' published in Science. He writes

> Therein is the tragedy. Each man is locked into a system that compels him to increase his [input] without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons (Hardin, 1968, p. 1244).

It has been suggested that Hardin's enormous influence and his depiction of the situation as a tragedy has been unfortunate (Ostrom, 1990, p. 8, Wilen, 2006, p. 543); in a tragedy, helpless individuals are lead to destruction in an inexorable process. Such a view underpins modern management systems (Wilen, 2006, p. 543).

3 Rent Dissipation, Inefficiency, and Overcapitalization

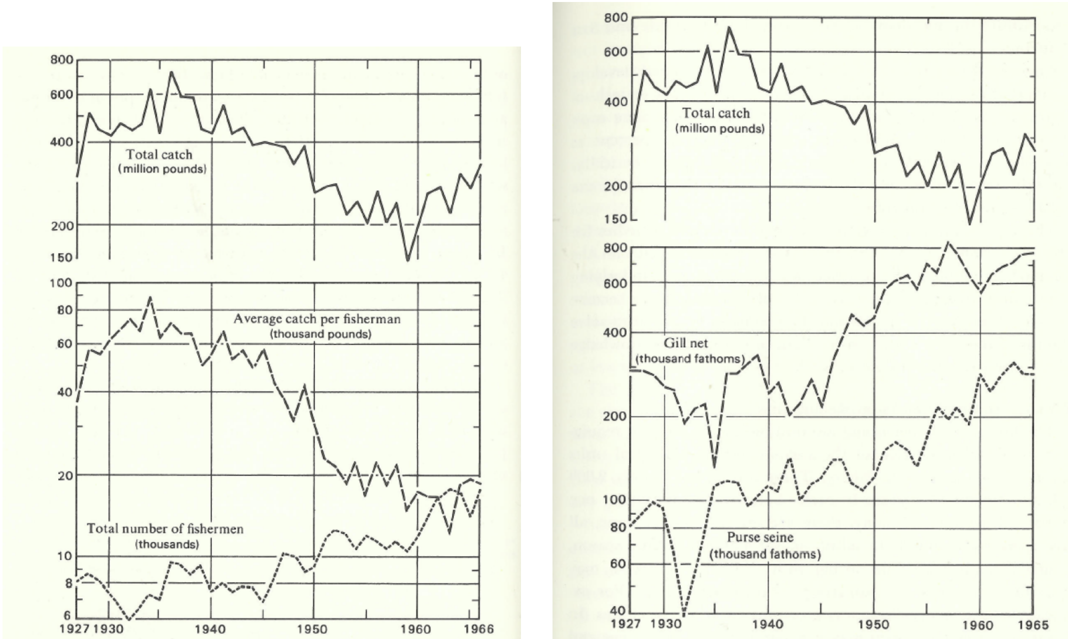
In their path-breaking analysis of the Pacific Halibut fishery, Crutchfield and Zellner were perhaps among the first to investigate and document rent dissipation and overcapacity in fisheries in an economic setting (Crutchfield and Zellner, 1962). They noted, for example, that from 1929 to 1951, the size of the fleet increased with 78 percent, while total catch increased only 27 percent from 1932 to 1951 (p. 44); a clear sign of overcapacity. The overcapacity lead to shorter fishing seasons, which went from more than 200 days in the early 1930's to close to 20 days in the 1950's (see table 4, p. 43).

Not only did Crutchfield and Zellner establish a quality standard for applied work in environmental economics (Zilberman, 2003, p. 177), with their historical account of the fishery and its regulation, their comprehensive analysis of the industry and related markets, and their policy recommendations, they also developed methods and new theory as they went along. A particularly interesting instance is the first appendix which was the first to solve the dynamic fisheries problem, that is, not only solving for the optimal steady state, but how to get there, (which depends on the discount rate, biological growth, and dynamic costs) using calculus of variations (Crutchfield and Zellner, 1962, pp. 112–117; for a discussion, see Wilen, 2000, p. 311, footnote 8).

Another early empirical analysis in fisheries economics was that of the Norwegian winter herring fishery by Pontecorvo and Vartdal (1967). (Pontecorvo visited the Norwegian School of Economics at the time.) They found 'disturbing results.' Assuming no productivity gains in the period 1950 - 1966, they found that 1/6 of the fleet was redundant (p. 81). The technical innovations had been many, however; echo sounder, sonar, nylon nets, power block, and larger and faster boats all probably increased the fishing power of the fleet (footnote 3, pp. 73–74). By assuming a 50 percent increase in productivity, more than 40 percent of capital and labor inputs in the fishery were found to be in excess. Pontecorvo and Vartdal were stricken by 'the gross nature of the misallocation' revealed (p. 81). It is important to keep in mind, however, that the fleet which operated on the winter herring also participated in other fisheries, and that the apparent excess capacity may have been less 'gross' in a larger picture. In that regard, while suggesting to limit entry to the fishery, Pontecorvo and Vartdal noted that it would, in the short run, only shift capacity elsewhere and that a more general evaluation were needed (p. 85). That is an interesting comment which resonates recent concerns about the shifting of capacity from the Northern to the Southern Hemisphere (see Alder and Sumaila, 2004, Figure 3, p. 166; figure shows 'total access years' agreements).

In 1969, Crutchfield and Pontecorvo published an analysis of the Pacific Salmon Fisheries (see Crutchfield and Pontecorvo, 1969). It had the subtitle 'A Study of Irrational Conservation,' which clearly signalled both Crutchfield & Pontecorvo's opinion of the current and historical regulation of the Pacific salmon fisheries and the nature of their findings. The salmon fisheries in North-West America is an extremely complicated situation to analyze, even by today's standards. The Alaskan fisheries, for example, are dispersed across 2000 miles of rugged coastline, from the Alexander archipelago in the east to the Bering Sea in the west. Five different species are present, sometimes all in the same river, and, at the time (late 1960's, that is), salmon was found in approximately 2000 streams across Alaska (Crutchfield and Pontecorvo, 1969, p. 60). Further, some salmon runs last for only a couple of weeks per year, but possibly at different times in different rivers, and different species spawn at different times of the year. In contrast, around the turn of the century (1900, that is), one man and one assistant were responsible for the enforcement of fishery regulation in all of Alaska (Crutchfield and Pontecorvo, 1969, p.95).

In their analysis, Crutchfield and Pontecorvo found clear evidence of overfishing and overcapitalization in the Alaskan fisheries (see Figure 1). For



(a) (b)

Figure 1: (a) Alaska Salmon fishery (number of fishermen, total catch, and catch per fisherman, 1927-66), see Crutchfield and Pontecorvo (1969, Figure 9, p. 58). (b) Alaska Salmon fishery (fathoms of purse seine and gill net, and total catch, 1927-65), see Crutchfield and Pontecorvo (1969, Figure 10, p. 59).

example, in 1969, at the time they wrote the book, twice as many fishermen, using more equipment, fished only 40% as many salmons as were caught in the mid-1930's (Crutchfield and Pontecorvo, 1969, p. 60). As the fishery was believed to be in an bionomic (rent dissipated) equilibrium in the mid-1930's, a rise in the real price of salmon explained the increase in effort (figure 8, p. 57). They also calculated (guesstimated) the dissipated rents and efficiency of the fishery and concluded that, if efficiency of gear had improved with 50% over 20 years, the relative amount of unnecessary gear was 83% in the latter half of the 1950's (table 5, p. 115).

Crutchfield and Pontecorvo also analyzed the salmon fisheries in the

Puget Sound (between Seattle and Vancouver). There, too, did they find evidence of excessive capacity (figure 12, p. 127). The fishery was from 1946 regulated by an international commission (U.S./Canada). The main, regulative measure was seasonal openings (and a host of gear specifications), and the target was a biological escapement level. (An escapement level is simply the share of stock unfished.) In addition, the distribution of catch between Canadian and U.S. fishers should ideally be 50/50, a clause which severely complicated the regulations. Further, one needed a license to fish, but these were seemingly unlimited. While issued licenses were increasing, average catches of pink salmon declined (figure 18, p. 156). Crutchfield and Pontecorvo concluded:

> As long as the present situation continues, there can be no real hope of economic health in the fishery. Any increase in relative prices of salmon is promptly swallowed up by increased entry, rising costs, and more stringent pressure on the physical resource and those charged with its management. It simply leads to a new equilibrium, no more satisfactory than the previous one, with a net loss to the economy as a whole as more factors of production are trapped in the fishery (Crutchfield and Pontecorvo, 1969, p. 196).

Just as Crutchfield and Pontecorvo's analysis appeared in print, Canada introduced a new regulation scheme, a fleet control program, in their salmon fisheries to cope with the overcapacity problems (see Pearse and Wilen, 1979, p. 765). The regulation scheme went through several steps in order to control capacity (Wilen, 1988, pp. 314–315):

- Limited numbers of vessels (1969).

- Limited total tonnage of fleet, with ton-for-ton replacement rule (1970).
- Limited length of smaller vessels with no registered tonnage.
- Limited gear types (1977).
- Limited combining licenses, prohibiting more than one license per boat.

Despite the spiraling regulations, effort continued to increase. As pointed out by Pearse and Wilen (1979), such regulations did not address the fundamental problem which needed be addressed; excessive use of inputs (p. 765).

The phenomenon observed by Pearse and Wilen in the Canadian salmon fisheries was already predicted by economic theory (Scott, 1962; see Pearse and Wilen, 1979, footnote 10, p. 765) and has later become known as capital stuffing; if some dimension of effort is restricted, fishermen will expand effort along some other dimension whenever they find it worthwhile. (And they usually do when property rights are incomplete.) The related, theoretical short-comings were pinpointed by Wilen (1979). Capital stuffing as observed by Pearse and Wilen (1979) is a case of regulatory induced innovation and regulatory induced changes in investment (Wilen, 1988, p. 319). Townsend (1985) claimed that some capital stuffing may indeed be economically desirable, but empirical investigation, on a case-by-case basis, would be necessary in order to evaluate the total, net effect. Squires (1994) formalizes input quantity control in the context of rationing theory.

Pearse and Wilen (1979) set out to analyze and evaluate the impact of the fleet control program. Their measure of success was 'whether the scheme [had] driven a wedge between costs and revenues and allowed some of the potential economic rents to be realized' (pp. 765–766). They found that labor input in the fishery had declined with 16 percent in the period 1968 - 1975 (p.

767), and that revenues had increased with 4.4 percent per annum from 1957 to 1977. Further, capital input increased annually with 5.7 percent and 3.7 percent prior to and after 1969 (p. 768). Pearse and Wilen concluded that the fleet control program, or 'rationalization scheme' as it also was called, had been partially successful in checking the expansion of capital engaged in the fishery' (p. 768). Capital input had, however, continued to increase from already redundant levels in 1969, as reported by Crutchfield and Pontecorvo (1969).

Moving to more recent evidence, Hilborn et al. (2003) reports that many fisheries are in good shape biologically, but the majority of fisheries are still overfished (see figure 6, p. 371). In another study, Worm et al. (2009) finds that 63 percent of worldwide fish stocks require rebuilding (p. 578). Taking a more depressing and controversial stand, Worm et al. (2006) project that all of the world's fisheries can be collapsed by the year 2048.

4 Rights-Based Management

As Gordon's (1954) legacy started to 'make inroads into the thinking' of others than economists and after the extension of national jurisdictions in 1976, putting many fish stocks in exclusive, national waters, the stage was set for a new approach to fisheries management. The new approach, known as Individual Tradable Quotas (ITQs), simply transferred use-rights to the fish stock to individual fishermen. ITQs are usually put on top of a quantity control such that they represent the right to a share of a total quota (Squires, 2009, p. 645). Christy (1973) presented the first theoretical consideration of individual quotas. Since then, ITQs have come into use worldwide. Prominent examples are the New Zealand and Icelandic fisheries (see Hannesson, 2004, for an extensive discussion). Subsequent, formal analysis of ITQs in combination with quantity controls have established that efficiency can improve as fishermen no longer have to compete for shares of the total quantity (Boyce, 1992). In contrast, ITQs cannot eliminate over-capitalization stemming from externalities caused by stock-level-dependent (density) harvesting costs and congestion externalitites; other issues are bycatch and highgrading (Boyce, 1992, see also Casey et al., 1995 and in particular Squires et al., 1995). Going into more details, Hannesson (2000) shows how the labor remuneration system may lead to overinvestment under ITQs.

The main, attractive feature of ITQs are that they align incentives between fishermen and regulators, and among fishermen themselves, to maintain a sustainable fishery. Further, ITQs stimulate development and innovation in end-products, self-enforcement, and input and effort are consolidated. They also lead to capitalization possibilities of future profits and wealth creation (Wilen, 2006, pp. 537–538).

The halibut fishery off British Columbia adopted individual quotas in 1991; there were initial constraints on trade and exchange which were subsequently loosened. The BC halibut experience is particularly interesting in several aspects; it had been exploited for a long time and could with reasonable confidence be assumed to be in a rent dissipated, inefficient equilibrium by 1991, it had been extensively studied under earlier regimes (Crutchfield and Zellner, 1962), and the BC fleet operated side by side the Alaskan fishery which remained open access.

The BC experience was broadly evaluated by Casey et al. (1995) through analysis of the fleet, the processing industry, markets, and several surveys. Among the most notable changes was the change in landing patterns. Part of the new quota program was the extension of the season to approximately eight months; prior to the new program the season openings were down to six frantic days (see Grafton et al., 2000, Table 1, p. 685). (The situation in the Alaskan halibut fishery was even more extreme, where season length was reduced to two or three 24-hour openings; individual quotas were adopted in the Alaskan fishery in 1995 [Knapp, 1996, p. 44].) Figures 2 and 3 (Casey et al., 1995, pp. 217–218) demonstrates the new landing pattern and compares it to the Alaskan open access fishery. Landings were distributed throughout the season with low volumes upon the Alaskan open seasons. Another notable change was the quality of the end product; prior to 1991, most halibut ended up as frozen products, after, most was sold as more valuable fresh fish (Casey et al., 1995, p. 219). In other words, the individual quotas in the BC halibut fishery created wealth through incentives to consolidate effort and through higher quality and more valuable end-products.

In a subsequent analysis of economic efficiency in the BC halibut fishery, exploiting the natural experiment provided by the individual quota program, Grafton et al. (2000, p. 705) found that efficiency fell from 1988 to 1991. The poor performance was explained by low catches and bad weather. From 1991 to 1994, efficiency increased, although the evidence was weak for large vessels (see Grafton et al., 2000, footnote 61, p. 706); there were gains from changes in product form as found by Casey et al. (1995). A possible objection to the analysis of Grafton et al. (2000) would be that the program was not exogenous, but rather endogenous in a manner discussed by Homans and Wilen (1997) ('[...] regulations are fundamentally endogenous and dynamic' [p. 2]). Notwithstanding, one would be hard pressed to argue for any expectation of improvement in a fishery with such a long history of rent dissipation.

As theory predicts and experience shows, open access leads to overfishing.

In certain instances, extreme degrees of overfishing leads to collapse in the fish stock. The Pacific halibut fishery, already discussed at great length, crashed spectacularly in the 1920's. And infamously, the Northern Cod stock collapsed in the early 1990's and has still not returned. Recent evidence suggest that ITQ management may reverse the collapse of fisheries (Costello et al., 208), which further suggest that fishermen behave more in line with conservation or stewardship ideals under ITQs. (It has been contested that many fisheries has gone directly from open access to ITQ schemes, and that it is simply the inherent total catch restriction which leads to decreased overfishing [R. Hannesson, personal communication]).

The last piece of evidence on behavior of fishermen under rights-based management discussed here is very recent (yet unpublished, reference by courtesy of the authors). In an innovate analysis, Grainger and Costello (2009, unpublished) investigates the relationship between the security of an ITQ and its market price. The idea is to exploit differences in ITQ schemes in different countries; in New Zealand, the property right vested in an ITQ is held in perpetuity while in the U.S., for example, ITQs can be revoked by the government at any time (Grainger and Costello, 2009, pp. 3-4, unpublished). They construct the ITQ lease to sales price ratio, called the dividend price ratio, as economic theory suggests that the security of an ITQ is reflected in its sales price but not in its lease price. Their evidence lines up with theory; lease to sales price ratios are smaller in New Zealand (Grainger and Costello, 2009, Figure 1, p. 7). The same effect is seen within New Zealand, where ITQs in less secure fisheries on migratory species have higher lease to sales price ratios (Grainger and Costello, 2009, Figure 2, p. 8). A further possible extension would be to see whether the quality of the total catch decision is reflected in the ITQ price.

Another form of rights-based management are territorial use rights in fisheries (TURFs), suggested by Christy (1982). A TURF involves the exclusive right to fish in a given area or territory. TURFs are perhaps less common in use than ITQs, but may become just as important as the focus of economists and marine scientists moves towards spatial behavior of both fish stocks and fishermen.

5 Spatial Behavior

Spatial behavior was in fact an important part of the very earliest insights into modern fisheries economics; both Warming (1911) and Gordon (1954) built their arguments upon a model of two fishing grounds and showed how net profit rates would equalize between the grounds. Despite the early notion of space and distance, empirical analysis of spatial behavior did not surface until the 1980's, and explicit, spatial models of fisheries did not appear until the 1990's.

Location choice among fishermen has been widely studied since the 1980's. In an early contribution, Eales and Wilen (1986) found that location choices among shrimp fishermen in northern California were economically motivated; fishermen maximized expected profits and behaved according to theory. Further, the studied fishermen were responsive rather than sluggish in their behavior, contrary to other evidence (Bockstael and Opaluch, 1983).

The mid-Atlantic clam fishery off the eastern U.S. coast use dredges to harvest surf clams. Prior to 1990, the fishery was regulated through the number of vessels and dredge time. In 1990, the regulations were replaced with an ITQ program (Marcoul and Weninger, 2008, p. 1935). Analyzing search and adaptive learning, Marcoul and Weninger (2008) find that fishers searched more for high abundance sites in response to tighter control on dredge time (p. 1939). Interestingly, restrictions on dredge time lead to higher catch per unit effort; whether it was an increase in abundance or caused by more searching and increased knowledge about the stock is unclear (p. 1943). Further, fishermen displayed behavior 'consistent with a model of rational search and learning' (p. 1942).

The conclusions from an analysis of location choice among New England Trawlers, seems partly at odds with the evidence cited above:

> To assume that effort will flow between areas or fisheries to equalize catch or revenue rates is unlikely to provide reliable predictions even when steam time differentials are accounted for. [...] What is very clear is that in a fishery with complex seasonal patterns of fish movement, catchability and value, individuals' historical fishing patterns are major determinants of how effort is distributed in the future (Holland and Sutinen, 2000, p. 148).

Holland and Sutinen (2000) do find a weak influence from differences in revenues on location choice, but the individual fisher's choice history has a stronger influence (p. 148). The approach taken by Holland and Sutinen (2000) may be 'useful in predicting the redistribution of fishing effort as conditions and regulations in the fishery change' (p. 149).

Upon more space and time, the discussion would extend to the relationship between spatial behavior and risk preferences. Interesting research is done by Mistiaen and Strand (2000), who develop a model of location choice which allows for heterogeneous risk preferences, by Smith and Wilen (2005), who look at risk preferences among Californian sea urchin divers and finds heterogeneous risk preferences and that preferences towards different types of risk (physical and financial) are correlated, and by Eggert and Tveterås

(2004), who study heterogeneous risk preferences and gear choices among Swedish demersal trawl fishermen.

A prominent assumption among biologists and marine scientists modeling spatial behavior of fishermen in response to spatial management measures is that displaced fishers simply redistribute over the remaining fishable areas in the same pattern as fishers were distributed prior to the spatial measures. Such assumptions can lead astray (Smith and Wilen, 2003, pp. 184, 200).

The analysis provided by Smith and Wilen (2003) has a new flavor to it. It evolves in two steps. First, they estimate a model of fishermen (sea urchin divers) behavior depending on a host of variables, among them wave period and hight, wind speed, distance, and expected revenues. Then, they simulate a highly sophisticated metapopulation model which integrates biological, spatial features such as ocean currents and biomass migration with a calibrated model of fishermen behavior. In certain instances, the inclusion of spatial fisher behavior leads to opposite conclusions about the benefits from spatial closures (Smith and Wilen, 2003, p. 200). Ultimately, they raise questions 'about whether oceanographic dispersal is the key driver of spatial closure impacts, or whether harvester dispersal may be equally important' (Smith and Wilen, 2003, p. 204).

In a subsequent analysis, Smith and Wilen (2004) added another layer by allowing for endogenous port choice. They found little response in port choice to changes in expected revenues in the short term, but found large effects in the long term (p. 102). Again, they concluded that naïve assumptions regarding spatial behavior may lead to conclusions 'substantially at variance' with more reasonable assumptions (p. 109).

6 Self-Governance

2009 Noble Prize winner Elinor Ostrom suggest that rights-based management, or privatization, is not necessarily the only way to solve the commons problem (Ostrom, 1990, p. 14).

> Institutions are rarely either private or public [...] Many successful [common pool resource] institutions are rich mixtures of "private-like" and "public-like" institutions defying classification in a sterile dichotomy. By "successful" I mean institutions that enable individuals to achieve productive outcomes in situations where temptations to free-ride and shirk are ever present (Ostrom, 1990, pp. 14–15).

A prominent example of a successful solution devised by participants in a small, inshore fishery in Alanya, Turkey. After years of trial-and-error efforts, they came up with an genuine set of rules to manage the fishery. The system spaces fishers far enough apart on the grounds such that production capabilities are 'optimized.' All boats have equal chances to fish at the best spots, resources are not wasted on searching for or fighting over spots, and there are no signs of overcapitalization (Ostrom, 1990, pp. 18–21).

Ostrom (1990) discusses a long list of both successful and unsuccessful self-organized institutional solutions to common resource problems. In a study of 30 coastal fisheries which were self-organized to some extent, Schlager (1994, p. 264) finds that fishermen self-organize to assign fishing spots (assignment problems) and reduce gear interference (technological externalities). However, in no fisheries were institutions addressing the commons problem developed. 'Since fishers cannot measure with sufficient accuracy the magnitude of the problem, nor the exact causes, they are unlikely to devise arrangements that would directly address [the commons problem], such as individual transferable quotas' (Schlager, 1994, p. 252). Schlager claims, however, that central governing bodies hardly would be able to configure as effective rules as the fishermen themselves (p.265) (see also Ostrom, 1990, Ostrom et al., 1994).

7 Experimental Research

Although not experimental, Bockstael and Opaluch (1983) introduced uncertainty and risk preferences in fisheries economics. Since fishing seemingly is a risky profession, fishermen are perceived to be risk lovers (Smith and Wilen, 2005, p. 54). There is little evidence to support such a conjecture (Eggert and Martinsson, 2004, p. 550).

The rational for using experiments to reveal preferences and agent characteristics is that the set of potential explanations for different outcomes ideally is small. (See Camerer and Loewenstein, 2004 for a discussion of experimental versus behavioral economics.) Perhaps the first to expose fishermen to experiments was Erling Moxnes. In an article 'Not Only the Tragedy of the Commons: Misperceptions of Bioeconomics,' he studied the ability of fishermen as well as scientists and bureaucrats from the fisheries sector and 'others' innocent of fisheries management to manage a renewable resource when the commons problem was absent (see Moxnes, 1998). Approximately three fourths of the subjects overinvested in exploitation (p. 1239). More seriously, perhaps, scientists and bureaucrats did not perform better than the other groups involved (p. 1241). (See Walker et al. (1990) for an experiment placing subjects in a limited-access common-pool resource setting; subjects were not fishermen, however.)

The experiment by Moxnes was not ideal to reveal subject's preferences; whether overinvestments were intentional betting (risk loving behavior) or 'misperceptions of bioeconomics' cannot be identified. Eggert and Martinsson (2004) were first to investigate risk preferences among fishermen with a stated preference approach (p. 551). In their sample of Swedish commercial fishermen, approximately half were risk neutral, a quarter risk averse, and a quarter strongly risk averse. Surveying their subjects, they found that strongly risk averse subjects earned 22% less than risk-neutral fishermen which strengthen their findings. Further, risk preferences were explained by the proportion of household income from fishing, type of gear, political preferences, and attitudes towards introducing individual quotas (p. 559).

Turning to fisheries in developing economies, Eggert and Lokina (2007) find that artisanal fishermen on Lake Victoria have somewhat similar preferences: In the sample, subjects distributed approximately evenly into characterizations as risk averse, risk neutral, and risk seekers (p. 49). The risk preferences were related to a set of other characteristics regarding boat size, assets, and others (p. 61).

8 Final Remarks

It is well established that Gordon's (1954) predictions and predictions from economic theory in general are correct; incomplete property rights create incentives which matter for common property outcomes. There is mounting evidence that addressing property rights, as with individual quotas, goes a long way to improve economic efficiency in fisheries. Fixing incomplete property rights reduces overcapitalization and create values.

Recent developments demonstrate the important role played by spatial behavior. Economists and biologists need to understand how spatial behavior relates to regulations and management.

Behavioral responses to regulations regarding bycatch has not been mentioned in the discussion. Regulating bycatch, however, becomes important in multispecies fisheries and when fisheries interfere with endangered species. Legislation regarding endangered species is strong in the U.S. and is likely to become stronger in the entire Western world. It will be of critical importance to understand behavior of economic agents related to endangered species type regulations and legislation.

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