MODEL SPECIFICATION AND POLICY ANALYSIS: THE GOVERNANCE OF COASTAL FISHERIES

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Coastal fisheries are often governed by institutional arrangements, devised by fishers, that limit who can enter fisheries and how harvesting of fish must be conducted. In this dissertation I present an analysis and explanation of these institutional arrangements. This explanation is based on data from case studies of tu^y different coastal fisheries located throughout the world. Using an institutional analysis approach, I examine the problematic situations fishers confront. These involve problems related to the flows of fish through fishing grounds, or stock externalities; and problems related to the physical space constituting fishing grounds, such as assignment problems and technological externalities. I also explain and examine the types of problematic situations fishers attempt to resolve by cooperating to devise property rights and rules to govern the utilization of their fishing grounds. Fishers typically focus upon governing the physical space of their grounds as opposed to managing the flows of fish. Finally, I evaluate the performance of different institutional arrangements, and how performance varies depending upon how the arrangements are structured. Groups of fishers that possess more complete sets of property rights in their fishing grounds, and who have devised rules defining the harvesting actions they can take, typically achieve superior

outcomes to those fishers who do not have as well defined institutional arrangements.

An institutional analysis approach to fisheries differs significantly from the standard approach used by policy analysts. The bionomic model is based on the assumption that fisheries are "common property", meaning that no institutional arrangements exist to limit access or regulate harvesting activities. In addition, the model presumes a single problematic situation, that of stock externalities, and fails to recognize significant problems arising in relation to multiple fishers interacting within the limited space of fishing grounds. As a consequence, policies based on the bionomic model, and developed for open access, unregulated situations have failed when applied to coastal fisheries where institutions already exist, and the institutional arrangements devised by fishers have, in some cases, been seriously harmed by the imposition of these policies.

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CHAPTER ONE

A BIONOMIC MODEL OF COASTAL FISHERIES

The environment of coastal fisheries is quite complex. Many aspects of the physical environment are not well understood because of highly fluctuating nature of the fish stocks, interaction among stocks of fish and other forms of ocean life, and climatic changes and human intervention, and how they impact ocean life. In addition, fishers have created a variety of institutional arrangements to govern their activities, and government agencies have imposed a variety of policies. Consequently, coastal fishery environments are physically and institutionally rich and varied. Yet, neither the physical nor the institutional aspects are well understood, creating severe problems for policy makers attempting to address and resolve problematic situations arising in the utilization of fisheries, both offshore fisheries, and inshore, or coastal fisheries.

A variety of problematic situations arise in the utilization of fisheries. Stock externalities arise from fishers failing to account for the costs they produce for other fishers as they harvest (Smith 1968). When a fisher harvests fish, he draws down the pool of fish available for harvest, increasing the costs of harvesting. Harvesting costs increase because it is more costly to search for and catch fewer fish. By failing to take these costs into

account fishers expend effort beyond that which is efficient to harvest fish, A second common problematic situation is technological externalities (Gardner, Ostrom and Walker 1990). Technological externalities arise when fishers interfere with each in harvesting fish. Either their gear becomes entangled, or they interfere with the flow of fish into each others gear. As a result, gear is destroyed or not utilized to capacity, A third common problematic situation is assignment problems (Gardner, Ostrom and Walker 1990). Assignment problems arise as fishers fight over and try to gain control of prime fishing spots. Typically, fish are unevenly distributed across fishing grounds. Fish congregate in areas that provide them food and shelter, if the number of fishers exceed the number of prime fishing spots, fishers may fight to gain access to those spots. Thus, common problems that arise in the utilization of fisheries are stock externalities, technological externalities, and assignment problems.

The predominant policy model, the bionomic model, utilized by many policy makers in devising management systems to regulate fisheries, only permits a consideration of stock externalities. The bionomic model is an extremely simplified representation of a fishery environment, within the model the physical environment is represented as a single stock of fish whose population dynamic is stable and well understood. Also, fish stocks are assumed to be homogeneously distributed across space. The physical environment is not problematic. In addition, the institutional environment is assumed to be non-existent. No entity regulates the utilization of fisheries. No limits exist in relation to who can access fisheries and no rules exist to govern how the harvesting of fish may be conducted once access has been gained. Fishers who operate within this institutional vacuum are assumed homogeneous. In particular, they are assumed to utilize identical technologies. On the basis of these assumptions the bionomic model is capable of only addressing problematic situations involving stock externalities. Given the assumptions of homogeneous distributions of fish over space, and the use by fishers of identical technologies—assumptions that eliminate assignment problems and technological externalities—the only problematic situation to be addressed is stock externalities.

In order to address stock externalities, advocates of the bionomic model argue that institutional arrangements must be imposed that will induce fishers to take these harvesting costs into account. A lack of institutional arrangements is problematic in that institutional nonexistence permits stock externalities to exist unchecked. Resolving such a problem, however, is not problematic. A government agency need only intervene to establish appropriate arrangements that would induce fishers to

harvest fish efficiently. In other words, within the scenario established by the bionomic model, no problems of collective action exist. Whether fishers will cooperate to engage in institutional design, and under what circumstances they may do so are not viable questions within the bionomic model. Rather, problems fishers face, in particular stock externality problems can easily be resolved through government intervention. Thus, most problems the physical and/or institutional environments actual coastal fisheries may present are not included in the highly simplified assumptions of the bionomic model.

Even though the bionomic model is highly simplified, it was the first model to combine biological and human behavioral interactions in relation to fisheries and, therefore, provides an important base on which to further develop an explanation of institutional processes occurring in coastal fisheries. By carefully changing physical and institutional assumptions of the bionomic model, it is possible to begin to construct an explanation for the variety of institutional arrangements fishers have devised to govern their harvesting activities, and the impact the physical environment has had upon such arrangements. In other words, rather than assuming away many problems, in this study stock and technological externalities, assignment problems, and collective action problems will all be addressed. Instead of replacing the bionomic model with an alternative model, the approach taken in this study is to extend the analysis of processes occurring within coastal fisheries, begun with the development of the bionomic model, to include an explanation of institutional arrangements devised by fishers.

Understanding the arrangements that fishers have created is important for devising effective policies in relation to fisheries. By utilizing the bionomic model many policymakers fail to recognize the existence of these arrangements, and consequently little work has been conducted in explaining and understanding their presence. If these arrangements present solutions to crucial problems fishers face, they must be recognized and built into policy initiatives. In addition, the institutional arrangements fishers have devised may provide the basis for addressing additional problems that can arise in the utilization of coastal fisheries without having to start from the beginning in creating institutional responses to new problematic situations.

In this chapter I will present an analysis of the bionomic model, the conclusions it reaches, and policies that have been developed from it. I will also examine the failure of these policies. Given the highly simplified nature of the bionomic model and its failure to take into account existing institutional arrangements, it may not be a useful model from which to derive actual policies (Townsend

1986). Next I will present the basic assumptions upon which an institutional, or collective action, approach is based and how it differs from the approach taken in the bionomic model. Finally, I will conclude with a brief discussion of the remaining chapters of this study.

A Bionomic Model

The bionomic model consists of two parts, a biological model and an economic model developed on the foundation of the biological model. The biological model, introduced by Schaefer, is a simple logistic function that represents the population dynamics of a single fish stock as follows (Schaefer 1954:673):

$$\Delta P_t = k_t P_t (M - P_t) \qquad (1)$$

where:

ΔP_t=change in size of fish population
k_t=growth rate
M=the natural equilibrium size of the fish population

It is a density dependent model. The change in the size of the fish population depends upon the size of the population (See Figure 1.1). At smaller population levels the difference between the current population size, P_t, and the equilibrium population size, M, is great; applying the growth rate to this difference results in a significant increase in the population. At intermediate and higher population levels, the difference between P_t and M is not as great, and applying the growth rate to the difference between P_t and M results in smaller population increases until the population size reaches M, which is a stable equilibrium.[1] As Schaefer explains:

> Over any reasonably long period of time, losses from the population must be balanced by accessions to the population. When, however, the percentage rate of loss is increased, decreasing the size of the population, from whatever cause, the percentage rate of renewal must increase also, so that the population comes into balance (Schaefer 1957:672).

When fishers begin to exploit the fishery a new equilibrium, different from H emerges. The new equilibrium "will be achieved at the level of population where the net increase...from natural factors just equals the net decrease due to fishing mortality" (Anderson 1977:25). This can be thought of as a harvestable surplus, which is equal to the change in population. By just harvesting the amount of fish that constitute the population increase at any population level, the population will be maintained at that level. For example, in Figure 1.1, applying E_1 amount of effort produces an F_1 harvest level, resulting in an equilibrium population of P_1.

Each point on the Schaefer growth curve, or the population dynamic curve, corresponds to a harvestable surplus which can be sustained over time if effort applied to take that surplus remains constant. Each point where effort corresponds to harvestable surplus represents a sustainable yield. Sustainable yield, or catch, is, therefore, a function of population size and effort. Schaefer argued that the following equation captures this relationship:

(2)

Where:

L_t»landings, or catch
E_t-effort
P_t«*fish population size
kj*catchability coefficient

That is, the change in catch is equal to some proportion of the effort applied to the population of fish. When a sustainable yield is being produced, when the amount of effort applied is such that just the change in fish population is being harvested, equations (1) and (2) are equal, so that:

$$k_2E_tP_t=k_1P_t(M-P_t) \quad (3)$$

Solving for P_t produces:

$$P_t=M-(k_2/k_1)E_t \quad (4)$$

Population size can be expressed as a function of effort. By substituting equation (4) into equation (2), catch can also be expressed as just a function of effort, although population size is implicitly captured in the term in parentheses, so that:

$$\Delta L_t=k_2E_t[M-(k_2/k_1)E_t] \quad (5)$$

Equation (5) is the long run production function for a fishery consisting of a single fish population. It represents the catch produced at different effort levels (See Figure 1.2). As effort increases, landings increase to some maximum, after which they decline until the fish population has been fished to extinction. This interpretation corresponds nicely with that of equation (1) representing the population dynamics of the fish stock. Since the harvestable surplus increases to a maximum and then declines, it is to be expected that landings, which should correspond to the harvestable surplus, exhibit a similar dynamic.

Having established the long run production function for the fishery, the next step in the analysis is to establish a benchmark, or an optimal level of production. Two optimal points have been considered, that which maximizes production, or where landings are at a maximum, and that which maximizes income (Gordon 1954, Schaefer 1957). In Figure 1.3, E_m is the level of effort that maximizes production. That is the point at which the sustainable yield is at its greatest.

To determine the level of effort that maximizes income, two additional assumptions must be made: 1) the price of fish is constant, and 2) the cost of effort is constant. Both assumptions keep the analysis simple, and are reasonable, it is argued, for a single fishery (Gordon 1954). The result of the first assumption is that the long run production function is similar to the total revenue curve, since landings are multiplied by a constant cost. The second assumption results in a linear total cost curve, which means that each additional unit of effort can be applied at a constant cost (See Figure 1.3). Income for the fishery as a whole is maximized when the difference between

total revenues (TR) and total costs (TC) is greatest. (For the individual fisher this occurs where marginal revenues equal marginal social costs). This is where the slopes of the TR and TC lines are equal; in Figure 1.3 this is at a level of effort of E,.

Gordon (1954) and many others advocate managing fisheries so as to maximize income (Christy and Scott 1965, crutchfield 1979, Pearse 1980). Maximizing income not only benefits fishers, it is argued, but society at large. As Anderson explains, revenues measure what people are willing to pay for fish, whereas costs represent the value of the next best use of the inputs needed to harvest the fish. When marginal social costs exceed marginal revenues, or, in terms of Figure 1.3, when effort in excess of E, is applied, society loses because additional fish are harvested at a cost greater than their value to consumers (Anderson 1986).[z]

The next step in the analysis is to determine how actual fisheries are utilized. If they are not utilized efficiently so that net income is maximized, then a question is raised as to whether policies exist that will change fishers incentives so that they are led to an optimal harvesting strategy. In order to proceed with the analysis assumptions about the institutional environment of fisheries must be made so that the behavior of individual fishers and the outcomes they achieve can be determined. Two institutional assumptions are made concerning fisheries.

First, fisheries are open access. Anyone who chooses can enter and harvest from fisheries. Second, effort is unregulated. Fishers can apply as much effort as they choose. Given these two assumptions—unlimited access and unregulated effort—fishers will apply effort until total revenues equal total costs, or where all rents are dissipated. Fishers invest capital and labor in the resource beyond the point where they maximize their net income, to the point where they just cover their costs. In Figure 1.3 this occurs at a level of effort of E_d. This is a stable economic equilibrium. At levels of effort greater than E_d, costs exceed revenues, resulting in the reduction of effort. At levels of effort less than E_d, revenues exceed costs attracting effort into the fishery. As Schaefer argues:

> In a fishery which is a common property resource, where anyone who wishes to do so is free to enter, new operators will be attracted to come into the fishery so long as the average cost is less than the average return...so that in the unrestricted common-property fishery the effort will grow until...the net economic yield is zero (Schaefer 1957:678).

Far from optimally utilizing fisheries, analysts have repeatedly concluded that fishers dissipate all rents.

Rent dissipation occurs, it is argued, because of the nature of the resource and because of a lack of well-defined property rights. In a fishery, fishers harvest from the same stock or stocks. A stock is jointly harvested. In such a situation, when a fisher harvests fish, he reduces

the stock, i.e., he subtracts from the amount of fish available to be harvested in the present period, which increases the costs of harvesting. The increased costs of harvesting due to reducing the stock not only affect the fisher who harvested the fish, but all fishers who fish that stock. Fishers generate negative externalities that they do not take into account in deciding how much effort to apply. Since they do not take into account all of their costs, they apply greater levels of effort than they would have if they had taken these externalities into account.[3] Numerous fishers harvesting from the same stock of fish produce stock externalities that they do not take into account, resulting in the application of excess levels of effort.

Fishers apply excessive levels of effort because a lack of property rights fails to produce incentives to conserve the resource or limit effort. Whatever one fisher does not harvest, another will. As Gordon states, "the fish in the sea are valueless to the fisherman, because there is no assurance that they will be there tomorrow if they are left behind today" (Gordon 1954:135). Scott argues that fishers harvesting from an open access, unregulated fishery, heavily discount the future. They do not take into account the effect their current harvests have on the size of future fish populations and consequently future harvests. Fishers maximize current returns instead of the present value of the future flow of fish (Scott 1955). As a result, excessive levels of effort—levels of effort beyond that needed to optimally utilize the fishery—are applied. According to the bionomic model, fisheries are not utilized so as to maximize income because fishers do not take into account the stock externalities they generate. They do not take into account the effect their harvesting has upon current and future harvest levels of other fishers. Consequently, excessive levels of effort are applied resulting in the complete dissipation of rent. This is the predicted outcome for an open access, unregulated fishery, which, it is presumed, accurately portrays most actual fisheries.

Policy Regulations Derived From The Bionomic Model

The next step in the analysis is to substitute alternative institutional arrangements for the open access, unlimited effort assumptions to determine policy regulations that would alleviate excessive investment in fishing effort. Alternative institutional arrangements must induce fishers to take into account the costs they visit upon each other. The presumption has been that this can only be achieved by an external authority imposing order in the fishery (Gordon 1954, Scott 1955, 1979, Christy and Scott 1965, Smith 1968, Anderson 1977, 1986, Crutchfield 1979, Pearse 1980). "Order" frequently means defining property rights in the fish and granting such rights to a single individual or entity. As Gordon states:

> Common-property natural resources are free goods for the individual and scarce goods for society.

> Under unregulated private exploitation, they can yield no rent; that can be accomplished only by methods which make them private property or public (government) property, in either case subject to a unified directing power (Gordon 1954:135).

Only by establishing a unified directing power will the harvesting of fish be organized efficiently.

Until recently, the unified directing power, or single owner, has been posited to be a government agency charged with reducing effort to levels that maximize income. A government agency, as owner, has a variety of command and control regulations it can use to limit effort. Effort consists of numerous factors, such as the number of vessels, their harvesting power, and the time fishers spend fishing, each of which can be substituted for the other. To reduce overall effort regulations must limit all aspects of effort. Otherwise, if only a single aspect is limited, such as the number of vessels that can be utilized, fishers will substitute other factors to avoid those limits, such as increasing the harvesting power of existing vessels, or by spending more time fishing.

Many regulations, as Anderson argues, only partially limit effort (Anderson 1986). Such regulations, primarily devised to prevent the destruction of fish stocks, include area and seasonal closures, and gear restrictions. Area closures forbid harvesting of fish in specific areas, usually spawning grounds. Seasonal closures forbid harvesting of specific types of fish during particular times of the year, often times when fish are spawning. Gear restrictions forbid fishers from using certain types of gear. Since these regulations only partially limit effort, such as the time that can be spent fishing, or the type of equipment that can be used, fishers can substitute other aspects of effort to avoid these regulations. For example, fishers can minimize the impact of seasonal closures by using their existing capital equipment more intensively, and by increasing their investment in variable inputs, such as labor, nets, etc. Fishers continue to harvest at the same level, but within a shorter time period. This increases the costs of fishing while failing to limit effort to a level that maximizes income (Ibid:200-201). Partial limits on effort not only fail to curb effort but they also increase the costs of applying effort.[4]

Institutional arrangements believed to limit overall effort to an efficient level are taxes on effort, limited access licensing, and individual transferable quotas.[5] By taxing effort, the total cost of applying effort increases, making average costs greater than average revenues, causing fishers to reduce effort. By establishing a tax at the appropriate level fishers will be deterred from investing effort in excess of that needed to maximize incomes. By increasing the cost of effort through taxes, fishers will apply effort at E_1 (see Figure 1.3). The resources that

would have been invested in inefficient levels of effort are now siphoned off by the tax.

A similar analysis applies to licenses. Licenses are granted to vessels, based on the presumption that vessels are adequate proxies for total effort. Only the number of licenses corresponding to the number of boats that would apply an efficient level of effort are distributed. Instead of reducing effort by increasing its cost, effort is reduced by forcing boats out of the fishery. As a result of either a taxing or licensing scheme:

> Assuming that the resources forced out of the fishery are put to constructive uses in other parts of the economy, the goal of fishery regulation has been met. The current catch is harvested in the most efficient manner, and excess resources are released for other uses (Anderson 1986:221).

In practice, taxes on effort have not been used to encourage the economic harvesting of fish.[6] Since effort is constituted by a number of factors which can be utilized in innumerable combinations resulting in a variety of effort levels, measuring effort precisely enough to establish a meaningful tax is virtually impossible. Even if effort could be accurately measured, additional complications arise when a variety of stocks of fish are harvested from a single fishing ground. Each stock possesses a different value. Consequently, different tax rates would have to be developed for each stock and some means of apportioning effort among mixed catches would have to be developed. Maloney and

Pearse argue:

> This approach thus puts rather unusual technical and econometric demands on the regulatory authority, and calls for a degree of continuous, discriminating adjustment to the levies on catch which probably cannot reasonably be expected of a public agency or regarded as acceptable to fishermen (Maloney and Pearse 1979:863).

Licensing as a means of limiting access and effort has, until recently, been the regulatory system most advocated as the means by which a government agency, as owner of the flow of fish, can control the activities of fishermen. Many licensing systems,-however, have not produced the intended outcomes because, in practice, licensing systems do not limit total effort. Also, such systems may conflict with institutional arrangements devised by fishermen that regulatory agencies fail to consider (Matthews 1988, Marschak, et.al. 1989).

One of the most documented cases of licensing failure occurred in the British Columbia salmon fisheries (Fraser 1979, Pearse and Wilen 1979, Rettig 1984). In 1969, a comprehensive licensing system was implemented to protect the salmon stocks and to eliminate economic waste in the form of overcapitalization. No additional vessels were permitted to enter the fishery and each existing vessel was granted either a part-time or full-time license which was transferable upon sale of the vessel. The fleet was to be reduced by phasing out part-timers, and by government buyouts of existing vessels. Initially no limits were

placed on vessel size so that smaller vessels were retired while larger vessels were introduced. The system was amended tying licenses to vessel tonnage, so that in purchasing a license a fisher was also limited in the size of vessel he could utilize. In spite of this, effort expanded, although at a slower rate than prior to the introduction of the licensing system (Pearse and Wilen 1979). Thus, the licensing system not only failed to reduce effort, it even failed to hold effort constant. The outcome of the British Columbia licensing system has been replicated in other systems, such as the Japanese tuna fishery (Keen 1973), Australian scallop fisheries (Sturgess, et.al. 1982), Australian rock lobster fisheries (Meany 1979), Alaskan salmon fisheries (Koslow 1982, Keen 1988), Canadian Pacific herring fisheries (Keen 1988), and the fisheries along the eastern coast of Canada (Matthews and Phyne 1988).

Licenses do not work because they do not limit total effort. Fishers who remain in the fisheries engage in capital stuffing (Copes 1986). They increase the amount of effort the remaining vessels can produce. For example, in the Japanese tuna fishery crew quarters in many boats were reduced to increase the size of the hold, and holds were lined with plastic to store fuel which increased the range of the boat (Keen 1973). These actions increase the level of effort of the remaining boats, thus foiling the attempt to reduce effort to economically efficient levels.

In other instances, licensing systems have failed because they conflict with institutional arrangements established by fishers, with fishers acting so as to limit the impact of the licensing system. For example, Anthony Davis, in a study of small boat fishers in southwest Nova Scotia, compares how the fishermen have organized their fishery in contrast to how the Department of Fisheries and Oceans (DFO) has attempted to organize it (Davis 1984). The small boat, inshore, fishers of Port Lameron Harbour, Nova Scotia, have carefully crafted rules concerning access and use of their fishery. They have a defined fishing area from which they may exclude fishermen from other harbors. Within their fishing ground they have reserved different areas for specific types of gear. Longlines, handlines, and gill nets used to fish for herring, mackerel, cod, haddock, and halibut, all have designated areas. In addition, the fishers have divided the lobster grounds among themselves. As Davis states:

> Use patterns reflect practical and informal resource management strategies developed by a community of fishermen through years of experience. Their knowledge of the relations between species, as well as the composition/complexity of the resource zone, is expressed in terms of the exploitative strategies that they pursue, and in the partition of the zone into use areas (Davis 1984:145).

While these rules constrain the activities of fishermen they also permit flexibility. The fishers can fish for any type of fish they want, and they can switch to whatever type of

gear they prefer. They are not locked into a particular type of fish or gear.

DFO officials, however, do not recognize the institutional arrangements of the Port Lameron Harbour fishers. Fisheries are assumed open access and unregulated requiring the federal government to intervene to ensure the economic use of fish resources (Ibid:153). The DFO, in the early 1970s, imposed a system of quotas and licenses affecting the Atlantic coast of Canada. The purpose of the licenses and quotas was to limit access and reduce effort. Fishermen had to purchase a general commercial fishermen's license as well as licenses to fish with particular types of gear. The response of the fishermen was to purchase many different types of licenses so that they could not be excluded from fishing, even if they did not intend to ever use a type of gear for which they had a license. As a result the DFO issued more licenses than it intended. To limit the flow of licenses it imposed stringent requirements for their acquisition, in addition to limiting the number of licenses available. This created hardships for the Port Lameron Harbour fishers because they had not purchased licenses for gear that they used to catch bait, as opposed to gear they used to catch commercial fish. In the mid-1970s, fishers were suddenly cutoff from their supplies of bait. After a wave of protests involving fishers from other harbors, the DFO reopened the application process long enough for fishers to gain licenses that allowed them to fish for bait.

Davis argues that the licensing system of the OFO failed because officials did not take into account both the local conditions facing fishers, and the strategies that fishers utilize. DFO officials attempted to limit access by issuing licenses assuming fishers would only purchase licenses for the use of one or two types of gear. Fishers, however, purchased numerous licenses to maintain their flexibility in fishing a variety of stocks with a variety of gears. As a result the DFO issued more licenses than it expected and:

> Instead of stabilizing or reducing specific types of exploitative activities, DFO's practices have, in fact, directly expanded (at least in southwestern Nova Scotia) the potential number of small boat producers (Ibid:158).

Davis questions the necessity for a licensing system for inshore fishers, given the institutional arrangements they have designed. Instead, he argues, licenses and quotas should be directed at the large scale offshore fishing fleet that more nearly resembles an open access fishery. By ignoring local situations and imposing unnecessary and costly regulations, the Canadian government has not only interfered with the successful operation of self-governing institutions, but it has generated unintended consequences.

Given the failure of licensing systems in reducing effort, advocates of the bionomic model now argue that full

ownership rights in the flow of fish should not be vested in a government agency. Rather, individual fishers should be granted full ownership rights in a portion of the flow of fish through individual transferable quotas (ITQs). Each fisher would have the right to harvest a certain number or amount of fish. As Scott states:

> In consequence we have come to prefer over fishing licenses a system of catch quotas or landing rights, each assigned to a vessel or captain...Ideally, they would be denominated in numbers of fish, and subdivided as to place of capture, species, and perhaps time. They would be transferable and perhaps auctioned anew every year or so (Scott 1982:795).

The attempt is to encourage fishers to harvest fish efficiently by granting them individual private property rights in fish. Although a system of individual transferable quotas would give fishermen direct ownership in a portion of fish, a government agency would still play a significant role as administrator of the system. Each ITQ system would vary somewhat due to specific circumstances, but a typical system would work as follows. First, the agency would establish the amount of fish to be harvested, ie., total allowable catches (TACs). The agency would presumably establish an appropriate discount rate, and would take into account the effects of the fishers' activities upon each other, and upon the stock of fish. The agency, with this information, would determine the amount of fish that could be harvested so as to maximize the net present value of the fish.

Second, the agency would issue quotas denominated in numbers of fish, the sum of which would be the total amount of fish to be harvested. In the initial period fishers would purchase quotas from the agency, but thereafter they would purchase quotas from each other. Given the security that individual private property rights in a portion of fish would afford, fishermen would not attempt to expand their effort in competing for as much of the catch as is possible. Instead, given rights to a specified number of fish, fishermen would organize their harvesting activities so as to maximize their income.

In order to retain efficient fishers while excluding inefficient ones from fishing, individual quotas would have to be transferable. Initially the total allowable catch permitted by the quotas would be insufficient to keep all existing boats operating at full capacity. Additional income could, therefore, be gained by some boat operators purchasing the quotas of other operators. As Copes explains:

> There should be a reasonable expectation that the prospect of rents will lead more efficient operators to buy out the quota entitlements of less efficient operators. Thus, quota rights would be consolidated in the hands of the most efficient operators who would be able to fish full time and reduce unit costs of operation. In the process both buyers and sellers of quota rights could share in the net benefits of the rents that would be generated (Copes 1986:280).

ITQs, by giving fishermen secure rights in a specific amount

of fish, would result in fishermen efficiently organizing their harvesting activities.

Since ITQs have only recently been advocated in academic circles, little opportunity has existed to put such systems into place and evaluate their performance. Nevertheless, several scholars argue that ITQs will fail to induce economically efficient harvesting of fish because of the nature of fish populations, and because of various incentives that will mitigate the effects of ITQs (Wilson 1982, Copes 1986). First, many fish populations are not stable, producing highly variable numbers from year to year. Because of this variability in many fish populations, establishing total allowable catches (TACs) is impossible. The sizes of different fish populations cannot be predicted in advance so that a meaningful TAC cannot be estimated (Copes 1986).

Second, many fish populations exhibit seasonal and spatial variation. Fish are located nearer to shore during some parts of the year reducing traveling costs. Also, fish are more abundant during particular times of the year. As a consequence, even with ITQs, fishers will engage in capital stuffing to catch as great a proportion of their quota as possible when fish are abundant, and on those grounds that are most productive. Stock externalities will not simply disappear under a system of ITQs. Excess investment in effort will continue even under a system of ITQs.

Third, other adverse consequences may occur that are rarely taken into account. For example, if the value of fish is high, fishers may engage in quota busting (Copes 1986). If the temptation is great enough fishers may harvest more fish than their quota permits. Also, fishers may engage in high grading. If a specific size of fish is particularly valuable, fishers may fill their quotas with the most valuable size of fish, dumping those that are not as valuable. High grading produces high mortality rates for the fish that are returned to the ocean.[7] Both quota busting and high grading result in inaccurate catch records making it even more difficult to establish useful TACs.

As Copes argues, the same process that occurred with licensing systems is now threatening to occur with ITQs. When licensing systems were first advocated and theoretically shown to rationalize the use of fisheries, the analysis was based on a series of simplifying assumptions that precluded consideration of practical problems that could arise. This is now occurring in relation to ITQs. In a stable and predictable world, where fish are homogeneously distributed in space and time, and where every individual always follows the rules, (or where the costs of monitoring and imposing appropriate sanctions are low), ITQs will work as predicted (Copes 1986:288). These attributes do not characterize most coastal fisheries. Consequently, there is

good reason to be skeptical of the possibility of ITQs resolving the problem of stock externalities.

The policies derived from the bionomic model have failed because the model is too highly simplified to be used to derive applicable policies. Fishing grounds are not constituted of a single stock of fish uniformly distributed across space. Rather, multiple stocks of fish inhabit most fishing grounds, stocks whose populations fluctuate unpredictably, creating significant difficulties in defining meaningful quotas or efficient levels of effort for particular stocks of fish (see Chapter Two for a more indepth discussion). In addition, in many situations in which policies derived from the bionomic model have been applied, institutional arrangements have already existed, affecting the implementation of such policies, and the outcomes they were designed to achieve. Instead of being applied in an institutional vacuum, they have been applied in institutionally rich environments. Oversimplification and the existence of prior institutional arrangements have adversely affected the efficacy of policies derived from the bionomic model.

In addition, empirical tests that apparently support the applicability of the bionomic model as a policy model are being called into question. For example, one of the most widely cited empirical tests in support of the bionomic model is a study by Bell of the western Atlantic lobster fishery stretching along the coast of North America from Labrador to Delaware (Bell 1972). Using catch and effort statistics for 1950-1966, Bell estimated a production function, as well as long run average cost and long run marginal cost curves for the lobster fishery. Based on these estimates, Bell argued that twice as much effort was employed in the fishery as was needed to harvest the amount of lobster that would produce the maximum economic yield (Ibid:156). The consequence of such excessive effort would be, Bell argued, the eventual destruction of the lobster resource.

Townsend has shown, however, that Bell's bionomic model only fits the data for the period he examines, and that Bell's work is misleading (Townsend 1986). Townsend utilized catch and effort data from 1950 through 1979. From 1966, when Bell's data ends, until 1979, effort increased approximately 2.3 times (Townsend 1986:282). At that level of effort, Bell predicted resource destruction (Bell 1972:154), however, actual landings remained constant (Townsend 1986:282). The lobster resource was not destroyed. The posited relationship between yield and effort in the bionomic model failed to hold.

Townsend argues that Bell's analysis is also misleading because he makes inferences outside of the range of his data. Both the maximum economic yield (MEY), and the maximum sustainable yield (MSY) that Bell derived from his

model lay outside of his data. "Bell, whose effort data ranged from 513,000 traps to 949,000 traps, predicted that MEY would occur at 433,000 traps and MSY at 1,030,000 traps"(Ibid:281). Bell fitted a small portion of the positive sloped segment of the Schaefer curve, but he did not validate the negatively sloped portion of the curve (Ibid:287). Yet, that portion of the curve is crucial to his argument that "overfishing" commonly occurs in fisheries (Bell 1972:155).

Townsend argues that since the lobster fishery was considered one of the most successful applications of the bionomic model, and that the model does not meaningfully describe the fishery, the usefulness of the model in general is questionable.

> The Schaefer model remains the preeminent pedagogical model of fishery economics, and that position is not based upon empirical applications. The Schaefer model succinctly illustrates how biological factors and economic factors interact to create a stock externality. The simplification inherent in this modelling may be too great to warrant empirical application (Townsend 1986:290).

Townsend argues that while the bionomic model may be metaphorically powerful, it should not be used as a management tool to derive policy regulations (Ibid).

A Different Approach to the Analysis of Fishery Situations

In this study, instead of attempting to replace the bionomic model, I will focus upon questions that the bionomic model cannot address. The attempt, in this study, is to understand the existence of the institutional arrangements fishers have devised to govern their harvesting activities, the types of problematic situations fishers have addressed, and the performance of the fisher designed institutional arrangements. While the two approaches—the bionomic and the institutional—share a common concern with stock externalities, the two examine different questions. The bionomic model examines the harvesting behavior of fishers in a very well specified situation. The approach that I develop in this study examines not only fishers' harvesting behavior but also their acts of collective action.

In developing an institutional approach to the analysis of fishery situations, I adopt assumptions and themes from a developing body of thought that broadly includes work from political science, economics, law, and anthropology in which the focus is upon explaining the emergence of institutions, their function, and their performance.[8] This approach differs from that implicitly taken in the bionomic model in numerous ways, but the factors I will focus on are the characteristics of the goods being produced and the facilities that produce them, the model of the individual, the importance of collective choice, the nature of institutional development, and the evaluation of institutional performance.

The Physical Environment

The characteristics of the goods being produced and the

facility that makes them available affect the existence and extent of interdependencies among individuals (Ostrom and Ostrom 1977a, Blomquist and Ostrom 1985, Schmid 1987, Gardner, Ostrom and Walker 1990). In relation to fisheries, it is difficult and costly to exclude fishers from accessing the fishing grounds. Fishing grounds cannot easily be "fenced". A single fisher would find it costly to exclude all others, therefore, fishing grounds are subject to joint use. More than a single fisher can access grounds and harvest fish. The fish that one fisher harvests, however, are not available for other fishers to withdraw. Fish within the jointly used fishing grounds are subtractable. The catch of one fisher affects the amount of fish that can be harvested by other fishers utilizing the same ground.

Jointness of use of fishing grounds and the subtractable nature of fish mean that fishery situations are characterized by high levels of interdependence among fishers. Fishers utilizing the same grounds and harvesting from the same stocks of fish affect the actions of each other and the outcomes that each achieves. Close interaction can produce problematic situations for fishers. As discussed earlier, problems arise because numerous fishers are acting within the finite space of a set of fishing grounds. Fishers can fight over the most highly valued spots within those grounds. Or, in harvesting fish, fishers can set gear too close together with the gear becoming entangled or destroyed. Thus, how fishers utilize the space of fishing grounds can be problematic. Problems also arise because numerous fishers are harvesting from the same stocks of fish. Fishers in harvesting fish draw down the stocks, increasing the costs of harvesting for all fishers, as pointed out in the bionomic model.

In coming to understand processes occurring within fisheries, characteristics of the physical environment of fisheries must be taken into account. That environment presents a variety of problems for fishers, and constrains the actions they can take. It is the nature of the interactions among fishers that present problems that must be resolved, and these interactions are fundamentally conditioned by the physical environments of fisheries. To understand the actions fishers have taken and the institutions they have created requires that the various characteristics of fishing grounds and stocks of fish be taken into account (see Chapters Two and Four).

Models of the Individual

In order to explain how individuals act within particular physical environments a model of their behavior must be posited. What are reasonable expectations concerning the actions of individuals in a particular environment? In the case of the bionomic model, a stable physical environment with no uncertainties creates a reasonable expectation that individuals possess complete

information about their environment, that they can assess the consequences of the various actions that they may take, and choose those that provide them the greatest benefit, given the situation, and the actions of others.[9]

once the environment of fisheries is no longer characterized as stable and highly certain, and, instead, considered variable and complex, reasonable expectations about the actions of individuals must change. Individuals no longer can be expected to possess complete information about their environment, assess the consequences of various actions that they may take in light of the actions of others, and choose the action that provides the greatest benefits. Rather, given uncertainties in the physical environment, it is reasonable to assume individuals act as fallible learners (Ostrom 1990), or that they are boundedly rational (Williamson 1985). Individuals "engage in a considerable amount of trial and error learning" (Ostrom 1990:51). They take actions without knowing the consequences of their acts, and they may achieve positive outcomes, or they may bring on disaster (Ostrom 1990). Over time, however, at least in relation to those aspects of their physical environment that remain relatively constant, fishers can accumulate information that can assist them in choosing actions that result in outcomes that provide greater benefits. Over time, individuals, as fallible learners, may choose actions that result in more desirable outcomes.

Collective Choice Processes

Langlois (1986) argues that a change in the model of the individual is required for another reason. He argues that individuals in economic models, such as the bionomic model, are portrayed as being "passive reactors" (Langlois 1986:3). They respond to the incentives that are presented them in a predictable way, i.e. they maximize their utility, however, they cannot react to their environment by changing it. Individuals are trapped in the situation in which they find themselves. If the outcomes they achieve are undesirable they cannot change the situation. Some external authority must intervene to change the structure of the situation so that in responding to the incentives the new situation provides, individuals achieve desired outcomes. In other words, individuals, as portrayed in the bionomic model, are incapable of engaging in collective choice processes.

Collective choice processes involve individuals devising and agreeing to follow rules that structure their day-to-day activities (Kiser and Ostrom 1982). Individuals specify the actions they must, may, or must not take in undertaking particular actions. By changing the rules that structure daily activities, the actions that individuals take and the outcomes they receive may also change. In

order to explain and analyze the variety of institutional arrangements that exist in relation to many coastal fisheries, fishers cannot be presumed to be passive reactors. Fishers are instead presumed capable of devising rules that govern their day-to-day harvesting activities. The questions that must be addressed are under what circumstances do fishers choose to engage in such action, for what purpose, and what outcomes are achieved through such action.[10]

Intertemporal Process of Institutional Change

In engaging in collective choice processes to change the rules that govern their activities, fishers change the situation in which they act. The new situation may structure the actions of fishers so that they avoid the problems they once faced, but the new situation may itself generate different problems, or present different challenges to the fishers. For instance, in devising rules that limit the types of technology that can be utilized, fishers may resolve problems that had arisen over gear entanglement and destruction, but such rules may limit their ability to adopt newer forms of technology that could reduce the costs of harvesting. Institutional change at one point in time does not resolve all problems a group of individuals may face for the rest of time. Consideration must be given to the consequences of new arrangements.

Williamson (1985), in his work on transaction cost •conoaics, pays careful attention to what he calls ex ante and ex post aspects of contracting, Ex ante aspects involve characteristics of the situation before the contract is put into place, while ex. post aspects involve characteristics of the situation after a contract has gone into effect. Williamson argues that the entire process of contracting must be understood, and not just the ex ante aspects, such as the problem that needs to be addressed, or just the ex post aspects, such as the outcomes a particular institutional arrangement, or contract, brought about. In addressing problematic situations, or in addressing exchange relationships based on contracting, attention must be paid both to the institutional arrangement being proposed to address the problem, as well as the incentives such an arrangement creates once put in place, and problems that may arise after its implementation. Processes may need to be established that permit fishers to make additional changes to institutional arrangements that have been established.

Evaluation of Institutional Arrangements

Evaluating the performance of institutional arrangements fishers have devised should involve comparing outcomes actual institutional arrangements have produced, rather than comparing outcomes actual institutions have produced against outcomes produced by "ideal" institutional arrangements (Dahlman 1979, Williamson 1985, Langlois 1986,

Schmid 1987).' The latter case is what often occurs in relation to the bionomic model. The bionomic model establishes an ideal outcome where all fishers are simultaneously maximizing their incomes. This outcome, however, cannot be achieved in actual fisheries because of the uncertainties arising from the physical environment and the institutional environment. All outcomes occurring in fisheries, when compared with outcomes arising from the ideal case, will be inefficient. An alternative approach is to compare outcomes fishers achieve under different institutional arrangements. Such comparisons permit an understanding of the operation of actual arrangements, and why different arrangements structure outcomes in alternative ways. Information concerning differences between different institutional arrangements provides useful guidelines for individuals in devising, altering, and evaluating existing arrangements.

An institutional approach differs from the approach underlying the bionomic model in a variety of ways. The physical environment and the constraints and challenges it presents fishers is explicitly taken into account. In addition, fishers are considered capable of undertaking institutional change in addressing problems they confront instead of passively reacting to the situations in which they operate. The challenge becomes one of understanding both the circumstances under which fishers are likely to engage in institutional change, and the types of institutions they devise to resolve problems they face. Also, as fishers engage in institutional change, they effect the structure of the environment in which they operate. New incentives are established to which fishers may respond in unanticipated ways, requiring that they change their institutions once again. Finally, to understand how institutions structure actions individuals take and outcomes they achieve requires that comparisons occur between actual institutional arrangements rather than ideal types.

In utilizing an institutional approach in this study I take a highly microanalytic stance. I focus exclusively upon the institutional arrangements that fishers have devised, their structure, and the outcomes fishers have achieved. I do not examine the larger institutional environments in which the fisher designed arrangements operate, and how the larger institutional environments have affected their design and performance. For instance, I do not compare the differences between fisher organizations in one country as opposed to another country. I have chosen a aicroanalytic focus, not because an institutional approach requires it—it does not. I have chosen this approach because little is known or understood of these arrangements, and an important first step is to understand how they are designed, for what purposes, and how they perform. Once this is accomplished, a logical next step to take is to

expand the analysis to include an explicit consideration of the larger institutional environment within which fisher organizations operate, and explore how wider environments affect fishers' abilities to organize and to make changes to institutional arrangements.

In developing an institutional approach in relation to coastal fisheries, and in testing hypotheses derived from this approach, I have utilized data collected from in-depth case studies of actual coastal fisheries. A requirement used in selecting case studies was that the case author had to report the rules that fishers utilized to organize their harvesting of fish. After examining hundreds of documents, thirty case studies were found that reported evidence of institutional arrangements that fishers had devised.[11] These coastal fisheries are located around the world. No emphasis is given to a particular area of the world rather than other areas, although seven of the thirty coastal fisheries are located in Canada (see Appendix 1).

In the following chapter I explore problems of harvest that fishers commonly face, and which of these problems fishers are more likely to address by cooperating to engage in institutional design. In Chapter Three, based upon an examination of the economics of property rights literature, I establish expectations concerning the performance of the institutional arrangements fishers have devised. Following Chapter Three is an appendix that describes the research methods I have used and that provides a brief introduction to the case studies I have utilized. Chapters Four and Five involve testing the expectations that emerge from Chapters Two and Three concerning the conditions under which fishers are likely to organize, the problems they are likely to resolve, and the performance of the institutional arrangements. Chapter Six, the concluding chapter, summarizes the argument, explores the implications and consequences of the findings for public policy, and points to future avenues of research.

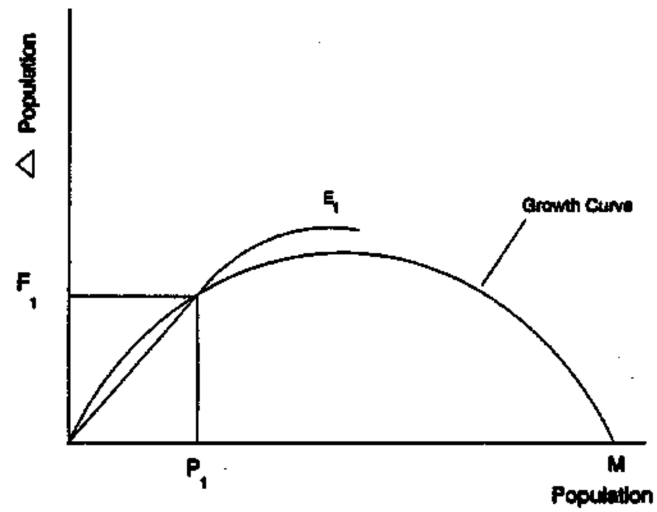


Figure 1.1. Schaefer Growth Curve For A Single Fish Stock

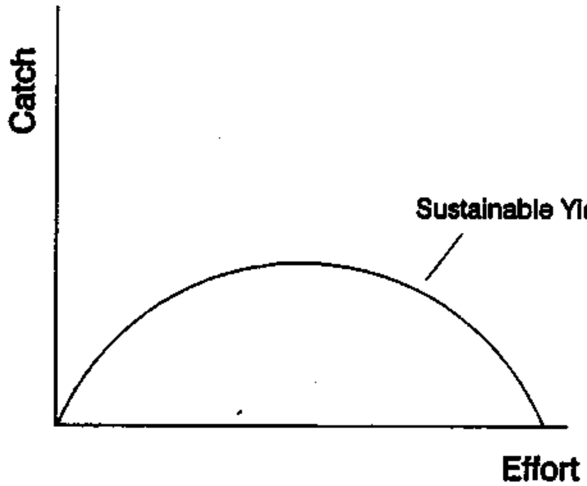


Figure 1.2. Sustainable Yield/Long Run Production Function Single Fish Stock

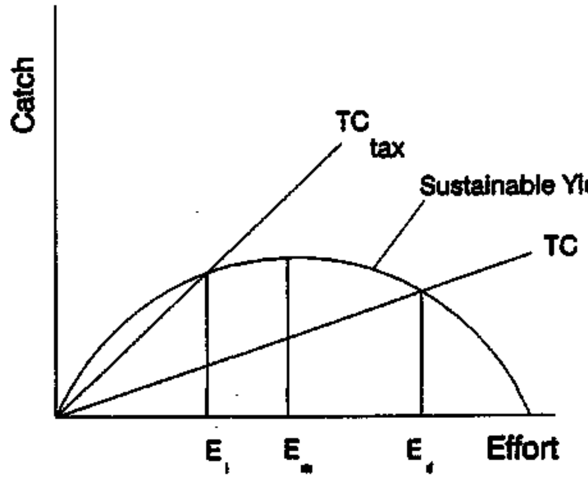


Figure 1.3. Total Revenue and Cost Curves For A Single Stock Fishery

1. The equation has one other equilibrium, where P_t-0, however, it is not stable. If P_t is perturbed so that it is greater than zero, the population size will then increase to H.

2. Or as Gordon states:

> So it is with every productive enterprise—the measure of its own contribution to human economic welfare is determined by its net output, after the costs of the factors necessary to that output's production have been deducted (Gordon 1953:443).

3. Smith labels these stock externalities and they arise because "No individual competitive fisherman has control over population size as a private decision variable yet it inters as a parameter in each fisherman's cost function[1]* (Smith 1968:413, Smith's emphasis).

4. Essentially the argument is that regulations designed to prevent the decimation of fish stocks induce inefficient harvesting patterns.

5. These arrangements are believed to induce the efficient harvesting of fish as well as prevent stock destruction.

6. Fishermen are still taxed for other purposes. The point is, is that taxes have not been used as a means of inducing economic levels of effort.

7. As Howell and Langon (1987) argue, the practice of high grading, or discarding, is little studied. Thus a significant negative impact on fish stocks in rarely taken into account. In their study they found that 20% of the catch of flounder from the commercial trawl fishery in the Gulf of Maine was discarded.

8. In economics this approach is known as the New Institutional Economics (Williamson 1985); in political science work on institutions is often associated public choice/social choice traditions; in anthropology work on institutions is found in economic anthropology (Plattner 1985).

9. As Ostrom explains:

> In simple and clear-cut, operational situations involving certainty or know probabilities, I am willing to assume that individuals undertake a complete analysis of all alternatives and outcomes and decide on that course of action that maximizes expected utility (Ostrom 1990:50).

10. Engaging in collective choice, or designing institutional arrangements, provides another source of uncertainty for fishers in addition to the physical environment in which they operate. As fallible learners, fishers cannot determine with certainty the possible outcomes that institutional arrangements make possible. Fishers face uncertainty concerning the operation of the institutional arrangements that they devise,

11. See Common Pool Resource Bibliography: Fisheries (1989), for an annotated bibliography of all fishery documents examined.

CHAPTER TWO

COASTAL FISHERIES DILEMMAS

In Chapter One I discussed a bionomic model of fisheries that has become the basic analytical tool used by scholars and public officials both to organize the way they view coastal and ocean fisheries and to propose policy alternatives. The bionomic model is utilized as if it were a general model, however, because it is based on very specific assumptions that are only infrequently approximated in natural settings it is better thought of as a specialized model of fishery situations. The highly specific assumptions that are made as an essential part of the bionomic model relate to the nature of the fish populations, to the attributes of the fishers and their control over fish populations, and to the institutional structure.

The bionomic model is based on an assumption that there is a stable homogeneously distributed fish population. The only important variables that presumably affect the harvestable yield of the fish population are under the control of the fishers and relate to the amount of effort devoted to fishing. In addition, fishers are presumed to have perfect information about the nature of the fishery and their cumulative effect on it. Fishers are also viewed as having similar skills, information, and assets.[1] Finally, institutional arrangements that both limit access and regulate effort are assumed not to exist. Fisheries are not governed by any arrangements. The central conclusion derived from the bionomic model is that fishers are caught in an institutional vacuum that produces perverse incentives leading to overproduction.

Many fisheries do not exhibit the characteristics defined in the bionomic model. Instead, they are characterized by multiple, fluctuating stocks, and heterogeneous distributions of fish over space and across time. Also, fishers are not identical in their skills, information, or assets, which combined with the physical environment can potentially lead to technological externalities of production, assignment problems, and stock externalities. Finally, in many instances, fisheries are governed by institutional arrangements that both limit access and regulate harvesting activities. Because the bionomic model predicts that fishermen will not organize themselves to create institutions, it does not explain the considerable variation in institutional arrangements that are observed to exist in coastal fisheries.

To improve policy analysis, theoretical tools are needed to provide an explanation of why and under what conditions fishers organize (or fail to organize) their harvesting activities, so as to gain better outcomes than those yielded when they follow uncoordinated, individual strategies. In this study I develop a more general

theoretical explanation for why and under what conditions fishers organize themselves. The theoretical explanation will be used to generate empirically testable hypotheses. This explanation is structured by the more general framework of institutional analysis which is based on work from diverse disciplines of political science, economics, and law, and continues to be developed and refined by numerous scholars (Kiser and Ostrom 1982; E. Ostrom 1986, 1990; Oakerson 1986; Blomquist 1987; Tang 1989; Gardner, Ostrom, and Walker 1990).

In presenting a theoretical explanation of why fishers have engaged in self-organization to solve collective problems, I first define common pool resource situations and dilemmas, and how the physical world affects the complexity of dilemmas that fishers often confront. Next I examine what constitutes rational behavior in an uncertain setting, such as coastal fisheries. Finally, I explore the circumstances under which fishers are likely to engage in institutional design to resolve dilemmas.

Coastal Fisheries as Common Pool Resource Situations and Dilemmas

All coastal fisheries may be characterized as common pool resource situations (Gardner, Ostrom, and Walker 1990). For a common pool resource situation to exist, the resource, i.e., the fishing grounds, must be subject to joint use. More than a single fisher or team of fishers must harvest fish from the resource. The situation involves individuals acting in interdependent ways. The outcome a single fisher achieves depends not only on her own actions, but also on the actions of the other fishers using the same grounds.

In addition, in a common pool resource situation, the flow of units through the resource must be subtractable. The fish that are harvested by one fisher are not available for harvest by other fishers. The condition of subtractability separates public good situations from common pool resource situations. In the case of public goods the units appropriated are nonsubtractable. Units appropriated by a single individual do not subtract from the flow of units made available by the resource (Ostrom and Ostrom 1977a). Thus, a common pool resource situation is characterized by a jointly used resource, i.e., fishing ground, that makes available a flow of subtractable units, i.e., fish.

While all coastal fisheries are common pool resource situations, only some may be characterized as common pool resource dilemmas. For a dilemma to exist two additional conditions must be met (Gardner, Ostrom, and Walker 1990). First, the strategies that the fishers pursue must result in suboptimal outcomes. As Gardner, Ostrom, and Walker explain:

> The strategies of the appropriators, given a particular configuration of the physical system, technology, rules, market conditions, and attributes of the appropriators, leads to suboptimal outcomes from the perspective of the appropriators (Ibid:336).

Second, alternative strategies must exist that are more efficient than current strategies, and these alternatives must be constitutionally feasible. That is, "given existing rules for institutional change, there exists a necessary consensus for such change" (Ibid). For a coastal fishery to be characterized as a common pool resource dilemma fishers must be pursuing strategies that result in suboptimal outcomes and alternative feasible strategies that are more efficient than current strategies must exist.

Common pool resource dilemmas that fishers typically experience are stock externalities, technological externalities, and assignment problems (Gardner, Ostrom, and Walker 1990).[2] As discussed in Chapter One, the bionomic model assumes a homogeneous distribution of fish over space and time and identical fishers harvesting from the stock of fish. Given this environment, which lacks any institutional constraints, the dilemma that arises is one of stock externalities. The dilemma arises because fishers are withdrawing fish from the same stock without taking into account the effects their harvesting has upon each other, both in the present time period and future time periods, as discussed in Chapter One. When a fisher harvests fish, he subtracts from the amount of fish available to be harvested now and in the future, increasing the costs of fishing. Fishing costs increase because greater amounts of effort are required to search for and catch the fewer remaining fish.

The increased costs of harvesting due to reducing the stock not only affect the fisher who harvested the fish, that is, the fisher who generated the costs, but all fishers who fish that stock. These costs, produced individually but externalized to other fishers, are stock externalities.[3]

Another dilemma fishers potentially face in natural settings are technological externalities. To understand the full range of technological externalities, one needs to change the assumption made in the bionomic model of homogeneous fishers using the same technology. Technological externalities are produced when fishers physically interfere with each other in harvesting fish. Wilson defines technological externalities as:

> gear conflicts or other forms of physical interference which arise because fishermen often find it advantageous to fish very close to one another (Wilson 1982:423).

Smith defines them similarly:

> externalities may also enter via crowding phenomena: If the fish population is highly concentrated the efficiency of each boat may be lowered by congestion over the fishing grounds (Smith 1968:413).

Technological externalities may be produced by direct physical interference between fishers when their gear becomes entangled. For instance, mobile gears can be swept through an area where fixed gears are set destroying the fixed gears and possibly the mobile gears. Direct physical interference, however, does not require different types of

gear to occur. Entanglement and gear destruction can occur by setting the same type of technology too close together.

Technological externalities may also be produced by indirect physical interference. Gear does not become entangled or destroyed, but it is set so close together that the flow of fish among gear is obstructed. For instance, a fisher sets her net so that the mouth of it opens into a current which directs fish into her net. Another fisher generates technological externalities for her by setting his net directly in front of hers, capturing most of the fish that would have flowed into her net. Thus, technological externalities are produced by gear entanglement or by crowding of gear.

Changing another assumption of the bionomic model, that of fish distributed evenly across space and time, produces another dilemma for fishers—assignment problems (Gardner, Ostrom, and Walker 1990). Fish are unevenly distributed across fishing grounds, congregating in areas that provide food and shelter. Consequently, particular areas or spots of the fishing grounds are more productive than others, with fishers desiring to fish the most productive spots. Assignment problems arise when the number of fishers exceed the number of productive fishing spots. Problems arise over who should have access to the productive spots and how access should be determined. Failing to solve assignment problems can lead to violence among fishers and increased production costs.

Rent Dissipation Occurring With Common Pool Resource Dilemmas

The result of stock externalities, technological externalities, and assignment problems is rent dissipation. As defined in Chapter One, rent, or income, is maximized whenever marginal revenue is equal to marginal social cost. Revenue measures what people are willing to pay for fish, whereas "costs represent the value of the next best use of the inputs necessary to produce the effort used to catch the fish" (Anderson 1986:33). A stock of fish is utilized most efficiently when fishers operate where their marginal revenues equal marginal social cost. As Anderson explains:

> what is desirable about this point is...that society's inputs are not being used to exploit the fishery unless using them in the fishery is their highest valued use (Ibid).

Rent dissipation occurs whenever marginal revenue is not equal to marginal social cost. In the case of coastal fisheries rent is dissipated because costs typically exceed revenue. Resources are used to harvest additional fish that are taken "at a cost greater than their value to consumers" (Ibid). Stock externalities result in rent dissipation because:

> each individual fisherman cannot perceive the marginal external costs of his fishing activity on the rest of the fleet. Consequently, fishermen as a whole tend to commit too much capital and labor to the fishery, i.e., too much fishing effort (Wilson 1982:423-424).

Since fishers do not take into account their full costs of harvesting they apply higher levels of effort than is necessary to harvest fish efficiently.

Technological externalities also produce rent dissipation. Technological externalities lead fishers to dissipate rent in relation to the resource. Given the finite space of the fishing grounds, the amount of capital in the form of vessels and/or gear cannot be fully utilized. Either some of the gear remains out of the water and idle, or that which is utilized is not used to capacity. In relation to the limited space of the fishing ground, fishers have invested in more capital than can be fully utilized on that ground. As a consequence, fish are harvested at a higher cost than is necessary resulting in the dissipation of rent. Finally, assignment problems also result in the dissipation of rent. Fighting over possession of a fishing spot, defending a fishing spot already occupied, or racing to get to the best spots first, all increase the costs of harvesting fish above that which would occur if the assignment problems were resolved.

All coastal fisheries are common pool resource situations. If fishers pursue strategies that produce suboptimal outcomes these situations are also dilemmas. Typical dilemmas that coastal fishers face are stock externalities, technological externalities, and assignment problems. Each results in the dissipation of rent, or the inefficient harvesting of fish. Each of these dilemmas also feature different physical characteristics that make them more or less complex, affecting fishers abilities to resolve them.

Physical Characteristics of CPR Dilemmas

One of the most complex dilemmas for fishers to solve are stock externalities. Unlike the assumption of the bionomic model that fishers harvest from a single stable stock of fish whose dynamic behavior is well known, fishers harvest from multiple stocks whose populations fluctuate unpredictably (Wilson 1982). Many different stocks and species of fish inhabit a single ground. In most cases the different stocks of fish that constitute a species of fish have not been identified. In fact, what constitutes a stock of fish is a debatable topic in fisheries biology (Dickie 1979, Cushing 1981, Almeida 1987). Cushing tentatively suggests that what defines separate stocks of fish are differing relationships between recruitment, growth, and mortality factors. These factors translate into each stock presumably having its own fixed spawning ground, a single spawning season, and a consistent migratory circuit (Cushing 1981, chapter 3). As Cushing admits, his hypotheses are based on very limited data. Thus, in most fisheries stocks of fish have not been identified.

Also, the population dynamics of many fish stocks have not been identified. Many scholars have worked and continue

to work on identifying the dynamics of fish populations. Yet, as both Cushing (1981) and Wilson (1982) point out, as long as the number of spawners are above a critical level, no apparent relationship exists between the number of spawners and the number of fish subsequently recruited into the population. The number of fish recruited into the population each year fluctuates widely and is affected by the environmental conditions occurring as fish larvae transform into fish fry (Dickie 1979). Thus, estimating future populations from current populations is virtually impossible.[4]

The implications of these findings for addressing stock externalities are serious. First, because fish populations fluctuate unpredictably it is difficult to determine whether a decrease in the fish population is due to harvesting of fish, environmental circumstances, or both. Second, since the populations dynamics of fish stocks are unknown, determining where the total level of effort is in relation to the population curve is impossible. The complexity of the physical characteristics of fish stocks makes measuring the existence and magnitude of stock externalities difficult. Fishers, fisheries biologists, resource economists, and other policy analysts face similar information constraints, information constraints that severely inhibit attempts to address stock externalities.

The same information constraints stemming from an uncertain physical environment do not, for the most part, hold in relation to assignment problems. The source of assignment problems relates to the physical structure of the fishing grounds as opposed to the nature of fish stocks, as is the case with stock externalities. The physical structure of fishing grounds, i.e., the constitution of the floors of grounds, food sources, and so forth, are relatively stable over time (Davis 1975). Consequently, prime fishing spots are also stable over time. Fish consistently congregate to those areas and spots that provide food and shelter from predators (Grossinger 1975, Miller 1989). Since these areas and spots are based on the physical characteristics of fishing grounds that remain stable across time, choice fishing spots also remain stable. The stability of the spots permits fishers to determine their location, which is often times common knowledge to the community of fishers who harvest from a shared set of fishing grounds (Forman 1966, Davis 1975, Berkes 1986). The stability of the physical structure of fishing grounds assists fishers in cumulating information, information fishers can potentially use in resolving dilemmas that arise from the physical structure of the grounds such as assignment problems.[5] Thus, unlike stock externalities that emerge from fluctuating flows of fish, assignment problems

emerge from the more stable aspects of the physical structure of fishing grounds.

Institutional Change in Coastal Fisheries

A Model of the Individual

The dilemmas that fishers potentially confront vary in their complexity, in part, due to the physical characteristics upon which the dilemmas are based. Stock externalities, which arise from fishers harvesting the same stocks, are difficult to measure and address because of the complex behavior of fish stocks. Assignment problems, which are based on the physical structure of the fishing grounds, are more easily identified because the structure of fishing grounds remain stable over long periods, allowing fishers to cumulate information concerning assignment problems.

Expectations concerning fishers' abilities to solve dilemmas depends upon how fishers are expected to behave as they harvest fish. To generate predictions about the outcomes likely to emerge from a given configuration of institutional and physical characteristics requires that a model of the individual be specified. As Ostrom argues:

> The model of the individual is the animating force that allows the analyst to generate predictions about likely outcomes given the structure of the situation (Ostrom 1986:18).

Given a set of dilemmas that fishers are likely to face what is a reasonable model of fisher behavior? In the case of the bionomic model a physically stable environment is combined with well-defined institutional arrangements to form a situation characterized by high levels of certainty. In such a situation, it is reasonable to use the standard microeconomic model of the individual which assumes a strictly rational, utility maximizer. Such an individual would completely analyze the situation she faces and act so as to maximize her individual utility.

Coastal fisheries, however, are characterized by high levels of uncertainty. Uncertainties arise not only as a result of the physical environment, as previously discussed, but also as fishers make choices in relation to the creation of institutional arrangements, or rules, to coordinate harvesting activities. Unforeseen circumstances, failure to take into account crucial events, and imperfect information about day-to-day processes can result in institutional arrangements that fail to generate desired outcomes. With both day-to-day operating uncertainties and uncertainties concerning the design of institutional arrangements, fishers cannot be expected to make a complete analysis of the situation they face, examine all alternatives and associated outcomes, and choose the actions that maximize their individual utility (Ostrom 1990). Rather, it is reasonable to assume that fishers are boundedly rational, and potentially opportunistic.

Bounded rationality assumes individuals to be "intendedly rational, but only limitedly so" (Simon 1957,

Williamson 1986:44-45). Individuals act rationally to better their position, but they are limited in so doing. Limits exist both in cognitive competence and in information availability. Opportunism is the attempt to gain strategic advantage by withholding information or purposely misleading others. In interdependent situations the outcome for a particular individual is not only a result of her actions but also of others' actions in the same situation. Often times in an interdependent situation, an individual can take advantage of others and gain a better individual outcome by acting opportunistically. Institutional arrangements may not function as intended if opportunistic behavior is not checked.

Assuming individuals are boundedly rational and potentially opportunistic in uncertain and interdependent situations such as coastal fisheries creates the expectation that fishers will not immediately adopt strategies that will result in optimal outcomes, either for fishers individually or collectively, if optimality in such an environment can be defined. Instead, uncertainty in the physical environment combined with incomplete and imperfect information about each others actions and about the effects of various institutional arrangements, fishers are more likely to act as fallible learners, adopting trial and error processes as they search for acceptable institutional arrangements (Ostrom 1990).

The Benefits and Costs of Institutional Change

Fishers, interacting in complex and uncertain environments, are likely to act as fallible learners. While they are not immediately capable of accessing and understanding all relevant factors within their environment, over time they are capable of learning more about their environments and responding to them in ways that improve their welfare. Fishers may respond to resolve dilemmas that they face by engaging in institutional design and change. Institutions and institutional arrangements are configurations of property rights and rules that constrain the actions of fishers. Just as the physical environment presents particular possibilities while foreclosing others, so also does the institutional environment within which fishers interact. Thus, the physical environment may provide fishers with very rich cod grounds and only marginal lobster grounds, presenting fishers with the opportunity of developing a cod fishery. In relation to the institutional environment, a particular configuration of rules may solve assignment problems by specifying that the fisher who occupies a spot first can utilize it for a day, but the same rules may not solve technological externalities. Fishers may be able to occupy spots that are very close together and thus interfere with each others' harvest of fish.

Unlike most aspects of the physical environment, however, fishers can potentially change the institutional

arrangements that constrain their behavior so as to achieve better outcomes than produced under the status quo set of arrangements. They can change or add to the set of rules they follow to better coordinate their activities. Taking the above example, the fishers could add a space rule to their first-in-time, first-in-right rule. Mot only would fishers control their chosen spots for a day, but fishers could not set their gear within a specified distance of each other. Through changing institutional arrangements fishers can potentially achieve coordinated strategies that permit them to achieve desirable outcomes.

Two questions arise in relation to fishers engaging in institutional change to address problems of rent dissipation. First, if fishers pursue strategies that produce rent dissipation, will they always attempt to adopt alternative sets of rules to restructure their strategies so as to avoid rent dissipation? That is, when faced with dilemmas will fishers always cooperate to coordinate their strategies so as to achieve superior outcomes? Second, when fishers engage in institutional change, when they adopt alternative institutional arrangements, do these arrangements always produce the most efficient outcomes possible?

A growing literature in political science and economics on institutions provides a variety of conflicting answers to these questions. A common starting point for all scholars focusing on the question of institutional design and change is that for institutional change to occur the expected benefits from such change must exceed expected costs of that change (Demsetz 1967, Davis and North 1971, Dahlman 1980, E. Ostrom 1990). As Davis and North explain:

> We postulate that economic institutions are innovated or property rights are revised because it appears desirable for individuals or groups to undertake the costs of such changes; they hope to capture some profit which is unattainable under the old arrangement. An institutional arrangement will be innovated if the expected net gains exceed the expected costs. Only when this condition is met would we expect to find attempts being made to alter the existing structure of institutions and property rights within a society (Davis and North 1971:10).

Thus, if fishers expect greater benefits from devising institutional arrangements to coordinate their harvesting activities than the costs associated with those institutional arrangements, Davis and North would argue that fishers are likely to invest in such institutional arrangements.*

Some scholars have interpreted the benefit-cost calculus as meaning whenever there are gains to be had by changing institutional arrangements, individuals will pursue those gains by engaging in institutional design, and that the resulting alternative set of arrangements will be efficient. As Binger and Hoffman state in their examination of the institutional economics literature:

> the point is often made that whatever emerges as an abiding institution must be efficient in light

> of the constraints facing the society. Otherwise it would not persist (Binger and Hoffman 1989:67).

Williamson (1985) in his examination of institutional arrangements in competitive market systems, Anderson and Hill (1975) in their examination of the development of property rights in grazing land in the American West, Dahlman (1980) in his examination of the persistence and eventual change in the open fields systems in England, and Davis and North (1971) in their examination of economic development in the Western world each answer the above two questions in the affirmative. In other words, they argue that individuals engage in institutional change whenever there are substantial benefits to be gained, and that these new arrangements will be more efficient than prior institutions.

As Binger and Hoffman (1989) point out, however, problems arise from such an optimistic approach. First, institutional arrangements can be considered collective goods. Once they are provided by a group they are enjoyed by all members of that group. It is costly to exclude members of the group from enjoying the benefits provided by the arrangements. Consequently, problems of collective action associated with producing public goods also arise in providing institutional arrangements. The problems of freeriding can be especially acute, preventing institutional change from occurring (Olson 1965). Even though the benefits exceed the costs of providing the institutional arrangement, individuals face incentives not to contribute valuable resources for such change. Instead they face incentives to freeride off of the benefits contributed by others. That is, why cooperate and expend any resources when others will provide the good (Elster 1989). Thus, simply because the gains to be had from engaging in institutional change exceed the costs of changing does not mean individuals will collectively be able to overcome problems of freeriding in order to change the sets of property rights and rules they utilize:[7]

> Institutions may arise as inefficient equilibria of repeated coordination games and persist because, though all would benefit from a change in joint strategies, no one individual can benefit from a unilateral change (Binger and Hoffman 1989:68).

In addition, there is no reason to believe a priori that newly created institutions will be more efficient than those they replace or that they will solve the problem(s) they were designed to solve. Particularly in environments such as coastal fisheries, characterized by information uncertainties, and a lack of any sort of selection mechanism that would favor more efficient institutions, fishers may design arrangements that provide greater benefits than if they were each pursuing individual, uncoordinated strategies. These arrangements, however, need not be the most efficient alternatives. In market situations where firms are subject to competitive pressures, at least in theory, firms that are more efficient survive. A selection

mechanism operates that supports the existence of the more efficient institutional arrangements.' In situations not characterized by such competition, arrangements that arise may or may not be efficient. Without at least some competition, repeated experiments with different institutional arrangements, and learning from trial and error processes, institutions that do arise most likely will not be efficient (Ostrom 1990).[8]

Libecap (1989) argues that problems arising from distributing the gains from new institutional arrangements can also prevent more efficient institutions from being adopted. If agreement among the group of people considering an alternative set of rules cannot be reached over how the benefits from such a change are do be distributed, the change may never take place (Libecap 1989).[9] Or, an alternative set of arrangements may be adopted even though other arrangements exist that would be more efficient because the group of people can agree on how the benefits of the former set are to be distributed, whereas they may not be able to agree on how the benefits of the latter set are to be shared.

For the purposes of this study, I will assume that a necessary but not sufficient condition for fishers to engage in institutional change is that the expected benefits generated by the new set of arrangements substantially exceed those of the status quo arrangements. Once this condition is met, the possibility of institutional change exists. Whether it will occur depends on a variety of additional factors to be discussed below. In addition, the institutional arrangements that fishers do adopt will be presumed to address a problem that fishers face, but the way in which the rules address this problem may not be the most efficient alternative that exists. Even more perplexing for the analyst is that newly invested institutions may create other unforseen inefficiencies for the fishers. For instance, in attempting to resolve technological externalities fishers may adopt a rule requiring a particular gear be used, excluding all other types of gear. While fishers may no longer interfere with each other in harvesting fish under the new rule, the rule may inhibit technological change, eventually resulting in fishers using gear that is less efficient than other types of gear available (Martin 1979).

In light of the above discussion of institutional change, the question arises whether fishers are more likely to address particular dilemmas as opposed to others. Wilson (1982) argues that dilemmas meeting three criteria are likely candidates for solution. The three criteria that he specifies are:

> 1. repeated encounters under roughly similar circumstances in which opportunistic individual behavior is seen to destroy the possibilities for collective gain (Wilson 1982:420).

> 2. an information network, arising from trading, competitive, or other interactions which forms the basis for the identification and negotiation of possible rules (Ibid).
>
> 3. there must evolve from the information network, a collective means for the enforcement of these rules (Ibid).

If the problematic situation is one which is repeatedly experienced by fishers so that it is noticeable and measurable, if it exists primarily within a single community of users, and if it is possible to devise enforceable rules, then Wilson argues, fishers are likely to devise arrangements to solve the problematic situation.

Wilson argues that on the basis of these three criteria fishers will not engage in institutional change in an effort to resolve stock externalities. The problem of stock externalities fails to meet any of the three criteria. Most inshore fishers lack information concerning the population dynamics of the fish stocks from which they harvest. They cannot determine how many fish constitute the stock, how many are withdrawn, and therefore, the effect that each fisher's catch has upon the catches of other fishers. Since they cannot measure the magnitude of the problem, nor the exact causes, they are unlikely to devise arrangements to resolve stock externalities. As Ostrom (1990) argues, the initial calculus that must be conducted before engaging in institutional change is to compare the benefits produced under the status quo institutions with those produced under an alternative set of institutions. If the latter exceed the former, then fishers may consider adopting the new arrangements. In relation to stock externalities, however, this initial calculation cannot take place because fishers have difficulty in measuring the underlying flow that is a necessary step in devising alternative arrangements.

In addition, numerous communities of fishers often harvest from the same stocks of fish, compounding the problem of determining the stock effects fishers have upon each other. Not only would fishers have to calculate the costs they create for each other within their own community, but they would also have to determine the costs generated by all other fishers utilizing the stock. The problem of stock externalities extends beyond a single information network, or community of fishers, to numerous communities, increasing the difficulties of addressing stock externalities.

Finally, given the lack of information and the complexity and uncertainty of most fishery environments, costs of administration and enforcement of rules associated with resolving stock externalities will be high. As proof that the cost of administration and enforcement will be high, Wilson points to the failure of limited access licensing. Wilson argues that the presumption underlying the bionomic model is that a single owner of a fishery would be capable of perceiving stock externalities and acting appropriately to solve them. Consequently policies based on the bionomic model must induce fishers to simulate a sole-

owner outcome (Ibid:424). The problem with attempting to imitate a sole owner outcome, however, is:

> that the rules structure eventually has to expand to include rules for the control of every possible variable a sole owner might be able to manipulate (Ibid:425).

Since it is not possible to specify and enforce a rule for every possible variable, policies that are put in place to accomplish such outcomes are likely to be cumbersome and costly, and are bound to fail.

Assignment problems and technological externalities are much more amenable to solutions devised by fishers than are stock externalities. Technological externalities arise due to the actions fishers take in utilizing their equipment. By setting gear so close that it becomes entangled, or by interfering with the flow of fish into another's equipment, fishers impose technological costs upon each other. These costs are noticeable and measurable. Direct physical interference, that is, entangling of gears, is immediately noticeable, and the causes of it understood. Indirect physical interference, which occurs when fishers set their gear so close together that they interfere with the flow of fish among their gears, is not immediately apparent, although through "repeated encounters under roughly similar circumstances[11] it may become so. Over time fishers may realize the effects upon their catches of fish when other fishers set their gears close by (Shortall 1973, Martin 1979, Raychaudhuri 1980). Possessing knowledge of the causes and the consequences of technological externalities fishers can consider alternative sets of rules to address these problems.

Second, unlike stock externalities that may span numerous communities of fishers, technological externalities often arise within a single "information network" or community of coastal fishers utilizing common grounds. The effects of technological externalities are localized to a few fishers or a group of coastal fishers. Their existence primarily within a single community of fishers reduces what Ostrom (1990) calls transformation costs. Transformation costs are the costs that fishers must bear in changing from one set of institutions to another. They are both external and internal to the group of fishers engaging in institutional change. The group of fishers may need to expend resources in meeting the requirements of some external authority. For instance, the fishers may have to expend resources in getting permission from an external government agency to engage in institutional change. Transformation costs are also internal to the group of fishers and are known as decision making costs. Decision making costs are expended as fishers negotiate among themselves to devise acceptable sets of property rights and rules. These include deciding how the benefits of the new arrangements will be distributed.

A variety of factors affects decision making costs. They are typically lower if members of a single community of fishers are negotiating among themselves as opposed to groups of communities attempting to reach agreement. In addition, smaller groups of fishers may face lower costs in negotiating agreement among themselves as opposed to larger groups of fishers (Olson 1965). Another factor is the homogeneity of the fishers. If they share a common ethnic background, and language, utilize similar technologies, and are similarly dependent on the resource for income, all of which encourage a common view of the fishing grounds, the group of fishers need not expend as many resources on achieving agreement on new rules for harvesting. Since a community of fishers are more likely to generate technological externalities among themselves, transformation costs are lower if they would attempt institutional change.

Assignment problems are also amenable to solution by fishers. Just like technological externalities, they meet the first two criteria established by Wilson. First, in competing for productive fishing spots fishers experience repeated encounters under similar circumstances. Day after day, and possibly year after year, fishers compete to gain the best spots. As the result of conflict and gear destruction, fishers are made aware that opportunistic individual behavior results in suboptimal outcomes. These problems are noticeable and measurable. It is possible, therefore, for fishers to consider sets of rules that could solve assignment problems. Alternatives to the status quo can be conceptualized.

Second, assignment problems typically arise among a community of fishers who are utilizing the same fishing grounds. In other words, these problems are restricted to a geographic area that the community of fishers can exercise some control over. Also, just as is the case with technological externalities, transformation costs are likely to be lower since they are confined to a single community of fishers.[10]

Assignment problems and technological externalities are more easily addressed by fishers than are stock externalities. Fishers are capable of determining the causes of these problems, and consequently they can also conceptualize alternative sets of rules that can potentially resolve these problems. In addition, since these problems are often confined to a single community of fishers, transformation costs which are incurred in gaining agreement for a rule change are likely to be lower. Of course, other factors also affect transformation costs so that it is not a foregone conclusion that if dilemmas only affect a single community of fishers, members of that community will always resolve them. Nevertheless, having to gain agreement within only a single community of fishers does reduce their magnitude. Finally, as will be discussed in Chapter Three

in some depth, many of the rules that can resolve assignment problems and technological externalities are also easily enforced. For instance, if a group of fishers adopts a first-in-time, first-in-right rule to resolve assignment problems, it is not easy to surreptitiously force a fisher from her spot. Such rule breaking behavior is easily noticed.

Conclusion

The bionomic model analyzes a single problematic situation, that of stock externalities, and presumes fishers are unable to cooperate to address problems they face. In this chapter I presented an institutional approach that recognizes multiple problems arise in harvesting fish; also it recognizes that under particular circumstances fishers can potentially cooperate to devise rules to resolve problems. Unlike the bionomic model that assumes perfect information about the fish stocks and grounds,- and costless rule definition and enforcement, an institutional approach presumes that different levels of information exist across problematic situations, that it is costly to define and enforce rules, and that these costs are affected both by the physical characteristics of the coastal fishery environment and by the extent and characteristics of the fishers. The expectations emerging from this alternative approach are: 1) fishers will not organize to address stock externalities, 2) fishers may organize to address technological externalities, and 3) fishers may organize to address assignment problems. Whether fishers will organize to solve collective problems that they confront requires that the benefits of the new set of rules exceed the costs of changing the rules. Even if the benefits exceed the costs the fishers must still overcome collective action problems, particularly problems of freeriding. In addition, given the environment of coastal fisheries, where there is little competition among institutional arrangements, there is no reason to believe that fishers will always adopt the most efficient set of arrangements. Rather, in an uncertain environment with fishers as fallible learners, fishers are likely to adopt arrangements that address the problems they face in a satisfactory manner and in a manner that they can agree upon.

1. Johnson and Libecap (1982) discuss the importance of skill differentials across fishers. Fishers with greater skills are much less likely to accept regulations that minimize skill such as individual transferable quotas.

2. Gardner, Ostrom, and Walker (1990) do not use the term stock externalities. Rather, they use the term rent dissipation.

3. Anderson defines stock externalities as follows:

> The individual fishermen do not consider the effect that their production will have on the production of all others in the current period...At the same time, however, the stock is being nonoptimally depleted because individual operators do not consider the user cost they are imposing on harvesters in future periods (Anderson 1986:47).

Smith states that stock externalities occur because:

> No individual competitive fisherman has control over population size as a private decision variable yet it enters as a parameter in each fisherman's cost function (Smith 1968:413).

Gordon argues that stock externalities arise because:

> It is not the relative <u>marginal</u> productivities of the two grounds but their <u>average</u> productivities. The fisherman does not ask what allocation of effort will maximize the aggregate production of the fishing fleet but what action will give him, individually, the greater yield (Gordon 1953:451).

4. See Radovich (1981) for a discussion of the various efforts to determine the population dynamics of the California sardine fishery. Also see Walters (1986) for various procedures in attempting to estimate the population dynamics of fish populations.

5. Technological externalities will be discussed in a later section. Technological externalities arise primarily from the behavior of fishers and are not defined by the physical characteristics of the fishing grounds or the stocks of fish in the grounds as are stock externalities and assignment problems.

6. As Wilson argues:

> The purpose of such rules, of course, is to create greater certainty about the outcome of individual interactions and thereby to make possible trade or production opportunities which might otherwise be forfeited (Wilson 1982:420).

7. As Binger and Hoffman state:

> Arguments to the effect that individuals will exhaust any gains from exchange and that institutional must be efficient do not apply when there are externalities and public goods (Binger and Hoffman 1989:71).

8. Defining efficiency has also been problematic. Defining efficiency simply in terms of traditional neoclassical constructs of minimizing production costs, irregardless of other constraints facing individuals means that no institutional arrangements will be efficient. As Furubotn **and** Richter state:

> If the only constraints considered are those traditional ones associated with the idealized neoclassical mode, every solution obtained in a real-world situation will be inefficient (Furubotn and Richter 1989:3, also see Dahlman 1979)

On the other hand, taking into account every possible constraint that may possibly exist means that every institutional arrangement will be efficient (Furubotn and Richter 1989). Also see Schmid (1986) for an indepth discussion of efficiency concepts.

9. As Libecap states:

> If influential parties cannot be sufficiently compensated through share adjustment in the political process to win their support, otherwise beneficial institutional change may not occur with potential economic'advances foregone. Even though society is made worse off, the distributional implications lead influential parties to oppose institutional change (Libecap 1989:8).

10. The discussion of monitoring and enforcing rules is **reserved** for Chapter Four.

CHAPTER THREE

INSTITUTIONAL ARRANGEMENTS FOR GOVERNING COASTAL FISHERIES

In order to address and resolve problems collectively faced, fishers may engage in institutional design; that is, they may begin to define rules that specify actions that are required, forbidden, or permitted in accessing fishing grounds and harvesting fish. By coordinating their activities through a common set of rules, fishers may alleviate some of the problems of rent dissipation—particularly assignment problems and technological externalities. The institutional environment that fishers may create affect the outcomes they achieve. Different combinations of property rights and rules produce a variety of incentive structures that affect how fishers behave, and consequently, the types of outcomes produced.

In this chapter I will follow up the previous chapter's analysis of the types of problems fishers are likely to address through institutional innovation, with an analysis of the types of institutional arrangements that may be created, how they may be constituted, how they may perform, and how actions in the context of these arrangements may be monitored. First, I will examine the role of property rights in affecting outcomes, before turning to a discussion of rules and the ways in which rules define how property rights are to be exercised.

The Role of Property Rights

Property rights define relationships between individuals in relation to things, rather than relationships between individuals and things. As Furubotn and Pejovich explain:

> property rights do not refer to relations between man and things, but, rather, to the sanctioned behavioral relations among men that arise from the existence of things and pertain to their use* Property rights assignments specify the norms of behavior with respect to things that each and every person must observe in his interactions with other persons, or bear the cost of nonobservance (Furubotn and Pejovich 1972:1139).

John R. Commons (1968) provides a more detailed explication of rights based relationships. He argues that the right/duty correlative relationship is the most basic to the ordering of transactions among individuals. A right, according to Commons, is the authority to act in regard to a particular area. A right is a general grant of authority; simply specifying that a person holds a right does not address how the right is to be exercised. How rights are exercised are defined by rules. For instance, suppose a fisher possesses a right to access a fishing ground. That is, the fisher has the authority to physically enter the ground. How the fisher can exercise her authority to enter the ground is specified through rules. A government authority may require that fishers who have the right to access the ground may do so only if they hold a fishing license. Or, a local community of fishers may specify that

to exercise the right of entry into their ground fishers must utilize a particular type of gear. A right is a general grant of authority to undertake acts in relation to a particular thing, whereas rules define specifically what acts are required, permitted, or forbidden in exercising the authority provided by the right.

The correlative of a right, according to Commons, is a duty to act in accordance with the right being asserted. Individuals with duties may not interfere with, or prevent, persons with rights from exercising their rights. If a fisher possesses the right of access to a fishing ground, other fishers cannot prevent her, or interfere with her entering the ground.

Commons also argues that limits exist to both rights and duties. Where individuals' rights end, their exposures begin. Exposure is the area of decision making where an individual cannot assert or enforce a right. Actions are taken or outcomes produced that may be expropriated by others. The correlative of exposure, or the limit of a duty, is liberty. This is an area of decision making where the individual is under no duty, but is at liberty to act (see V. Ostrom 1976). Behavior in this area in relation to others is not constrained. As Commons explains:

> The field of authorized liberty is the field where behavior is unrestrained or uncompelled by authority, one is at liberty to do as he pleases in dealing with the other, and, in doing so, one commits no unauthorized act, that is, <u>no wrong,</u> or legal injury. He is not required to avoid, nor to

> perform a service, nor to forbear exerting excessive power over another. To say that one has "no right" is to say that the opposite person has "liberty", and to that extent the one is exposed to the possibility of any behavior that the other may choose within that dimension of his physical, economic, or moral power (Commons 1968:99).

An example of the liberty/exposure correlative is a group of fishers who do not possess the right of exclusion, that is, the authority to decide who can and cannot enter the resource, but who nevertheless invest resources in designing rules to organize their harvesting activities. This group stands exposed to the actions of others. Benefits produced by these arrangements may be enjoyed by others who are not a part of the group, yet who are at liberty to act so as to enter the fishing grounds and enjoy the outcomes of the rules that the group of fishers designed.

Property rights systems are configurations of rights and duties, and liberties and exposures, that define relations among persons in regard to the use of things. Different configurations of rights and duties result in different types of property rights systems. A useful typology of rights, that in various combinations constitute many property rights systems, is as follows (Becker 1977):

Access: The right to enter a defined physical property (eg. a fishing ground).

Withdrawal: The right to harvest units of the flow from a resource (eg. catch fish, appropriate water).

Management: The right to regulate internal use patterns and transform the resource by making improvements.

Exclusion: The right to determine who will have access or withdrawal rights.

Transfer: The right to sell, lease, or bequeath any or all of the above rights.

In examining the performance of different combinations of rights, two approaches are common (de Alessi 1980, Schlager and Ostrom 1987). In the first approach the outcomes of different bundles of rights held by individuals (as opposed to groups of individuals) are compared. These bundles of rights are defined by whether they include either the right of transferability, or exclusion, or both. Private property is defined as an individual possessing the rights of exclusion and transferability, as well as access, withdrawal, and management (Alchian and Demsetz 1973, de Alessi 1980, Schlager and Ostrom 1987). The individual holds a full set of rights. Usufructuary property is defined as an individual possessing the right of exclusion, as well as access, withdrawal, and management, but not transferability (de Alessi 1980). The individual enjoys "exclusive rights to the use of a resource; he cannot, however, transfer the rights at his own volition" (Ibid: 9). Communal property is defined as an individual possessing neither the right of exclusion nor the right of transfer (Alchian and Demsetz 1973), but only the rights of access, withdrawal, and management (Schlager and Ostrom 1987). The rights of exclusion and transferability are considered crucial for the efficient use of resources. Exclusion and transferability permit an individual to capture current and future benefits from investing in the resource. By excluding, or by preventing others from entering and harvesting from a resource, the individual who possesses the right of exclusion faces the incentive to invest in increasing the productivity or simply maintaining the resource. Such an incentive exists because the individual will gain the benefits of the investment, while others will be prevented from expropriating those benefits. The same reasoning holds for the right of transfer, but now future benefits from investing in the resource can be captured. Current investments may generate future benefits. For instance, increasing the future size of stocks of fish requires limiting harvesting in the current period. The future benefits derived from a larger stock size can potentially be captured through the transfer price of the resource.[1]

Rights of transfer and exclusion provide incentives for individuals to invest in resources and maintain them over time, because both rights permit individuals to gain the benefits of their investments. In addition, transferability permits the resource to be utilized at its highest value. Individuals who place the highest value upon the resource, in theory, will offer the highest amount for its purchase. Without either of these rights:

> Commonly owned pasturelands, fisheries, hunting grounds, and forests typically are used more

> intensively, and exhausted earlier in time, than they would have been under private ownership (de Alessi 1980:6).

Thus, de Alessi concludes, "differences in the structures of rights to use resources affect behavior systematically and predictably" (Ibid:42). As individuals acquire more complete sets of rights, resources are used more efficiently. Consequently, private property rights systems perform better than usufructuary rights systems, and usufructuary systems perform better than communal property rights systems (de Alessi 1980).

The second approach in analyzing property rights systems involves holding the bundles of rights constant, while comparing different forms of ownership. Forms of ownership can vary from a single individual holding a set of rights; to groups of private individuals holding sets of rights, such as the stockholders of a corporation or the share holders in a cooperative; to a public agency holding a set of rights (Schlager and Ostrom 1987). Outcomes produced by private individuals holding sets of rights are often compared with forms of ownership that involve varying degrees of involvement by a public agency, from regulating how property rights can be exercised to outright ownership of property rights (de Alessi 1980). Outcomes produced by individuals holding full sets of rights are often found superior to outcomes produced under public ownership (de Alessi 1980). The evidence from either approach, comparing different bundles of rights or comparing different forms of ownership, lead to similar conclusions, that individually held private property generates superior outcomes to other forms of property rights and ownership systems.

Given the superior performance of individually held private property rights, some scholars have argued that for common pool resources to be utilized efficiently, i.e., for problematic situations to be resolved, individuals must possess private property rights in relation to these resources. Alchian and Demsetz argue that when the flow of units through resources governed by a communal property rights system become scarce, the flow of units will be mined unless individual private property rights systems are developed.

> The instability inherent in a communal right system will become especially acute when changes in technology or demands make the resource which is owned communally more valuable than it has been. Such changes are likely to bring with them harmful and beneficial effects which can be measured and taken account of only by incurring large transaction costs under the existing property rights structure. In such situations, we expect to observe modifications in the structure of rights which allow persons to respond more fully and appropriately to these new costs and benefits...The control system adopted by the Indians in the Northeastern part of the continent was to substitute private rights in land for free access to hunting lands. By owning the right to exclude others from their land, Indian families were provided with an incentive to inventory their animals. Under a free access arrangement, such inventories would have been depleted by other hunters (Alehian and Demsetz 1973:24-25).

That is, individuals utilizing the resource must be granted individual rights of exclusion and transfer.

Other scholars disagree that individual private property rights systems are always the most effective institutional arrangements for utilizing natural resources. The disagreements arise in two different areas. First, it is argued, that the physical characteristics of the resource affect the performance of systems of property rights. Consequently, not all resources are amenable to individual private property systems. Second, other scholars disagree concerning definitions of property rights systems. In particular, it is argued that common property or communal property has been misspecified.

Netting suggests that whether private property systems will be efficient depends upon characteristics of the resource (Netting 1976). Netting, in his research on the Swiss Alps, examined different forms of institutional arrangements that exist in the Alps in relation to different types of resources. Individuals in the Swiss Alps utilize both private property and communal property systems. Netting found that farmed land and vineyards are held privately by individuals, but that other resources, such as forests and high altitude grazing meadows, are held collectively by groups of individuals. Since these people possess considerable autonomy and capabilities to define their own property rights systems, Netting argues that this nix of property arrangements is not an historical anachronism. Rather, people have purposely chosen to continue to use communal property systems in relation to some of their land. They have done this because some resources, such as forests and grazing meadows, are more valuable if they are held collectively. That is, resources such as forests and meadows are not as valuable divided into individual plots. For instance, a single section of an alpine meadow cannot continuously support cattle. In addition, the best pasturage varies across a meadow from season to season and year to year. Sometimes a single section of the meadow is quite productive, and at other times it is not as productive. Having access to the entire meadow, and being able to utilize its varying microenvironments minimizes the variability of production from the meadow, since some portion of it is productive every year. Instead, if the meadow was divided into individual plots, one person's plot may be productive once every several years.

Netting hypothesized that resources with low value of production per unit area, low dependability of yield, little possibility of improvement, and a large area required for effective use, are inefficiently utilized under private property rights systems (Ibid:144). Partitioning these types of resources into individual plots makes everyone worse off. Rather, collective forms of property rights

systems in relation to these types of resources results in such resources being utilized more efficiently. In other words, according to Netting, depending upon the characteristics of the resource, private property rights systems may or may not yield superior results.

Other scholars point to an additional oversight in the property rights literature. Property rights are defined and examined almost exclusively in relation to individuals, with little consideration given to bundles of rights that are collectively held by groups of individuals. Focusing on individuals apart from any group to which they may belong has resulted in communal property being wrongly defined. Ciriacy-Wantrup and Bishop (1975), Runge (1986), and Bromley (1986), among others, argue that because of the failure to recognize collective forms of ownership, communal property systems have been misspecified. Communal property systems are not characterized by individuals who lack rights of exclusion. An individual as a member of a group has the right to exclude nongroup members from the resource, but not group members. As Ciriacy-Wantrup and Bishop state:

> The term "common property" as employed here refers to a distribution of property rights in resources in which a number of owners are co-equal in their rights to use the resource...The concept implies that potential resource users who are not members of a group of co-equal owners are excluded (Ciriacy-Wantrup and Bishop 1975:714-715).

In other words, common property, or communal property, refers to a set of collectively held rights which include the rights of access, withdrawal, management, and exclusion. As a group, members can exercise exclusion against those who are not members of the group. With the right of exclusion, group members face incentives to invest in the maintenance and use of the resource, since they can capture the benefits of their investment. Thus, common property, in some situations, may perform better than other property rights systems, and cannot, therefore, by definition be considered inefficient (Dahlman 1980). Rather, given the right of exclusion combined with resource systems that cannot be productively divided into individual plots, collective ownership may be more efficient than individual ownership. The work of Netting, Ciriacy-Wantrup and Bishop, Bromley, and Dahlman, does not challenge earlier findings that more complete sets of property rights typically lead to more efficient outcomes. Rather, their work points to a growing recognition that not a single ownership type is the most efficient in all instances.

The Role of Rules

Collective forms of ownership raise coordination problems that do not exist in relation to individual forms of ownership. Exclusion alone is not sufficient to avoid undesirable outcomes. If members of a group do not cooperate to order their harvesting activities, they can inefficiently utilize the resource. As Dahlman states:

> It follows that even if the commons were exclusive, this in no way guarantees efficient resource allocation. In the case of communal ownership exclusivity is only a necessary but not sufficient condition for efficiency—it is further necessary that each rights owner agrees to limit his use, in exchange for similar limitations on the use of others, so that over-use and rent dissipation do not result (Dahlman 1980:201).

If rights owners do not limit their use, if they do not coordinate their actions, even if they possess a full set of rights, they can still generate technological externalities and assignment problems. According to Dahlman (1980) necessary and sufficient conditions for the efficient utilization of a resource is for a group to collectively possess the right of exclusion and to have organized their harvesting activities.[2]

In order to organize harvesting, fishers must devise rules to define how they may exercise their property rights. While property rights are general statements that establish the right/duty correlative, they do not establish how rights are to be exercised in particular situations. Rules give substance to rights, defining how they are to be exercised.

> Rules are prescriptions commonly known and used by a set of participants to order repetitive, interdependent relationships such as formal games. Prescriptions refer to which actions (or states of the world) are permitted, obligatory, or forbidden. Rules may be the result of self-conscious choice or may have evolved over time as individuals develop shared understandings of what actions or outcomes may, must, or must not be done in particular situations (Gardner and Ostrom forthcoming).

Rules, in giving substance to property rights, structure a situation. They do so by requiring, permitting, or forbidding specific individuals to take certain actions, given particular information. Identical sets of rights, combined with different rules defining how those rights may be exercised can produce different outcomes. For instance, given two groups of fishers in an identical physical environment with each group possessing rights of access, withdrawal, management, and exclusion, different rules that specify how fishers can harvest fish produce different outcomes. If one of the groups uses a rule that states whoever gets to a fishing spot first may use it for the day, the group may experience a variety of problems. If two fishers arrive at the spot simultaneously they may fight over the spot. Also, fishers may waste resources in racing to the best spots. If the second group of fishers uses a rule requiring a fisher to announce in advance which spot she will fish, with the other fishers required to abide by that announcement, fishers will not travel to the same spots, nor will they race to gain the spots, thus avoiding conflict and the wasteful use of resources. The difference in a single rule defining how property rights can be exercised can produce very different outcomes (Gardner and Ostrom forthcoming).

Whether or not fishers will define rules to structure how they can utilize their fishing grounds depends not only on the problematic situations they confront, as discussed in Chapter Two, but also upon the extent of the bundle of

property rights that they collectively hold. Property rights vest fishers with grants of authority to take decisions concerning particular activities. The more complete the set of rights the less exposed a group of fishers are to the actions of others not a part of the group. The less exposed their actions are, the less risk fishers confront in expending resources in organizing their harvesting activities. That is, nongroup members face greater limits in attempting to expropriate the benefits that a group of fishers who have organized their harvesting activities may generate. With the greater certainty a more complete set of property rights provides a group that they will be the primary beneficiaries of their own institutional investments, fishers are more likely to undertake those investments and to begin to define rules constraining the actions they can take in relation to each other. Simply establishing rules, however, to direct harvesting activities is not sufficient to ensure that problems will be adequately addressed. Rules, to be effective, must be crafted to the exigencies of the situation that fishers face (Ostrom 1990). For instance, rules that establish quotas do not address problems of assignment if that is the difficulty that fishers face. The types and complexity of the rules most suited for a situation are affected by the physical environment and the level of information that fishers possess concerning the problematic situation they face, as discussed in Chapter Two; and they are affected by the types of actions that are to be regulated, and the ease by which fishers can avoid required or forbidden actions by substituting other behavior.

The types of action regulated vary in complexity and thereby affect which rules are most effective. Action that is binary is often times easier to regulate than continuous forms of action. Binary action either occurs or does not occur. A binary act can be required or forbidden. Continuous action, on the other hand, can potentially occur at an infinite variety of levels, or magnitudes. It is variable. Determining the appropriate magnitude of the action and then measuring it in relation to all individuals involved is complex and costly.

Assignment problems typically involve binary action whereas stock externalities involve continuous forms of action. Assignment problems are often characterized by relatively stable physical environments. The best spots, which are a function of the bottom geography of the fishing ground, remain fixed from year to year. This stability aids fishers in generating high levels of information concerning the spots, and the consequences of actions taken to gain control over the best spots. Either a fisher is fishing from a choice spot or she is not. Either a fisher is trying to force another fisher from his spot or he is not. The action to be regulated, in this instance, is binary.

Binary action is easy to measure and to regulate. A simple rule that states that the first fisher to occupy a spot may fish that spot for a specified time period (ie., a day, week, or season), forbids other fishers from driving the first fisher from the spot, and resolves many difficulties associated with assignment problems. In addition, there are few actions that other fishers can take to circumvent the rule. Attempting to gain control of a choice spot that is already occupied is impossible without breaking the first-in-time, first-in-right rule. Fishers cannot substitute other actions for the one being regulated in order to avoid the rule. Thus, in relation to assignment problems, given a stable physical environment, high levels of information, and a single action—driving fishers from choice spots—that can be forbidden through the use of a single rule, it is possible to devise relatively simple institutional arrangements to address the problem.

The possibility of resolving assignment problems through the use of relatively simple rules is demonstrated in the work by Gardner and Ostrom (forthcoming) in which they develop an assignment problem game. They developed this game, in part, to explore the impact that rules have on actions that people take and outcomes they achieve. The physical environment of the game consists of two fishers; two fishing spots, one more productive than the other; the costs of traveling to the two spots; and the damage that fishers can inflict on one another in fighting for the spots. The authority and scope rules that Gardner and Ostrom examine within the context of this physical environment are:

> **default:** fishers are permitted to take any physically possible action
>
> **first in tine,** first in right: the fisher who settles on a spot first, has the right to use that spot for a given period of time
>
> **prior announcement:** prior to harvesting fish, fishers announce which spot they will harvest from, giving them the right to use that spot to the exclusion of others
>
> **rotation:** fishers rotate through spots in a pre-assigned order

These rules define how fishers could exercise their rights of withdrawal.

The initial game involves the default authority and scope rule. No restrictions exist. There are no limits on the actions either player can take, outcomes that can be achieved, information that can be exchanged, or on payoffs **to** actions or outcomes (Ibid:8). Player 1 can travel to either spot. Player 2 moves next, without observing player l's move, and also travels to either spot (See Figure 3.1). If they each travel to a different spot the game ends with each player receiving the value of the spot less travel costs. If player 2 chooses the same spot as player 1, player 1 can move or threaten to fight. Player 2 then has the choice of moving to the open spot or fighting. Fighting often occurs in this game, but its frequency depends on the

level of damage that the fishers can inflict upon each other. If the damage is low, fishers are more likely to fight, whereas if the damage is higher, fighting occurs less often (Ibid:28).

By adopting a simple rule fighting can be avoided. Instead of permitting any action on the part of the players, their action is constrained by an announcement rule. Either player has an equal chance of being the first to announce the spot they will fish. The other fisher must abide by this announcement, and fish the unannounced spot. This simple rule changes the structure of the game considerably. In effect, the game is eliminated as no strategic moves remain for the fishers. The outcome is for each player to fish a separate spot with no fighting occurring **(see** Figure 3.2). Authority and scope rules, while quite simple, may make a significant difference in terms of reducing conflict and damage.

A situation characterized by stock externalities contrasts sharply to that of assignment problems. Characteristics of the physical environment, the **level** of information that fishers possess, and the actions that are regulated in relation to stock externalities require more complex sets of rules to resolve the problem. The aspect of the physical environment that most affects stock externalities—the flow of fish—is very unstable. Fishers in turn experience severe difficulties in generating information concerning the quantity of fish available to be harvested and how both their own behavior and the behavior of other fishers effects that volume. With little information concerning the causes and effects of stock externalities, it is difficult for fishers to define rules to address the problem.

In addition, regulating effort is considered the means by which stock externalities can be resolved (see Chapter One). Applying effort, however, is not a binary choice. Effort is not either applied or not. Rather, fishing effort can be exerted in multiple ways at many different levels. Fishers can adopt new technologies that permit them to harvest more intensively from fish stocks, or they can simply fish for longer periods of time, or more fishers can enter a fishery increasing the amount of effort being produced. To regulate effort fishers must decide the level of effort that is acceptable and establish an entire series of rules specifying levels of effort that cannot be exceeded. Next they must measure the level of effort each fisher applies to ensure compliance with the rule. Defining acceptable levels of effort is difficult given the amount of information that fishers have concerning populations of fish stocks and the multiple ways in which effort can be generated.

Finally, as discussed in Chapter One, fishers can easily substitute other actions for those forbidden by rules

that regulate effort. For example, a rule that limits the number of fishing vessels that can enter a fishery in an attempt to limit effort does not address the amount of effort that those vessels can produce. Once fishers gain access to the fishery they can harvest fish as intensively as they choose. Or, if particular types of technology are forbidden from being used, fishers can simply spend more time fishing with already existing technologies, maintaining or increasing the amount of fishing effort being produced. If fishers face incentives to maintain or increase the levels of effort they exert, then the rules utilized to reduce that effort must address each possible action that fishers can take to exert effort, a circumstance that is impossible to achieve.

Collectively owned bundles of rights in relation to common pool resources, such as coastal fisheries, raises problems concerning how individual fishers who are part of the group of owners exercise their property rights in relation to each other so as to avoid undesirable outcomes. Rules become crucial in coordinating the harvesting activities of fishers. The types of rules devised, and their usefulness, depends on the physical environment in which they are applied, the levels of information fishers have about the problematic situation they face, and the ease with which actions can be restricted. Assignment problems are more amenable to resolution through relatively simple rules, whereas it is problematic whether stock externalities are resolvable without very complex and restrictive sets of rules. The more complete the set of property rights that a group of fishers hold, combined with rules defining how those rights are to be exercised, the more likely fishers will achieve superior outcomes than fishers who hold less complete sets of rights, or who have not established rules specifying how their rights are to be exercised.

Monitoring and Enforcement of Institutional Arrangements

For institutional arrangements to be maintained over tine, conformance to the rules must be monitored and enforced. If rights are to be meaningful, individuals must have recourse to enforcement mechanisms, otherwise rights may devolve into exposures, with others having the liberty to act where once they were under duty to refrain from acting (Commons 1968). Without monitoring and enforcement mechanisms, if opportunities arise in which significant benefits can be had by not following the rules, some individuals may disregard them, endangering the continued existence of institutional arrangements. Dahlman argues that without monitoring and enforcement mechanisms to support institutional arrangements, resources will not be used efficiently. He argues that the two necessary and sufficient conditions for a resource to be utilized inefficiently are scarcity and the impossibility of enforcing restrictions on use (Dahlman 1980:202).

The ease and costliness of monitoring rules devised to organize the harvesting of fish depend upon the physical structure of the resource, the design of the rules used, and the type of behavior upon which the rules focus (Ostrom 1990:329). The number of times the action must be measured affects the costliness of monitoring. The more often the action must be measured the more costly monitoring becomes. For instance, measuring the quantity of catch or the size of the fish caught is more costly than measuring the type of equipment used. In addition, the required precision of the measure also affects the ease and costliness of monitoring. If all that is required is measuring whether or not an action took place, as opposed to measuring the magnitude of the action, monitoring is less costly. For instance, measuring whether a fisher is utilizing gear in a specified area is easier than measuring the number of times fishers cast their nets.

The ease and costliness of monitoring is also affected by whether fishers can monitor compliance with their rules as they fish, or whether they must establish specialized arrangements for monitoring each other's behavior. Monitoring, as a byproduct of fishing, is facilitated by the size of the resource, its physical characteristics, and the interdependencies that the rules create among the fishers. Smaller fishing grounds, and fishing grounds in lagoons and harbors facilitate self-monitoring. Fishers, as they move about a relatively smaller ground, are more able to watch each other fishing. Also grounds constrained by well-defined physical boundaries are easier for fishers to monitor access. In addition, if fishers unload their boats at a single facility they can easily monitor each other's catch and the type of equipment utilized. Finally, if the rules create dependencies among the fishers, the fishers can more readily monitor each other. For instance, if fishers are required to rotate through a series of fishing spots, one fisher failing to move to the next spot in the rotation, will prevent all other fishers from rotating, signalling that some one individual has failed to abide by the rules.

Enforcing rule conforming behavior is as important as monitoring behavior, and to be effective it must be crafted to the situation. In most coastal fisheries harvesting is a long term activity. Fishers not only fish together, they often live in close proximity to one another. They rely upon each other for assistance when crises arise while fishing, and they often socialize together while onshore. Fishers often form a long term community. Martin (1973) argues that to maintain that community, and the long term relationships on which it is built, enforcement processes must check rule breaking, yet do so in a way that does not fracture the community. This is often achieved through mediation processes, and the bringing to bear of social pressures as opposed to punishment of rulebreakers by

monetary fines or physical coercion. A respected official, such as a fisheries officer, a religious official, a respected elder, or a prominent businessman, may be called upon to negotiate between fishers to ensure the rule breaker ceases his destructive behavior (Martin 1973, Raychaudhuri 1980). In general for monitoring and enforcement systems to function effectively, fishers must have a stake in the governing institutional arrangements and must be involved in their monitoring and enforcement (Townsend and Wilson 1987).

Conclusion

Given a common pool resource—a fishing ground—that is not amenable to division into individually held parcels of ocean, fishers engage in harvesting in an interdependent environment. The actions that an individual fisher takes and the outcomes she achieves are affected by the actions of the other fishers harvesting from the same ground. In interacting with each other fishers can produce dilemmas, such as assignment problems and technological externalities, that if fishers could resolve would permit them to achieve improved outcomes. In order to resolve dilemmas, however, fishers must cooperate to coordinate their harvesting activities. They must devise institutional arrangements that will structure their actions in ways that allow them to achieve desired outcomes.

In Chapter Two I examined the types of dilemmas fishers commonly face, and the dilemmas they are more likely to attempt to resolve through institutional design and change. In this chapter I explored different types of institutional arrangements—property rights and rules—and expectations about their performance. Simply because fishers devise institutional arrangements to resolve dilemmas that they confront does not mean that those arrangements will successfully structure fishers actions in desirable ways. Particular types of institutional arrangements are expected to perform better than other types. Institutional arrangements that include rights of access, withdrawal, management, and exclusion, coupled with rules that specify how those rights are to be exercised are expected to outperform arrangements that do not include the right of exclusion or rules. That is, groups of fishers who collectively hold more complete sets of property rights are more likely to invest in establishing rules of harvest. More complete sets of property rights limit the exposures of the group of fishers to the actions of others providing them with incentives to invest in rule definition. Thus, fishers who collectively hold more complete bundles of rights are more likely to undertake rule definition and thereby address problems that they face in harvesting. In addition, for these arrangements to be effective and to be maintained, compliance with them must be monitored and enforced. Simply engaging in institutional design does not ensure fishers

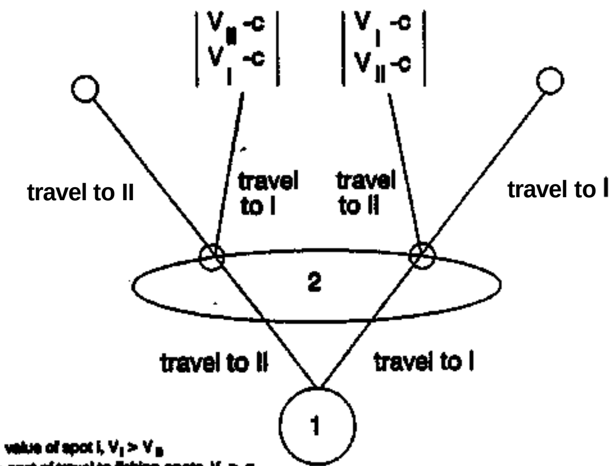
desirable outcomes, the outcomes achieved depend upon the types of institutional arrangements created.

In the following two chapters research questions raised in Chapters Two and Three will be explored. These questions will be addressed using data collected from thirty case studies of coastal fisheries located around the world. How the data was collected and a general overview of the case studies is presented in the following appendix.

Figure 3.1. Game Using Default Rules

1 \ 2	stay	leave
stay	W_{II1}-c, W_{II2}-c	V_{II} -c, V_{I} -2c
leave	V_{I} -2c, V_{II} -c	W_{I1}-2c, W_{I2}-2c

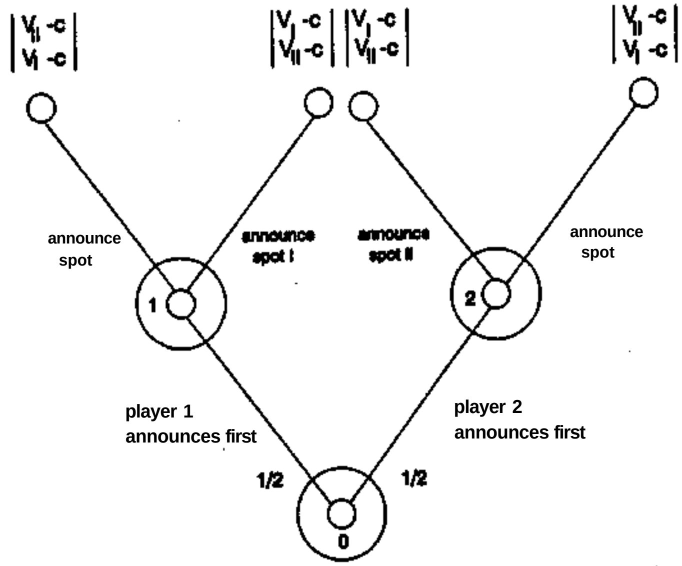
1 \ 2	stay	leave
stay	W_{I1}-c, W_{I2}-c	V_{I} -c, V_{II} -2c
leave	V_{II} -2c, V_{I} -c	W_{II1}-2c, W_{II2}-2c



V_i = value of spot i, $V_I > V_{II}$
c = cost of travel to fishing spots, $V_{II} > c$
W_{i1} = value of spot i to fisher 1 if fisher 1 takes the spot and fisher 2 suffers damage
W_{i2} = value of spot i to fisher 2 if fisher 2 takes the spot and fisher 1 suffers damage

from Gardner and Ostrom (forthcoming)

Figure 3.2. Game Using Announcement Rule



from Gardner and Ostrom (forthcoming)

1. An example of this may occur in relation to oyster beds. A fisher who possesses a transferable lease to particular beds may be able to receive compensation for future benefits she generates through investing in the beds. Through the transfer price of the lease she can potentially capture the future benefits she has generated.

2. A variety of evidence both from field studies and from laboratory experiments show that even if access is limited resource users still dissipate rent and in some cases destroy the resource. See Walker, Ostrom and Gardner (1990).

APPENDIX ONE

RESEARCH METHODS

The research questions developed in Chapter Three and in Chapter Four will be tested using data collected from thirty in-depth case studies of coastal fishing grounds. Scholars from a variety of disciplines, such as cultural anthropology, cultural ecology, geography, and sociology, conducted these case studies which have been published in a variety of ways such as dissertations and theses, books, journal articles, monographs, occasional papers, and conference papers. The thirty fishing grounds are located in various parts of the world, with fishers harvesting a variety of demersal and pelagic fish, as well as crustaceans, and molluscs.[1] In some instances the situation described in the case is quite simple. By quite simple I mean that a single group of fishers, during one time period, harvest a single type of fish, using similar technologies. In other instances, the case author describes a situation where more than one group of fishers may be competing with other groups to harvest several types of fish, or the case author describes a situation that changes over time. Taken together, this diverse group of cases presents an excellent set of data by which to explore the assertions made in Chapters Two and Three. In this appendix I will describe how the case studies of coastal fisheries were collected in addition to providing a general overview of the studies.

Collection of Case Studies

A research project, "Towards an Institutional Theory of Collective Action", headed by Professor Elinor Ostrom at Indiana University, has served as a major source of data for this study. A part of the research project has been to undertake a systematic analysis of in-depth case studies on common pool resources including fisheries, irrigation systems, forests, and grazing lands. As a member of this project, I helped develop a series of in-depth coding forms containing mostly close-ended questions to capture physical, institutional, and community attributes of common pool resources. Forms most relevant to this study are the following:

1. Location Form — examines the major geographic and demographic features of the location where an appropriation resource is located.

2. Appropriation Resource Form — examines the boundaries and physical characteristics of an appropriation resource, i.e., fishing ground.

3. Operational Level Form — examines the types of situations faced by participants, the level of information available to them, their potential actions and levels of control, their patterns of interactions, and outcomes they obtain. Each operational level form reports a "time slice" during which the actions of the appropriators are relatively consistent. By "relatively consistent", it is meant that the rules governing the appropriation resource, the community of appropriators, and the physical characteristics of the resource are the same throughout the period. When any one of these attributes changes, another

operational level form is coded for a new "time slice".

4. Subgroup Form — examines the stakes and resources, potential actions and levels of control, and strategies of participants in a subgroup.

5. Operational Rule Form — examines the kinds of boundary, authority, scope, information, payoff, and aggregation rules used in governing an appropriation resource.

6. Collective Choice Form — examines the collective choice entities that govern an appropriation resource.

These forms are derived from a theoretical framework known as institutional analysis developed by Riser and Ostrom (1982), Oakerson (1986), Ostrom (1986, 1990), and Gardner, Ostrom, and Walker (1990). Institutional analysis rests upon three levels of action; the operational level, which is the day-to-day operating activities of individuals; the collective choice level, which involves devising rules that structure the operational level of action; and the constitutional'choice level, which involves the devising of rules that structure the collective choice level of action (see Kiser and Ostrom 1982). The research project, and consequently the coding forms, focus primarily upon the operational level of action, with some exploration of the collective choice level of action. In addition, exclusive attention has been paid to appropriation or withdrawal of units, i.e., fish, from common pool resources, as opposed to marketing of harvested units.

The operational level of action is itself divided into several parts. The action situation focuses upon several variables that structure a situation.

(1) The set of positions to be held by participants.

(2) The set of participants (including a random actor where relevant) in each position.

(3) The set of actions that participants in positions can take at different nodes in a decision tree.

(4) The set of outcomes that participants jointly affect through their actions.

(5) A set of functions that map participant and random actions at decision nodes into intermediate or final outcomes.

(6) The amount of information available at a decision node.

(7) The benefits and costs to be assigned to actions and outcomes (Ostrom 1986:17).

The action situation together with a model of the individual are required to construct a formal model of a situation (Ostrom 1986:17). The coding forms that capture most of the information of an action situation, or a common pool resource situation, are the operational level form and the subgroup form. The action situation is itself structured by physical and institutional features of its broader environment (Kiser and Ostrom 1982). Such features include property rights, rules, the physical characteristics of the resource, and cultural characteristics of the individuals involved in the action situation. The coding forms that capture these variables are the location form, the resource

form, the operational level form, the operational rules form, and the collective choice fora.

I used these forms in coding in-depth case studies of different coastal fishery situations. I placed two restrictions on choosing case studies to code. First, the study had to describe either a resolved or unresolved coastal fishery dilemma. Second, the study had to contain information on the rules that fishers used to organize their harvesting activities. Typically, if the case study authors provided information on rules, they also provided information on the groups of fishers and on the fishing grounds they used. This allowed me to code most of the approximately 600 variables contained in the coding forms. No other restrictions were used in choosing case studies. After searching through hundreds of documents, I inditified and coded thirty coastal fishery case studies.

Even though minimal restrictions were used in choosing case studies, these studies, nevertheless, are not a random sample from the population of coastal fishing grounds located throughout the world. Consequently, I cannot generalize my findings beyond these studies. On the other hand, I have imposed a consistent set of variables across the cases permitting consistent comparisons to be made among them. Thus, there is no reason to believe that the values of the variables on which I have collected data are not randomly distributed among the case studies. I can generalize my findings across the thirty case studies.

The case studies provide a wealth of information that has not before been brought together. In particular, detailed information on property rights and rules across numerous fishing grounds has not been collected prior to this attempt. The work in this study must, therefore, be compared to prior studies that have attempted to generalize from a very few set of cases and not be compared with what could be obtained if it were possible to draw a random sample of all inshore fisheries around the world.

Unit of Analysis

In examining how various types of property rights and institutional rules affect behavior and outcomes in coastal fisheries, the unit of analysis that I use is the subgroup. A subgroup is a group of fishers who harvest from the same fishing ground and who are relatively similar in relation to the following five characteristics:

1. Their legal rights to appropriate units, i.e., fish.
2. Their withdrawal rate of fish from the resource.
3. Their exposure to variation in the supply of fish.
4. Their level of dependency on fish withdrawn from the resource.
5. How they use the appropriation units.

This definition of a subgroup does not depend on the presence or absence of an organization of fishers. Instead, a group of fishers must share similar circumstances, as defined above, in relation to commonly shared fishing

grounds to be a subgroup. Also, more than one subgroup of fishers can utilize the same resource simultaneously. It is important to examine individual subgroups for this study because the property rights and rules of different subgroups using the same fishing grounds may differ radically from one another.

Forty-four subgroups of fishers utilize the thirty fishing grounds that were coded from the in-depth case studies listed in Table 1. The information contained in the original case studies provided sufficient data to code one time period for 36 of the subgroups utilizing 28 of the fishing grounds. For two of the fishing grounds the author provided sufficient information that it was possible to code three time periods.

I treated the subgroups in each of the three time periods as separate groups, even if their membership remained unchanged. I did this because the second and third time periods represented very different situations from the initial time period and from each other. Crucial variables differed from period to period. Additional fishers or subgroups began harvesting from fishing grounds, different sets of property rights and rules were utilized in later periods, and so forth. Also, the hypotheses I am examining have been derived from static models. Consequently, the analysis will be static. Thus, treating the subgroups in each of the three time periods as separate groups does not harm the analysis.

Description of Case Studies

The profiles of the thirty coastal fishery resources are shown in Table 1. These resources are located in sixteen different countries, with eleven located in Central and South America, eight in North America, seven in Asia, and four in Europe. A variety of demersal and pelagic fish, crustaceans, and molluscs are harvested from these fisheries by relatively small numbers of fishers. The average number of fishers constituting a subgroup is 189, with the smallest subgroup being 29 and the largest being 750. These groups of fishers are relatively homogeneous. Most groups consist of men who share similar racial, ethnic, and religious backgrounds. In addition, most of these fishers use fixed gear. They use gear that is stationary, such as various forms of fish traps, handlines, longlines, and stationary nets.

Even though the thirty resources are small scale coastal fisheries, all but two, for which there is information, are commercial. These fisheries are not just subsistence fisheries, rather they are important sources of monetary income for the fishers who harvest from them. The thirty coastal fisheries, together with the forty-four subgroups that utilize them, constitute the sample from which hypotheses established in Chapters Two and Three will be examined in the following two chapters.

TABLE 1

DESCRIPTION OF CASE STUDIES

Country	Location	Unit Harvested	Subgroups	Time Periods	Commercial Fishery	# of Fishers Harvesting	Documents
Belize	Caye Caulker	Lobster	1	1	yes	297	Sutherland (1986)
Belize	San Pedro	Lobster	2	1	yes	185	Gordon (1981)
Brazil	Arembepe	Mixed	1	1	yes	178	Kottak (1966)
Brazil	Coqueiral	Mixed	1	1	yes	85	Forman (1966, 1970)
Brazil	Valença	Mixed	5	3	yes	500	Cordell (1972, 1974, 1978, 1983, 1984)
Canada	Baccalieu Cove	Cod	2	1	missing	61	Powers (1984)
Canada	Cat Harbour	Cod	2	1	yes	72	Faris (1972)
Canada	Fermeuse	Cod	2	1	yes	36	Martin (1973, 1979)
Canada	James Bay	Whitefish	1	1	no	387	Berkes (1977, 1987)
Canada	Petty Harbour	Cod	2	1	yes	104	Shortall (1973)
Canada	Port Lameroon Pagesville	Lobster	1	1	yes	29	Davis (1975, 1984)
Canada	Port Lameroon Pagesville	Mixed	1	1	yes	33	Davis (1975, 1984)
Greece	Messolonghi Etolica	Mullet/ Seabream	2	1	missing	370	Kotsonias (1984)
India	Jambudwip	Mixed	2	1	yes	243	Raychaudhuri (1980, (1972)
Jamaica	Farquhar Beach	Mixed	1	1	yes	94	Davenport (1956)
Japan	Ebibara	Shrimp	1	1	yes	missing	Bremeld (1968)

TABLE 1 CONTINUED

DESCRIPTION OF CASE STUDIES

Country	Location	Unit Harvested	Subgroups	Time Periods	Commercial Fishery	# of Fishers Harvesting	Documents
Korea	Kagoda	Anchovy	1	1	yes	missing	Han (1972)
Malaysia	Kampong Mee	Mixed	1	1	yes	missing	Anderson and Anderson (1977)
Malaysia	Perupok	Mixed	1	1	yes	245	Firth (1966)
Mexico	Andres Quintana Roo	Mixed	1	1	yes	missing	Miller (1982)
Mexico	Andres Quintana Roo	Lobster	1	1	yes	65	Miller (1982)
Mexico	Ascension Bay	Lobster	1	1	yes	110	Miller (1982, 1989)
Nicaragua	Tasbapauni	Turtle	2	1	no	80	Nietschmann (1972, 1973)
Sri Lanka	Gahavalla	Mixed	3	3	yes	284	Alexander (1982)
Thailand	Rusembilan	Mackerel	1	1	yes	200	Fraser (1960, 1966)
Turkey	Alanya	Mixed	1	1	yes	100	Berkes (1986)
Turkey	Ayvalik-Haylazli	Mixed	1	1	yes	105	Berkes (1986)
Turkey	Tasucu	Mixed	1	1	yes	140	Berkes (1986)
Venezuela	Chiguana	Lisa	1	1	missing	48	Breton (1973)
U.S.A.	Mount Desert Island	Lobster	1	1	yes	72	Grossinger (1975)

1. Demersal fish are bottom dwelling whereas pelagic are surface dwelling. Crustaceans and molluscs refer to lobsters, crabs, oysters, clams, and so forth.

2. The descriptions of coding forms was taken from S.Y. Tang (1989) "Institutions and Collective Action in Irrigation Systems" Ph.D dissertation, Indiana University, p.62.

CHAPTER FOUR

FISHERS' RESPONSES TO COASTAL FISHERY DILEMMAS

Fishers, in jointly using fishing grounds and in subtracting fish, act in interdependent situations. The outcomes they achieve depend on the actions of other fishers in addition to their own. As a result, if fishers do not coordinate their harvesting activities they can produce problematic situations or dilemmas. Common dilemmas that fishers face are stock externalities, technological externalities, and assignment problems. At least some of these problems may be solved if fishers choose to cooperate to coordinate their actions. The conditions under which fishers choose to engage in institutional design, the problems they address, and the rules they adopt are the subject of this chapter.

Institutional Arrangements and Organizations

Institutional arrangements are sets of property rights that fishers possess in relation to their fishing grounds, and the rules that define what actions they can take in utilizing their grounds. Institutional arrangements are analytically separate from organizations, and may or may not be associated with a formal organization. Kiser and Ostrom define organizations "as composites of participants following rules governing activities and transactions to realize particular outputs. These activities occur within specific facilities" (Kiser and Ostrom 1982:193). Organizations consist of groups of people following a common set of rules to achieve particular outcomes within a specific facility. In relation to fisheries, common organizations are cooperatives, unions, and government agencies.

The focus of this chapter is upon institutional arrangements, which may or may not be associated with formal organizations, and not upon organizations per se. An example of coordinated harvesting activities independent of any formal organization is presented in a case study by Anthony Davis of a group of fishers and the cod grounds they harvest from off of the southwestern coast of Nova Scotia, as discussed in Chapter One (Davis 1975). The thirty-three fishers studied by Davis live in closely situated villages adjacent to the harbor where they dock their boats.[1] Their grounds consist of approximately 120 square miles of ocean extending to the south and east of the harbor. They utilize similar equipment in harvesting fish—handlines and longlines for cod, and gillnets for herring used as bait for cod. Over time, they have evolved rules specifying where certain types of gear can and cannot be utilized in their grounds. For instance, gillnets:

> are not set 'inside' (ie., further up the estuary) of the base line because they would restrict the channels into the Port Lameron, Upper Port Lameron, and Pagesville harbors (Ibid:71).

In addition, handlines are set "within six to eight miles of the shore. The remaining four to six miles to the outer limit are used mainly by the longliners"(Ibid).

Enforcement of these rules among the fishers themselves and against "outsiders" is undertaken primarily on an individual basis by the fishers. Outsiders are permitted to fish the grounds if they follow the rules. If they set gear in areas forbidden to that gear they are ejected from the grounds by whomever first notices the violation (Ibid:103). Among the fishers themselves social sanctions are applied to rule violators. Fishers will stop sharing bait and information concerning the location of fish with rule violators.

The coordination of harvesting activities among these fishers has occurred without recourse to a formal organization. No cooperative or union has been established as a mechanism to create and enforce rules. Because the fishers live in the same village and share so many common facilities in that village, they interact with one another on a regular basis without the need for establishing a formal organization to engage in self-conscious institutional design and rule enforcement activities. Thus, for the purposes of this chapter the focus of analysis extends beyond the outcomes that specific organizational forms produce, and includes various institutional arrangements, with or without associated organizational forms.[2]

Measuring Institutional Arrangements

For purposes of this study, whether fishers have devised rules that specify who can fish and how harvesting is to be conducted will be used as an indicator of fishers having created institutional arrangements to resolve dilemma situations. Rules are chosen as opposed to just property rights, or property rights and rules, for two reasons. First, government agencies have granted fishers most of their property rights. Fishers, except in relation to the right of exclusion, have not devised their own property rights. Focusing on property rights that groups of fishers possess does not indicate whether fishers have actually coordinated their activities. Property rights, for the most part indicate the rights an external authority has granted to the groups of fishers. Second, fishers have devised almost all of the rules that structure their actions. Except for seasonal closures and minimum size rules regarding fish harvested, fishers have devised all other rules. Thus, rules are an excellent indicator of fishers cooperating to coordinate their actions.

Since rules are an indicator of whether fishers have engaged in institutional design to address collective problems they face, the question arises as to what types of rules should count as evidence that fishers have organized

their harvesting activities. A useful starting point is to assume that in light of problematic situations fishers may, through the use of rules, try to exclude others from entering their fishing grounds, and/or they may try to define the types of actions that can be taken in harvesting fish. The most important types of rules in gaining greater control over fishing grounds are boundary, authority, and scope. Boundary rules define who can enter a resource. They establish criteria that individuals must meet before they can access a resource. For instance, boundary rules may specify that only men older than 16 years, who live in a particular area, and who use particular types of gear can enter specific fishing grounds. The criteria boundary rules usually specify in relation to inshore fisheries are gender, age, residency and technology.

Authority and scope rules define the types of actions that can be taken and the states of the world that can be affected. Authority and scope rules specify actions that must, may, or must not be taken in harvesting fish. For instance, an authority rule may state that fishers can only harvest fish by setting their gear in specified spots, and that they have exclusive rights to their spots for the entire season. A scope rule may state that only fish larger than a certain size may be harvested. Once fishers meet the boundary rule requirements that give them access to fishing grounds they must conduct their harvesting activities in accordance with the authority and scope rules in effect.

For purposes of this analysis, evidence that fishers have organized their harvesting activities include boundary rules whose criteria involve more than just residency. Christy (1982) argues that for fishers to gain control over their grounds the boundary rules that they utilize must require residency in a locality in addition to other criteria, such as the purchasing of a license, the use of a particular type of technology, etc. Simply requiring residency in a locality will not usually exclude a sufficient number of fishers from most fishing grounds so as to avoid crowding and the possible destruction of fishing grounds. Rather, additional barriers to entry must also be put in place (Christy 1982:2).

In addition, authority and scope rules utilized by fishers must specify particular types of actions to be taken in harvesting fish. Fishers must not be permitted to take any action they please in harvesting. As argued in Chapters Two and Three, for fishers to begin to address dilemmas that they face they must coordinate their harvesting activities. Coordination occurs through specifying authority and scope rules. In considering the boundary and authority and scope rules among the forty-four subgroups, only those subgroups whose boundary rules require more than residency in a country, region or locality, to gain access to the fishing

ground, and whose authority and scope rules forbid fishers from taking any actions they choose in harvesting fish are counted as having instituted arrangements to constrain harvesting behavior.[3] Among the forty-four subgroups, thirty-three have devised rules to govern the use of their grounds, whereas eleven have not devised rules of harvest.

Dilemmas Addressed by Institutional Arrangements

In Chapter Two based on the work of Gardner, Ostrom, and Walker (1990), I argued that in harvesting fish, fishers are likely to face three problematic situations: 1) stock externalities, 2) assignment problems, and 3) technological externalities. Based on the work of Wilson (1982) and Ostrom (1990), I also argued that fishers are much more likely to address assignment problems and technological externalities than they are stock externalities. Stock externalities derive from the nature of the flow of fish, which are subtractable. What one fisher harvests is not available for others to harvest. Drawing down the pool of fish available during a season increases the costs of harvesting, yet fishers do not take into account the costs they visit upon one another. These costs are stock externalities.

In order to address stock externalities effort directed at harvesting the flow of fish must be regulated. Effort that each fisher produces must be reduced. If fishers attempt to solve stock externality problems they will organize in relation to the flow of fish. That is, they may notice the effects their harvesting has upon each other, possibly through declining levels of fish available to be harvested, and they may collectively agree to limit their effort.

A problem in examining this assertion is that not only do fishers have little information concerning stock dynamics, and the effects their actions have upon one another, but neither do most researchers. Thus, information concerning stock externalities was not reported in the case studies. Although the existence of stock externalities was not directly reported, many of the case authors did report whether the stock of fish appeared to be abundant or scarce. This report can be used as a simple, though rough method of measuring stock externalities. According to the dynamics of the bionomic model, sfock externalities typically emerge when the size of the stocks of fish are declining and the quantity of fish given demand levels is consequently scarce.[4] The question to be examined is whether in the face of declining stocks of fish, fishers organize their harvesting.

In examining the relationship between reported evidence that the stock of fish is scarce and whether fishers have defined institutional arrangements for organizing their harvesting activities, a measure of the reported evidence concerning scarcity was taken at the beginning of the time

period of the case study. An example of a group of fishers who were not facing scarcity is reported by Sutherland (1986). Sutherland describes a group of Belizean lobsterfishers who live on an island (Caye Caulker) off of Belize and who harvest lobster just inside the barrier reef of Belize. The fishers harvest lobster with the use of traps and also by scuba diving. They began to develop the lobster fishery in the 1920s. At the time lobster was quite abundant.

> At the beginning of the twentieth century, spiny lobster were abundant in the seabed around Caye Caulker, where the shallow, warm coastal waters provided an ideal habitat. Islanders tell stories of lobster crawling up on the beaches in such numbers that they were considered "rubbish" food (Sutherland 1986:49-50).

Table 4.1 exhibits a moderately strong relationship between scarcity of stocks of fish and fishers having defined institutional arrangements for organizing their harvesting activities, but the relationship is of the wrong predicted sign.[5] If the predicted relationship were to hold, most of the cases should lay along the main diagonal, with a few on the off diagonal. If subgroups of fishers experience a scarcity of fish they should organize, otherwise they should not. In this instance the opposite is the case. Host of the cases lay along the off diagonal. Twenty subgroups who experience abundant fish stocks have devised institutional arrangements for governing harvesting activities. They have organized even though the flow of fish are not scarce.

It may be the case that the twenty subgroups of fishers who face abundant fish stocks originally organized in response to scarcity. That is, prior to the period which the case author reports the subgroups may have experienced scarcities of fish and in response organized their harvesting activities to limit effort. The case author may now simply be reporting the successful outcomes of such institutional arrangements. While this scenario is possible it is not likely to be the case. As argued in Chapter Three, fishers have little information concerning the dynamics of the fish stocks or how their fishing activities affect fish population dynamics. If fishers do not perceive or understand their role in creating a problematic situation they are unlikely to attempt to address it. Second, as Martin argues in relation to the Newfoundland cod fishers he describes, they perceive fluctuations in cod stocks as resulting from natural occurrences or from the harvesting activities of offshore fleets, and not as a consequence of their own activities (Martin 1979). Evidence from the forty-four subgroups suggests that fishers do not organize to address problems of stock externalities. Other factors affect fishers choices to organize.

A second problematic situation, assignment problems, involves governing the use of the resource, i.e., the

fishing grounds, as opposed to the flow of fish through those grounds. Fishers possess substantial amounts of information about their fishing grounds, and about the effects that their actions, in gaining access to the choice spots, have upon one another. The problem is identifiable and measurable, and is also a source of conflict. Thus, as I argued in Chapter Two, fishers are more likely to attempt institutional change in light of conflict over a limited number of productive areas within the grounds.

An example of fishers experiencing conflict in relation to gaining access to choice fishing spots is reported by Berkes (1986). Berkes describes a group of Turkish fishers who reside in Alanya and who harvest bonito and large carangids using nets, just off of the coast of Alanya in the Mediterranean. Prior to 1960, the number of choice fishing spots matched the number of fishers. In the 1960s, however, the number of fishers increased resulting in fewer choice spots than fishers who wanted to fish those spots. Fishers began to fight over the spots with fishers losing gear. Eventually,

> small groups of fishermen started to cooperate by giving one another sufficient berth and then taking turns at the better sites. Over a period of some 15 years, there developed a fishing system to optimize production at the best sites, and in turn to allocate these sites by lottery, with a rotation provision to ensure that all fishermen get an equal chance to fish the best sites (Berkes 1986:16-17).[6]

Table 4.2 arrays whether fishers have experienced conflict over choice spots by whether fishers have organized their harvesting activities. A moderately strong relationship of the correct sign exists between the existence of assignment problems and whether fishers have organized their harvesting activities.[7] The expected relationship requires that most cases lay along the main diagonal. Subgroups who have experienced problems over scarcity of spots should have organized their harvesting activities, whereas subgroups who have not faced a scarcity of productive spots should not have undertaken the definition of rules. Certainly among subgroups that have faced scarcity of spots they have overwhelmingly organized. Out of nineteen subgroups who have confronted a shortage of choice spots, sixteen have organized their harvesting. Conflict over productive areas is one factor in explaining why fishers have devised institutional arrangements for governing the appropriation of fish.

On the other hand, other operative factors exist as revealed by the fact that of the ten subgroups who have not experienced conflict over spots, seven, or 70% have still organized. Another factor, discussed in Chapter Two, that should have an impact is conflict over different types of gear being utilized within the same fishing grounds, or gear being utilized too close together, which generate technological externalities. An example of fishers

experiencing technological externalities is presented by Cordell (1972). He describes the evolution of an estuarian fishery off of the coast of Valenca, Brazil. At the beginning of this century when the fishery was first being developed, the fishers utilized a variety of technologies and interfered with each other in harvesting fish. This interference resulted in the destruction of gear and in physical violence among the fishers. As Cordell explains:

> From my conversations with older fishermen it was apparent that long ago they recognized the chance of interference, even if unintentional, was fairly high, especially during spawning seasons. Because of the difficulty in establishing exclusive long-term control over net fishing areas, considerable violence was characteristic of canoe fishing in its earlier phases. However, as fishermen noted, the more violence-prone participants in fishing had gradually abandoned it (os mais vilentos se seoararam da oescaria). The reasons for this were clear: loss of equipment due to retaliatory acts, canoes sunk, nets burned or stolen, and in some cases people shot while attempting to take a lanco by force (Cordell 1972:105).

Table 4.3, arrays the relationship between potential conflict over harvesting processes and whether fishers have organized harvesting.[8] If fishers organize in the face of technological externalities, then most subgroups should lay along the main diagonal in Table 4.3. Fishers who experience technological externalities should organize, and fishers who do not, should not organize. Among the seventeen subgroups who utilize multiple types of gear within the same grounds, thirteen have organized their harvesting activities to avoid such conflict. This evidence suggests that fishers also organize to address technological externality problems. The relationship between conflict over incompatible types of gear and fishers organizing to avoid such conflict is relatively strong.

Table 4.4 combines the effects of conflict over access to limited numbers of spots, and conflict over multiple types of gear, with fishers organizing the harvesting of fish. The existence of conflict arising over productive spots and/or incompatible gears exerts a strong influence upon subgroups of fishers to devise institutional arrangements to organize their harvesting activities. Of the twenty-eight subgroups of fishers that have faced conflict over either problem, or both, 86% have defined rules to order their harvesting activities. On the other hand, among the nine subgroups of fishers who have not experienced conflict over limited spots or incompatible gears, six, or 67%, have still organized. Another factor, or factors, continue to affect whether fishers organize.

In considering the six subgroups who have organized but who have not experienced assignment problems or technological externalities, two very closely related processes appear to be occurring that explain why they have organized. Members of two of the six subgroups were required by law to organize before they could access fishing grounds and withdraw fish. The fishers constituting one of these subgroups reside in Turkey and harvest from a lagoon.

As reported by Berkes (1986), Turkish fishers who organize themselves into cooperatives can apply to the Turkish government for exclusive rights to harvest from specific lagoons, with Turkish law giving preference to fishers' cooperatives over other organizations in granting such rights. As Berkes states:

> The cooperative was established in 1974 to make a bid for the lease of the lagoon, which had previously been operating under a private company...Taking advantage of a provision under the Aquatic Resources Act to give priority to cooperatives in the leasing of lake and lagoon fisheries, the Ayvalik-Haylazli Cooperative was successful in its bid (Berkes 1986:75).

Thus the Turkish fishers were required to organize before they could gain access to their fishing ground.

The other subgroup that is organized but did not do so on the basis of assignment problems nor technological externalities, resides in Ebibara, Japan (Brameld 1968). In 1950, the Japanese federal government adopted a law placing coastal waters under the control of local cooperatives. Coastal waters were divided among local communities and fishers from each community were required to belong to their coop and to fish in their waters only (Ibid:26). Thus, two of the six subgroups that have organized but that did not initially face potential conflict over spots or gear exist within a larger institutional environment that requires organization as a pre-requisite to access and harvesting activities in at least some types of coastal waters.

Each of the other four subgroups that have organized harvesting without facing conflict over spots or technology initially organized for some other purpose or was part of a more general organization. Two of the subgroups reside in San Pedro, Belize and harvest lobster (Gordon 1981). Over a period of years the San Pedro fishers faced a monopoly buyer of their lobster. With assistance from a variety of governmental agencies they eventually formed a marketing cooperative whereby they could take competitive bids from buyers in the international market. While the fishers initially organized to solve marketing problems, the coop later became involved in organizing harvesting activities. In the case of the two remaining subgroups, the fishers are each part of a local communal governmental system that has organized many aspects of life in addition to fishing (Fraser 1960, Firth 196*6). Thus, among the six subgroups that have ordered their fishing practices, two did so in order to gain access to coastal fishing grounds, and the remaining four were organized for some other purpose which then extended into the harvesting of fish.

On the other hand, another four subgroups, that have faced assignment problems and technological externalities failed to design, establish, or maintain institutional arrangements with disastrous consequences. Three of the four subgroups, whose harvesting activities are not organized, are associated with the Valenca, Brazil fishing

grounds (Cordell 1972). Prior to the 1960s a single subgroup of Brazilian fishers organized the harvesting of the Valenca grounds. With the advent of governmental policies that encouraged an influx of new fishers, these fragile institutional arrangements were destroyed. Not only did the arrangements cease to function, but problems of assignment and technological externalities once again plagued the fishers.

Prior to 1960, a single group of fishers, numbering approximately 350, harvested a variety of fish from an estuary near Valenca. The fishers had devised institutional arrangements to address problems of assignment and technological externalities. The fishers divided the estuary into various areas, where different technologies were used and did not overlap.

> The mangrove fence and barricade net are always located highest on the shore, succeeded by the dragged nets, encircling nets, and tidal flat fish corrals. Finally, moving out to the channel are positioned the fish traps, trotlines and gillnets. In any case, the distribution of techniques in a wedge of water is always such that they do not overlap(Ibid:42).

The types of gear used and the location of their use depended on the tides since some techniques required weak currents and others moderate currents. In order to avoid conflict over access to particular spots, several rules were used. When more than a single boat arrived at a specific spot simultaneously, the fishers of each boat would often draw lots to determine the order of use of the spot. In some instances, however, fishers refused to follow the established order, creating conflict (Ibid:94). In other instances fishers used a prior announcement rule to claim a spot for a day.

> When someone wishes to fish in a particular spot at a particular tide level, he may announce his intentions several days in advance. This is called publicando o lanco and serves to establish his claim to a designated water space. The place set aside for this purpose is a local bar where fishermen congregate (Ibid:98).

In the late 1950s the Brazilian government, in an attempt to "modernize" fisheries, provided nylon nets to investors, arranging financing through the Banco do Brasil. Several wealthy individuals, none of whom had been involved in fishing, purchased nylon nets. The canoe fishers themselves could not afford to purchase nets. The owners of the nylon nets hired men to fish with the nets. These new fishers were inexperienced. They intruded into the fishing grounds with little understanding of the structure of the grounds or the rules the original fishers had devised. Conflict erupted between the two groups of fishers, with fishers being shot and equipment destroyed (Cordell 1972). The institutional arrangements that had prevented such conflict were also destroyed as fishers fought for whatever spots they could gain.

Because institutional arrangements, to continue in existence, require individuals who know and agree to follow the rules, the entry of individuals (supported in their

efforts by the national government) who did not know or acknowledge the legitimacy of the rules of this fishery led to the destruction of these successful institutional arrangements. Without rules constraining the behavior of the fishers the fishery was severely degraded, with problems of assignment and technological externalities reappearing. Eventually, many of the original canoe fishers exited the fishery, leaving primarily the nylon net fishers. Cordell reported a decline in the size of catches for several years in the 1970s which also worked to drive the nylon net fishers out of the fishery. The original set of fishers retreated to the surrounding swamps scavaging for crabs, oysters, and mussels (Cordell 1978). As this case study by Cordell clearly demonstrates, well understood rules are crucial for solving and preventing problems arising in harvesting fish. Without boundary, and authority and scope rules to limit competition, severe problems can erupt among fishers.

The remaining subgroup of fishers who have faced technological externalities and assignment problems but who have not organized their harvesting activities is from the Messolonghi-Etolico lagoon in Greece (Kotsonias 1984). Two subgroups of fishers harvest from the lagoon. One subgroup of fishers has organized their harvesting activities under the direction of several coops, and they have leased parts of the lagoon from the Greek government. The other subgroup of fishers, the group that has not organized its harvesting activities, fishes from the unleased portions of the lagoon.

The unorganized set of fishers, instead of devising their own set of rules, have attempted to join the existing co-ops. The organized subgroup, however, does not allow members of the unorganized group to join their ranks. In fact, they are attempting to expel them from the lagoon. Fights have erupted among these two groups, and the fishers who are not organized are finding access to the lagoon increasingly more difficult (Ibid:527).

The four subgroups of fishers who have not ordered harvesting activities, in spite of facing problematic situations, do not, or did not, operate in institutional environments supportive of organizing efforts that they may have wanted to undertake. In each resource, subgroups fought among each other either destroying existing institutional arrangements, as in the case of Valenca, Brazil, or preventing a subgroup access to already established institutional arrangements, as in the case of the Messolonghi-Etolico Lagoon in Greece. While in each of these cases the subgroups that devised rules to organize their harvesting had for the most part resolved dilemmas that they faced, the groups with no rules to coordinate their actions experienced severe problems.

Evidence from the forty-four subgroups of fishers provide support for the research questions developed in

Chapter Two. There is little evidence to suggest that fishers attempt to adopt rules to coordinate their actions so as to avoid stock externalities. Fishers typically do not perceive stock externalities and, therefore, do not try to resolve them (Wilson 1982). In the case of assignment problems and technological externalities, the evidence is quite different. Among the forty-four subgroups of fishers, those who have confronted either problem have often times defined rules to order their harvesting activities. On the other hand, the subgroups who were not able to devise rules continued to face severe problems.

Incentives for Designing Institutional Arrangements

Even though fishers address particular problematic situations rather than others, a variety of factors affect whether they will cooperate at all to design institutional arrangements. That is, asserting that fishers are more likely to attempt to resolve assignment problems and technological externalities does not mean that whenever they are confronted with these problems they will always solve them. As discussed in Chapter Two characteristics of fishers' physical environment, institutional environment, and cultural environment structure the situation of fishers, facilitating their ability to collectively resolve common problems to varying degrees.

The importance of various physical and institutional factors in structuring facilitative environments for collective action are revealed in the differences in those environments between the subgroups of fishers who have devised rules for coordinating their actions and those who have not organized. These characteristics affect the information fishers possess about their environment, their ability to communicate among themselves, and their ability to design institutional arrangements that address the problems that they face.

In relation to the physical environment the factors considered important are the size of the resource, and the boundedness of the resource (Ostrom 1990). The smaller the size of the resource the less costly it is to develop a fundamental understanding of the processes occurring within its bounds, and also the less costly it is to monitor compliance with the rules. In relative terms, smaller resources are facilitative of fishers cooperating to devise institutional arrangements. Among the subgroups that have engaged in institutional design, for which there is information, on average the surface area of their fishing grounds is half that of the surface area of subgroups who have not engaged in institutional design. The average surface area of the fishing grounds of the fishers who have organized their harvesting is 243 square kilometers, as compared with an average surface area of 579 square kilometers of the fishing grounds utilized by unorganized sets of fishers.[9]

If the boundaries of the resource are well-defined physically by natural barriers; monitoring of who enters the resource is less difficult, and it is easier to exclude individuals from gaining entry. Given the feasibility of exclusion and the ease of monitoring associated with well-defined boundaries, cooperation is facilitated in such circumstances. Among the forty-four subgroups under consideration, no meaningful difference regarding resource boundaries exists between subgroups who are organized and those who are not organized. Twenty-two of the thirty-three subgroups who have organized, or 67%, access grounds whose boundaries pose no barrier to entry. Seven of the eleven subgroups who have not organized, or 64%, access grounds whose boundaries pose no barrier to entry.[10] Thus, among the forty-four subgroups the existence, or lack thereof, of physical boundaries that limit entry have little effect on whether fishers have organized their harvesting activities.

Economic factors can also potentially effect fishers' organizing capabilities. Whether fishers face relatively stable markets, whether they are highly dependent on the grounds as their major source of income, and the value of additional units of fish, all potentially effect fishers choices about whether to engage in the development of institutional arrangements. Given a relatively stable economy in which no fundamental changes are occurring such as a transition from a subsistence economy to a market economy, fishers face less risk in investing in their fishing grounds. If they do not have to contend with a rapidly changing economic environment, fishers can more easily access the value to them of using the grounds over time (Nietschmann 1972, 1973). Among the thirty-three subgroups who have organized their harvesting activities, and for which there is information, twenty-six, or 84%, operate within a stable economic environment, whereas among the eleven subgroups who have not organized institutional arrangements, five, or 50* operate within a stable economic environment.[11] The economic environment within which fishers operate can effect their ability to devise institutional arrangements. Fishers who operate in more stable environments are more likely to organize than those who do not interact within a stable environment.

Another economic variable potentially effecting fishers' choices to engage in institutional design is their degree of dependence upon the fishing grounds as their major source of income. Given a high level of dependence upon the grounds, fishers face incentives to organize their harvesting activities to sustain the grounds over time, and to ensure continued and reliable access to those grounds. Among the thirty-three subgroups who have organized their harvesting, and for which there is information, twenty-seven, or 87%, are very dependent upon their fishing grounds

for income. Members of these subgroups gain most of their income from harvesting fish. The remaining four subgroups who have organized their harvesting are moderately dependent upon fishing for their income. They gain about half of their income from harvesting fish. Among the eleven subgroups who have not organized harvesting activities, and for which there is information, only three, or 30%, are heavily dependent upon fishing as their predominant source of income, whereas seven, or 70%, are only moderately dependent upon fishing for income. Fishers who have organized their harvesting are more heavily dependent upon their fishing grounds as their major source of income.

Another crucial economic variable that can potentially effect fishers choosing to cooperate to organize their harvesting activities is the value of additional units of harvested fish. If the value of additional units is high, fishers face the incentive to harvest rapidly, and the disincentive to invest in fishing grounds, or in institutional arrangements to govern the use of grounds. Among the subgroups that have engaged in institutional design, for which there is information, 68% or 13, would receive moderate to high returns for additional units of fish, and 32% or 6 subgroups would receive low returns for additional units of fish harvested. Among the subgroups that have not organized, and for which there is information, 87% or 7 subgroups would receive high to moderate returns and 1 would receive low returns. Subgroups of fishers who have organized their harvesting of fish face less pressure to harvest fish rapidly in order to gain immediate benefits.

Economic variables play an important role in whether fishers engage in institutional design. These variables establish incentives for fishers to invest in institutional arrangements to sustain their harvesting activities over time. If fishers operate in a stable economic environment, if they are heavily dependent upon fishing as their only source of income, and if the marginal returns from harvesting additional units of fish are not too high, they face incentives to cooperate to devise rules of organization rather than rapidly harvest the stocks of fish.

In addition to economic variables affecting whether fishers choose to cooperate to engage in institutional design, cultural characteristics may also have an impact, especially upon fishers' abilities to communicate with each other. If groups of fishers experience ethnic, racial, caste, religious, or other cleavages, members of these groups of fishers are more likely to have difficulty in communicating concerning how their fishing grounds can best be utilized. These cultural differences may also result in differing perceptions among the fishers concerning how the fishing grounds can best be utilized. This expectation cannot be examined in relation to the forty-four subgroups

since each subgroup is culturally homogeneous. None exhibit differences in race, ethnicity, religion, or language that affects communication among members.

Another factor believed to be of importance for a group to undertake collective action is whether any member of the group assumes an entrepreneurial role (Olson 1965). A member can serve as a catalyst for collective action by investing notable amounts of resources in an attempt to coordinate the other members' strategies. Among the subgroups of fishers that have devised rules, and for which there is information, fifteen, or 58%, included a member who undertook entrepreneurial activity in order to coordinate the other members' strategies. Eleven, or 42%, of the organized subgroups did not include an entrepreneur. Among the subgroups who have not defined rules, no entrepreneurs emerged to undertake attempts at coordinating strategies.[12]

A variety of environmental factors help or hinder fishers attempts at organizing their harvesting activities. Simply being confronted with a problematic situation does not mean that fishers will always address it. The broader physical, institutional, and cultural environment within which fishers operate effect their ability to engage in collective action. Among the forty-four subgroups under consideration, clear differences exist among the environments in which they operate that have supported some and hindered others in attempting to engage in collective action to address problematic situations. Groups that are organized fish from relatively smaller fishing grounds, operate within a stable economic environment, are highly dependent upon fishing for their income, and do not face as great a temptation to harvest the stocks of fish rapidly. In addition, more than half of the groups that have organized possessed at least one entrepreneurial member who was willing to invest in institutional change, whereas of the members of the subgroups who have not organized none were entrepreneurs. Thus, not only must fishers face problematic situations that they can address, but they must also operate in a somewhat supportive environment in order to begin to engage in collective action.

institutional Arrangements Devised By Fishers

Fishers face potentially problematic situations such as stock externalities, assignment problems, and technological externalities. In response, some groups of fishers have devised institutional arrangements to constrain their harvesting behavior, especially in response to assignment problems and technological externalities, as opposed to stock externalities. Another means of exploring the types of problematic situations that fishers have addressed, is to examine how the institutional arrangements fishers have devised are constituted, with the presumption being that the arrangements will differ depending upon the problem to ^be solved. If fishers are attempting to ameliorate stock

externalities they may devise quota systems, or some form of limited access licensing, as is advocated by policymakers who rely upon the bionomic model. On the other hand, if fishers are attempting to reduce technological externalities they may utilize rules that forbid certain types of technology, or they may separate different technologies by assigning them to separate parts of the fishing grounds.

Table 4.5 provides a frequency count of the authority and scope rules that fishers of the forty-four subgroups utilize in harvesting fish. There are eight different types of rules that are in use in the particular cases included in this study. Subgroups may utilize more than a single type of rule. The first type of rule is one that limits harvesting activities to specific locations or spots. This rule forbids fishers from harvesting anywhere they might choose in the fishing grounds. Rather, they must harvest from particular locations or spots. Access to these spots is dependent on meeting any one of a variety of requirements. A fisher might be required to harvest from a particular location because of the gear used (Davis 1975). Or a fisher may gain access to a choice fishing spot through a lottery (Faris 1972). By entering a lottery that distributes spots, a fisher may gain access to, and be required to fish from a particular spot. Rules that limit harvesting activities to specific locations or spots are the most commonly used among the forty-four subgroups. Thirty-one, or 70%, of the subgroups utilize a location or spot rule that determines how choice spots are distributed, and also that separates gear on the grounds.

The second type of rule is "withdraw fish of at least a specific size". This scope rule requires that fishers harvest fish that are greater than a certain size. The rule is typically used to ensure that fish achieve maturity and have a chance to spawn before being harvested. This rule is the second most common rule. Nine, or 20%, of the forty-four subgroups utilize such a rule. In all instances except for one, an external authority, not the fishers, has defined the rule.[13]

The next most often used rules involve seasonal restrictions and "taking turns". Seasonal restrictions forbid the harvesting of fish during specific times of the year, typically when fish spawn. Harvesting in a fixed order defines how choice spots on the grounds can be accessed and harvested from. Often times the rule requires that fishers take turns in accessing particular spots. In the case of seasonal restrictions, all but one of the rules was devised by a government authority. All of the order rules were devised by fishers. Seven, or 16%, of the subgroups use each of these rules.

Rules that have not been defined by the fishers among the forty-four subgroups are quota rules. In no instance has a subgroup defined a specified amount of fish that each

fisher can harvest. There has been no attempt specifically to regulate the flow of fish, and the amount that can be withdrawn from that flow. Combining a lack of quota rules with a predominance of spot or location rules reveals that fishers are attempting to govern the use of the space of their fishing grounds as opposed to managing the flow of fish through the grounds. The rules that fishers have defined are of the type that could resolve assignment problems and technological externalities that arise as numerous fishers utilize the same grounds,

An examination of required boundary rules also reveals attempts on the part of fishers to limit the number of fishers who can access fishing grounds and the types of technology that can be utilized (see Table 4.6). Seventeen different types of boundary rules are utilized among the forty-four subgroups. The most common types of rules used are residency rules that require fishers to reside in a particular village or region of a country to gain access to particular grounds. Residency rules do have the effect of limiting those who use the fishing grounds to those who have a higher chance of having a low discount rate. Those living nearby are more likely to want to use the resource over a long period of time and to ensure that their children and grandchildren can also use the fishing grounds,

The second most common type of boundary rule used is gender. Thirty-two of the subgroups require that fishers be male to have access to the fishing grounds. After residency requirements and gender, twenty-seven subgroups limit access to their fishing grounds on the basis of the type of technology used. Among 61% of the subgroups, only fishers who utilize particular types of technology are permitted entry into the grounds. Boundary rules based on gear assist in alleviating technological externalities. By limiting the types of gear that can be brought into the grounds, and then through authority rules specifying where in the grounds types of gear can be utilized, interference among gears is minimized. Thus, the types of authority, scope, and boundary rules that the fishers of the forty-four subgroups most often utilize reveal an attempt to resolve problems of assignment and technological externalities, as opposed to stock externalities. Fishers are trying to govern how the space that constitutes'their fishing ground is utilized to minimize conflict over choice spots and types of gear used.

Conclusion

As fishers engage in harvesting several problematic situations may arise. In drawing down the pool of fish fishers increase the costs of harvesting the remaining fish creating stock externalities. In addition, given the uneven distribution of fish across fishing grounds some spots on the grounds are more productive than others. A limited number of choice spots requires some sort of assignment procedure to be developed if conflict over who can access

the spots is to be avoided; Finally, the use of multiple types of gears within the finite space of fishing grounds produces the possibility of technological externalities arising unless gear types can be separated.

Only the latter two problems are ones fishers have the greatest capability of addressing. These problems are noticeable and measurable, and they are relatively bounded. They typically occur within a given fishing ground and do not extend over numerous grounds and communities of fishers. Consequently, fishers can conceptualize and design rules that would prevent such problems from continuing. Fishers are more likely to cooperate to organize their harvesting activities to address assignment problems and technological externalities than they are to organize in relation to stock externalities. Among the forty-four subgroups of fishers examined, this expectation held. Fishers in the subgroups that defined institutional arrangements did so in the face of assignment problems and technological externalities as opposed to stock externalities. Fishers cooperate to solve problems that they have some possibility of addressing.

Simply because fishers face problematic situations that they can potentially address, does not mean they will always collectively act to do so. The physical, institutional, and cultural environments in which they act affect their potential for engaging in collective action. Subgroups that harvest from relatively smaller fishing grounds, that operate in stable economic environments, that are more heavily dependent upon fishing from their grounds for income, that do not face incentives to harvest rapidly, and that contain entrepreneurs willing to invest their own resources in encouraging collective action, are the subgroups, who in the face of problematic situations, designed institutional arrangements to address those problems. Finally, the institutional arrangements that fishers devised focused upon resolving assignment problems and technological externalities. These subgroups adopted or evolved rules that governed how the space within the grounds was to be utilized as opposed to managing the level of the flow of fish within the grounds, as has been advocated as a solution to stock externalities (Anderson 1986).

In the next chapter I will examine the performance of the institutional arrangements that fishers have devised, in addition to exploring the role monitoring plays in maintaining these institutional arrangements.

TABLE 4.1. SCARCITY OF FLOW OF FISH BY ORGANIZED HARVESTING

	Flow of Fish Scarce	Flow of Fish Abundant	Total
Harvesting of Fish Organized	67% (6)	83% (20)	(26)
Harvesting of Fish Not Organized	33% (3)	17% (4)	(7)
Total	100% (9)	100% (24)	(33)

Gamma= -.43
Missing Cases: 11

TABLE 4.2. ASSIGNMENT PROBLEMS BY ORGANIZED HARVESTING

	Assignment Problems	No Assignment Problems	Total
Harvesting of Fish Organized	84% (16)	70% (7)	(23)
Harvesting of Fish Not Organized	16% (3)	30% (3)	(6)
Total	100% (19)	100% (10)	(29)

Gamma=.39
Missing Cases:15

TABLE 4.3. TECHNOLOGICAL EXTERNALITIES BY ORGANIZED HARVESTING

	Technological Externalities	No Technological Externalities	Total
Harvesting of Fish Organized	76% (13)	57% (4)	(17)
Harvesting of Fish Not Organized	24% (4)	43% (3)	(7)
Total	100% (17)	100% (7)	(24)

Gamma=.42
Missing Cases:20

TABLE 4.4. EITHER ASSIGNMENT PROBLEMS TECHNOLOGICAL EXTERNALITIES OR BOTH BY ORGANIZED HARVESTING

	Either Assignment Problems Technological Externalities Or Both	Neither Assignment Problems Nor Technological Externalities	Total
Harvesting of Fish Organized	86% (24)	67% (6)	(30)
Harvesting of Fish Not Organized	14% (4)	33% (3)	(7)
Total	100% (28)	100% (9)	(37)

Gamma=.50
Missing Cases: 7

TABLE 4.5. REQUIRED AUTHORITY/SCOPE RULES

Types of Rules	Frequency of Rule Type	Percent Of Rules	Number of Subgroups Using Rule	Percentage of Subgroups Using Rule
withdraw at specific locations/spots	31	53%	31	70%
withdraw fish of at least a specific size	9	16%	9	20%
withdraw only during specific seasons	7	12%	7	16%
withdraw in a fixed order	7	12%	7	16%
withdraw at a fixed time slot	2	3%	2	5%
withdraw whenever and wherever desired	2	3%	2	5%
withdraw up to a fixed percentage of fish	0	0%	0	0%
withdraw up to a fixed number of fish	0	0%	0	0%
TOTAL	58	100%		

TABLE 4.6. REQUIRED BOUNDARY RULES

Types of Rules	Frequency of Rule Type	Percent of Rules	Number of Subgroups Using Rule	Percentage of Subgroups Using Rule
residence in a village	34	16%	34	77%
residence in a region of country	31	15%	31	70%
residence in a country	19	9%	19	43%
gender	32	15%	32	73%
use of a particular technology	27	13%	27	61%
membership in an organization	15	7%	15	34%
obtaining a license for entry or for required equipment	8	4%	8	18%
ownership or leasing of land in the area	7	3%	7	16%
ownership of some form of limited property related to harvesting from this resource	7	3%	7	16%
membership in an ethnic group	7	3%	7	16%
race	6	3%	6	14%
registration on an eligibility list	5	2%	5	11%
obtaining of access rights through a lottery	5	2%	5	11%
continuing usage of entry rights	3	1%	3	7%
membership in a caste	2	1%	2	5%
demonstration of skills	2	1%	2	5%
the purpose for which the withdrawn units will be devoted	1	0%	1	2%
TOTAL	211	100%		

1. The pseudonyms that Davis uses for the villages are Pagesville, Brazil, East Brazil, and West Brazil.

2. The advantage of focusing on institutional arrangements as opposed to types of organizations, is that the names of organizational types, ie., unions, coops, and corporations, do not speak to the types of operating rules each uses. Thus, a coop and a corporation may use very similar rules in specifying harvesting activities, whereas two different coops may use very different harvesting rules.

3. In the case of boundary rules, the rule in addition to residency could not be gender, since virtually every subgroup required that the fishers be male. In the case of authority and scope rules, rules devised by external authorities, which were size and season rules, were not taken into account. Only rules fishers themselves devised were considered.

4. A serious problem in measuring stock effects is whether the reduction in the amount of fish harvested is due to environmental effects or the harvesting engaged in by fishers.

5. The question concerning the abundance of flow is from the operation level form and is worded as follows:

> For biological resources at the beginning and end of this period, the balance between the quantity of units withdrawn and the number of units available is: 1) extreme shortage, 2) moderate shortage, 3) apparently balanced, 4) moderately abundant, 5) quite abundant.

I utilized the data from the beginning of the time period. Also I collapsed the above five categories so that 1), 2), and 3) signified not abundant, and 4) and 5) signified abundant.

6. The Alanya fishers experienced technological externalities as well as assignment problems (Berkes 1986:16-17).

7. The question concerning conflict over spots is from the resource form and is worded as follows:

> If there are distinct and stable microenvironmental or ecological zones within the resource, and if the quality and/or quantity of units has been regularly better in some of the zones than in others, at some point in time has this condition created conflict among fishers? 1) yes, 2) no.

8. The question about interference among different types of gear appears on the resource form and is worded as follows:

> If multiple appropriation processes are used within this resource, characterize the relationship among these processes if no rules in use were being followed: 1) little adverse effects, 2) complementary effects, 3) conflictual effects.

I combined the values of the question so that 1) and 2) signified no conflict and 3) signified conflict.

9. The t score for a difference of means test is 3.7, which is significant at the .01 level. The null hypothesis that the two means are not significantly different can be rejected.

10. The question relating to boundaries is located on the resource form and is worded as follows:

> The boundary is primarily a result of: 1) natural/constructed attributes which limit entry, 2) natural/constructed attributes which do not limit entry, 3) institutional arrangements, 4) Natural/constructed and institutional arrangements which limit entry, 5) natural/constructed and institutional arrangements which do not limit entry

Institutional barriers, in this case, refer to the existence of a town or village that may rest along the border of a resource and whose own boundaries may limit entry.

11. In one instance a subgroup operates outside of established economic networks.

12. The question concerning entrepreneurs is located on the subgroup form and is as follows:

> Has any member of this group assumed entrepreneurial activity in trying to achieve coordinated strategies: 1) no, 2) yes, in relationship to withdrawal of appropriation units, 3) yes, in relationship to investment or maintenance, 4) yes, in relationship to both withdrawal and investment, 5) other

13. That exception is the Cree Indians in northern Canada as reported by Berkes (1977, 1987).

CHAPTER FIVE

PERFORMANCE OF INSTITUTIONAL ARRANGEMENTS FOR THE GOVERNANCE OF COASTAL FISHERIES

In Chapter Four evidence from thirty case studies of coastal fisheries suggests that fishers devise rules to attempt to solve some types of dilemmas, but not others. Specifically, inshore fishers appear to address dilemmas such as assignment problems and technological externalities that involve governing how the space within the fishing grounds may be utilized in order to avoid conflict. Fishers rely primarily upon boundary rules that require residency in particular localities, usually those towns and villages nearest the fishing grounds, in addition to technology rules that limit the types of gear that can be utilized on fishing grounds. Fishers also rely upon particular types of authority and scope rules to coordinate their actions while they fish. They often use a location rule to allocate choice spots and to establish secure tenure in a spot for a given period of time.

Even though fishers have devised institutional arrangements in order to resolve dilemmas that they confront, attention needs to be paid to the performance of these institutions. No presumption can be made that the property rights and rules that govern fishers' activities do so in ways that resolve the problems that they once faced. How the arrangements are structured is as important as whether they exist at all. In Chapter Three, based on a review of property rights literature, I established several expectations concerning the performance of different systems of property rights and rules. Fishers who hold bundles of rights that include the right of exclusion, are expected to achieve better outcomes than fishers who possess bundles of rights that do not include the right of exclusion.

More than particular bundles of property rights, however, are required for resolving common pool resource dilemmas. Coastal fisheries are jointly utilized by numerous fishers. In order to coordinate their strategies rules must be specified that define how fishers can exercise their property rights. Without rules that coordinate their behavior fishers may create dilemma situations. It is property rights and rules together that affect the outcomes that fishers achieve. - Thus, institutional arrangements that consist of rights of access, withdrawal, management, and exclusion, combined with rules that define how these rights are to be exercised are expected to perform better than institutional arrangements that do not include the right of exclusion or that do not entail rules for governing behavior.

Finally, these institutional arrangements must be monitored and enforced. Without monitoring and enforcement, institutional arrangements cannot be maintained. If fishers face incentives to break the rules, they are much more

likely to do so if they do not believe they will be observed and sanctioned. Without monitoring and enforcement, property rights and rules become mere suggestions for how fishers ought to behave and not prescriptions for how they must, may, or must not act. In this chapter, I evaluate the performance of institutional arrangements that fishers have devised to organize the use of their fishing grounds.

Property Rights and Rules

Property rights, as grants of authority to take decisions in relation to others regarding the use of some thing, structure the choices made by individuals. Individuals, or groups, possessing different bundles of rights face different incentives, and often times make choices to take alternative types of actions, achieving different outcomes. In other words, "differences in the structures of rights to use resources affect behavior systematically and predictably[11] (de Alessi 1980:42).

Among the forty-four subgroups of fishers, the sets of property rights each possesses varies. One subgroup possesses all five rights, those of access, withdrawal, management, exclusion, and transfer. The fishers of this subgroup reside at Punta Allen in Quintana Roo State in Mexico and harvest lobster from Ascension Bay (Miller 1982, 1989). The fishers belong to the Vigia Chico Co-op to which the Mexican government has granted the rights of access, withdrawal, management, and exclusion. The fishers divided the Bay into individual fishing zones.

> These divisions were typically arrived at informally, with boundaries being established as fishermen were stopped from expanding in a given direction by the presence of another fisherman's gear or boundary marker (Miller 1989:190).

Fishers place artificial habitats or shelters in their zones, which attract lobsters. These shelters are spaced 20 to 30 meters apart. By common agreement they are not placed within 25 meters of the boundary of any fisher's zone in order to minimize conflict over the boundaries of the zones (Miller 1989:191).

Fishers have exclusive rights to harvest lobsters in their individual zones, however, others have the right to **engage** in line fishing for other species across the zones. To **engage** in gillnetting, which holds the potential of harvesting some lobste'rs, permission must be granted from the owner of the zone. These individual zones are "sold, bartered, and traded among co-op members" (Ibid:192). Only a **few sales** are registered with the co-op. In a single instance a sale has been registered in court. The right of transfer is limited in this case. Fishers are able to transfer their rights to their lobster zones only to other co-op members.

Twenty-four of the subgroups possess four rights, those of access, withdrawal, management, and exclusion. These groups have not been granted the right of transfer, nor have

they developed it among themselves as have the fishers from Mexico. Another ten subgroups possess three property rights. Nine of these subgroups possess the rights of access, withdrawal, and management, whereas one possesses the rights of access, withdrawal, and exclusion. Finally, the remaining nine subgroups possess only two rights, those of access and withdrawal. They do not possess the right to decide how the resource should be utilized, to exclude others from the resource, or to transfer their rights in their fishing grounds. They simply possess the rights to access their fishing grounds and harvest fish.

Table 5.1 displays the bundles of property rights each subgroup possesses to ascertain if the rights are part of a single dimension. These bundles of property rights scale, almost perfectly; the scale of reproducability is .99. The only exception is the subgroup that possesses the rights of access, withdrawal, and exclusion, without a right of management. What the scale means is that if a subgroup possesses the right of transfer, it also possesses the other four rights. If a subgroup possesses the right of exclusion it also possesses the prior three rights of management, withdrawal, and access. It is meaningful then to state that a subgroup of fishers possesses three property rights and those three rights are specifically access, withdrawal, and management; or, a subgroup of fishers may possess four rights and those are the above three rights plus the right of exclusion.

Each individual property right builds upon the one prior to it to produce a complete set of property rights. The right of withdrawal permits additional actions to be taken in light of the right of access. The right of withdrawal, in fact, is meaningless, without the prior right of access. The same logic holds for the other rights as well. The rights of exclusion—the authority to decide who can enter the resource—is meaningful in light of the rights of access, withdrawal, and management. Without the other rights, exercising the right of exclusion becomes useless. Each additional property right builds on the authority of the previous rights and extends that authority to take decisions about the resource somewhat further, until given all five rights, the individual or group possesses extensive authority in relation to the resource.[1]

As discussed in Chapter Three, some natural resources are not suited for individual private property rights systems (Netting 1976). They gain value when they are utilized collectively by numerous individuals, instead of being divided into individual plots. This holds true for fishing grounds. Given the extent of ocean necessary to encompass a productive fishing area, and the uneven distribution of fish across the grounds, being able to utilize all of the microenvironments of the grounds, instead

of being confined to a single individual plot of ocean, that may or may not be productive, is of more value to fishers. Consequently, fishers often collectively hold property rights in relation to fisheries. Collective ownership of rights in relation to coastal fisheries, makes how those rights are to be exercised important. How fishers within a group can exercise their rights in relation to each other and in relation to nongroup members is defined through rules. Without rule definition, even given a more complete set of property rights, the group of fishers can still utilize the resource inefficiently, and even possibly destroy it if they do not organize their harvesting activities.

Rule definition, however, is more likely to take place as fishers possess more complete sets of rights in their fishing grounds. More complete sets of rights grant fishers greater authority to make decisions concerning the use of the grounds, and limit their exposure to the actions of others. They are more likely to capture the benefits of investments they make in rules to order their harvesting activities. Among the forty-four subgroups of fishers this expectation in relation to authority and scope rules holds (See Table 5.2). Groups that possess three or more property rights are much more likely to devise rules concerning how fish are to be harvested than groups possessing fewer than three rights. Ninety percent of the groups holding three rights devised authority rules, and 88% of the subgroups holding more than three rights devised authority rules.[2] Property rights and rules are clearly associated.

Strong expectations exist in the property rights literature concerning the outcomes that various property rights systems produce, as discussed in Chapter Three. Among those scholars who have focused upon common pool resources, the expectation is that for collectively utilized resources, the group of users must possess the right of exclusion, and they must have devised rules that specify actions they can take in harvesting from the resource (Dahlman 1980, Bromley 1986, Runge 1986). The group must be able to exclude nongroup members from accessing the resource and expropriating benefits that group members are producing for themselves. But, as Dahlman argues, the right of exclusion is only a necessary, but not a sufficient, condition for the efficient use of a resource (Dahlman 1980:202). The resource users must also define how each can utilize the resource. Rules must define what harvesting actions can be taken or not taken to avoid the wasteful use and possible destruction of the resource.

In the following analysis of the performance of institutional arrangements that fishers of the forty-four subgroups utilize, comparisons will be made between institutional arrangements that involve the right of exclusion, that is, four property rights and rules

associated with those rights, and institutional arrangements that do not involve the right of exclusion. These latter arrangements I have further subdivided into two types, one includes the right of management, or three property rights, and the rules associated with those rights; and the other includes everything else, which involves arrangements constituted of two property rights with and without rules, and arrangements involving three or more rights but no associated rules.

Performance of Institutional Arrangements

In examining the outcomes produced by the institutional arrangements that fishers have devised to structure the harvesting of fish, I use four measures of performance. Two of the measures focus upon characteristics of the flow of fish; one of the measures examines the extent of technological externalities; and the final measure examines the existence of assignment problems.

Resource Characteristics

The first measure of the characteristics of the flow of fish that I will examine is the balance between the quantity of fish withdrawn and the amount of fish generally made available by the resource. This is a measure of the abundance of fish within the fishing ground. It is an identical measure to the one used in the previous chapter in exploring stock externalities, except in this case the measure was taken at the very end of the time period reported by the author. While this measure is relatively crude in that the values of the variable are imprecise ranging from extreme shortage to quite abundant, it was difficult to obtain any more precise data. Authors did not report the productive capabilities of the fishing grounds, since this information is typically not known. They would often report, however, whether the stocks of fish appeared to be abundant or not.

The underlying presumption of the bionomic model is that the volume of the flow of fish can be controlled through the amount of effort exerted. The abundance or scarcity of the stocks of fish can be regulated by the levels of effort applied. Regulating the amount of effort exerted, it is argued, minimizes the level of stock externalities in addition to lessening the possibility of drawing down the stock to dangerously low levels (Wilson 1982, Anderson 1986). Since most institutional arrangements provide some check on the amount of effort that fishers can apply, for instance, through rules that limit permissible types of technology, groups of fishers that have organized and limited their harvesting activities supposedly will experience a greater abundance of fish.

This argument, however, presupposes that fish populations are little affected by environmental factors, such as water temperature, water pollution, the availability of food, and the existence of predators, it also

presupposes that only a single group of fishers harvest from the stock, so that by regulating their own effort, they can regulate the volume of the flow of fish. As discussed in Chapter Two, however, many fisheries biologists argue that fish populations are affected by their environment, and that the size of the populations fluctuate depending on environmental conditions, water temperature, the supply of food, etc. For instance, Sutherland, in her case study of lobster fishers located at Caye Caulker, Belize, describes a year in which lobsters were quite abundant due to unusual environmental conditions. In 1982 record levels of lobster were harvested.

> The dramatic increase in production was due primarily to the 'Red Tide', which affected the coastal waters of Belize during August and September in 1980. This natural phenomenon is a result of a dense concentration of small plantlike organisms that create patches of toxic discolored water when they start to multiply in large numbers. While the toxin does not directly affect the lobster, it killed off many of the fish that feed on young lobster. Consequently, the lobster population exploded (Sutherland 1986:36).

In addition, given the migratory nature of most fish stocks many groups of fishers harvest from a single stock. Even if a single group limited the amount of effort they exerted, this may have no effect on the amount of fish available for harvest. In this alternative view, given the fluctuating nature of most fish stocks, and the existence of many groups of fishers harvesting from the same stocks, fishers have little control over the volume of the flow of fish. Whether they have organized their harvesting activities will have little effect on the quantity of fish available for harvesting.

In Table 5.3 institutional arrangements are arrayed by the scarcity of the flow of fish. This measure of the flow of fish is at the end of the time period discussed by the author of the case study. If the author mentioned that the amount or flow of fish was less abundant than at earlier times, or that fishers were experiencing shortages of fish, then the flow of fish was coded as being either in moderate or extreme shortage.[3] For instance, Shortall presents a case study of fishers who reside in Petty Harbour, Newfoundland, and who harvest cod using traps and handlines. The quantity of cod has steadily declined over time. As Shortall states:

> Since this earlier period, the main migration has been observed by the fishermen to enter the Petty Harbour area before mid-June and to consist of smaller fish schools and of fish of reduced average size...The smaller size of the fish schools and the reduced average size of the fish, however, are attributed to the growth of the offshore fishing fleets and to the introduction of gillnets in the inshore fishery elsewhere (Shortall 1973:92).

Thus, the cod fishers of Petty Harbour are experiencing a moderate shortage in the quantity of fish available for harvest.

In considering Table 5.3 no association exists between institutional arrangements and the level of the flow of fish. Most subgroups, twenty-six, experience shortages in

the quantity of fish available for harvest, regardless of the institutional arrangements they have designed. Among the twenty-two subgroups who possess four or more property rights and who have designed rules to exercise those rights, 41% face an abundant flow of fish. Among the subgroups who possess fewer than three rights or who have not designed rules, 38% face an abundant flow of fish. Clearly fishers have little control over the volume of the flow of fish through their grounds, whether or not they have organized their harvesting. Ensuring the maintenance of stocks over time is beyond the control of any single subgroup of fishers. Rather this is a problem that must be addressed by numerous groups of fishers.

Another outcome measure related to the flow of fish concerns the quality of the flow. The quality of the flow of fish is a proxy measure for the value of the fish. The value of fish is highly associated with size. Mature fish are often more highly valued than fish fry, or adolescent fish. Mature fish are most times sold for human consumption, which is more highly valued than fish fry, which are often times rendered into less valued animal feed or fertilizer.

Fishers can potentially exercise greater control over the quality of the fish they harvest than over the quantity of fish, although this control is limited for some of the same reasons that control over the quantity of fish passing through the grounds is limited. Institutional arrangements that define the types of actions that may be taken in harvesting fish limit, to a certain extent, the highly competitive behavior among fishers to capture as many fish as is possible, including immature fish. Institutional arrangements, reflect and in turn impose a longer time horizon on fishers, providing them with incentives to harvest more highly valued fish. In addition, rules may have consequences that potentially affect several variables. Rules that limit the types of technology that can be utilized may prevent fishers from taking lower quality fish, even though the rule was adopted to alleviate or prevent technological externalities. Thus, it is reasonable to suppose that groups of fishers who have designed institutional arrangements to govern their harvesting activities are more likely to harvest higher quality fish.

Fishers do not exercise complete control over the quality of fish that are available for harvest, however, since numerous fishers harvest the same stocks of fish. The quality of the fish harvested is effected by the harvesting techniques of other fishers withdrawing from the same stocks. Fishers who harvest from the same stocks prior, to another group of fishers may utilize techniques such as fine mesh nets that capture virtually every size of fish from the very small to the very large. The group of fishers who harvest later face little choice in the type of fish to

harvest from that stock, since most fish that remain are of a smaller size.

Table 5.4 arrays institutional arrangements by quality of the fish harvested. This measure of the quality of fish is at the end of the time period discussed by the author of the case study.[4] An example of a discussion of the quality of fish harvested appears in a case study of Chinese fishers who live in Kampong Hee, Malaysia (Anderson and Anderson 1977). The Chinese fishers harvest a variety of stocks of fish using small trawlers. They began fishing in 1962. The Andersons report the quality of fish in 1976, fourteen years later:

> The value of landings has dropped, because a higher and higher percentage of the landings is made up of tiny fish and miscellaneous sea life valued only for making fish-meal fertilizer...The more valuable fish make up a lower and lower percentage (Anderson and Anderson 1977:191).

In this case the quality of fish is declining, and has become quite low.

The association between institutional arrangements and the quality of fish harvested is moderate. Of the nineteen subgroups that have four or more property rights and rules, 68% harvest high quality fish, whereas among the remaining subgroups less than half harvest high quality fish. For instance, among the nine subgroups who hold three property rights and rules, only 44% harvest high quality fish. Institutional arrangements do make a difference in the quality of fish fishers are likely to harvest.

Assignment Problems

As argued in Chapter Two, and analyzed in Chapter Four, fishers as fallible learners acting in an uncertain environment are more likely to engage in institutional design to address problems that they have some control over and are capable of resolving. Common problems that fishers face in harvesting fish are assignment problems and technological externalities, both of which fishers, within their own community, can potentially address.[5] The question then becomes whether the institutional arrangements devised by the fishers who experienced assignment problems have successfully resolved those problems.

In Table 5.5 institutional arrangements are arrayed by the existence of assignment problems.[6] The measurement of the existence of assignment problems is the case studies authors' evaluation of whether the problem has been resolved. For instance, prior to 1919, along the eastern coast of the Avalon Peninsula of Newfoundland, most cod trap berths were acquired on a first-come first-served basis (Martin 1973, 1979). This resulted in lost gear and conflicts over spots. Fishers would set their traps earlier in the year so as to gain the best spots first, exposing the traps to winter storms which would destroy the traps. In addition, if a fisher had to haul his trap for any reason, the spot would often be taken by another fisher before the original fisher could replace his trap, leading to conflict

over the spot. Several groups of fishers experimented with a lottery system as a means of distributing cod trap berths to fishers for entire seasons. In this way fishers would not race to obtain the best spots nor need they fear losing their spot in the middle of the season.

Groups of fishers petitioned the Newfoundland government to formally recognize these lottery systems and to have fishery officers enforce compliance. This gave the fishers access to formal adjudication procedures and control over their own local spots, preventing other fishers from intruding. In 1919, the Newfoundland government passed legislation allowing groups of fishers to establish cod trap committees that would oversee the operation of cod trap berth lotteries, and that would control who would have access to the spots (Martin 1973:14). Many communities of fishers took advantage of the enabling legislation and formed cod trap committees. This form of organization has generally been viewed as successful in resolving the problems associated with assigning cod trap berths (Martin 1973, Faris 1972, Shortall 1973, Powers 1984).

As Table 5.5 illustrates, fishers have been very successful in addressing and resolving assignment problems through the development of institutional arrangements. Of the nineteen subgroups of fishers who at some point in time faced assignment problems, thirteen of the groups have resolved them. The successful resolution of assignment problems is particularly high among subgroups of fishers that hold four property rights and have devised rules. Of those eleven subgroups, ten, or 91%, have minimized assignment problems. Among the five subgroups of fishers who hold three property rights and have devised rules, 60% no longer face problems of assignment. Among the subgroups that have not devised institutional arrangements, none have resolved their assignment problems.

Technological Externalities

The finding that institutional arrangements make a difference in resolving assignment problems also holds for the resolution of technological externalities. The measure of technological externalities is taken at the end of the time period described by the case study author.[7] An example of a resolved technological externality problem is reported by Raychaudhuri in his' case study of migrant fishers who for part of each year establish fishing camps on the island of Jambudwip in the Bay of Bengal off of the coast of India (Raychaudhuri 1980). These fishers use bag nets suspended between two posts in harvesting a variety of types of fish. The mouth of the net faces into the current sweeping fish into the net. Over time fishers have established distance rules between nets to prevent interference occurring among nets. If nets are set too close together one net will intercept most of the fish, interfering with the operation of the second net, producing conflict among the fishers

(Ibid:101). By using distance rules that prevent them from setting their nets within a certain distance of each other fishers have resolved their technological externalities.

Table 5.6 arrays institutional arrangements by the level of technological externalities. Of the forty-four subgroups, twenty-one have experienced technological externalities. Fishers who have devised more complete sets of institutional arrangements are much more likely to have resolved technological externality problems. Of the ten subgroups holding four or more property rights and rules, 80% no longer experience problems with technological externalities. The outcomes for groups of fishers who hold three property rights and who have organized their harvesting is quite different. Of the five subgroups 20%, or one, has resolved its technological externalities problems, while four, or 80%, have not. And, not surprisingly, of the six subgroups who have not organized their harvesting activities, none have resolved their problems of technological externalities. Clearly, the types of institutional arrangements fishers have devised affect whether they are able to solve technological externalities. Fishers who hold four property rights and who have devised rules are much more likely to have successfully addressed technological externalities.

The Right of Exclusion

Of the thirty-one subgroups who have confronted problems of assignment, technological externalities, or both, holding the right of exclusion made a significant difference in their ability to resolve these problems. Those who held the right of exclusion almost always successfully addressed their problems. Having the authority to decide who can and cannot enter their grounds has a powerful impact upon the functioning of the institutional arrangements fishers have devised.

This finding raises the question of the origin of the right of exclusion. Did governing authorities grant these subgroups the formal right of exclusion? Or, did the fishers themselves carve out a right of exclusion amongst themselves as against other fishers, without formal recognition by external governing authorities? That is, do the groups of fishers who possess rights of exclusion possess de jure rights or de facto rights? De jure rights of exclusion are rights that have been granted to fishers by a formal governing authority. De facto rights of exclusion are rights that communities of fishers have developed among themselves without recognition by a formal governing authority.

> A right holder who has de jure rights can presume that, if these rights were challenged in an administrative or judicial setting, the rights would most likely be sustained. Users of a resource who have developed de facto rights act as if they have de jure rights among themselves and they may enforce these rights on one another...Whether or not these de facto rights will be sustained in a court of law is uncertain. So long as no one challenges the rights exercised

> as a result of locally developed rules, the property rights regimes are as stable and predictable as de jure property rights regimes (Schlager and Ostrom 1987:17).

Among the thirty-one subgroups who have experienced assignment problems, technological externalities, or both, twenty-three have the right of exclusion. Of those twenty-three only five possess a full de jure right of exclusion. Eighteen subgroups have devised de facto rights of exclusion by creating highly restrictive rules. For instance, as discussed earlier in this chapter, the cod fishers of the Avalon Peninsula in Newfoundland were granted de jure rights of exclusion over just their cod trap berths from the beginning of the cod season each year in Hay until July 1, when fishers from other communities could utilize any unused spots. The cod fishers were not, however, granted rights of exclusion in relation to any other part of their grounds. Yet, they parlayed the partial de jure rights of exclusion into de facto rights of exclusion over their entire range of grounds by devising restrictive rules of harvest. As Martin states:

> 'Outsiders' are not and cannot be legally excluded but they are forced to observe local fishery regulations (Martin 1979:285).

These local regulations ban particular types of technologies from being used on the fishing grounds, technologies that surrounding communities of fishers utilize extensively. Shortall (1973) and Davis (1975) report the same type of activity occurring among the fishers of Petty Harbour and Port Laneron/Pagesville respectively.

Fishers in Alanya, Turkey have also gained the de facto right of exclusion over their grounds by establishing a complete set of rules for organizing harvesting (Berkes 1985, 1986). The fishers of Alanya utilize similar technologies such as small inboard motor boats and nets with large mesh sizes to harvest bonito and large carangids off of the coast of Alanya in the Mediterranean. As is typical of most fishing grounds, the Alanya ground is not uniformly productive. In fact, only a limited number of spots are sufficiently productive to make fishing worthwhile. Approximately 25 years ago demand for productive spots was greater than the supply, resulting in intense competition and conflict among fishermen for existing spots. Over a period of 15 years the fishers devised a system of utilizing the fishing ground. Each September all licensed fishers endorse a list of fishing spots which are spaced so that the fishers cannot interfere with each other. In addition, the fishers agree upon the size of nets to be used. A lottery is held with each boat being assigned a spot. Each day the fishers move to an adjacent spot so that each rotates through the entire series of productive areas. In order to participate and to be successful within the Alanya grounds fishers must know and abide by these rules. Fishers of

Alanya understand that their harvesting rules effectively exclude others as Berkes reports:

> A fisherman who wants to participate in the system has to know the rules of the game and the named fishing spots. (As one fisherman put it, "Suppose some guest worker comes from Germany in his Mercedes car and wants to fish, do you think we would allow him? No way.")(Berkes 1985:78)

In relation to the right of exclusion, fishers have, through the creation of harvesting rules, effectively excluded others from gaining access to their grounds.

There are groups of fishers, however, who possess neither a de lure nor de facto right of exclusion, yet who have devised rules to govern their harvesting activities, and have successfully addressed assignment problems and technological externality problems. Three subgroups of fishers who each collectively possess the rights of access, withdrawal, and management, and have devised rules to govern their harvesting activities, successfully addressed assignment problems and technological externalities. All three share a common attribute and that is they harvest from marginal grounds in which no other groups of fishers expressed interest. One instance involves the original subgroup of fishers who harvested from the coastal estuaries near Valenca, Brazil as discussed in Chapter Three (Cordell 1972). The other two subgroups are the migrant fishers who established fishing camps on Jambudwip Island and harvested fish just off the island in the Bay of Bengal, off of the coast of India, as discussed earlier. Both the Brazilian fishers and the Indian fishers, while having successfully organized their harvesting activities, are vulnerable to other groups of fishers invading their grounds and destroying their institutional arrangements, as happened in the case of the Brazilian fishers. Thus, under particular sets of circumstances involving "societal neglect" or, perhaps, physical isolation, fishers are capable of designing institutional arrangements to resolve problematic situations, even if they do not hold de facto rights of exclusion.

On the other hand, some subgroups who do hold the rights of exclusion, and who have devised rules to organize their harvesting, have not fully resolved problematic situations they have encountered. There are three such subgroups of fishers who continue to experience problems. One of the subgroups harvest lobsters off of Mount Pleasant Island, Maine (Grossinger 1975). Lobstermen in Maine have demarcated the boundaries of their grounds based on residency. The lobstermen of each community harvest from grounds surrounding their harbor, and they defend these grounds against intrusions from fishers of other harbors. Over the past several decades as fishers have increased their mobility through a series of technological innovations, they have expanded their territories so that now their grounds increasingly overlap each other, yet they continue to exclude others from the core of their grounds

(Acheson 1975). Within their lobstergrounds, fishers harvest from the same areas over their lifetimes, and pass these areas on to their offspring.

Even though the fishers have devised extensive rules defining access to the grounds and how harvesting may occur, the number of men who have chosen to harvest lobster for a living has increased over time, resulting in increased competition for the lobster.[8] In response, the lobstermen of Mount Pleasant Island have begun setting more lobster traps to increase their share of the harvest. Fishers who typically set 300 pots, now set 500 pots (Grossinger 1975:197). In addition, some fishers are attempting to breakdown the internal divisions within the lobster grounds; that is, they are attempting to replace the current assignment rules to default rules which would permit any action to be taken in harvesting lobster. Instead of being restricted to areas harvested by their fathers or uncles, lobstermen are attempting to harvest across the grounds, resulting in moderate levels of assignment problems continuing to plague the group.

Crowding through the use of more space consuming technology creates problems for the two subgroups of cod fishers harvesting the grounds off of Fermeuse, Newfoundland (Martin 1973). These fishers are increasingly experiencing technological externalities as more equipment is placed within their grounds. The Fermeuse fishers have tightly regulated the types of technology that may be used on the grounds. As Martin states:

> space division is directly related to the number of fishing units by which local exploitable space must be divided. In situations where there are substantial numbers of fishermen and only limited amounts of exploitable space (as in Fermeuse), we find regulations that limit the majority, if not all, of community grounds to those extractive technologies that permit the highest density of fishing-unit participation (Martin 1979:286).

The Fermeuse fishers divided their grounds into two primary areas or sanctuaries (Ibid). One sanctuary is reserved for handlining and the other for longlining, both of which are space conserving technologies. In the mid-1970s the Canadian government subsidized several technologies that utilize more extensive areas, such as the cod net, and larger boats, called longliners, that hold more gear. Several Fermeuse fishers have adopted cod nets which are placing pressure on the other technologies. Four to five cod net units can exploit the same amount of space as twenty to thirty handline units (Ibid). Given population pressures, as in the case of Mount Pleasant Island, and technological changes as in the case of Fermeuse, even though fishers possess the right of exclusion and have devised rules of harvesting, they still may face technological externalities and assignment problems.

The right of exclusion—being able to decide who can enter the fishing grounds—provides fishers with the incentive to devise rules governing access and harvesting

activities that resolve the problems that they face. Groups of fishers who hold the right of exclusion have overwhelmingly addressed and resolved assignment problems and technological externalities. Even so, the right of exclusion combined with rules of organization are neither necessary nor sufficient conditions for the efficient utilization of fishing grounds (Dahlman 1980, also see Chapter Three). Given sufficient isolation, even without the right of exclusion, fishers are capable of devising rules to order their harvesting activities, although these institutional arrangements are vulnerable to exogenous pressures. In addition, even with the right of exclusion and organized harvesting, fishers can continue to experience problems because of population pressures and technological changes internal to the community of fishers. Nevertheless, exclusion and the development of rules play a crucial role in whether fishers are capable of addressing problematic situations.

A Comparison of Assignment Problems and Technological Externalities

In addressing assignment problems and technological externalities fishers utilize similar boundary and authority and scope rules. The similarity of rules across problem type may stem from the fact that resolving either problem involves governing the use of the space of fishing grounds. In either case there is the attempt to separate fishing units. In relation to boundary rules the three most often used rules both among the groups of fishers facing technological externalities and those facing assignment problems are residency, technology, and membership in an organization or racial or ethnic group (see Table 4.7). Fishers must reside in a local community, use particular types of technology, and be a member in a local organization, such as a co-op, or an ethnic or racial community.

The similarity also holds in relation to authority and scope rules. The two authority/scope rules used most often among the groups of fishers is a location or spot rule, and an order rule (see Table 4.6). The location rule is somewhat different in relation to the two types of problems. In addressing assignment problems, the spot is a well-defined area occupied by a single fishing unit that holds a right of occupancy for a specified period of time, typically a day or a season. In relation to technological externality problems the location rule often involves two steps. First, a specific expanse of the fishing ground is set aside for the use of a particular technology (Martin 1973, Davis 1984). Within the space of the fishing grounds, only a particular type of technology can be utilized. Second, within that area if fishers utilize fixed types of gear, assignment rules are used to govern access to spots. Typically, a first-in-time, first-in-right rule is used. Given the use of a particular technology within the

specified area of the grounds, a fisher who gains a spot first can utilize it for a specific time period (Faris 1972, Shortall 1973, Martin 1979, Raychaudhuri 1980).

In spite of the similarity in boundary rules and authority/scope rules across technological externalities and assignment problems, fishers are, nevertheless, more likely to resolve assignment problems than they are technological externalities. For instance, of the nineteen subgroups who faced assignment problems, thirteen have successfully resolved them. That is, 68% of the subgroups have successfully resolved their assignment problems. Of the twenty-one subgroups that faced technological externalities, nine, or 43%, have successfully resolved the problem.

One factor, discussed in Chapter Three, appears to exert a strong influence on fishers' abilities to control particular types of behavior. The actions associated with assignment problems are binary and hence easier to regulate than are actions associated with technological externalities, which are more continuous in nature and thus more difficult to control. The basic action constituting an assignment problem is the occupation of a fishing spot. Either a fishing spot is occupied or it is not. Determining whether a spot is taken, and taken by someone who has rights to it, is relatively easy. Thus, actions related to assignment are binary—they occur, or they do not occur. A fisher either does or does not occupy a spot.

On the other hand, actions related to technological externalities are much more mixed. Some actions are binary. Many others are not. A binary action in relation to technological externalities is the use of particular types of equipment. Either a fisher uses a handline or she does not. In most coastal fisheries it is relatively easy to determine the types of gear being used. If technological externalities are being generated by incompatible types of equipment, one way of addressing the problem is to ban the use of particular types of gear. Rules that require the use of particular types of gear are often used, as discussed earlier.

Ensuring that particular types of gear are utilized on fishing grounds, however, only addresses part of the underlying cause of technological externalities. Other sources of such externalities include too much gear being utilized in a given space. Placing too much gear in a given space, or placing different gears too close together are more continuous types of actions and thus it is more difficult to define or determine what type of action constitutes a technological externality. For instance, how much gear is too much? If one fisher sets gear close to that of another, is that fisher generating technological externalities or has he simply engaged in a clever strategic move? As Martin explains:

> when handlining, if A is anchored in a particularly coveted location and B anchors

> directly astern of him (thereby attracting the bulk of the fish away from A), it is considered 'dirt'. But if B anchors his boat so that, when the tide changes, A's boat swings away from the location and B swings into it, that is regarded as good 'slippery' fishing (Martin 1979:290).

Regulating the more continuous forms of behavior in relation to technological externalities is much more difficult, and in most cases this has not been attempted by the subgroups of fishers.

Differences in the types of actions being regulated in relation to assignment problems and technological externalities explains fishers capabilities in addressing these problems. While the primary action in relation to assignment is binary, the primary actions in relation to technological externalities are a mixture of both binary actions and continuous actions. Thus, some form of a spot rule, whether it is based on first-in-time, first-in-right, or prior announcement, or on a lottery, can immediately and almost completely address problems of assignment. In relation to technological externalities, however, a spot rule, or a technology rule, only addresses a portion of the causes of technological externalities. Attempting to address the more continuous aspects of the problem is more difficult.

Clear patterns emerge in examining the performance of the institutional arrangements that fishers have devised. Both property rights and rules are important in addressing and resolving problems of assignment and technological externalities. In particular, the right of exclusion combined with rules of use perform exceedingly well. Subgroups who possess the right of exclusion and who have organized their harvesting are much more likely to have resolved problematic situations they have faced. Underlying this finding, however, is the fact that fishers have been more successful in resolving assignment problems than they have technological externalities. This pattern may reside in the fact that behavior resulting in assignment problems is easier to regulate than behavior causing technological externalities.

Monitoring and Enforcement of Institutional Arrangements

To sustain the institutional arrangements that fishers have devised over time requires that compliance with the rules be monitored, and rule transgressions be sanctioned. Monitoring of these arrangements is primarily a group affair. The subgroups of fishers rely heavily upon self-monitoring. They monitor each other and outsiders.[9] Among the forty-four subgroups information concerning monitoring was reported for thirty-two. Of the thirty-two subgroups, twenty-nine engage in self-monitoring.[10] They observe each others' harvesting activities, ensuring that they each follow the rules.

In fact, few of the subgroups participate in any formal monitoring arrangement where a position of guard is defined either by the fishers or by some external authority.[11] Only

one subgroup of fishers has devised their own formal monitoring arrangements where the fishers rotate through the position of guard. This subgroup involves a community of fishers in Turkey who harvest from a lagoon (Berkes 1985, 1986). The fishers who harvest from the Ayvalik-Haylazli lagoon use a combination of rowboats and motor boats to harvest a variety of mullets, groupers, and snappers. The relatively small size of the lagoon (16 square kilometers), and its single entrance eases the difficulty of monitoring. Fishers take turns patrolling the entrance to the lagoon to prevent other fishers from accessing it. As Berkes reports, three outside fishing boats were apprehended in 1983 (Berkes 1985:72).

Of the twenty-nine subgroups that engage in self-monitoring, nine are also monitored by guards appointed by an external government authority. In addition, of the three subgroups that do not engage in self-monitoring all three are monitored by external guards. In each of these cases a government authority has devised some of the rules that the fishers are to follow such as size requirements for the fish harvested, seasons during which fishers can harvest fish, or the types of technology that are permissible. In other instances the government authority has given official recognition to some of the rules the fishers have devised for themselves and provided monitors to ensure that the rules are being followed. Out of the forty-four subgroups information was provided concerning monitoring for thirty-two of them. All thirty-two subgroups are subject to some form of monitoring.[12]

In addition to monitoring the behavior of fishers, sanctions must also be applied to those who have broken rules to both penalize and discourage such behavior. The twenty-nine groups that engage in self-monitoring rely primarily upon social sanctions to enforce rule compliance. Of the twenty-nine groups there is information concerning their use of social sanctions among twenty-four. Of these twenty-four, twenty-one are likely to use social sanctions whereas three are not.[13] Social sanctions typically take the form of threats against the rule breaker if he does not change his actions (Berkes 1985, 1986), or the breaking off of reciprocal relations (Davis 1975). For instance, Davis, in his description of 'the coastal fishers of Pagesville and Port Lameron Harbours in southwest Nova Scotia, emphasizes the intricate exchange relationships fishers have devised in relation to each other in order to support each other in fishing. Fishers exchange information concerning the location of fish, they exchange bait, they assist each other in repairing equipment and in hauling boats. These relationships, developed among a community of fishers, supports the success of the fishers of that community. Without information concerning the location of fish, without help in gaining access to bait, without assistance in

repairing damaged equipment a fisher is unlikely to survive. While these relationships are supportive they can also be used to sanction fishers who do not follow the rules of harvest. As Davis explains:

> With involvement in the system comes an explicit social responsibility to hold up your end of the bargain. Negligence in doing so leads to both social and, more importantly, economic sanctions. Socially, a man may be branded with a reputation which ends all of the necessary economic and communicative relationships. Not only would such an individual be ostracized from the social life of the community, he would be treated as an •economic outsider[1]. In other words, his access to scarce resources and information systems would be severely limited. A fisherman in this unenviable position could not last long as a viable producer. Eventually, he would be forced either to leave the community or to get out of fishing (Davis 1975:141-142).

Fishers are less likely to rely upon physical sanctions to ensure rule compliance. Of the twenty-nine subgroups that engage in self-monitoring there is information concerning the use of physical sanctions for eighteen of them. Of these eighteen subgroups only eight are likely to impose physical sanctions upon rule violators. Physical sanctions take the form of gear destruction (Grossinger 1975, Davis 1984) or even bodily harm (Cordell 1972).

Monitoring and sanctioning of behavior in relation to the institutional arrangements that fishers have devised are important factors in maintaining these arrangements. Fishers rely primarily upon each other for ensuring rule conforming behavior. They carefully observe each other's actions and the actions of outsiders to ensure that rules are being followed. In addition, they also mete out punishment among themselves when someone has violated a rule. Rulebreakers are socially ostracized, and in some instances they may face physical sanctions. Whether or not differences in monitoring and enforcement affect the outcomes fishers achieve, however, could not be explored in relation to this data set since all subgroups for which there was information engaged in monitoring and enforcement. In other words, there was no variation among the subgroups concerning the existence of monitoring and enforcement activities.

Conclusion

Fishers operate under and have devised a variety of institutional arrangements to organize their access and use of fishing grounds. These arrangements involve different bundles of property rights and rules to exercise those rights. Given differences in arrangements there are also differences in their performance. While all arrangements have little impact on the level of the flow of fish and only a moderate affect on the quality of fish, some arrangements are better at solving assignment problems and technological externalities than are others. Institutional arrangements that involve four property rights, those of access, withdrawal, management, and exclusion, and rules that define how these rights are to be exercised are much more likely to be associated with situations that no longer involve

problems of assignment or technological externalities than other forms of arrangements.

In addition, fishers have been much more successful in resolving assignment problems than resolving technological externalities. One possible explanation for this is that actions related to assignment problems are more easily regulated than actions associated with technological externalities. Assignment problems involve binary acts, whereas technological externalities involve a mixture of binary acts and continuous acts. While binary acts involve clear cut behavior, continuous acts do not. Thus, acts related to assignment problems are easily measured and can be regulated with relatively simple rules. Continuous actions are not as easily measured and it is more difficult to determine what type of action creates a technological externality. Finally, fishers monitor and enforce the arrangements they have created. For the most part they monitor their own arrangements instead of relying upon outside officials to monitor. They also rely upon social sanctions as opposed to physical sanctions in punishing rulebreakers.

TABLE 5.1.

PROPERTY RIGHTS ARRANGED ACCORDING TO A GUTTMAN SCALE

Access	Withdrawal	Manage	Exclusion	Transfer	Number of Subgroups
yes	yes	yes	yes	yes	1
yes	yes	yes	yes	no	24
yes	yes	no	yes	no	1
yes	yes	yes	no	no	9
yes	yes	no	no	no	9

CR (coefficient of reproducibility)=1-1/44x5=.99

TABLE 5.2.

NUMBER OF REQUIRED AUTHORITY RULES BY PROPERTY RIGHTS

	Two Property Rights	Three Property Rights	Four-Five Property Rights	(Total)
No Required Rules	64% (6)	10% (1)	12% (3)	(10)
One or More Required Rules	36% (3)	90% (9)	88% (22)	(34)
(Total)	100% (9)	100% (10)	100% (25)	(44)

Gamma=.59
Missing Cases: 0

TABLE 5.3.

INSTITUTIONAL ARRANGEMENTS BY SCARCITY OF THE FLOW OF FISH

	Four-Five Property Rights And Rules	Three Property Rights And Rules	Other	(Total)
Abundant Flow Of Fish	41% (9)	29% (2)	38% (5)	(16)
Scarce Flow Of Fish	59% (13)	71% (5)	62% (8)	(26)
(Total)	100% (22)	100% (7)	100% (13)	(42)

Gamma=.07
Missing Cases: 2

TABLE 5.4.

INSTITUTIONAL ARRANGEMENTS BY QUALITY OF FLOW

	Four-Five Property Rights And Rules	Three Property Rights And Rules	Other	(Total)
High Quality of Fish	68% (13)	44% (4)	38% (5)	(22)
Low Quality of Fish	32% (6)	56% (5)	62% (8)	(19)
(Total)	100% (19)	100% (9)	100% (13)	(41)

Gamma=.44
Missing Cases: 3

TABLE 5.5.

INSTITUTIONAL ARRANGEMENTS BY ASSIGNMENT PROBLEMS

	Four-Five Property Rights And Rules	Three Property Rights And Rules	Other	(Total)
Minimal Assignment Problems	91% (10)	60% (3)	0% (0)	(13)
Moderate to Unresolved Assignment Problems	9% (1)	40% (2)	100% (3)	(6)
(Total)	100% (11)	100% (5)	100% (3)	(19)

Gamma=.90
Missing Cases: 0

TABLE 5.6.

INSTITUTIONAL ARRANGEMENTS BY LEVEL OF TECHNOLOGICAL EXTERNALITIES

	Four-Five Property Rights And Rules	Three Property Rights And Rules	Other	(Total)
No Technological Externalities	80% (8)	40% (1)	0% (0)	(9)
Technological Externalities	20% (2)	80% (4)	100% (6)	(12)
(Total)	100% (10)	100% (5)	100% (6)	(21)

Gamma=.88
Missing Cases: 0

1. Each right may be significant in and of itself apart from the other rights. For instance, the right to access a forest or a park is valuable to the person who enjoys hiking or simply observing wildlife even if the person does not have the right to harvest wood or hunt for animals.

2. Among the forty-four subgroups, 58 authority rules are used. Of those 58 rules, only 11 have been imposed by an external authority, with 5 being size rules, and 6 being season rules. All other authority rules have been devised by the fishers themselves.

3. The question concerning the quantity of the flow of fish appears on the operational level form and is worded as follows:

> For biological resources at the beginning and end of this period, the balance between the quantity of units withdrawn and the number of units available is: 1) extreme shortage, 2) moderate shortage, 3) apparently balanced, 4) moderately abundant, 5) quite abundant.

In establishing Table 6.3 I collapsed answers 1), 2), and 3), into scarcity and answers 4) and 5) into abundance.

4. The question concerning quality of fish appears on the operational level form and is worded as follows:

> As of the beginning and end of this period, characterize the quality of units being withdrawn: 1) extremely high quality, 2) high quality, 3) passable, 4) poor quality, 5) extremely poor quality

For Table 6.4 I collapsed answers 3), 4), and 5) into low quality, and answers 1) and 2) into high quality.

5. The following discussion of assignment problems and technological externalities involves thirty-one distinct subgroups. Ten subgroups have experienced assignment problems only, twelve have faced technological externalities only, and nine have experienced both. For thirteen subgroups, not enough information was presented to determine whether or not and what type of problem the fishers experienced.

6. This discussion involves nineteen subgroups--ten of which have experienced assignment problems only and nine which have experienced both.

7. The question concerning technological externalities appears on the operational level form and is worded as follows:

> As of the beginning and end of this period, what is the extent of technical externalities resulting from the appropriation activities of participants from this resource? 1) the level of technical externalities is quite low, 2) the level of technical externalities is relatively low, 3) modest levels of technical externalities exist, 4) relatively high levels of technical externalities exist, 5) very high levels of technical externalities exist.

For Table 6.6 I collapsed answers 1), 2) as low levels of technological externalities, and answers 3), 4), and 5) as high levels of technological externalities.

8. For instance, there are six different requirement (or boundary rules) fishers must meet before they can engage in harvesting: they must be a long term resident of a local community, 2) they must own their own fishing equipment, 3) they must continuously harvest from the grounds, 4) they must exhibit a certain level of skill in harvesting, 5) they must use a particular technology, i.e., lobster pots, and 6) they must hold a fishing license.

9. The question concerning self-monitoring is located on the operational level form and is worded as follows:

> Do appropriators monitor the appropriation activities of each other apart from the monitoring of any "official" guards? 1) yes, 2) no.

10. Of the three remaining subgroups, one does not engage in self-monitoring, and no information was reported for the other two groups concerning self-monitoring.

11. The question concerning formal monitors appears on the operational level form and is worded as follows:

> Does an "official" position of monitor exist (apart from the willingness of all appropriators to monitor)? 1) no, 2) yes, appropriators (not necessarily all) rotate into this position, 3) yes, appropriators are selected by appropriators for this position, 4) yes, local non-appropriators are selected by appropriators for this position, 5) yes, local non-appropriators are selected by a local general purpose government, 6) yes, monitors are employees of an external governmental authority, 7) yes, some are selected by appropriators and some are selected by a local general purpose government, 8) yes, some are selected by appropriators and some are employees of an external government authority, 9) yes, some are selected by a local general purpose government and some are employees of an external government

authority, 10) yes, some are selected by appropriators, some are selected by a local general purpose government, and some are employees of an external government authority

12. Since there is no variation on the monitoring variable (all subgroups for which there is information are monitored) I cannot examine the importance of monitoring; that is, whether institutional arrangements that are monitored perform better than those that are not monitored.

13. The question concerning social sanctions appears on the operational level form and is worded as follows:

> If someone violates rules-in-use related to the appropriation process from this resource, how likely is he/she to encounter social sanctions imposed by other appropriators (who are not filling positions as official monitors)? 1) very likely, 2) likely, 3) likely as not, 4) unlikely, 5) very unlikely.

CHAPTER SIX

GOVERNING COASTAL FISHERIES

Coastal fisheries, as common pool resources, present difficult and complex problems, both for those that utilize the fisheries, and government officials and policymakers. As discussed in Chapter Two, costly exclusion from and jointness of use of fishing grounds combined with the subtractable nature of the stocks of fish, produce a situation where fishers' actions affect each other. The outcomes each individual fisher achieves is a function of the actions of that individual fisher as well as all other fishers utilizing the same grounds, or harvesting from the same stocks of fish.

Problems arise in relation to the use of the physical space constituting fishing grounds, and in relation to the flow of fish through the grounds. The heterogeneous distribution of fish across fishing grounds produces fishing spots of varying productivities. Fishers, in searching out and harvesting from the most productive spots, nay fight over the choicest spots. Assignment problems arising from conflict over access and distribution of spots, as discussed in Chapters Two and Four, increase the costs of harvesting fish through the destruction of gear, by fishers expending resources racing to the most productive spots, and so forth.

Problems also arise when fishers utilize different types of gear, too much gear, or if they set their gear too close together. Any of these circumstances can lead to fishers interfering with each other in harvesting fish. Gear can become entangled or destroyed, or the flow of fish into nets and traps can be intercepted, lowering the catch levels of fishers. Technological externalities also increase the cost of harvesting through the destruction of gear, and by gear laying idle, or not being used to full capacity.

Finally, problems potentially arise from fishers harvesting the same stocks of fish. As fishers harvest, they draw down the available stocks of fish. Drawing down the number of fish to be harvested increases the costs of harvesting. Fishers must spend more time and resources in hunting and capturing fewer fish. Stock externalities are the focus of the bionomic model, and are believed to produce extreme inefficiencies in the harvesting of fish.

No single fisher acting alone can resolve any one of these problems. A fisher who does not compete over spots or over catch does not reduce assignment problems or stock externalities. Rather, that fisher simply does not gain access to the most productive spots. Or, the fish that the fisher does not harvest, will be harvested by another. Unilateral action does not resolve these problems and is not in the fisher's interest to undertake.

The interdependent nature of the problems fishers face require that fishers coordinate their actions in order to resolve them. Rules that define actions that can be taken by fishers in harvesting fish must be established. For instance, as discussed in Chapter Two, a prior announcement rule whereby fishers announce the spot they intend to fish the following day limits the competition for spots. Prior announcement gives fishers the exclusive right to the spot they announce. They do not have to race to get to a spot first, nor do they have to fight for spots. Problems of assignment, and technological and stock externalities require fishers to engage in collective action to resolve these problems.

Collective action, however, is also problematic. Institutional arrangements that structure harvesting activities are costly to devise. Resources must be expended to negotiate the arrangements, and to monitor and enforce compliance with them once they are in place. In addition, excluding fishers from the benefits of these arrangements is difficult and costly. Once members of a group supply arrangements, excluding other group members is difficult. Costly establishment of institutional arrangements, as well as difficulties in excluding others, presents fishers with incentives not to cooperate to provide these arrangements. Instead, they face the incentive to freeride off of the cooperation and resources of others who may provide the arrangements. In other words, fishers face the incentive not to expend resources devising rules of harvest when others may provide those arrangements.

Fishers face troublesome situations that involve assignment problems and technological and stock externalities that require them to cooperate to coordinate their activities, even though they may not face incentives to cooperate. Fishers have, however, in relation to particular types of problems and under particular circumstances, designed institutional arrangements to resolve problematic situations, as discussed in Chapters Two and Four. They have primarily attempted to govern the use of space within their fishing grounds as opposed to managing the flows of fish within those grounds. In particular, fishers have attempted to address assignment problems and technological externalities. Evidence presented in Chapter Four suggests that groups of fishers who faced either assignment problems or technological externalities were much more likely than not to define rules of harvest.

The rules fishers devise are directed at governing the use of space. Authority and scope rules that fishers have created define access to productive fishing spots as well as dividing fishing grounds into use areas for particular technologies. Boundary rules fishers have created limit the number of fishers who can access grounds as well as the types of technology that can be utilized within the grounds.

Fishers did not devise rules that directly managed the flows of fish in fishing grounds. Fishers did not attempt to address stock externalities.

Fishers govern the use of space within their grounds for several reasons. First, the causes and consequences of problems arising from multiple individuals interacting within a finite amount of space are identifiable and measurable. The causes of assignment problems are a limited number of productive fishing spots to which fishers are attempting to gain access. The causes of technological externalities are fishers using incompatible gears within the same area of the fishing grounds so that the gears become entangled, or fishers setting their gear too close to one another causing gear entanglement or interference with the flow of fish among gears. Over time, with experience, fishers can identify the causes of assignment problems and technological externalities. In addition, in acting in ways that create these problems, given the noticeability of the causes, fishers understand that "opportunistic individual behavior" destroys the "possibilities for collective gain" (Wilson 1982:420). In repeatedly fighting over productive spots, or in repeatedly setting gear too close to one another, fishers may begin to realize that they are worse off than if they could cooperate to prevent such behavior from occurring.

Second, problems arising from the use of space occur within a given set of fishing grounds often utilized by the same groups of fishers over time. Assignment problems and technological externalities occur within a particular fishing ground and are limited to the group or groups of fishers who utilize that ground. The impact of assignment problems arising in one ground does not extend across numerous grounds and numerous groups of fishers. Consequently, the limited extent of problems based on the use of physical space of grounds provides the basis for fishers to identify and negotiate sets of rules to resolve these problems. A group of fishers can potentially exercise control over the fishing grounds they utilize so that in devising rules of harvest they can resolve assignment problems and technological externalities. The rules fishers design in relation to these problems, if followed, can potentially resolve them.

Whether rules are followed in part depends upon their monitoring and enforcement. Monitoring and enforcement provides incentives for fishers to follow the rules rather than face the penalties associated with departures from the rules. If enforcement is effective, it may raise the cost of rulebreaking sufficiently so as to eliminate most incentives to depart from the rules. Also effective enforcement assures fishers that others are not taking advantage by breaking the rules. Knowing others are

following the rules encourages a fisher to also comply (Levi 1988, Ostrom 1990).

These three conditions, 1) repeated occurrences of a problematic situation in which individuals are aware of the suboptimal outcomes their behavior produces, 2) the problematic situation being confined to a community of fishers utilizing the same fishing grounds, and 3) enforcement of rules devised to resolve the problematic situation, however, do not hold in relation to flows of fish through fishing grounds, and problems arising from numerous fishers harvesting from the same stocks of fish. The existence of stock externalities is difficult to identify, as discussed in Chapters One and Two. Defining stock externalities requires information concerning the size of fish populations and the levels of effort being applied, neither of which are available to fishers, or to policymakers for that matter. Also whether declines in fish populations are caused by harvesting activities or by environmental factors is difficult to determine, as discussed in Chapters Two and Four. The impact fishers[1] catches have upon each other's harvesting levels, therefore, cannot be measured. In other words, defining the causes and consequences of stock externalities in actual fishery settings is virtually impossible.

Second, given the migratory nature of most fish species, numerous communities harvest from the same stocks of fish. To address stock externalities would require the identification of all communities of fishers who harvest from the stocks. These communities of fishers would then have to negotiate and define harvesting rules to address stock externalities. Since, identifying and measuring the existence and magnitude of stock externalities is virtually impossible, the second factor becomes a moot point. Defining rules of harvest in relation to a problem that is difficult to identify and measure is unlikely to take place. Thus, while assignment problems and technological externalities are much more amenable to resolution by single communities of fishers, stock externalities are not, and as a consequence they are typically not addressed by fishers.

This finding, based on an institutional analysis approach, that fishers do not address stock externalities is similar to that of the' bionomic model. The bionomic model also predicts that fishers will not address stock externalities. Yet, these conclusions are arrived at in very different ways. The bionomic model, based on perfect information of a stable physical world, assumes that stock externalities are the source of severe inefficiencies, and that they are easily measured. Fishers do not take stock externalities into account in their harvesting decisions because of the institutional environment within which they operate. No institutional arrangements are presumed to exist to limit access to fisheries and to regulate the

harvest of fish. Consequently, fishers face the incentive to harvest as many fish as possible with little regard for the effects their actions have upon current and future harvest levels. To resolve the problem of stock externalities, a government authority, that possesses information concerning the population dynamics of fish stocks and the amount of effort fishers currently apply, must intervene and directly manage the fishery or establish some form of private property regime in relation to the fishery. In either case a government authority will establish institutional arrangements that will induce fishers to apply that level of effort that represents an optimal harvest level for the fishery. While fishers do not address stock externalities, a government authority can, and can do so successfully.

An institutional analysis approach does not presume perfect information. Rather, the presumption is imperfect and incomplete information, both in relation to the physical environment and in relation to the actions of fishers and the outcomes institutional arrangements produce. Imperfect and incomplete information exists, in part, because of the complex and uncertain physical environment of coastal fisheries. Complexity and uncertainty primarily arise in relation to the flows of fish, or the dynamics of the fish populations. Fish populations fluctuate unpredictably overtime due to changing environmental conditions. Fishers, fisheries biologists, and others, therefore, do not possess a sufficient level of understanding of fish populations to define an optimal yield from a stock of fish. Thus, fishers do not address stock externalities, because stock externalities are virtually impossible to measure, and therefore resolve. In addition, it is unlikely that officials of a government authority can resolve stock externalities, since they too lack the requisite information.

Instead, fishers have addressed problems of assignment and technological externalities. In resolving problems of assignment and technological externalities, fishers have cooperated to devise a variety of institutional arrangements. Most property rights, particularly the rights of access, withdrawal, and management, have been granted to fishers, typically by an external authority. Most fishers are co-equal among each other in the rights they possess in relation to the fishing grounds. No single fisher owns a fishing ground. Rather, groups of fishers collectively hold rights in relation to particular grounds.

The collective nature of rights in fishing grounds requires fishers to coordinate their actions to avoid problematic situations. Fishers have devised many of their own rules of harvest. They have defined how their property rights are to be exercised. In so doing they have often taken the additional step of creating for themselves the

right of exclusion, even though that right was never formally granted them by an external authority. They have accomplished this by carefully specifying the types of gear that may be utilized in their grounds excluding all others who do not utilize that gear (Shortall 1973). Some groups of fishers have also specified intricate rules of harvest that are known to the fishers themselves, but which the fishers do not share with others who may want to use their grounds (Berkes 1986).

While these rights of exclusion may or may not be sustained in formal adjudication procedures, they make a significant difference in the performance of the institutional arrangements that structure fishers actions. Institutional arrangements that involve rights of access, withdrawal, management, and exclusion, in addition to rules that specify how the rights are to be exercised, perform better than institutional arrangements consisting of fewer than four rights, with or without rules. The arrangements consisting of four property rights and rules are much more likely to structure fishers' actions so that fishers avoid assignment problems and technological externalities. If fishers are capable of excluding others from accessing their grounds, they are more likely to organize their harvesting activities so as to resolve problems that can arise in relation to multiple fishers interacting within the same fishing grounds.

In addition, as between the two problems fishers typically address—assignment problems and technological externalities—fishers have had more success in resolving the former as opposed to the latter. A primary reason for the greater success in addressing assignment problems is that assignment problems are based upon binary actions, as discussed in Chapter Five. Binary actions involve an either-or choice. Either a fisher harvests from a prime spot or she does not. Technological externalities, on the other hand, are based on more continuous forms of action. Continuous actions allow a gradation of choices. Gear can be set an infinite number of distances apart. The distance that generates technological externalities and the distance that does not is difficult to determine and define.

Binary actions are more easily regulated. In regulating binary action the choice between two options can be truncated so that the choice that causes conflict is eliminated. Instead of choosing between two different spots, one of which is occupied, the choice may be transformed through rules into fish the assigned spot or do not fish at all, as discussed in Chapter Five. In addition, binary actions are more easily monitored. If an act is taken that is forbidden it may be immediately noticed. For instance, if a rule states that fishers cannot harvest from an already occupied spot, attempting to gain control of and fish from an occupied spot is noticeable. It is difficult

to avoid a rule that states an occupied spot cannot be fished.

Continuous action is more difficult to regulate. What constitutes interference in harvesting fish is not as easily defined. As discussed in Chapter Five in relation to technological externalities, whether setting gear close to another fisher is a clever strategic move or an act generating technological externalities is not easily determined. In addition, monitoring compliance with rules designed to eliminate technological externalities is more difficult. Instead of measuring whether or not an act has occurred, as in the case of assignment problems, the magnitude of an act must be measured. For example, the distance between gear must be measured. In general, it is more difficult to regulate continuous acts than it is binary acts, and consequently, fishers have had more success in solving assignment problems which are based on binary acts, than they have technological externalities which are based on continuous acts.

Institutional arrangements devised by fishers to solve assignment problems and/or technological externalities, commonly share a superior ability to utilize time and place information that is unique to each of the grounds. Assignment problems and technological externalities are localized to specific grounds. They arise in the context of single grounds and are a function of the actions fishers take who utilize a ground and also the physical structure of a ground. These two factors—the actions fishers take and the structure of grounds—vary from ground to ground. Thus, to solve assignment problems and technological externalities requires specific time and place information about the situation in which the problem arises.

This information is typically not available to individuals who are not a part of the community of fishers experiencing problems. A government official who does not live in the area will most likely not be aware of both problems arising in the harvesting of fish and of likely solutions to those problems. Government officials cannot craft larger scale institutional arrangements to address local level nuances. Instead, a standard policy is applied to a single region, such as the eastern coast of Canada (Davis 1984). Government officials, lacking the information necessary to effectively address problems arising from localized circumstances. Fishers, however, do possess local time and place information, and they have utilized it in developing institutional arrangements to resolve problems they confront. They have fashioned institutional arrangements to meet their needs, and in many circumstances they have been quite successful.

A second strength of the institutional arrangements devised by fishers is a concern with providing equal opportunities for fishers who are a part of the community

the institutional arrangements extend across. This concern with providing equal opportunities arises in how productive spots are distributed in relation to assignment problems, and how the physical space in the grounds is governed in relation to technological externalities.

In assigning productive spots, particularly in situations where there are a few very productive spots that all fishers would prefer to fish as opposed to the average or less productive spots, the institutional arrangements devised often ensure that all fishers have equal opportunities for gaining access to the very productive spots. For instance, as discussed in Chapters Four and Five, in the coastal cod fisheries in eastern Canada lotteries are often utilized to distribute spots (Faris 1972, Shortall 1973, Martin 1979, Powers 1984). At the beginning of each lottery fishers possess equal opportunities for gaining access to the most productive spots, and over time fishers are likely to have gained access to the best spots a proportionate number of times.

In governing the use of space in the grounds so as to avoid technological externalities, care is often taken so as not to exclude fishers who have rightful claims to accessing and utilizing particular fishing grounds. In situations where fishers have devised institutional arrangements, and where crowding may be problematic, a balance is often sought between the numbers of fishers who have access to the grounds and the space consuming capabilities of the technology permitted in the grounds. Technologies that consume large amounts of space are often limited so that fishers who have been consistently utilizing grounds are not suddenly expelled by other fishers using space consuming technologies. Thus, there is also attention paid to ensuring fishers continued access to fishing grounds that they have historically used.

The focus upon ensuring equal opportunity relates primarily to.ensuring access to fishing grounds or to particular spots within fishing grounds. Rarely is there an attempt to directly limit the amount of effort, or the amount of fish that can be harvested. That is, the free play of skill and ability is permitted and encouraged (Johnson and Libecap 1982). The institutional arrangements fishers have devised typically ensure equality of access, once particular requirements have been met, such as residency or technology. How successful a fisher is, as in relation to the quantity and consistency of her harvests, is a function of her skill, which is not directly regulated.

A third strength of the institutional arrangements fishers have devised is the flexibility and adaptability that are permitted fishers as they harvest. Rarely are restrictions placed upon the types of fish that may be harvested. In addition, while some forms of technology are regulated, fishers often have choice among different types

of gear. As a consequence, fishers can harvest across different stocks depending upon their abundance, using gears that best fit the fishers' strategies. Fishers are not locked into fishing a specific stock or utilizing a single type of equipment (Townsend and Wilson 1987). Rather, they can adapt to the opportunities that are presented to them by their environment. As Townsend and Wilson (1987) point out, however, adaptability and flexibility is not encouraged by many current policy initiatives. Licensing systems and quotas often lock fishers into using a single type of equipment or harvesting a single species of fish. Licenses are often issued for a particular type of gear, or in relation to a single species of fish (Davis 1984). Quotas are usually established on a stock by stock basis. Purchasing a license or participating in a quota system thereby locks fishers into single gear types, or single fish species. Given the complexity and uncertainty characteristic of many fisheries, being able to adapt to changing opportunities is crucial for the continued survival of many fishers.

Solving problems that are specific to particular grounds, ensuring equal opportunities in accessing fishing grounds or parts thereof, and permitting fishers to be adaptable are all strengths of the institutional arrangements fishers have devised. Yet, these same institutional arrangements are also weak in particular areas. First, the institutional arrangements that only cover single inshore fishing grounds are incapable of affecting problems that originate and extend beyond the boundaries of their jurisdiction. Problems arising from multiple communities of fishers harvesting from the same stocks of fish, such as declining levels of fish populations and declining quality of harvestable fish, cannot be resolved by any single arrangement or community of fishers. The same also holds true in relation to other problems that originate outside the jurisdictions of the arrangements but impact upon the fishing grounds, such as pollution.

Second, the institutional arrangements fishers have devised to govern their use of fishing grounds are vulnerable to external shocks. For example, a rapidly changing economic environment where the economy is transformed from one of subsistence to one of market exchange can erode arrangements created for a subsistence economy (Nietschmann 1972). A substantial increase in the value of fish harvested from a fishing ground can also strain the institutional arrangements as fishers face incentives to break rules so that they can harvest fish more rapidly. New groups of fishers who move in and begin utilizing a fishing ground without a recognition or understanding of existing institutional arrangements can also result in the destruction of the arrangements (Cordell 1972). Finally, the vulnerability of these arrangements is

increased because often times they are not recognized or taken into account by government policymakers. Policies are implemented or actions are taken by government officials that may disturb or even destroy the arrangements (Cordell 1972, Davis 1984). Without formal recognition by external authorities the institutional arrangements devised by fishers are exposed to the actions of others, with fishers possessing little recourse for protection.

The existence of the institutional arrangements fishers have devised, the role they play in solving problematic situations, and their strengths and weaknesses, requires that policy approaches based upon the bionomic model of fisheries be reconsidered. In attempting to resolve a single problem, that of stock externalities, government policies can potentially destroy local institutional arrangements that are extremely effective in solving localized problems. Instead of assuming that because government agencies are not regulating fisheries no one is regulating their use, attention must be paid to these self-governing organizations, and their existence and operation must be built into policies directed at managing fisheries. In many cases, at least in relation to coastal fisheries, this may mean that government agencies adopt a different role than devising operational rules that specify the day-to-day harvesting activities fishers can engage in, such as the types of fish that can be harvested, or the amount of fish that can be harvested. That role nay be one of supporting existing institutional arrangements, facilitating the creation of self-governing organizations among communities of fishers that have not yet devised them, and addressing problems that are beyond the scope of these arrangements.

The institutional arrangements fishers have devised can be strengthened by government agencies recognizing their existence, and providing fishers recourse to formal adjudication procedures. If fishers[1] property rights are infringed upon or their rules violated, fishers would have the option of not only relying upon community sanctions to penalize rule violators, but they could also choose to have sanctions imposed on the violators by an external authority. The arrangements can also be strengthened by including representatives from fishing communities in the policy process when new policies are being considered in relation to fisheries. In that way the impact new policies may have on such arrangements can be taken into consideration. Policies can be adapted to the existence of the institutional arrangements, and care can be taken so as not to destroy them.

Government agencies can also encourage or facilitate fishers in devising their own institutional arrangements to govern how harvesting activities are to take place. Fishers can be encouraged to cooperate to solve problems that arise

in relation to the use of the grounds they harvest from. An example of this type of facilitative policy has occurred in Turkey. The Turkish government has encouraged coastal fishers to organize cooperatives both for marketing purposes and to devise rules of harvest (Berkes 1985:74). The government has established particular conditions that the cooperatives must meet, such as forbidding discrimination on the basis of ethnicity in relation to accepting members (Ibid:72). Fishers, however, are given great leeway in devising the charters of their cooperatives and their operating rules. As long as the rules fishers devise are created in the context of their cooperatives, the Turkish government will typically recognize those rules.

Recognizing existing institutional arrangements, and encouraging or permitting fishers to create their own arrangements requires a different conceptualization of the forms of ownership that may be most effective in relation to coastal fisheries. The current approach, as discussed in Chapters One and Three, is to establish individual private property rights in relation to the flows of fish by creating individual transferable quotas. Not only does establishing quotas serve as an attempt to resolve a very specific problem—stock externalities—but it is also an attempt to take advantage of the perceived strengths of individual private property rights systems.

As discussed in Chapter Three, however, individual private property rights systems are often inappropriate in the context of coastal fisheries. Flows of fish, their variability over time and space, and their migratory nature, are not amenable to being divided into individual quotas. In addition, the varying productive capabilities of fishing grounds limits the usefulness of individual private property rights systems. Dividing fishing grounds into individual plots may make them less valuable than if they could be utilized as a single ground (Netting 1976). Some individual plots may be barren, others may only be productive during certain times of the year and not during others. By permitting fishers access to the full expanse of grounds that they utilize, they can avoid the barren areas, and access the productive areas over time, evening out their production. Thus, in relation to coastal fisheries, collective forms of ownership may permit more effective utilization than individual forms of ownership. The effectiveness of different forms of ownership must be taken into account.

Besides facilitating fishers in developing their own institutional arrangements, either by providing a supportive environment as in the case of Turkey, or by simply not forbidding the creation of such institutional arrangements, government authorities can assist communities of fishers in cooperating to address problems of declining fish

populations and declining quality of fish. Government authorities can provide arenas whereby communities of coastal fishers who harvest from the sane stocks of fish can cooperate to devise rules to address problems that extend across the fisheries. For instance, fishers can devise rules that forbid particular types of technologies that are particularly destructive to stocks of fish, such as small mesh size nets that harvest immature fish.

Finally, government agencies can provide public goods that are supportive and sustaining of fisheries. These services are public goods in the sense that once they are provided it is difficult to exclude any community of fishers from consuming them. Examples of such services are regulations that protect fishery environments such as pollution requirements, or forbidding of mining and drilling in or near fishing grounds, or the banning of particular types of gear that are destructive of fishery environmehts. Research on fish stocks, identifying different species and subspecies, and the population dynamics of fish populations provides information that can aid in avoiding the destruction of stocks. Research on fishing technologies and their impact on the physical structure of fishing grounds and on fish stocks can also assist fishers in utilizing more advanced forms of technology without necessarily destroying fish populations.

In general, government authorities can engage in a variety of roles in relation to governing coastal fisheries besides directly structuring the day-to-day harvesting activities of fishers. Existing institutional arrangements can be recognized and given legal protection, fishers can be encouraged to devise their own arrangements, fishers can be brought together to work on problems that extend beyond their own fishing grounds, and services that support the maintenance of fisheries can be provided. These roles require the nesting of institutional arrangements instead of having a single centralized authority directly managing fisheries. That is, local arrangements that take advantage of time and place information to resolve local problems can be nested within arrangements whose jurisdiction extends beyond any single community of fishers. Larger arrangements that address problems extending across coastal fisheries in turn may be nested in even larger arrangements such as a national system of government. Nested arrangements permit the utilization of time and place information that is necessary for effective rules to be devised, while also permitting the establishment of arrangements that more closely correspond to the extent of various problems that must be addressed. While local arrangements address problems occurring within particular grounds, regional arrangements may address problems that extend across several grounds, and national arrangements may address problems or

provide services that extend across numerous grounds, or that involve international issues.

In order to support an alternative approach to the governance of coastal fisheries, an approach that is supportive of the institutional arrangements fishers have devised, additional research is necessary. As this study reveals, fishers have established institutional arrangements to solve particular problems such as assignment problems and technological externalities, but how they established the arrangements, and how the larger institutional environment in which fishers operate affected their ability to cooperate was little explored. That is, the exact decision rules fishers utilized in designing institutional arrangements, and the autonomy fishers possessed to design their own rules, and how that autonomy varied from jurisdiction to jurisdiction, were topics not explored in this study, but which are logical next steps in any future research program. It is important not only to know that fishers have designed institutional arrangements in order to solve particular problems, and that these arrangements perform well, but it is also important to understand how fishers undertake the process of institutional design, and how these processes are affected by the larger institutional environments of which fishers are a part. Understanding the collective choice processes utilized by fishers and how other institutional arrangements affect such processes permit the development of policies that encourage and support institutional design on the part of fishers.

In governing coastal fisheries the challenge is to recognize the opportunities and constraints a complex and variable physical environment provides instead of ignoring these difficulties by assuming a stable and well-defined physical environment. In addition, recognition must be given to existing institutional arrangements that have been devised by fishers to resolve particular problems instead of assuming no institutional arrangements exist because a government agency is not directly regulating the situation. Assuming a stable physical environment and an institutional void, as is done with the bionomic model, dismisses many of the most crucial questions in relation to governing common pool resources such as coastal fisheries. Little attention is paid to how the physical environment creates a variety of problematic situations for fishers, or to how different levels of information fishers possess, or the extent of their control over a situation, affects the types of arrangements they devise. Nor is any attention paid to how institutional arrangements fishers have devised perform differently depending upon the problem or problems fishers are attempting to resolve, or how the arrangements are structured. Ignoring crucial variables of the physical and institutional environments characteristic of many coastal fisheries results in inappropriate policies being

implemented, and the possible destruction of existing governing arrangements. By recognizing and understanding the existence of arrangements fishers have devised or have the potential of devising, more appropriate and beneficial policies can be created that serve to maintain coastal fisheries.

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