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THE BIONOMIC MODEL, INDIVIDUAL TRANSFERABLE QUOTAS AND SELF-GOVERNING FISHERY INSTITUTIONS

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I. INTRODUCTION

In the fields of fisheries management and fisheries economics there remains a fundamental puzzle. The policy recommendations derived from economic models are rarely voluntarily adopted by coastal fishers, whereas policies that economic analysis demonstrate to be inefficient are, often times, voluntarily adopted by coastal fishers. Two conclusions may be drawn. First, fishers are ignorant, or, if not ignorant, trapped in cultural or economic systems that prevent them from adopting more efficient forms of management. Second, fishers know something that policy analysts have thus far failed to grasp. In this paper, I focus upon the second conclusion. The models that most economic analyses rest upon, fail to capture critical aspects of the fishery environment. In particular, such models fail to account for the various common-pool dilemmas that fishers experience, and they fail to explain the various institutional arrangements that fishers have adopted.

Even if institutional arrangements in coastal fisheries are accounted for, however, similar conclusions as those from standard fisheries economics models are drawn. External governmental intervention is necessary. Self-governing arrangements devised by fishers are generally effective in addressing local common-pool resource dilemmas, but dilemmas that engulf numerous, interconnected, fisheries require external intervention. The form such intervention should take is subject to dispute, nevertheless, it is necessary. I argue this conclusion represents another example of policy analysts, myself included, of failing to fully understand the complexity and impact of the institutional arrangements that fishers have designed. In particular, little attention has been paid to the unintended consequences, or the emergent properties, of these institutions. External intervention is, in many instances, unnecessary to address CPR dilemmas that fishers face. Even in circumstances in which external intervention may be necessary, that intervention can take many different forms. It need not involve direct control.

The paper is organized in the following manner. In Section II, the bionomic model, and policies derived from it, are briefly discussed. This leaves us with the puzzle of why fishers adopt economically inefficient policies. In Section III, this puzzle is explored through a careful examination of self-organized fishing institutions, the types of rules that fishers adopted, why these organizations appear to "work" for fishers, and why rules suggested by policy analysts are unlikely to "work". Nevertheless, fishers seem to be unable to address at least some CPR dilemmas, leading to the conclusion that some form of external intervention is necessary. In Section IV, however, I discuss the possibility that self-governing fishery organizations may exhibit emergent properties that are capable of addressing a wide range of CPR dilemmas. If that possibility is realized, I argue that self-governing fishery organizations will perform better than the latest policy fad--individual transferable quotas. Finally, in Section V I make concluding remarks and suggestions for further research.[1]

II. THE BIONOMIC MODEL

The environment of coastal fisheries is quite complex. Many aspects of the physical environment are not well understood because of fluctuating fish stocks, interaction among stocks of fish and other forms of ocean life, and climatic changes and human intervention. In addition, fishers have created a

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[1] I have shamelessly copied, verbatim, arguments from Schlager (1990, 1994) in Sections II and III. Those familiar with my work (i.e., Lin) can "cut to the chase" (as they say in Hollywood) and focus on Section IV.

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 problems arising in the use of fisheries, both offshore fisheries, and inshore, or coastal fisheries.

A variety of what Ostrom, Gardner and Walker (1994) call common-pool dilemmas, arise in the use of fisheries. Appropriation externalities arise from fishers failing to account for the costs they produce for other fishers as they harvest (Smith 19S8). 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. 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. 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.

The predominant policy model, the bionomic model, used by many policy makers in devising management systems to regulate fisheries, only addresses appropriation externalities.[2] The bionomic model is a 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. The fish stock is assumed to be homogeneously distributed across space. In addition, the institutional environment is sparse. No entity regulates the use of fisheries. No limits exist on who can access fisheries and no rules exist to govern the harvesting of fish. Fishers who operate within this institutional vacuum are assumed to use identical technologies. Given the assumptions of homogeneous distributions of fish over space, and the use of identical technologies by fishers--assumptions that eliminate assignment problems and technological externalities--the only problematic situation to be addressed is appropriation externalities.

Appropriation externalities occur because 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.
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).

[2] For example, see Matthews (1988) and Matthews and Phyne (1988) for a discussion of the use of the bionomic model for managing Canadian fisheries.

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, possesses a variety of command and control regulations 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 used, 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 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.[3]

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. Effort is reduced by forcing boats out of the fishery. As a result of a 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).

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. Fishers who remain in the fisheries may 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.

Institutional arrangements believed to limit overall effort to an

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

efficient level are taxes on effort, and individual transferable quotas. 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. The resources that would have been invested in inefficient levels of effort are siphoned off by the tax.

In practice, taxes on effort have not been used to encourage the economic harvesting of fish. 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).

Instead of taxing effort or catch, an increasingly accepted policy is individual transferable quotas (ITQs), whereby each fisher would have the right to harvest a certain number or amount of fish. Each ITQ system would vary somewhat due to specific circumstances, but a typical system would work as follows. First, a government agency would establish the amount of fish to be harvested, ie., total allowable catches (TACs). In so doing, presumably the agency would 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 (Copes 1986:280).[4]

[4] Since ITQs have only recently been put in place, few empirical evaluations exist. Nevertheless, several scholars argue that ITQs will fail to induce economically efficient harvesting of fish. As one critic, Copes argues, the same process that occurred with licensing systems is now threatening to occur with ITQs (Copes 1986). 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

Policies derived from the bionomic model are quite specific. Fishery-managers should not impose area or seasonal closures, gear restrictions, and licensing as means of limiting effort. Fishers can easily substitute other types of effort in order to avoid such restrictions. Instead, taxes and ITQs are economically efficient methods of limiting effort. Since ITQs are administratively more feasible than are taxes, ITQs are the favored method of limiting fishing effort.

III. SELF-ORGANIZED FISHERY INSTITUTIONS

In considering coastal fisheries, the predicted outcome of the bionomic model--the inefficient use of fisheries--is correct, but only in those coastal fisheries in which the institutional assumptions of the model hold. Fishers, in those fisheries in which there are no entry or harvest restrictions, likely experience substantial inefficiencies. In many coastal fisheries such assumptions do not hold. Fishers have organized themselves and adopted entry and harvesting rules that govern their use of fishing grounds. These self-governing management regimes, however, are strikingly different from those advocated by resource economists. Fishers manage fishing grounds through use of seasonal and area closures and gear restrictions. They do not manage fishing grounds through taxes or ITQs. In other words, fishers adopt policies that resource economists claim are inefficient.

In the following paragraphs I argue that fishers confront a variety of CPR dilemmas, not just appropriation externalities, as is supposed by the bionomic model. Fishers are more likely to address these other dilemmas because they can exercise more direct control over them, than they can appropriation externalities. In addressing different dilemmas, fishers adopt "inefficient" policies, inefficient, that is, if appropriation externalities are to be directly resolved. To understand this argument, it is first necessary to understand the complexity of the various dilemmas that fishers face.

In the context of the physical environment of coastal fisheries, appropriation externalities, technological externalities, and assignment problems vary in their complexity. This complexity affects the likelihood of fishers designing institutional arrangements to address specific externalities. Wilson (1982) argues that dilemmas meeting three criteria are likely candidates for solution. These three criteria are:

1. Repeated encounters under roughly similar circumstances in which opportunistic individual behavior is seen to destroy the possibilities for collective gain.
2. An information network, arising from trading, competitive, or other interactions which forms the basis for the identification and negotiation of possible rules.
3. A collective means for the enforcement of these rules (Wilson 1982:240).

In other words, according to Wilson, if fishers are to voluntarily address CPR dilemmas, fishers must first recognize that their actions negatively affect each other. Such recognition is more likely to emerge in repeated situations. But simple recognition is not enough. Fishers must also regularly interact within a community that provides them with opportunities to discuss

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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 appropriation externalities.

their common problems and to propose collective solutions. Finally, if solutions (i.e., rules) are adopted, they must be enforced to be effective.

Whether these criteria are met, however, depends critically upon the aspects of the physical environment of coastal fisheries most closely intertwined with the CPR dilemma. As discussed below, dilemmas that are based upon the flow of fish are much less likely to meet Wilson's three criteria, whereas dilemmas that are based upon the physical structure of fishing rounds are much more likely to meet his criteria.

Appropriation Externalities

On the basis of the criteria, fishers are not likely to engage in institutional change in an effort to directly resolve appropriation externalities. This dilemma, which arises because numerous fishers harvest from shared stocks, is one of the most complex for fishers to resolve due to the nature of fish stocks. Fishers harvest from multiple stocks whose populations fluctuate unpredictably and whose population dynamics are not well understood (Dickie 1979; Wilson 1982). Consequently, it is extremely problematic for fishers to determine whether a decrease in the fish population is due to harvesting, environmental circumstances, or both. In addition, because coastal fishers lack information concerning the population dynamics of fish stocks, determining 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 is also very difficult, if not impossible. Since fishers cannot measure with sufficient accuracy the magnitude of the problem, nor the exact causes, they are unlikely to devise arrangements to resolve appropriation externalities. Appropriation externalities do not meet Wilson's first criterion of repeated encounters under similar conditions.

Wilson's second criterion, that the dilemma be confined primarily to fishers who harvest from shared grounds, also is frequently not met in relation to appropriation externalities. Numerous communities of fishers often harvest from the same stocks of fish, compounding the problem of determining the production effects fishers have upon each other. In order to address appropriation externalities fishers would have to determine the costs generated by all other fishers utilizing a common stock. All communities of fishers harvesting from a single stock would have to coordinate their activities to eliminate appropriation externalities. Having failed to meet Wilson's first two criteria, considerations concerning the third criterion--enforceability of agreements--are moot.

Technological Externalities

Unlike appropriation externalities, technological externalities may be more amenable to solution because they are not based on fluctuating flows of fish. Direct physical interference, that is, entangling of gears, is immediately noticeable, and the causes of it understood. Indirect physical interference is not immediately apparent, although through "repeated encounters under roughly similar circumstances" 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). By possessing knowledge of the causes of technological externalities fishers can consider alternative sets of rules to address these problems. Technological externalities appear to meet Wilson's first criterion.

Second, unlike appropriation 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. As fishers engage in harvesting within a finite space they can interfere with each others activities. Mobile gears can be dragged through an area where fixed gears are set, damaging both technologies. The effects of technological externalities may be localized to a few fishers or a group of coastal fishers, meeting Wilson's second criterion.

The ease and costliness of monitoring rules affects the likelihood and extent to which rules will be enforced--Wilson's third criterion. The costliness of monitoring is affected by the type of behavior upon which the rules focus, the design of the rules used, and the ability of fishers to monitor as a byproduct of harvesting fish. In relation to technological externalities, rules typically constrain the types of gear that may be utilized as well as the spacing of gear (Berkes 1977; Cordell 1972; Davis 1984). Such required behavior is relatively easy to monitor. In many instances, one need only look at a boat to determine the type of gear utilized and whether it is located in an appropriate area. Thus, monitoring is easily accomplished by fishers as they engage in harvesting. In fact, it is often in their direct self-interest to do so. If a fisher notices another boat utilizing gear in an area forbidden to that gear, the fisher, in either reporting the violation or confronting the transgressor, acts to protect his own gear. In many instances, technological externalities meet Wilson's third criterion.

Assignment Problems

Assignment problems are defined by the physical structure of fishing grounds and often meet the first two criteria established by Wilson. Fish consistently congregate to those areas and spots that provide food and shelter from predators (Grossinger 1975; Miller 1989). Since those areas and spots of fishing grounds 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 a community of fishers (Forman 1966; Davis 1975; Berkes 1986).

The stability of choice fishing spots meets Wilson's first criterion. 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 possible escalation of conflict, fishers are made aware that opportunistic individual behavior results in suboptimal outcomes. These problems are immediately noticeable. In addition, because choice spots arise in relation to the physical structure of fishing grounds, assignment problems arise among the community of fishers who are utilizing those grounds. Because these problems are restricted to a geographic area, they often meet Wilson's second criterion.

The ease and costliness of monitoring and enforcing rules designed to address assignment problems may, in many instances, be relatively low. In relation to assignment problems, rules typically allocate spots for a specified period of time (Berkes 1986; Martin 1979). Such required behavior is relatively easy to monitor. One need only look at the positioning of a boat to determine whether it is located in its specified area. This can easily be accomplished by fishers as they engage in harvesting. In fact, it is often in their direct self-interest to do so. To avoid being foreclosed from harvesting fish, fishers face strong incentives to ensure that their assigned spots are not utilized by others. Wilson's third criterion is often met in relation to assignment problems.

Given Wilson's criteria and the physical environment in which fishers operate, when confronted with appropriation externalities, technological externalities, and assignment problems, fishers are more likely to attempt to mitigate technological externalities and assignment problems than they are appropriation *externalities.When confronted with* technological externalities and assignment problems, a group of fishers can reduce such problems by changing the structure of their situation by adopting rules that coordinate their use of a shared fishing ground. That is, they can manage the use of space within their fishing ground. In contrast, a group of fishers are unlikely to reduce appropriation externalities by adopting a set of rules since the cause of such externalities extends beyond the boundaries of a single group of fishers, and, consequently beyond their ability to resolve.

Fishers' Responses to CPR Dilemmas

In this section, the above assertion will be examined using a data collected from 30 coastal fishery case studies involving 44 subgroups of fishers. These 44 subgroups are the units of analysis that form the basis for this study.[5] The rules that organized fishers have adopted to coordinate their use of shared fishing grounds will be presented and discussed. The rules that fishers adopt support the conclusion that fishers directly address technological externalities and assignment problems, but not appropriation externalities, although resolving technological externalities and assignment problems may also work to lessen appropriation externalities.

As well as examining the types of rules fishers adopt, another means of exploring the types of dilemmas fishers are more likely to address is to examine whether fishers, when confronted with technological externalities, assignment problems, and appropriation externalities, are equally likely to address each dilemma, or if instead they are more likely to attempt to address particular ones. While it is possible to conduct such an inquiry in relation to technological externalities and assignment problems, because data on such problems is available, it is not possible to do so in relation to appropriation externalities. Obtaining a measure of appropriation externalities is highly problematic. Not only do fishers lack sufficient information concerning stock dynamics and the effects of their actions upon each other's harvest, researchers also have inadequate measures of stock dynamics in field settings. Thus, direct measures of appropriation externalities are not reported in the case studies. Consequently, only data on technological externalities and assignment problems will be presented. Such data suggest that fishers often attempt to address technological externalities and assignment problems when confronted with them.

Finally, the performance of the rules adopted by the fishers is examined. The rules are generally successful in assisting fishers in resolving technological externalities and assignment problems. Fishers, however, appear to be more adept at reducing assignment problems than they are at reducing technological externalities.

Organized Fishers. One response to a fishery dilemma is to do nothing. By assumption, each fisher makes the best response to the fishing strategies adopted by others. Another response is to attempt to organize so as to change the structure of the rules affecting fishing activities. As stated above, one could hypothesize that fishers are more likely to organize to address technological externalities and assignment problems than they are to address production externalities.

In examining this assertion, one is immediately faced with the question of how does one know whether fishers are organized, since many fishers' organizations are quite informal. They may involve meeting in the local coffee house to discuss common problems at the end of the day rather than create a formal organization that is somehow recognized from the outside. Christy (1982) argues that for fishers to organize and gain control over their grounds, they must be able to use a boundary rule that requires something in addition to simple residency in a locality such as the purchase of a license

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[5] For an exhaustive discussion of the data see Schlager (1990, 1994) and Schlager, Blomquist and Tang (1994).

or a required type of technology. This is the first criterion used here to determine whether fishers are organized--the presence of a boundary rule with more provisions than simply local residence. The second criterion used to determine whether some form of organization is present relates to the existence of harvesting rules that place limits on the actions that can be taken or the outcome achieved. Of the forty-four subgroups for which data is available, thirty-three meet these two criteria and are considered "organized." Eleven of the subgroups do not have restrictive boundary or harvesting rules and are thus not considered to be organized.

Boundary Rules. Established boundary rules reveal 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 1). Fourteen different types of boundary rules are utilized among the thirty-three subgroups. Each of the 33 subgroups use combinations of rules. That is, no subgroup uses just a single boundary rule. The rules used by most subgroups (30 out of 33) are residency rules that require fishers to reside in a particular village or region of a country to gain access to particular grounds. The second most common rule is a technology rule. Twenty-two subgroups (67%) limit access to their fishing grounds on the basis of the type of technology used. Boundary rules based on gear assist in alleviating technological externalities. By limiting the types of gear that can be brought into the grounds interference among gears is minimized. Note, further, that boundary rules can have an effect upon appropriation externalities. Limiting both the number of individuals who can access a ground and the type of technologies they can utilize limits the amount of fishing effort applied in harvesting, and thereby possibly affecting the magnitude of appropriation externalities.

Harvesting Rules. A frequency count of the harvesting rules used in the 33 organized subgroups is shown in Table 2. Five different types of rules are used in these groups: location rules, size rules, season rules, order rules, and time-slot rules. Subgroups frequently rely on more than one harvesting rule. The most often used rule is one that limits harvesting activities to specific locations or spots. Every subgroup in the sample used a location rule to determine how choice fishing spots are distributed. Access to fishing spots is dependent on meeting any of a variety of requirements. The gear that a fisher uses may affect which fishing spots are available to a given fisher (Davis 1975). Or a fisher may gain access to a choice spot through a lottery (Faris 1972).

The second most frequently used rule is a size rule requiring that fishers harvest fish greater than a minimum size. This rule is typically used to ensure that fish achieve maturity and have a chance to spawn before being harvested. Nine of the 33 subgroups utilize this rule. In all but one instance an external authority imposed the size rule on the fishers.

The third most frequently used rules are seasonal restrictions and harvesting in a fixed order. Seasonal restrictions forbid the harvesting of fish during specific times of the year, typically when fish spawn. In the case of seasonal restrictions, all but one of the rules was devised by a government authority. Harvesting in a fixed order defines how choice spots on the grounds can be accessed and harvested. Often times the rule requires that fishers take turns in accessing particular spots. All of the order rules were devised by fishers.

The fourth most frequently used rule is a fixed time slot rule. This rule is often combined with a fixed order rule or a location rule. It limits the amount of time that a boat can remain on a choice fishing spot. Typical limits involve one casting of a net, or one day (Alexander 1977, Cordell 1972).

The Missing Rule. Given the attention placed by policy makers on quota rules, it is surprising that in no instance among the sample of coastal fishing grounds included in this study did fishers utilize a quota rule. A quota rule defines a specific amount of fish that each fisher can harvest. Thus, in this sample, no attempt has been made to directly regulate the quantity of fish harvested. Combining a lack of quota rules with a predominance of spot or location rules suggests that fishers are attempting to govern the use of the space of their fishing grounds as opposed to directly managing the quantity of fish appropriated. The rules observed focus more on the resolution of assignment problems and technological externalities.

Commons Dilemmas and Organized Fishers

Another approach to examining whether fishers are more likely to address particular types of commons dilemmas, in addition to examining the types of rules that fishers have adopted, is to explore whether fishers have adopted such rules when confronted with commons dilemmas. Are fishers more likely to organize when confronted with particular types of dilemmas?

Table 3 arrays technological externalities and/or assignment problems at the beginning of the case history by whether fishers had organized harvesting activities. The expected relationship that subgroups who experience either or both of the dilemmas will have organized their harvesting activities holds. Among all 44 subgroups comprising this data set, 31 subgroups experienced moderate to high levels of assignment problems and/or technological externalities. Of those 31, 27 have organized their harvesting activities, while 4 have not.

Performance of Fishers' Organizations

Do the rules that fishers utilize to coordinate their use of fishing grounds reduce technological externalities and assignment problems? The evidence suggests that rules adopted by the fishers do reduce the severity of the two commons dilemmas. Considering just the 31 subgroups that experienced technological externalities and/or assignment problems, Table 4 examines whether fishers who adopted rules where more likely to have reduced the severity of those dilemmas by the end of the case study.

Among the 31 subgroups of fishers, 10 experienced only assignment problems, 12 experienced only technological externalities, and 9 experienced both. Table 4 examines the 19 subgroups that experienced assignment problems. Of those 19, 16 are organized. Of those 16, 81% experienced minimal assignment problems, while 19% experienced moderate assignment problems. All three unorganized subgroups experienced high levels of assignment problems. Clearly, fishers who have organized themselves have been successful in reducing assignment problems.

Table 4 examines the 21 subgroups that have experienced technological externalities. Of those 21 subgroups, 17 are organized. Of those 17, 53% experienced minimal levels of technological externalities, 47% experienced moderate to high levels of technological externalities. Fishers who have organized have been more successful in addressing technological externalities. Clearly, fishers who have been able to devise and adopt rules that change the structure of their situation have achieved better outcomes than fishers who have failed to coordinate their harvesting activities.

The harvesting activities that fishers engage in are not captured by the bionomic model. Fishers organize to coordinate their harvesting activities in order to directly address assignment problems and technological externalities. Most of the rules used govern the type of technologies that can be used in fishing grounds rather than the quantity of fish harvested. In addition, fishers allocate space within their fishing grounds either to particular technologies or to fishers to be used for a given period of time.

IV. QUOTAS, EMERGENT PROPERTIES, AND NESTED INSTITUTIONS

The bionomic model can be interpreted to imply that the rules that fishers voluntarily adopt to address technological externalities and assignment problems will not address appropriation externalities. In fact, rules that limit entry and technology, and rules requiring seasonal and area closures, may very well exacerbate appropriation externalities since these rules fail to limit overall effort. The only means of addressing appropriation externalities is to limit effort by limiting catch. External intervention in the form of individual transferable quotas is the best management tool to address appropriation externalities.

Oddly enough, scholars and practitioners who do not automatically assume that all fisheries are open access, and who are more sympathetic of fishers' efforts to adopt self-governing institutions, scholars such as myself, are often led to the same conclusion. Since fishers are only able to address a limited number of CPR dilemmas, those dilemmas that emerge as a result of the physical structure of the fishing grounds, and are unable to address CPR dilemmas that stem from the flow of fish, some type of external intervention appears necessary, if the full range of CPR dilemmas is to be addressed.

The call for external intervention is too often used when phenomena like self-governing fishery institutions are not fully understood. It may be the case that even though rules adopted by fishers directly address technological externalities and assignment problems, they also indirectly address appropriation externalities. The argument is not a difficult one to make. First, as discussed in the previous section, the fishers who have organized themselves have very carefully regulated entry. In order to gain access to fishing grounds, local residency is a must. Local residency is often difficult to establish. In the case of Maine lobster grounds, a man could not simply move to a coastal fishing village and expect to gain immediate access (Grossinger 1975). The newcomer would have to find a local sponsor who would be willing to fish with the newcomer. Only after an apprenticeship had been served, and the lobstermen of the village had an opportunity to determine what the newcomer was like, would that person gain access to the lobstergrounds. In addition, local residency is combined with other conditions of entry, most typically a technology requirement. A fisher gains access only if he uses a particular type of technology. Thus, entry requirements alone limited the fishing effort in a fishing ground.

Fishing effort is also limited by harvesting rules. Fishers cannot harvest at will. A particular technology cannot be used throughout a fishing ground, rather it is relegated to a particular area. Fishers gain access to particular spots only during specific times of the year and only for specific time periods. These rules of harvest limit effort, once access to the grounds is gained. In addition to the access and harvesting rules that fishers adopt, there are myriad social pressures brought to bear on fishers that have the effect of bounding effort. For instance, although there were no formal rules-of-use, defining the maximum number of lobster pots a lobsterman could use, approximately 300 was the upper limit, and lobstermen discouraged each other from using more (Grossinger 1975). Many of the scholars who studied fishing villages of Nova Scotia and Newfoundland often commented on the very strong norm of equality that guided fishers behavior. This norm did not involve absolute equality, rather it was more of a notion that one should not be too much better than one's peers or one's neighbors (Martin 1975).[6]

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[6] The social norms used by fishers are every bit as real as the norms that many of us in academia experience that define how late into the evening we stay at our offices, the number of papers that should be under review at any one time, the number of committees that we sit on, how serious we take our teaching, and so forth. Even though these "rules" cannot be found in any faculty handbook, they

One could reasonably argue that the combined effect of the rules and norms is to prevent the emergence of appropriation externalities, or, more likely, delay the onset of appropriation externalities for several decades. While fishers may not have intended to limit effort, that is the effect of the rules and norms used. In other words, self-governing fishery institutions may be more than the sum of their parts. They may exhibit emergent properties, or produce unintended, but desirable, consequences. They may be more rich and complex than they initially appear to be by simply examining the rules by which they are constituted.

Whether this is the case requires substantial research and should, in my opinion, be made a priority among scholars investigating common-pool resources. The Workshop's research project on common-pool resources has done, and continues to do, an excellent job of examining and explaining the development, maintenance, success and failure of local level, self-governing institutions in relation to a wide variety of common-pool resources.[7] For the most part, however, the focus has been on examining the conditions that support or inhibit collective action, the rules adopted by resource users, the dilemmas such rules resolve, and evaluating the performance of such institutions. In other words, these institutions have been accepted at face value, they have been treated as if they are simply the sum of their individual rules. I suspect, however, that many of these self-governing institutions exhibit emergent properties, that they do more than is realized. Consequently, most studies of these institutions have probably understated their benefits, and overstated their limits and their fragilities.[8]

Understanding emergent properties promises a better understanding of appropriate relations between different levels of government and different means of governing CPRs. It is often the case that because something does not "formally" exist, it is assumed not to exist at all. For instance, if a government agency does not regulate a fishery, or if a government agency does not recognize fishers' property rights in a fishery, the fishery is presumed to be open access. A government agency must intervene and limit access, even though fishers may have organized themselves. Or, if fishers devise rules that directly address technological externalities and assignment problems, but not appropriation externalities, then fishers must be unable to address appropriation externalities. A government agency must intervene and assist the fishers in resolving appropriation externalities, even though the self-governing arrangements of fishers may have resolved appropriation externalities. In either case, direct external governmental intervention is recommended, often to the detriment of existing local self-governing institutions (Davis 1984, Matthews 1988).

I have, in the past, argued for direct governmental intervention in coastal fisheries[9], and now I want to redeem myself and make a somewhat different argument (Schlager 1990, Schlager, Blomquist and Tang 1994). If we can assume that self-governing fishery institutions do a reasonably good job of limiting effort, then local fishery institutions are more likely to perform better than are ITQs, and we need to rethink intergovernmental relations. Let's begin with a comparison of the two governing systems. First, local fishery institutions address multiple common-pool dilemmas--technological

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exert greater pressure on our actions than does any handbook.

[7] Even if I do say so myself.

[8] The one exception to this, that I am aware of, is the work of Lansing (1991) and Lansing and Kremer (1993) on the irrigation systems of Bali.

[9] *mea culpa.*

externalities, assignment problems, and appropriation externalities. ITQs address a single common-pool dilemma--appropriation externalities. An ITQ system does not limit the type or the use of technologies, and, therefore, does not address the other two types of dilemmas.

Second, local fishery institutions provide fishers with more flexible harvesting strategies, allowing fishers to distribute their effort across several stocks of fish, unlike ITQs that often lock fishers into one or two stocks that then must bear substantial levels of effort. Under local governing institutions, fishers typically change their harvesting strategies, depending upon the abundance of different stocks of fish. If a fisher is doing poorly in his attempts to harvest one stock of fish, as long as he follows technology and assignment rules, he can switch to other stocks of fish in search of better catches (Davis 1984, Shortall 1973). On the other hand, ITQs are often devised on a stock by stock basis, and fishers are limited in the number of different types of ITQs they may acquire. Fishers are locked into one or two stocks thereby strictly limiting their harvesting strategies.

Third, and most importantly, it is much easier to effectively monitor and enforce compliance with self-governing fishery institutions than it is to monitor and enforce a system of ITQs. Compliance with fisher devised rules can be monitored by fishers as they engage in harvesting. Fishers can readily identify boats that do not belong in their fishing grounds, they can easily determine if their fellow fishers are using appropriate technologies in appropriate areas, and they can immediately determine if another fisher is harvesting from their assigned spot.

Not only can fishers readily monitor compliance with rules as they harvest, in most instances, it is in their direct self-interest to do so. As discussed is Section III, if a fisher notices another boat utilizing gear in an area forbidden to that gear, the fisher, in either reporting the violation or confronting the transgressor, acts to protect his own gear; and to avoid being foreclosed from harvesting fish, fishers face strong incentives to ensure that their assigned spots are not utilized by others.

Monitoring and enforcing ITQs is much more difficult. Fishers cannot monitor each other while they are fishing. The only way to determine whether a fisher is harvesting within his quota is to examine his catch. Thus, most monitoring of ITQs takes place by officials at the dock, and many actions can occur away from the dock that undermine the effectiveness of the ITQs. Fish, in excess of the quota, can be sold in the black market. Even if fish are not harvested in excess of a quota, the practice of high grading can prove detrimental to fish stocks. If a specific size of fish is particularly valuable, fishers may fill their quotas with that particular size, dumping those fish that are less valuable. High grading results in high mortality rates to the fish that are returned to the ocean.

In addition, fishers face few incentives to monitor each others' compliance with ITQs. Quota cheating by one fisher does not pose a direct and immediate threat to other fishers. On the contrary, fishers face powerful incentives to cheat on quotas, given the difficulty in monitoring and the gains to be achieved by quota busting. Compliance with ITQs can quickly unravel as fishers come to believe that others are cheating and as they realize that they are unlikely to be caught if they do cheat.

Contrary to the accepted wisdom of the bionomic model, fishers are not engaged in inefficient practices by adopting entry and harvesting rules grounded in technology and area restrictions. Rather, coastal fishers have devised governing arrangements that can be expected to perform better than policies derived from the bionomic model. Instead of directly intervening in coastal fishery situations to fix problems, the protection and promotion of these self-governing arrangements should be made a high priority for external governmental authorities.

As local self-governing institutions in their full complexity come to be better understood, relations among different levels of government need to be more carefully considered. In many cases, direct intervention may be unnecessary and even harmful- Instead, what may become more important is ensuring that higher levels of governments limit their destructive actions. For instance, a policy that is often destructive of self-governing fishery institutions is subsidizing new, more powerful technologies, without considering the technologies' effects on fishing effort. Fishers who take advantage of the subsidies and acquire new technologies often face powerful incentives to cheat on existing rules--by invading other fishing grounds, or using the technologies in larger areas of their own grounds—so that they can more completely utilize the technology and meet their loan payments.[10]

Not only are there destructive acts that should be avoided, but there are supportive acts that should be taken by external government authorities. Granting resource users the authority to organize themselves and make fundamental management decisions concerning their resources would be beneficial. In addition, recognizing the rules that such local governments adopt, supporting the monitoring and enforcement of such rules, and providing arenas for conflict resolution would also be beneficial. In other words, substantial benefits can be realized in managing common-pool resources simply by providing resource users who have devised their own governance systems with a less hostile institutional environment.

V. CONCLUSION

The bionomic model, for once and for all, needs to be sunk. The record of policies derived from it is dismal. Licensing systems have failed. ITQs are unlikely to live up to the expectations heaped upon them. In addition, policies believed to be inefficient, such as technology and area restrictions, from the standpoint of the bionomic model, appear to work reasonably well in addressing several of the most common common-pool dilemmas that fishers experience. Policy research in fisheries should instead focus upon producing better understandings of the self-governing institutions that fishers have devised, through the use of modeling and computer simulations (Walters 1986). In particular, care must exercised so as to avoid reductionist explanations of these rich and complex institutions.

[10] For a more complete discussion of destructive of local self-governing institutions see E. Ostrom (1993).

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TABLE 1 **Required Boundary Rules**

Type of Rule	Number of Organized Subgroups Using Rule ($N = 33$)	Percentage of Subgroups Using Rule
Residency-local	30	91
Use of particular technology	22	67
Membership in an organization	13	39
License	7	21
Ownership of limited property related to harvesting (i.e., fishing berths)	7	21
Lottery	5	15
Race	5	15
Registration on eligibility list to participate in lottery	4	12
Continuing usage of access rights	3	9
Ethnicity	3	9
Ownership or leasing of land in area	3	9
Caste	2	6

TABLE 2 **Required Authority and Scope Rules**

Type of Rule	Number of Subgroups Using Rule ($N = 33$)	Percentage of Subgroups Using Rule
Withdraw at specific locations/spots	33	100
Withdraw fish of at least a specific size	9	27
Withdraw in a fixed order	7	21
Withdraw only during specific seasons	7	21
Withdraw at a fixed time slot	4	12

Source: Schlager, Edella (1994) "Fishers' Institutional Responses to Common-Pool Resource Dilemmas", in Rules, Games and Common-Pool Resources, by Elinor Ostrom, Roy Gardner, and James Walker, University of Michigan Press.

TABLE 3 **Technological Externalities and/or Assignment Problems by Organization**

	Moderate to High Technological Externality and/or Assignment Problem	Minimal Technological Externality and/or Assignment Problem	Indeterminate	Total
Organized	27 (87%)	0 (0%)	6[a] (75%)	33
Not Organized	4 (13%)	5 (100%)	2 (25%)	11
Total	31 (100%)	5 (100%)	8 (100%)	44

Lambda = .45

[a]Of these 6, none experienced assignment problems. There was insufficient information to determine whether any of the 6 experienced technological externalities.

TABLE 4 **Performance of Fishers' Organizations**

	Organized	Not Organized	Total
Assignment Problems			
Minimal assignment problems	13 (81%)	0 (0%)	13
Moderate assignment problems	3 (19%)	0 (0%)	3
High assignment problems	0 (0%)	3 (100%)	3
Total	16 (100%)	3 (100%)	19[a]
Technological Externalities			
Minimal technological externalities	9 (53%)	0 (0%)	9
Moderate technological externalities	7 (41%)	1 (25%)	8
High technological externalities	1 (6%)	3 (75%)	4
Total	17 (100%)	4 (100%)	21[b]

[a]Of these 19, 9 experienced technological externalities.
[b]Of these 21, 9 experienced assignment problems.

Source: (same as previous tables)