Restricted Access vs. Open Access Methods of Management: Toward More Effective Regulation of Fishing Effort

JAMES R. WATERS

Introduction

This paper provides background information about why economists advocate limited entry as a method of fishery management. Its purpose is to give a general overview of the rationale for limited entry rather than a detailed account of existing programs. Townsend (1990) provides a review of existing limited-entry programs.

There are many criteria and objectives by which alternative methods of fishery management can be judged. For example, biologists are interested in the maintenance of adequate recruitment or improvement in recruitment, population age structure, and genetic diversity. Economists are interested in the long-term achievement of these goals in an economically efficient manner. Economic efficiency is loosely defined here as society's ability to maximize the combined value of commercial, recreational, and aesthetic products and services that can be obtained for a given level of cost, or the achievement of a given level of products and services at minimum cost. Economists advocate limited entry as a method of fishery management because economic efficiency is not likely to be achieved in an open-access fishery.

James R. Waters is with the Southeast Regional Office, National Marine Fisheries Service, NOAA, 9450 Koger Boulevard, St. Petersburg, FL 33702. Current address: Beaufort Laboratory, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Beaufort, NC 28516-9722.

ABSTRACT—This paper gives an overview of the economic rationale for limited entry as a method of fishery management and discusses general advantages and disadvantages of license limitation and catch rights as the two primary methods of restricting access to marine fisheries. Traditional open-access methods of regulation (e.g., gear restrictions, size limits, trip limits, quotas, and closures) can be temporarily effective in protecting fish populations, but they generally fail to provide lasting biological or economic benefits to fishermen because they do not restrict access to the fishery. The general result of regulation with unrestricted access to a fishery is additional and more costly and complex regulations as competition increases for dwindling fishery resources. Regulation that restricts access to a fishery in conjunction with selected traditional methods of regulation would encourage efficient resource usage and minimize the need for future regulatory adjustments, provided that enforcement and monitoring costs are not too great. In theory, catch rights are superior to license limitation as a means of restricting access to a fishery.

This paper is presented in five sections. The first section describes how unrestricted access to a fishery leads to inefficiency and overfishing. Unharvested fish are common property, which eventually creates a situation in which there are too many fishermen in the fishery, each applying too much effort. Excess capital and labor could be used elsewhere in a more cost effective manner and the same quantity of fish could be produced at lower overall cost.

The second section describes how open-access methods of regulation lead to further inefficiencies. Restrictions or prohibitions on the use of certain types of fishing gear, quotas, size limits, trip limits, and seasonal and area closures can achieve short-term biological improvements, but only by forcing fishermen to use more costly or less productive methods of fishing. The third section describes why, in the long term, unrestricted access tends to compromise the biological objectives of regulation. The potential long-term benefits of open-access regulations tend to disappear due to uncontrolled increases in fishing effort, all regulated to use economically inefficient methods of fishing. See Anderson (1986), Bell (1978), Crutchfield (1973), Crutchfield and Pontecorvo (1969), Crutchfield and Zellner (1963), Gordon (1954), Keen (1988), and Scott (1979) for further discussion.

Methods of limiting entry attempt to minimize the need to implement regulations that impose further economic inefficiencies. The fourth section summarizes some advantages and disadvantages of license limitation and catch rights as the two primary methods of restricting access to a fishery. Catch rights have better potential to improve long-term biological and economic benefits, provided that enforcement and monitoring costs are not too great. Section five summarizes the paper and discusses why managers of marine fisheries in the United States seem to prefer open-access regulations. Limited entry is generally considered to apply to commercial fisheries. This paper follows that supposition; however, section five speculates about the possibilities of applying limited-entry methods of regulation to recreational as well as commercial fisheries.

Open Access and Incentives to Overfish

Marine fisheries represent a modern version of Hardin's (1968) "tragedy of freedom in a commons" in which fishermen, each acting in his or her own self interest, are compelled to overfish and deplete the resources upon which they depend. Fish are said to be common property because no individual owns the ocean or the fish in it. Hence, fish may be harvested on a first-come-first-served basis by anyone with appropriate gear, subject

to existing regulations established by state and Federal governments as trustees of the public's resources. This creates a situation in which what is optimal for the individual fisherman is not always optimal for all fishermen combined.

The number of fishermen in a fishery tends toward an equilibrium in which the net revenues (after accounting for fixed and variable costs) earned by an additional fisherman just equal his opportunity cost, defined as the net income that could be earned in another fishery or another occupation[1]. Fishermen will enter a fishery if they expect to earn more than they could elsewhere; conversely, they will leave a fishery if they cannot earn as much as they could elsewhere. However, when a fisherman expands his effort or a new fisherman enters the fishery, he imposes what are called indirect or external costs on everyone else. These external costs represent the value of the additional overfishing created by his extra fishing effort and correspond to the negative component of utility in Hardin's (1968) example about overgrazing.

There are several types of external costs in a fishery. Crowding externalities reduce catch rates during the current harvesting season by distributing the available catch among a greater number of participants. Stock externalities reduce future catch rates by reducing the size of next year's fish population via reductions in fish survival and spawning potential.

A crowding externality occurs because fishermen harvest from a common pool of fish. Therefore, every new entrant into a fishery would capture some fish that would have been caught by his competitors (Bell, 1978; Cheung, 1970). Each fisherman may seem to have little or no effect on the catch rates of his competitors, but when fishermen simultaneously expand their fishing effort, the result is lower catch rates for all. In other words, the addition of fishing effort causes the fishery pie to be divided into smaller pieces. The commercial trap fishery for spiny lobsters in Monroe County, Fla., is a good example. The number of traps fished has tripled since the early 1970's while total harvest has fluctuated without trend.

A stock externality occurs because common property subverts the incentives to save fish for future harvest. By postponing the harvest of some fish, fishermen could invest in future fish supplies and future commercial income or recreational enjoyment. But few fishermen would voluntarily alter their harvesting techniques or strategies to conserve fish for the future because there is no assurance that the fish they save would not be caught, either now or in the future, by competing fishermen (Scott, 1955; Christy, 1978). Once again, each fisherman may have no noticeable effect on the size of the next year's fish population, but the simultaneous expansion of effort by all fishermen results in smaller populations of fish available for capture in the future. Fish like the deep-water groupers probably have significant stock externalities because they are relatively long lived, slow growing, and easily depleted.

The magnitude of external costs varies with the overall exploitation rate. When exploitation rates are low, expansion of fishing effort may have a negligible adverse effect on current and future catch rates. Overfishing may not occur or may not be severe. However, when exploitation rates are high, expansion of effort may have a considerable effect on current and future catch rates. The problem is that each fisherman receives the entire benefit of employing his additional fishing effort, but the additional, indirect effects of overfishing are dispersed among all fishermen. Although external costs are real, they occur mainly at the expense of other fishermen so that the individual has little incentive to curtail or alter his harvesting practices to avoid them. Hence, fishermen do not account for external costs in their decisions to enter or leave a fishery or to expand their scales of operation. The result is too many fishermen, each fishing too intensively[2].

The net addition to the value of output after accounting for external costs is less than the costs of employing the extra effort (Anderson, 1986; Cheung, 1970; Gordon, 1954), which implies that the resources used to produce excess effort would be more cost effectively employed in other fisheries or other sectors of the economy. The existence of significant external costs reflects what economists call "market failure" in which the normal competitive forces which affect the decisions of individual fishermen do not result in an optimal overall harvest from the perspective of society as a whole.

Although certain resources, such as some marine fishes, are scarce, they have remained common property because the costs of defining and enforcing a claim of ownership are higher than the expected benefits[3] (Cheung, 1970; Demsetz, 1967). Therefore, public regulation of marine fisheries appears necessary to overcome the incentives to overfish and its consequences. Limited entry attempts to overcome the problem of external costs and its built-in incentives to overfish through the creation and enforcement of property rights where they have not evolved naturally. More correctly, limited-entry systems of management introduce elements of property rights into a fishery through the issuance of what may be called fishing use rights, fishing privileges, or the right of access to the fishery. Limited entry does not assign ownership of the ocean or the fish in it.

Open-access Regulations Create Economic Inefficiencies

Traditional, open-access methods of managing a fishery attempt to reduce fishing mortality either directly (with gear restrictions or prohibitions) or indirectly (by restricting the allowable catches through the use of quotas, trip limits, size limits, and seasonal and area closures). These methods can work biologically, at least in the short term, but they create economic inefficiencies by forcing fishermen to adopt less produc-

[1] For example, consider the person who earns $30,000 per year as a hired captain on a company-owned fishing vessel. His next best employment alternative might pay only $20,000. That is, his opportunity cost is $20,000. If he were permanently unemployable elsewhere, then his opportunity cost would be $0.

[2] Other factors, such as government loan programs and tax law, may exacerbate the problem of overcapitalization in the fishery, but the tendency to overfish in the open-access (common property) fishery would remain even if those other factors did not exist.

[3] The benefits of private property rights depend on the ability to exclude others from using a resource if they are not willing to pay for its use. If it is too costly to exclude nonpayers, then common property prevails and fishermen are compelled to harvest as quickly as possible to keep up with their competitors.

tive, and hence less profitable, harvesting techniques and/or to incur higher costs to comply with or react to the regulations. Some economic consequences of traditional regulatory techniques are briefly summarized below. Anderson (1986), Bell (1978), Christy (1978), Crutchfield and Pontecorvo (1969), and Crutchfield and Zellner (1963) provide more complete discussions.

Gear restrictions and prohibitions tend to induce economic inefficiency by forcing fishermen to use more expensive and/or less productive fishing techniques. Fishermen could switch to other gear types, but presumably these fishermen were already using their most profitable gears, so the switch would reduce profits. Also, fishermen could increase their usage of uncontrolled components of effort. For example, if the number of lobster traps per boat were restricted, fishermen might reduce soak times, adopt faster trap pullers, or experiment with new trap designs or different baiting techniques. Or, fishermen could invent a new gear or fishing technique. Even if fishing mortality were initially reduced by gear restrictions and prohibitions, it would not necessarily be maintained at a reduced level because with open access there could be a long-term increase in the number of fishermen each using the restricted gear.

Annual quotas and the resultant seasonal closures encourage fishermen to seek more effective ways to maximize their shares of the overall catch before the quota is reached and the season is closed. Fishermen would fish more intensively earlier in the season and would actively seek out and adopt new gear, larger vessels, or different technologies designed to increase catches before the fishery is closed. Yet, catches per fisherman do not necessarily increase due to crowding and stock externalities and the overall limit on production. Hence, quotas and seasonal closures increase harvesting costs, reduce the length of the fishing season, and may reduce dockside prices because the entire industry's catch is landed during a shorter period of time. Also, a shorter fishing season could lead to an overall reduction in product quality if fish are not properly stored when boats are at sea during the race for fish, if a larger fraction of the overall catch must be frozen rather than sold in fresh markets, and if fish must be frozen for longer periods of time before they are marketed.

One reviewer questioned why gear restrictions/prohibitions and annual quotas are identified as creating additional inefficiencies if they spur innovation. Actually, there is nothing wrong with innovation per se. The inefficiencies arise when fishermen are compelled to adopt innovations which lead to premature capital replacement and overinvestment in fishing power for the expected harvest rate. The total commercial harvest will not be taken with minimum cost. In addition, more fishing power applied to an already stressed fish population would simply hasten the next round of regulations designed to restrict or prohibit the new technology.

Minimum size limits, another commonly used regulation, tend to reduce catch rates or increase harvesting costs in several ways. Normal commercial operations often preclude fishermen from promptly returning undersized fish to the water, which would tend to reduce the likelihood that fish survive when released, especially in deeper water. These fish are wasted because they do not contribute to current or future catches or to an enhanced fish population. Even if fish survive when released, fishermen incur extra costs to cull them from the rest of the catch. Fishermen may minimize their catches of undersized fish by using larger hooks or net mesh openings and by avoiding fishing grounds known to have large concentrations of small fish, but they would incur extra gear and fuel costs to do so. Some fishermen could use undersized fish for bait, thereby saving bait costs as well as extra gear and fuel costs, but this practice would deny the potential future benefits of the size limit. In addition, because size limits do not restrict access to a fishery, they would not prevent potential long-term increases in fishing effort, which would increase the proportion of fish harvested as soon as they reached the minimum legal size, with the ironic consequence that relatively few fish would survive to exceptionally large or trophy sizes.

Other open-access methods of regulation also increase fishermen's costs of harvesting a given quantity of fish. For example, seasonally closed fishing areas or permanently closed marine sanctuaries (Davis, 1989; Plan Development Team, 1990; Tisdell and Broadus, 1989) would eliminate current and future catches from the closed areas, and fishermen would incur increased travel costs to legal fishing grounds. Trip limits would force fishermen to make shorter but more frequent fishing trips, which would increase fuel costs and the amount of nonfishing time spent traveling from port to fishing grounds and back.

Open-access Regulations Cannot Control Long-term Increases in Fishing Effort

Although open-access methods of management can reduce harvest levels and may initially reduce fishing effort, none of them can control potential long-term increases in fishing effort. Commercial and recreational fishing effort is presumed capable of increasing over time. In the commercial sector, fishing effort is not fixed; capital and labor are observed to enter and leave the fishery for a variety of reasons, including changes in fishery regulations and changes in the profitability of participating in a particular fishery compared to alternative fisheries. While these factors could cause fishing effort to either increase or decrease, effort is expected to increase over time due to long-term increases in the population of consumers of commercial fishery products and cost-saving technological change. The demand for commercial fishery products will probably increase over time as the population of consumers and their incomes increase. In addition, cost-saving technological change enhances the profitability of fishing, which would attract more effort into the fishery. In the recreational sector, marine fishing activities have increased and probably will continue to increase due to increases in coastal populations, per capita income, tourism in coastal regions, and improvements to highways that facilitate travel to coastal areas.

If regulations such as gear restrictions, quotas, minimum size limits, trip limits, and closures were successful in enhancing stock biomass and, therefore, catch

rates and profits (for commercial fishermen) or utility (for recreational fishermen), fishing effort would be expected to increase. This increased effort would tend to compromise short-term biological gains that had been achieved, and eventually would require additional regulations to further control fishing mortality. Increased effort would also cause catch per unit of effort to decline due to the crowding and stock externalities described earlier. This leads to the phenomenon known as dissipation of fishery rent[4] in which potential long-term economic benefits of regulation tend to disappear as more effort enters the fishery. However, fishermen do not enter or leave a fishery at exactly the same time because their opportunity costs (i.e., potential incomes in alternative fisheries or land-based employment) are not the same for themselves or for their investments in boats and gear, and because their expectations differ about the future profitability of the fishery. Therefore, the potential benefits of regulation would be minimized but not completely eliminated (Anderson, 1985).

If traditional regulations proved ineffective and fish stocks became depleted and catch rates declined, fishermen could leave the fishery in search of more profitable fisheries or other employment. On the other hand, fishermen could maintain or even increase their levels of participation in a fishery if increases in demand and cost-saving technological change kept financial returns at acceptable levels despite a declining fish population (Bell, 1978; Christy, 1978). For example, ex-vessel prices for red snappers in the multispecies reef fishery of the Gulf of Mexico have increased over time due, in part, to an increased demand by consumers, a deteriorating domestic red snapper population, and loss of fishing privileges in foreign waters. In addition, fishermen have received higher prices for groupers and other (than red) snappers as consumers increased their demand for substitute species in response to higher red snapper prices. Thus, fishing has remained profitable although red snappers represent a declining share of the overall catch of reef fish.

The usual result of regulation with unrestricted access to a fishery is more and increasingly restrictive regulations as competition increases for dwindling fishery resources. Each regulatory adjustment offers temporary relief to the fish population, but over time additional effort likely will create the need for still more gear restrictions and prohibitions, stricter quotas, more seasonal and area closures, and stricter size and trip limits. If political considerations diminish the effectiveness of open-access regulations to achieve even short-term biological goals, then the need for additional regulation arises more quickly. Fishermen tend to perceive the continued introduction of new, more restrictive, costly, and complex regulations as a source of instability in the fishery and to see the management agency as part of or the source of the problem[5]. The likely outcomes of traditional methods of management are higher fishing costs, less productive fishermen, additional regulations to control fishing effort in the long term, and an adversarial relationship between fishermen and fishery managers.

Methods of Restricting Access to a Fishery

Regulations that restrict access to a fishery are classified as limited-entry methods of management. They attempt to overcome the fundamental economic incentives to overfish by establishing new systems of fishing rights or privileges in terms of a limited right of access or a limited right to take specific quantities of fish.

This paper focuses on the two most common forms of limited entry: License limitation and catch rights. Various existing programs that use license limitation or catch rights are discussed in Clark et al. (1988), Geen and Nayar (1988), Huppert (1987), Mollett (1986), Pearse (1979), Rettig and Ginter (1978), Rettig (1984) and Townsend (1990). Other less frequently mentioned alternatives include territorial use rights (Christy, 1982; Smith and Panayotou, 1984) and sole ownership (Keen, 1988; Scott, 1955). Licenses represent the right to participate in the fishery at any level of activity. Catch rights (also called individual transferable quotas, ITQ's, or individual fishermen's quotas, IFQ's) represent the right to land specific quantities of fish. Territorial use rights represent the exclusive right to harvest from a given area, and have been commonly associated with relatively sedentary species; private oyster leases are a good example. Sole ownership in large bodies of water appears to be of interest primarily as the theoretical standard with which the various institutional arrangements for harvesting fishery resources are compared. Keen (1988), however, recently advocated sole ownership as a management tool.

License Limitation

License limitation is a management system in which the right to deploy some basic unit of effort, usually the vessel, is restricted to those with licenses, and the number of licenses is limited by the regulating agency[6]. License limitation

[4] Fishery rent refers to the overall sum for all fishermen of profits, including a return to capital, above opportunity costs for labor. Over time, the existence of profits above opportunity costs would attract new effort into the fishery unless the capital costs of entry were prohibitively high. If relatively large amounts of effort entered the fishery whenever fishery rent existed, then the resulting external costs would wipe out most or all of the difference between profits and opportunity cost. If relatively small amounts of effort entered the fishery, then some fishery rent would remain and would accrue to fishermen as additional profit.

[5] I thank Dean Ahrenholz and John Gauvin for pointing this out to me.

[6] Minimum income requirements, which reserve the commercial allocation of a fish stock for those who derive at least x % of their earned income from commercial fishing, possess some attributes of the license limitation method of restricting access to a fishery in that individuals must qualify to participate in the fishery and that catch per individual would be unrestricted until the commercial quota had been achieved. However, minimum income requirements differ from license limitation in that 1) individuals must qualify each year rather than only at the beginning of a limited-entry program, 2) there would not be a limit on the total number of potential qualifiers, and 3) qualifiers could not sell or rent their fishing privileges to potentially more profitable individuals. It is transferability of fishing privileges that enables a given quantity to be harvested at minimum cost. Hence, from an economic efficiency perspective, minimum income requirements may or may not result in the lowest possible costs of producing a given quantity of fish. Also, items 1) and 2) imply that minimum income requirements would not restrict the potential long-term growth in fishing effort by persons who may qualify as full-time commercial fishermen or the long-term growth in effort by recreational fishermen (for whom minimum income requirements do not apply). The primary effect of minimum income requirements is to protect the competitive position of full-time commercial fishermen by preventing part-time commercial and recreational fishermen from selling their catches.

was the first method used to restrict access to a fishery, probably because the concept of a license was familiar to fishery managers and fishermen, because most limited-entry programs began with an agreement that there were or would soon be too many fishermen, and because the license system was relatively easy to administer and enforce (Rettig, 1984). The following discussion summarizes more detailed descriptions found in Beddington and Rettig (1984), Crutchfield (1979), Huppert (1987), Pearse (1980), Rettig (1984), Townsend (1990), and Wilen (1988).

Economic Effects

License limitation is an attempt to fix fishing mortality by limiting the number of vessels in the fishery. In theory, potentially large conservation benefits are possible when fishing mortality can be fixed, usually at a reduced level when compared to the status quo. Another advantage of a fixed fishing mortality is that fishery managers would not have to predict changes in stock abundance. Catches would increase automatically when the size of the fish population is above average and would decrease automatically when the fish population is below average. In addition, license limitation would offer a means of inducing compliance with other regulations in the fishery because illegal behavior could result in loss of license.

In practice, fishing mortality and fishing effort are seldom equivalent. Effort is produced by a variety of factors such as vessel size, engine type and horsepower, the number and type of gear, the number of crew, and fishing time. Limitations on the number of vessels would encourage fishermen to increase their fishing power through improvements in other, unrestricted components of effort (Rettig, 1984). This phenomenon has been called "capital stuffing." For example, new, larger vessels could replace old, smaller vessels. And all vessels could add more sophisticated fish finders, more and newer gear, larger crews, more and/or longer trips. Although most license limitation programs restrict other components of effort, such as vessel tonnage, as well as the number of vessels, it is impossible to control all aspects of fishing effort, even if fishing technology appears to be fairly inflexible. The effect of license limitation would be similar to that for gear restrictions in that those with licenses would increase their use of unrestricted components of effort. The two management systems differ in that there could be no net increase in the number of operating units with license limitation.

Licenses acquire value by excluding nonlicense holders from participating in the fishery. Licenses acquire a value approximately equal to the expected profitability of adding another vessel to the fishery. If licenses expired and were reissued every year, then the license value would represent the expected profits for the current fishing year. If licenses never expired, then the license value would reflect the net present value of expected current and future profits. Licenses issued in perpetuity would be preferred as a means of ensuring a stable economic environment for employment and investment.

License values represent the creation of wealth. This wealth is derived from the fishery rent that would normally have been dissipated via the external costs created by extra fishing effort that would have been expended in an open-access fishery. Fishermen would receive a windfall of new wealth if licenses were distributed initially by random drawing (lottery) or given away according to a criterion usually based on some measure of historical participation and investment in the fishery[7]. Theory and experience suggest that even with a moratorium to prevent entry into the fishery during the planning phase, fishing effort would increase as existing fishermen compete to qualify for licenses. The increase in fishing effort would be more pronounced without a moratorium as new entrants scramble to qualify for licenses and wealth. Once licenses have been distributed, fishermen would gain or lose wealth over time as the value of their licenses fluctuated due to changes in the factors (e.g., prices, costs, catch rates, and interest rates) that determine current and expected future profits in the fishery. The creation of new wealth makes it imperative that fishery managers and fishermen cooperate during the formulation of the licensing system.

The transferability of licenses is a desirable characteristic. Transferability facilitates the development of a market in which licenses are traded or leased[8]. An organized market for licenses would allow new fishermen to enter the fishery. License limitation would not bar new entrants, but they would have to buy a license and someone else would have to leave the fishery. The market for licenses would encourage the least profitable fishermen to leave the fishery if offers for their licenses were greater than what they expected to earn in the fishery, but at least they would be paid to leave.

The existence of a market value for licenses implies that those who fish would incur an additional fixed cost equal to the value of the license. If the license were leased, then there would be a (cash) rental fee. If the license were owned by the fisherman, then there would be an opportunity cost in that the fisherman could retire and rent or sell the license to another. In essence, the fisherman would have to pay himself for the use of the license. This opportunity cost would prevent license holders from becoming complacent and inefficient because if they were, they would be able to earn more by selling or renting the license to others. Competition in the market for licenses

[7] In theory, licenses could also be distributed by auction but the Magnuson Fishery Conservation and Management Act does not allow permits or licenses to be issued for amounts in excess of the administrative cost of issuing the licenses. The government would receive the wealth generated through the initial distribution of licenses if they were auctioned. Newly created wealth could be shared by fishermen and the government if annual fees were established as a means of financing the costs of research, administration, and enforcement of fishery management plans, and the purchase and retirement (buy-back) of licenses as a means of reducing participation in the fishery.

[8] Licenses would be valuable in terms of their ability to generate profits even if they were not officially transferable. If licenses were assigned to fishing vessels (to prevent nonfishermen from owning licenses), then license value would be incorporated into the price of the vessel so that the purchase of the right to fish would require the additional purchase of a particular vessel. If licenses were assigned to individuals rather than to vessels, then fishermen who would have sold their licenses were they transferable would be expected to enter into off-the-record partnerships with other potentially more profitable fishermen. License holders would be reluctant to retire from the fishery because their income from the license would simply vanish.

ensures that those most willing or able to buy or lease licenses, usually the most efficient and profitable fishermen, would acquire or lease them, whatever the initial distribution.

Also, the market for licenses would enable the government to reduce fishing effort by buying and retiring licenses. However, buy-back schemes generally have been found to be expensive[9]. Usually, a large number of licenses must be purchased to reduce the overall catch by enough to rebuild depleted fish stocks.

Other Considerations

License limitation programs suffer from shortcomings in addition to the problem of capital stuffing. For one thing, if the market price of licenses were determined by fishermen who work full time in the restricted fishery, then license limitation would tend to exclude fishermen who participate in other fisheries at one time or another during the year. The problem is that those who wish to participate in a restricted fishery on a limited basis may not earn enough in it to justify the purchase of a license.

Other details would have to be addressed before an acceptable and workable licensing system could be established. For example, would the use and transfer of licenses be restricted within particular vessel size classes, gear types, seasons, or geographical areas to maintain historical patterns of participation by various interest groups or to reduce the number of competitors within each group (see Wilen, 1988; Dupont, 1990)? Would ownership of licenses be restricted to fishermen, or could nonfishermen such as dealers, processors, recreational fishing clubs, nonfishing corporations, and environmental groups own licenses? Could license limitation be enforced if licenses were not required in state waters?

Catch Rights

Catch rights represent a management system in which fishermen would receive transferable certificates, with each certificate conferring the right to catch and sell a small, fixed proportion of the total allowable catch. The total allowable catch would be determined each year by the management council. An alternative formulation would define each certificate as the right to catch a relatively small, fixed amount of fish. In either case, each fisherman's quota could consist of a few or many certificates to accommodate differences in scales of operation. Annual revisions of the estimated total allowable catch (TAC) would offer direct control over each season's total catch. If certificates were expressed as a fixed percentage of the TAC, then each fisherman's quota would be automatically revised whenever a new TAC was announced. If certificates were expressed in pounds, then the government could either issue additional certificates whenever TAC was increased or buy certificates whenever TAC was reduced[10]. More detailed discussions are found in Clark and Duncan (1986), Clark et al. (1988), Copes (1986), Crutchfield (1979), Geen and Nayar (1988), Moloney and Pearse (1979), Peacock and MacFarlane (1986), Pearse (1980), and Robinson (1986).

The use of catch rights as a management system is similar to license limitation in that both systems would create marketable fishing rights or privileges. License limitation would confer the right to deploy fishing effort, but each fisherman's catch would be unrestricted. This would lead to capital stuffing as fishermen compete to maintain or increase their shares of the overall catch. Catch rights would represent a more complete system of fishing rights: The right to deploy effort and catch a particular quantity of fish. Catch rights would restrict access to the fishery only in that fishermen without certificates could not fish. But catch rights would not reduce the number of participants to a predetermined level as with license limitation. The fishery could have any number of fishermen with small, medium, or large vessels, provided that they own or lease certificates. Nevertheless, the number of active participants in the fishery would be expected to decline because the total allowable catch (summed over all catch rights) would be less than what would be caught without catch rights as a means of rebuilding depleted fish stocks.

Economic Effects

Catch rights would offer advantages to fishermen by enabling them to plan investment and harvesting strategies more efficiently. Catch rights would eliminate much of the uncertainty about the magnitude of each fisherman's catch[11]. In essence, a known portion of the fish stock would be reserved for each fisherman with catch rights. Therefore, fishermen would not be compelled to invest in extra fishing power (capital stuffing) to compete for fish on a first-come-first-served basis. They could invest in the fishing power required to minimize rather than maximize the cost of harvesting a given quantity of fish. In addition, with transferable catch rights of relatively small denominations, the investment in catch rights would not necessarily be prohibitive for fishermen with small vessels, part-time fishermen, and fishermen who participate in several fisheries throughout the year. Another advantage is that the harvesting season could last longer with catch rights, thereby avoiding temporary market gluts which could reduce fish prices and quality. For example, fishing seasons could last longer because fishermen would be less likely to fish in poor weather, or they could postpone part of their catches to take advantage of higher prices later in the season. Nevertheless, most fishing would probably still occur when fish are most abundant to minimize the costs of locating and catching fish.

But what is to prevent fishermen from making additional trips and illegally landing fish in excess of their quotas? Catch rights will not work unless each fisher-

[9] The inability to distribute licenses by auction would eliminate a potentially large source of revenues with which to fund a buy-back program.

[10] The inability to auction or sell catch rights for more than the cost of issuing them would limit the ability of the government to generate the revenues required to buy catch rights whenever the TAC was reduced. Therefore, in practice, it may be preferable to define catch rights as a percentage of TAC. This would eliminate the need for a large budget to reduce the number of outstanding catch rights, but it would add another element of uncertainty about the magnitude of each fisherman's catch.

[11] Some uncertainty about future catches would remain because the management agency could adjust the number of certificates outstanding (if certificates were expressed in pounds) or the number of pounds per certificate (if expressed as a percentage of total allowable catch) in response to annual variability in stock size.

man's quota of fish is really there when he wants it. Therefore, the government must enforce the rules so that fishermen have a reasonable expectation of being caught and convicted if they attempt to land more than their quotas. And there must be a relatively severe schedule of penalties for cheating, such as loss of catch, fines, and temporary or permanent revocation of fishing privileges. If enough fishermen are known to cheat, then others would be compelled to cheat also or else risk losing their shares of the overall catch. Dealers who buy illegally landed fish would also be subject to penalties. If government cannot enforce the rules, then the system has no chance of success. The implication is that substantial enforcement costs may be required to achieve adequate compliance.

Enforcement could be accomplished at dockside and could be costly because many individual quotas landed at many different ports would have to be monitored. Fishermen could underreport landings by failing to report the correct quantities, by landing fish surreptitiously at secret or existing landing sites, or by incorrect identification of species. Regulated red snappers might be reported as unregulated vermilion snappers, for example. Enforcement becomes more difficult as the numbers of fishermen, landing sites, and regulated species increases (Copes, 1986).

The Mid-Atlantic Fishery Management Council facilitated dockside enforcement for surf clams and ocean quahogs by issuing cage tags each year to fishermen in proportion to their individual quotas (U.S. Department of Commerce, 1990). Tags must be affixed to cages of surf clams and ocean quahogs before the cages leave the vessel and must be removed when cages are emptied at the final processing site. Anyone in possession of filled cages without a tag or empty cages with a tag is in violation of the management plan. Fishermen, dealers, and processors must report (among other things) tag numbers of cages that they handled. New Zealand implemented a double-entry data collection system to supplement dockside enforcement in its restricted-access fisheries (Muse and Schelle, 1988). Both the fisherman and buyer must file separate records of each off-loading. Computer analysts then check to determine that the records match and that each fisherman's quota has not been exceeded.

If government demonstrates that it can successfully enforce the rules, then fishermen will recognize that catch rights truly represent a limit on the ability to land and sell fish. More important, fishermen will then be willing to pay for catch rights to expand their scales of operation, to enter the fishery, or to adjust their holdings of catch rights to match their actual annual catches. The value per catch right would be determined in the market for catch rights by the capitalized value of additional profits expected to be earned over time with an extra certificate. Events, such as a higher ex-vessel price, that would increase the profitability of fishing would cause an increase in the price per certificate. Conversely, such events as an increase in fuel prices which would decrease the profitability of fishing, would cause a decrease in the price per certificate. Fishermen would incur an additional variable cost equal to the market value of their catch rights if they leased catch rights or an opportunity cost if they owned catch rights. Fishery rent would accrue to owners of catch rights rather than be dissipated among a larger number of fishermen as in an open-access fishery.

An adequate level of enforcement would create incentives for fishermen to conserve fish for the future and to report others who are known to violate the rules. Once fishermen have a substantial investment in catch rights, then it becomes to their advantage to protect their investments by voluntarily reporting those who attempt to cheat[12]. Widespread cheating would reduce, and eventually eliminate, the market value of catch rights: Fishermen would not be willing to pay for something that they could obtain for free simply by cheating with impunity (Peacock and MacFarlane, 1986).

When a system of catch rights is initiated, a formula would have to be established to determine who would be included in the program and how many certificates each person would receive. The initial allocation of catch rights must be considered by fishermen to be equitable. The opportunity for the initial recipients of catch rights to gain a windfall of wealth suggests that negotiations about criteria to qualify for an initial distribution of catch rights probably will be arduous and contentious. Certificates could be distributed initially in a variety of ways. Most likely they would be given away based on criteria such as each fisherman's historical landings, investment, or experience in the fishery over some recent period[13]. As with license limitation, fishing effort would increase during the planning stages as fishermen compete to qualify for an initial distribution of catch rights. Catch rights could be issued seasonally, annually, in perpetuity, or any other convenient term. Longer terms would lower the costs of administration and provide more stability for investment (in vessel, gear, and career choice) purposes.

As a means of rebuilding the fish population, each fisherman would probably receive certificates to catch fewer fish than he historically had caught. Transferability of certificates would allow a market to develop in which certificates would be redistributed to better match desired levels of production. The most profitable fishermen would increase their quotas by buying or leasing catch rights from the least profitable fishermen, who would then probably switch to other fisheries. By selling their catch rights, fishermen who leave the fishery would at least receive some financial compensation for leaving. From an economic perspective, the redistribution of catch rights to the most profitable fishermen would

[12] In contrast, open-access regulatory methods generally do not foster self-enforcement for economic reasons, although a majority of fishermen may comply for moral reasons. With open-access regulations, the temptation to cheat would always exist except for the penalties that could be levied if a fisherman were caught and convicted in violation of the rules. Severe penalties and/or a high probability of detection and conviction may prevent fishermen from cheating. Relatively small penalties and a low probability of detection and conviction would encourage fishermen to cheat. And individuals have no incentive to voluntarily obey the rules if others are known to violate them with impunity because fish conserved by one fisherman would likely be harvested by another. The alternative to continuous enforcement would be widespread cheating, which would thwart the intent of the regulations.

[13] Catch rights could also be auctioned, but the Magnuson Act currently does not permit fees in excess of administrative costs.

improve economic efficiency; fish would be landed at minimum cost. However, it could also lead to additional inefficiencies in other fisheries if access to them is not controlled.

Transferable catch rights offer additional consequences. First, transferability gives fishermen the flexibility to match their holdings of catch rights to their desired scales of operation, which may vary due to differences in boat size or a desire to participate in other fisheries during the year. Second, without transferability, fishermen would be unlikely to match exactly annual catches with their holdings of catch rights. Fishermen could end the season with unused catch rights. Or, fish would be discarded if actual catches exceeded holdings of catch rights. Third, transferable catch rights facilitate entry into a fishery with controlled access. Fishermen could enter the fishery at a low level with a relatively small initial investment in catch rights. Then they could gradually increase their holdings of catch rights as they gain experience in the fishery and their financial position improves. Fourth, in addition to fishermen, other people associated with the fishery may wish to participate in the market for catch rights. For example, dealers and processors may wish to purchase catch rights to ensure an adequate and timely supply of fish. Vessels could be hired and dispatched to the fishing grounds as needed to fill sales orders, processing, and storage capacity.

Other Considerations

Multispecies fisheries present obstacles for the successful use of catch rights. Total allowable catches would need to be specified and catch rights would need to be issued in one form or another for all major species or species groups in the fishery. Catch rights issued for fish in general, regardless of species, may not offer adequate protection for severely depleted species. On the other hand, catch rights issued for each species would cause problems for fishermen who need to match their multispecies catches to many quotas and would increase monitoring and enforcement costs. An appropriate compromise may be to issue catch rights for species groups which are generally caught together and which exhibit similar biological characteristics.

In addition, the potential exists for an increased volume of discarded fish. Catch rights could lead to "high-grading" in which fishermen sort and discard the lowest valued fish so as not to exceed their individual quotas for a given species. Also, after their individual quotas for one species or species group has been reached, fishermen could continue to fish for other species and discard their additional catches of the species for which quotas had already been filled. The practice of discarding makes the choice of appropriate total allowable catches, which must account for total extractions (discards plus landings) from the wild fish populations, more difficult. Copes (1986) offers a more detailed discussion of the potential problems with catch rights as a management technique.

Summary and Discussion

Traditional, open-access methods of regulation in a fishery will not significantly improve the economic performance of fishermen. In the short term, fishermen will be forced to use less productive and/or more costly methods of production. In the long term, the potential biological and economic benefits of regulation will not be sustained because access to the fishery would remain unrestricted. Temporary biological improvements in fishery resources will encourage new fishermen to enter the fishery and existing fishermen to increase their effort. Even if traditional regulations proved ineffective and biological improvements were not forthcoming, fishing effort could increase over time due to cost-saving technological change and increases in the demand for commercial fishery products and recreational fishing activities. Increases in fishing effort will tend to minimize potential long-term economic and biological benefits of regulation. New regulations will have to be implemented to further reduce fishing mortality by closing loopholes, restricting other gears or components of effort, or prohibiting new innovations. The result of management with unrestricted access to the fishery will be additional and more costly and complex regulations as competition increases for dwindling fishery resources.

Limited-entry systems of management would restrict access to a fishery through the issuance of a limited number of fishing rights or privileges. These fishing rights would acquire a value which would accrue to their owners as an additional benefit from fishing. The market price of fishing rights would also increase the cost of participation in a fishery as an incentive for the least efficient fishermen to shift to other fisheries or land-based employment opportunities. This would likely improve economic performance in the restricted fishery, but it could also lead to additional inefficiencies in other fisheries if access to them is not controlled. Greater regulation in alternative fisheries may be necessary if the additional fishing effort leads to overfishing of the alternative species or hastened their decline if they were already overfished.

License limitation and catch rights are the most common methods of restricting access to a fishery. With license limitation, qualifying fishermen would receive a license for the right to fish, but each fisherman's allowable catch would be unrestricted. Among other things, Townsend (1990) concluded that license limitation slows the race for fish on a first-come-first-served basis only in that there would be fewer fishermen. Hence, license limitation does not contribute to biological conservation of fish stocks. The quotas often accompanying limited entry offer biological conservation while license limitation offers economic benefits by reducing short-term crowding externalities.

Catch rights, when adequately enforced, have the potential to change fishing strategies. Ideally, catch rights should have certain desirable characteristics to facilitate attainment of economic efficiency and biological conservation. The catch right must be recognized by the judicial system as a legitimate and exclusive right of participation in the fishery, and it should be permanent so that fishermen individually and collectively believe that they have a vested interest in the continued well-being of the fishery resource. In addition, government must demonstrate that it can prevent fishermen from illegally landing fish in excess of their quotas. If these conditions are satisfied, then fishermen will have an

incentive to cooperate in the use of conservative harvesting strategies, including peer pressure to discourage noncompliance with fishery regulations and/or acceptable fishing practices (Scott, 1988). In this sense, the existence of catch rights would facilitate individual control over fishing effort as a substitute for some, but not necessarily all, direct government restrictions on fishing times, locations, gear types, and keep rates. Fishing effort would be limited, but fishermen would retain more flexibility in their choices of when, where, and how to fish, including the ability to fully utilize existing capital before replacing it. Catch rights could be complemented with traditional methods of regulation in specific circumstances. For example, minimum size limits could reduce catches of juvenile fish, and seasonal and area closures could reduce catches of spawning fish. However, the retention of open-access methods of regulation would also retain their negative qualities, with perhaps only the scale of their problems changed. It would be better to eliminate or simplify as many traditional regulations as possible rather than to add catch rights to a host of existing open-access regulations.

Why are traditional methods of regulation adopted if they are ineffective in the long term? For one thing, they offer at least temporary biological protection. Also, these types of regulations, especially gear restrictions and minimum income requirements, have tended to benefit politically dominant groups of fishermen by allocating a relatively larger share of the overall catch to their members (Karpoff, 1987). In this sense, traditional regulations minimize social and political discord due to regulation and hence may elicit relatively high voluntary compliance and may be relatively inexpensive to enforce.

Open-access regulations may be preferred over limited entry for philosophical reasons in what Acheson (1980) called the "Adam Smith response." The number of fishermen in a fishery is self regulated by competition. Limited entry may be perceived as an additional restraint on the free enterprise system in which a select few would be protected from normal competitive forces.

Economists counter with two arguments. First, because fish are common property, the unregulated free enterprise system does not result in optimal levels of fishing effort and overall harvest from the perspective of society as a whole. As Hardin (1968) wrote, "Freedom in a commons brings ruin to all." Open-access regulations allow as much freedom of access as possible while restricting how, when, and where people fish. Limited-entry regulations restrict access while allowing as much freedom as possible to choose how, when, and where to fish. Many fishermen and fishery managers may simply prefer to maintain the historical tradition of open access to marine fisheries. Second, limited entry would not protect individuals from competition for the limited number of fishing privileges as long as licenses or catch rights are transferable.

The prospect of a market-based distribution of fishing privileges may evoke additional opinions about limited entry. Many fishermen and fishery managers may oppose the potential redistributional effects of limited entry (Acheson, 1980). Open-access regulations allocate fish among fishermen on a first-come-first-served basis subject to certain restrictions described by the regulations. With limited entry, on the other hand, after the initial distribution of fishing rights, access to the fishery would be determined by market forces. Newcomers could buy or rent fishing rights to enter the fishery, and retirees would be paid to leave. But the final distribution of fishing rights among small-scale fishermen, large-scale fishermen, processors, and other investors would be different from open access and may be viewed as less predictable or less desirable than that of traditional regulations. Some fishermen may fear that they would receive an unfair initial distribution of fishing rights, that they may be excluded from the fishery altogether, or that ownership of fishing privileges would soon be purchased by wealthier fishermen and corporations. And excess capital and labor may not be easily transferred to other fisheries or land-based employment, which would create large short-term losses for those who were excluded.

Fishery managers may prefer open-access regulations if there is a large recreational fishery for which access cannot be easily controlled. Limited-entry programs are generally applied to commercial fisheries and traditional methods of regulation (e.g., bag limits and annual quotas) to the recreational sector. But without geographical separation of the fish stocks sought by commercial and recreational fishermen, open-access competition by the recreational sector would undermine the potential benefits of limited entry for the commercial sector.

It is not clear how limited entry could be applied to recreational fishermen. One option would be a separate limited-entry system of licenses or catch rights for recreational fishermen. A management system based on catch rights could include recreational fishermen more easily than could a system based on license limitation. Recreational fishermen could receive initial allocations of catch rights, probably by lottery because historical levels of participation in the fishery are difficult to verify. Then they could participate in the market for catch rights to increase or decrease their holdings of catch rights. Fishing tackle shops and marinas may wish to purchase catch rights for resale to recreational fishermen while charter and party boat operators may purchase catch rights for their clients. If recreational and commercial fishermen competed in the same market for catch rights, then the allocation of the total allowable catch between the recreational and commercial sectors would be determined in the market for catch rights rather than by tradition or political clout. By definition, fish would be allocated to their most highly valued uses because catch rights would be purchased by those most willing and able to pay for them. Nevertheless, if compliance is poor then enforcement would be costly because of the large numbers of fishermen and points of landing. Whatever methods are chosen, however, if recreational fishing effort is not restricted, then the potential biological and economic benefits of reducing commercial fishing effort would be minimized by long-term increases in recreational effort.

Finally, fishery managers and fishermen may hesitate to forego familiar open-access methods of management if they sense that economists, in their zeal, have

overstated the potential advantages of restricting access to a fishery and overlooked some of the disadvantages. In fact, early advocates of license limitation underestimated the ability of fishermen to expand their use of uncontrolled components of effort. Various license limitation programs have existed for many years and their advantages and shortcomings are now well documented (Townsend, 1990). In theory, the use of catch rights is superior to license limitation. However, management programs with catch rights are relatively new, and hence their effects in practice have not been as thoroughly scrutinized. Copes (1986) provides a discussion of potential problems in the implementation of catch rights.

Turvey (1964) noted that "(A) fishery is one of those spheres of economic policy where what is the best thing to do depends on what can be done." Nevertheless, given the long-term disadvantages of traditional, open-access methods of managing marine fisheries, it makes sense to explore the possibilities of alternative methods of regulating fishing effort. An empirical question is whether or not the potential benefits would exceed the costs of starting, monitoring, and enforcing a limited-entry system of management.

Acknowledgments

The ideas in this paper benefitted from discussions about limited entry in informal workshops with the Ad Hoc Limited-Entry Committee of the Gulf of Mexico Fishery Management Council and with the Snapper-Grouper Committee of the South Atlantic Fishery Management Council. The helpful comments and insights of Dean Ahrenholz, Richard Raulerson, John Gauvin, and Douglas Vaughan are gratefully appreciated.

Literature Cited

Acheson, J. M. 1980. Attitudes towards limited entry among finfishermen in northern New England. Fisheries 5(6):20-25.

Anderson, L. G. 1985. Potential economic benefits from gear restrictions and license limitation in fisheries regulation. Land Econ. 61:409-418.

_____. 1986. The economics of fisheries management. Rev. ed. Johns Hopkins Univ. Press, Baltimore, 296 p.

Beddington, J. R., and R. B. Rettig. 1984. Approaches to the regulation of fishing effort. FAO Fish. Tech. Pap. 243, 39 p.

Bell, F. W. 1978. Food from the sea: The economics and politics of ocean fisheries. Westview Press, Boulder, Colo., 380 p.

Cheung, S. N. S. 1970. The structure of a contract and the theory of a non-exclusive resource. J. Law Econ. 13:49-70.

Christy, F. T., Jr. 1978. The costs of uncontrolled access in fisheries. *In* R. B. Rettig and J. J. C. Ginter (Editors), Limited entry as a fishery management tool, p. 201-210. Univ. Wash. Press, Seattle.

_____. 1982. Territorial use rights in marine fisheries: Definitions and conditions. FAO Fish. Tech. Pap. 227, 10 p.

Clark, I. N., and A. J. Duncan. 1986. New Zealand's fisheries management policies—past, present and future: The implementation of an ITQ based management system. *In* Nina Mollett (Editor), Fishery access control programs worldwide: Proceedings of the Workshop on Management Options for the North Pacific Longline Fisheries, p. 107-140. Univ. Alaska Sea Grant Rep. 86-4.

_____, P. J. Major, and N. Mollett. 1988. Development and implementation of New Zealand's ITQ management system. Mar. Resour. Econ. 5:325-349.

Copes, P. 1986. A critical review of the individual quota as a device in fisheries management. Land Econ. 62:278-291.

Crutchfield, J. A. 1973. Economic and political objectives in fishery management. Trans. Am. Fish. Soc. 102:481-491.

_____. 1979. Economic and social implications of the main policy alternatives for controlling fishing effort. J. Fish. Res. Board Can. 36:742-752.

_____ and G. Pontecorvo. 1969. The Pacific salmon fisheries: A study of irrational conservation. Johns Hopkins Univ. Press, Baltimore, 220 p.

_____ and A. Zellner. 1963. Economic aspects of the Pacific halibut fishery. Fish. Ind. Res. 1:1-173.

Davis, G. E. 1989. Designated harvest refugia: The next stage of marine fishery management in California. CalCOFI Rep. 30:53-58.

Demsetz, H. 1967. Toward a theory of property rights. Am. Econ. Rev. 57:347-359.

Dupont, D. P. 1990. Rent dissipation in restricted access fisheries. J. Environ. Econ. Manage. 19:26-44.

Geen, G., and M. Nayar. 1988. Individual transferable quotas in the southern bluefin tuna fishery: An economic appraisal. Mar. Resour. Econ. 5:365-387.

Gordon, H. S. 1954. Economic theory of a common-property resource: The fishery. J. Polit. Econ. 62:124-142.

Hardin, G. 1968. The tragedy of the commons. Science 162:1243-1248.

Huppert, D. D. 1987. Limited access alternatives for the Pacific groundfish fishery. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 52, 45 p.

Karpoff, J. M. 1987. Suboptimal controls in common resource management: The case of the fishery. J. Polit. Econ. 95:179-194.

Keen, E. A. 1988. Ownership and productivity of marine fishery resources: An essay on the resolution of conflict in the use of the ocean pastures. McDonald and Woodward Publ. Co., Blacksburg, Va., 122 p.

Mollett, N. (Editor). 1986. Fishery access control programs worldwide: Proceedings of the Workshop on Management Options for the North Pacific Longline Fisheries. Univ. Alaska Sea Grant Rep. 86-4, 366 p.

Moloney, D. G., and P. H. Pearse. 1979. Quantitative rights as an instrument for regulating commercial fisheries. J. Fish. Res. Board Can. 36: 859-866.

Muse, B., and K. Schelle. 1988. New Zealand's ITQ Program. Alaska Commer. Fish. Entry Comm., CFEC 88-3, 46 p.

Peacock, F. G., and D. A. MacFarlane. 1986. A review of quasi-property rights in the herring purse seine fishery of the Scotia-Fundy region of Canada. *In* N. Mollett (Editor), Fishery access control programs worldwide: Proceedings of the Workshop on Management Options for the North Pacific Longline Fisheries, p. 215-230. Univ. Alaska Sea Grant Rep. 86-4.

Pearse, P. H. (Editor). 1979. Symposium on policies for economic rationalization of commercial fisheries. J. Fish. Res. Board Can. 36: 711-866.

_____. 1980. Regulation of fishing effort: With special reference to Mediterranean trawl fisheries. FAO Fish. Tech. Pap. 197, 82 p.

Plan Development Team. 1990. The potential of marine fishery reserves for reef fish management in the U.S. southern Atlantic. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-261, 45 p.

Rettig, R. B. 1984. License limitation in the United States and Canada: An assessment. N. Am. J. Fish. Manage. 4:231-248.

_____ and J. J. C. Ginter (Editors). 1978. Limited entry as a fishery management tool. Univ. Wash. Press, Seattle, 463 p.

Robinson, W. L. 1986. Individual transferable quotas in the Australian southern bluefin tuna fishery. *In* N. Mollett (Editor), Fishery access control programs worldwide: Proceedings of the Workshop on Management Options for the North Pacific Longline Fisheries, p. 189-205. Univ. Alaska Sea Grant Rep. 86-4.

Scott, A. 1955. The fishery: The objectives of sole ownership. J. Polit. Econ. 63:116-124.

_____. 1979. Development of economic theory on fisheries regulation. J. Fish. Res. Board Can. 36:725-741.

_____. 1988. Development of property in the fishery. Mar. Resour. Econ. 5:289-311.

Smith, I. R., and T. Panayotou. 1984. Territorial use rights and economic efficiency: The case of the Philippine fishing concessions. FAO Fish. Tech. Pap. 245, 17 p.

Tisdell, C., and J. M. Broadus. 1989. Policy issues related to the establishment and management of marine reserves. Coastal Manage. 17:37-54.

Townsend, R. E. 1990. Entry restrictions in the fishery: A survey of the evidence. Land Econ. 66:359-378.

Turvey, R. 1964. Optimization and suboptimization in fishery regulation. Am. Econ. Rev. 54 (March):64-76.

U. S. Department of Commerce. 1990. 50 CFR Part 652: Atlantic surf clam and ocean quahog fishery, final rule. Federal Register 55(June 14):24184-24196.

Wilen, J. E. 1988. Limited entry licensing: A retrospective assessment. Mar. Resour. Econ. 5:313-324.