Community fisheries management What structure and why?

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ABSTRACT

Theory has shown and experience has verified that individual fishing rights such as territorial user rights (TURFs) and individual transferable quotas (ITQs) can be effective in overcoming the common property problem and generating economic efficiency in fisheries. Unfortunately, these property rights are not applicable to all fisheries. TURFs only work for species that are sufficiently sedentary to remain largely within individual TURFs. ITQs only work if the individual quota constraint can be sufficiently enforced and it turns out that in many fisheries the cost of this is simply prohibitively high. This applies not the least to the numerous artisanal fisheries around the world.

These limitations have drawn attention to the possibility of allocating not individual but collective rights to groups of harvesters. While noting that the type of rights conferred as well as the group receiving them may be quite varied, it is customary to refer to this arrangement as *community fishing rights*. Community fishing rights, of course, do not constitute a fisheries management regime. They merely endow the community with the formal powers and opportunity to implement an effective fisheries management regime. Obviously, there is no guarantee that this opportunity will be used.

This paper is concerned with identifying conditions under which community fishing rights are likely to enhance the economic efficiency of fishing. Such conditions can be seen as design principles that can assist fishing authorities around the world interested in setting up systems of community fishing rights.

Key words: fisheries management, community fishing rights, community fisheries management, fishing rights

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1. Introduction

Over the past thirty years or so, fisheries management has made substantial progress. Amongst fisheries management theorists there has now emerged a general agreement about which fisheries management systems work and which do not. More precisely, it has been established that only two classes of fisheries management systems, namely i) *corrective taxes* and ii) *property rights regimes*, are theoretically capable of generating lasting efficiency in fisheries (Arnason, 2007). Fisheries management by restrictions — such as total allowable catch, closed fishing areas and fishing seasons, restrictions on allowable fishing gear, limitations on fishing days, restrictions on the type and quantity of fishing capital etc. — has been found economically ineffective and, taking into account the cost of applying and enforcing these measures, possibly worse than nothing (Arnason, 1994; Arnason, 2007).

These theoretical results have been confirmed by experience. Worldwide it has been found that direct restrictions are both costly to apply and ineffective in improving the profitability of the fisheries (OECD, 1997; Schrank *et al*. 2003). At the same time fisheries management on the basis of property rights — sole ownership, territorial user rights (TURFs), individual quotas (IQs) and individual transferable quotas (ITQs) have been found beneficial (OECD, 1997; Shotton, 2000; Sutinen and Soboil, 2002). I have not been able to find any examples of taxation being employed as a means to manage fisheries.

Sole ownership and TURFs have limited applicability in ocean fisheries; sole ownership for socio-political reasons and TURFs for biological and technological reasons.[1] IQs and ITQs, on the other hand, are widely and increasingly employed. Indeed, by my recent count 22 fishing nations have already adopted ITQs as their primary fisheries management tool and about 25 % of the global ocean fish catch is currently taken under ITQs.[2] Experience with ITQs has generally been favourable. Under ITQs, fishing effort has usually decreased, fish stocks improved or stopped and, most importantly, economic rents have increased (Hatcher *et al*., 2002; Costello *et al*., 2008). Broadly speaking, it appears that ITQ systems, once they have been perfected, are capable of bringing fisheries reasonably close to the optimal point.

Unfortunately, ITQs, just as sole ownership and TURFs, do not seem to be applicable to all fisheries. There are two fundamental reasons for this; i) too high enforcement costs and ii) political opposition.

In some fisheries the cost of enforcing the ITQ constraint is simply too high relative to the benefits. This applies in particular to fisheries characterized by one or more of the

1. Most species of fish are too migratory to stay within a relatively small exclusive area.
2. These nations are New-Zealand, Australia, USA, Canada, Greenland, Iceland, Holland, Norway, Denmark, Sweden, Estonia, Germany, UK, Portugal, Spain, Russia, Morocco, Namibia, South Africa, Chile, Peru, Falkland.

following; i) a high number of small fishing units, ii) numerous low tech landing places, iii) high unit value of the catch (relative to the going wage), iv) readily accessible local consumer markets and v) little secondary processing and transportation of the catch. These factors make observation of harvested quantity difficult and, consequently, render the cost of enforcing individual quota constraints high.[3]

In many communities there is a high degree of antagonism to the marketization and economic rationalization that ITQs entail. The rationality of and reasons for these sentiments are not of concern in this paper. It suffices to note that this antagonism, in addition to making enforcement costlier, often translates into political opposition that makes it impossible to adopt ITQs. Thus, in the fisheries where these sentiments are sufficiently strong, the ITQ system is not a feasible option for fisheries management.

Thus, looking at the world as a whole, there are numerous fisheries in which neither TURFs nor ITQs are feasible. This applies to all kinds of fisheries but is perhaps most obvious in the labour intensive, low income artisanal type of fisheries that are typical in the less industrialized parts of the world including South-East Asia and Africa. These fisheries, although small scale and low tech, are economically important because they often represent subsistence activity, provide much needed high quality protein in low income areas and, taken as a whole, account for a high proportion of the global harvest of fish for human consumption (FAO, 2000; World Bank and FAO, 2008).

This observation has drawn attention to the possibility of allocating not individual but collective rights to groups of harvesters. While noting that the type of rights conferred and the nature of the recipient group may be quite varied, it is convenient to refer to this type of arrangements as *community fishing rights*.

The fundamental economic rationale for allocating collective fishing rights is the belief that the group or community receiving these rights is somehow more able than the central authority to improve the economic efficiency of the fishing activity (Berkes *et al*., 1989; Hanna, 1990; Ostrom, 1990; Ostrom and Gardner, 1993; McKay, 2000 Walker *et al*., 2000). In addition many authors seem to feel that this kind of an arrangement is socially more appropriate (Jentoft, 1985; Ostrom, 1990; McKay and Jentoft, 1998). A possible third reason for the surging interest in community fishing rights is that governments, frustrated by the complicated and seemingly intractable problems of fisheries management, are seeking a face-saving way to move the problem from their desks to someone else's.

This paper is primarily concerned with the first rationale for community fishing rights, namely that this arrangement is conducive for enhancing economic efficiency in the harvesting activity. This outcome, however, is by no means a forgone conclusion. Community fishing rights does not constitute a fisheries management regime. They merely constitute a delegation of the authority to manage the fishery to the community. The

3. Recent studies have shown that the cost of fisheries management often constitutes a very high fraction of the gross revenue of the fishery (Arnason *et al*., 2000; Schrank *et al*., 2003).

members of the community are still faced with the fundamental problem of designing and implementing a good fisheries management regime. The success of that undertaking depends fundamentally on the various parameters of the situation including the quality of the community rights, the number, composition and culture of the community members, the biological and economic situation and various other factors.

Members of a community with collective fishing rights find themselves in a situation where they have to play bargaining games with their fellow members. The games are firstly about what rules to adopt; both fisheries management rules and, more fundamentally, rules for decision making. Secondly the games are about measures to be taken within the existing set of rules. These measures may for instance concern the total allowable catch in the community. It should be intuitively clear that the outcomes of these bargaining games depend in a fundamental way on the group dynamics in the community and the rules under which the game is played.

The aim of this paper is to consider the nature of these bargaining games and to identify conditions under which the community management of fisheries on the basis of community rights is likely to succeed in increasing the economic efficiency of the harvesting activity.

Before proceeding it should be noted that community fisheries management is nothing new. When a group of households find themselves utilizing a limited natural resource, they have a great incentive to develop and enforce common utilization rules. Thus, especially in the absence of a centralized authority, community fisheries management may well emerge spontaneously. Indeed, as it turns out, there are numerous cases of large and small communities managing their fishing activities both in inland water-bodies and the ocean (*e.g.* Ostrom, 1990; Scott, 2008). According to Ostrom (1990), these community management units often appear to have been moderately successful. Unfortunately, in many instances, these community management structures seem to have been largely destroyed by the advent of larger centralized authority and its usurpation of fisheries management power (Ruddle, 1989; Ostrom, 1990; Scott, 2008). From that perspective, the present interest in community fishing rights and fisheries management represents a certain return to a previous arrangement.

The sharing of the right or power to manage fisheries may be seen to span a continuum from the exclusively (100%) the national government to exclusively the community. Anything in between these extremes can be referred to as government/community co-management. Some degree of co-management is, of course, what is most often the case in the real world although one party or the other may have most of the rights. In this paper, community fishing rights will refer to the situation where the community holds certain well-specified fishing rights and can, at least to a great extent, decide how these rights are used.

The paper is organized broadly as follows. The next section reviews the main arguments for the belief that community fishing rights may indeed increase economic efficiency in fishing and the empirical and experimental evidence on the matter. An important conclusion of this section is that the outcome of community fisheries management is quite varied. There are both cases of apparent success and failures. Which applies seems to depend on the particulars of each situation. The following section, section 2, attempts to specify conditions under which community fisheries rights are likely to lead to good fisheries management. As will become apparent, most of these conditions are neither very specific nor powerful in the sense of guaranteeing particular outcomes. Nevertheless, this chapter concludes with a set of recommendations for the set up of community fishing rights and management. The third section of the paper then discusses the possible application of community fisheries management to the fisheries around the world. Finally, the last section summarizes the main results of the paper.

2. What is the attraction of community fisheries management?

The fundamental economic rationale for allocating community fishing rights is that the community is at better improving the efficiency of the fisheries than the government. Increased efficiency may stem from three main sources. First, it is possible that the community will indeed be able to manage the local fishery better than the central authority. Second, it is possible, even likely, that the community may be able to enforce whatever fisheries management system it chooses more effectively and less expensively than the central authority. Third, community management of fisheries represents the devolution of power from the central government to a much smaller community of fishers. Decentralization of this kind makes it possible to reduce the size of government activities and, consequently, rent seeking and taxation. This is usually regarded as contributing to overall economic efficiency (Buchanan and Tullock, 1962). Let us now examine the first two of these rationales a bit more closely.

There are a number of reasons why the community may manage fisheries better than the central government. These reasons have to do with i) information, ii) incentives and iii) responsibility.

Effective fisheries management depends on good information. The crucial information relates to the fish stocks and their biology, the economics of the fishing fleet and market and price information. There can be little doubt that the fishermen are always much better informed about their own profit functions than any centralized authority. The same applies to information about local fishing conditions and stocks. It is also likely, that the fishermen are or can be better informed about price and market conditions than

the central government. Finally, if at all relevant to them, fishermen would probably be better informed about the overall fish stock conditions and their dynamics than the central government.[4] After all, the fishermen's own income and possibly family welfare depends on collecting all relevant information and interpreting it correctly.

Central authority officials first of all have difficulties collecting the necessary information as explained above. Secondly, they have much less incentives than the actual fishermen to effectively process the information the gather and to draw the correct inferences from it. After all, they are not risking their own money by being slow, ineffective or even wrong. On top of this, the centralized authority and its staff often have other agendas than maximizing the value of the fishery, even when that is their ostensible task.

Finally, community fisheries management puts the responsibility for management squarely on the shoulders of the fisheries community itself. If the community fails in this management, it will most likely have to suffer the consequences. Even in western type welfare societies, is unlikely that social safety nets will be as easily forthcoming when fishing communities fail in managing their own fisheries than when the central authority fails in its fisheries management function. Hence, this added responsibility contributes to even greater effort by the community members to conduct their fisheries management effectively.

The cost of enforcing fisheries management rules has turned out to constitute a substantial fraction of the gross value of the fisheries (Arnason *et al*., 2000; Schrank *et al*., 2003). There are reasons to believe that if communities of fishermen conduct the fisheries management these costs can be substantially reduced. Again the main reason for this is belief is information. The predominant part of most enforcement activities is usually the collection of information about the relevant activities.[5] There can be no doubt that fisheries communities, at least if they are not to large, are much better placed to obtain information about the operations of individual fishermen than any centralized authority. In fact, in most fisheries communities I know about, most everything of significance concerning the fishery is common knowledge. It follows that the fisheries communities can economize greatly on the information collection part of enforcement. Fisheries communities are also much better placed to impose the necessary sanctions than the central authority. Unlike the central authority, which has to follow formal rules, the community has all sorts of informal penalties at its disposal. Not the least can it drawn on the very effective powers of social sanctions in various forms.

Thus, it appears that fisheries communities can almost certainly enforce fisheries management rules much more effectively and inexpensively than any central authority.

4. It is important to realize that under the common property arrangement, this kind of biological information is of little relevance to the fishermen.
5. This is often referred to as monitoring and surveillance in the fisheries management literature.

There are further reasons for the attraction of community fisheries management of a more social or socio-political nature. First, awarding fishing rights and the authority to manage fisheries to communities clearly contributes to their greater independence of the communities as well as their ability to control their own destination. Community independence and autonomy, in turn, are frequently mentioned as one of the objectives of social arrangements. Second, fisheries management has proven an intractable and politically unrewarding task for many national governments. Therefore, any politically acceptable method for removing this obligation from the list of government responsibilities is automatically welcomed.

There are many community-based fisheries management systems in the world. Most of them are in fairly small traditional fisheries and the quality of the community rights and the overall set-up usually deviates quite a bit from what would be ideal for economic efficiency. Nevertheless, according to reports mainly in the anthropological and social science literature, many of these systems exhibit a marked ability to avoid the worst excesses associated with the common property arrangement (*e.g.* Ostrom, 1990; Ostrom and Gardner, 1993; McKay, 2000). There is also some experimental evidence (Walker *et al.*, 2000) supporting the hypothesis that community management may indeed, under certain circumstances, lead to a degree of economic efficiency in fisheries.

It is important to realize, however, that the outcomes of community fisheries management, both as reported from the field and in experiments, are quite widely spread. There are relative failures as well as successes. This suggests that it is not the mere existence of a community fisheries management that counts. The actual set-up of the community management and the particulars of each situation seem to be crucial.

3. Making community management work: Design principles

We now turn our attention to conditions that increase the probability that community management will result in an efficient fishery.

Assume the following setting:

- There is group of economic agents. We refer to this group as a community. Although we do not need to be overly concerned about the composition of this community at this stage, we may take it that it consists of both individuals and companies some of which may not necessarily be in the fishing profession. In the real world, the community would for instance often be a fishing village.

- The community collectively receives fishing rights. These community fishing rights may be of various kinds. They may for instance be TURFs, *i.e*. territorial user rights, or they may be harvest quotas, *i.e*. rights to a certain quantity of harvest or a share in the harvest of a species for a period of time. They could even be a combination of the two. In any case, these fishery rights constitute a collective property right.
- The community has the right to manage these rights. This means that it can for instance organize the fishing activity, allocate individual rights to members, set rules for harvesting and enforce these rules. In the interest of simplicity we assume that these community management rights are not constrained.

Now as already pointed out, there is no guarantee that the community will be able to use these collective management powers to manage the fishery well or even better than the government did before. However, there are certain conditions which increase the probability of this happening. Since the government in awarding the fisheries management rights to the community can to a certain extent create these conditions, we refer to them as design principles.

3.1 A high quality community property right

In the economic profession it is commonly argued that the economic efficiency of asset utilization increases with the quality of the property right in the asset (Demsetz, 1967; Arnason, 2000; Scott, 2000; Arnason, 2007b). By the same token, less than perfect property rights lead to less than full efficiency.

According to Scott (1996), the most crucial components of a property rights are:

- Security
- Exclusivity
- Permanence
- Transferability

As discussed in Arnason (2000), it is convenient to measure these properties on a scale from zero to unity, *i.e*. [0,1], with unity indicating the fullest extent of that property. It is not difficult to show that any deviation from the unitary value of these properties will result in loss of economic efficiency (Arnason, 2007). A property right with unitary values for each of its components is referred to as a perfect property right.

It immediately follows that community fisheries management can not be fully

efficient unless the collective property right is perfect.[6] This means that it must be secure, exclusive, permanent and transferable. Full security means that the right cannot be challenged or challenges can be brushed off at zero costs.

Exclusivity means that others cannot infringe on the rights and the rights-holder can utilize the subject of the right in any way he wants. Full exclusivity is generally very hard to ensure in ocean fisheries. Fish are mobile and usually not easily fenced in. Therefore, rights to particular fish are usually meaningless. Poaching is also hard to defend against. Finally, fisheries are often subject to policy interference by various segments of the population. What count here, therefore, are formal exclusive rights and the ability of the community to defend these rights.

Permanence means that the right is formally forever in the same way as any other property right. Permanence does not, of course, imply that the community will hold these rights forever. It merely means that if the rights are to be withdrawn full compensation must be paid. Permanence thus means that the community does not involuntarily have to give these rights. In practice a very long time horizon is sufficient for efficiency.

Transferability merely means that the community can transfer its rights to someone else if it wants to. If transferability is restricted, efficiency may suffer in the sense that someone else, perhaps another community, may be able to achieve higher efficiency in harvesting than the community in which the fishing right resides. Note, however, that while security, exclusivity and a certain degree of permanence are essential for the community fishing right to generate economic efficiency, transferability is not to the same extent essential. Thus, in many cases, restrictions on transferability of the fishing right to other communities could be imposed without seriously reducing the efficiency of fishing.

These considerations have clear implications for setting up community fishing rights. If efficiency is desired, these fishing rights should be as secure, exclusive, permanent and transferable as possible.

3.2 Decision making processes

The community will not be able to conduct fisheries management unless it can make decisions that are binding for community members. A necessary condition for that is that there is a decision making process in the community that enjoys sufficient support or at least acceptance by community members. This process consists of a decision making body (or bodies) and procedures.

In principle this decision making process can be anything. Generally, however, to enjoy the necessary support, it has to have sufficient basis in the culture and traditions

6. This, however, is not sufficient for efficiency because the community consists of members with nonexclusive rights.

of the community. Thus, in some cultures this decision making process has to be sufficiently democratic, possibly with a formal association, annual meetings where key decisions are made and an executive board. In other cultures, the decision making process could be in the hands of the elders of the community or even the traditional chief.

Irrespective of the set up of the decision making process, it is crucial that it is structured in a way that makes it capable of making decisions sufficiently expediently and is responsive to the economic wants of the community. At the same time, the transaction or bargaining costs of the decision making process should, to the extent possible, be minimized. Clearly certain decision making structures are more capable of attaining this than others. Presumably the government awarding the community rights can require the adoption of certain decision making processes or at least influence what decision making processes are set up

Note that a formal decision making process does not eliminate the need for bargaining. It merely defines when, where and in which way bargaining may take place. It should be intuitively clear, however, that if this is done in the appropriate way, the bargaining may be greatly facilitated.

3.3 Inclusive membership

It is certainly conceivable to set up a community with collective fishing rights with voluntary participation. This means that individual fishermen can stay out of, or even opt out of the community at a later stage, and still retain fishing rights. In fact, this arrangement would be in accordance with our usual idea of freedom of association in human societies. However, in the case of fisheries this would be ill-advised.

First, and most fundamentally, this possibility goes right against the exclusivity of the community rights. If outsiders can fish from the same stocks or harvest quotas as the community, then clearly community exclusivity is reduced. As a result, the arrangement can never be fully efficient.

Second, and perhaps more damagingly, this arrangement reintroduces the familiar common property problem. Thus, unless outsiders are subject to firm binding restrictions on expansion, they will expand until their private marginal benefits of expansion are zero. This will happen in particular, if the fisheries community undertakes fisheries management that enhances the fish stocks. Thus, in this case, all such efforts by the fisheries community will be fruitless. In this way, the outsiders will undermine and ultimately nullify all attempts by fisheries community to increase the efficiency in their fishery. As a result there will be no long term improvements in overall fisheries management.

This prognosis is further exacerbated by the fact that members of the fisheries community will have an incentive to leave the community. If the community fisheries management is to be at all successful, it must constrain the fishing effort of its members.

Thus, as is formally shown in the Appendix (Proposition 1), each of these members could do better outside the community, where he is unconstrained, than within. Thus, the community is continuously subject to fundamental fission forces of this kind. It follows that if it is possible to opt out of the community, this is very likely to happen, especially if this can occur with impunity and there are already outsiders operating.

The practical implications are clear. For a fisheries community to be able to increase efficiency it must be inclusive in the sense that it includes all fisheries operators. It must form a closed shop, so to speak. Alternatively, any outsiders must be subject to restrictions that are at least as binding as those faced by members of the community (Proposition 1 of the Appendix).

3.4 Homogeneity of members

Bargaining within a fisheries community about what fisheries policy to adopt is unlikely to lead to an economics efficient outcome unless the members of the community have identical profit functions or some further restrictions on the bargaining scope are introduced. This is formally shown in the Proposition 2 in the appendix, but it is not difficult to provide an intuitive explanation.

Consider for instance a fisheries community composed of fishermen and fishworkers. For simplicity let us assume that each group consists of identical individuals with identical technology. The fishworkers get their benefits from remuneration for processing the fish. Let's assume that their benefits increase with the volume of fish processed. The fishermen, on the other hand, get their benefits as profits from the fishing operation. Under these circumstances, the fishermen would like to see a fisheries policy that maximizes the present value of profits in the fishery. In biomass equilibrium, this corresponds to the optimal economic yield (OEY). Assuming a reasonably well functioning market system,[7] this, incidentally, is also the socially optimal policy. The fishworkers, on the other hand, would normally like to see a fisheries policy that maximizes the harvest volume over time. In biomass equilibrium this would correspond to the maximum sustainable yield (MSY). These policies do not in general coincide. Thus, there are conflicting interests and these two groups find themselves in a game-theoretic situation. Since both groups belong to the same fisheries community, the game is probably a bargaining or co-operative game. The evolution of this game and its equilibrium (if it exists) depends on many factors, including the respective threat points of both groups and procedures for decision making. Most likely the equilibrium outcome will be a convex combination of the two policies.[8]

7. *I.e.* that prices are true.
8. This would follow from all conventional bargaining game solutions including the Nash bargaining and the Shapley value solution (Friedman, 1987).

That is to say, the bargaining equilibrium harvest will lie in the interval between the optimal sustainable yield (OSY) and the maximum sustainable yield (MSY). However, it is only the former that is socially optimal.

If the composition of the fisheries community is more heterogeneous, including for instance local suppliers to the fishing activity such as boat makers, and fishing gear makers, the range of desired fisheries policies will, obviously, expand further. As a result, the equilibrium outcome of the bargaining game may diverge even further from the social optimum.

The practical implication of all this is that, in the interest of economically efficient fisheries policy, fisheries communities should, to the extent possible, be composed of fishermen only. Other members of the fishing community should not be included. If they are, that is liable to reduce the efficiency of the fisheries operation.

Note, that by fishermen in this context, we are referring to fishing firms or vessel owners, not the hired labour working in the harvesting sector. Hired fishing labour is typically paid a share of the value of the catch. Therefore, it is interested not so much in the profitability of the fishing operations[9] as it is in the volume and value of the harvest. Thus, hired fishing labour, much like the processing sector, prefers a fisheries policy that is closer to the maximizing the present value of harvest volumes than would be socially most appropriate.

Note, moreover, that even if the fishing community consists of fishermen or fishing firms only, the problem of conflicting objectives is not eliminated. If the fishermen are not homogeneous in the sense of having identical profit functions they will still pursue different fisheries policies. As formally shown in propositions 2 and 3 in the appendix, unless individual pay-offs are monotonically increasing functions of aggregate profits, the outcome of the bargaining game will normally not maximize the aggregate profits. In other words, it will normally not be efficient.

3.5 Pay-offs as shares in aggregate benefits

There is a set-up, *i.e.* limitation on the scope for bargaining, which that virtually guarantees that the fisheries community will converge to the most efficient fisheries policy. This is the case where each member's pay-off depends positively on (is a montonically increasing function of) the aggregate profits from the fishery. In this case, moreover, the composition of the members of the fisheries community is of no consequence, except perhaps along the dynamic path toward bargaining equilibrium.

9. At least not fully, although the interest they have in profitability depends on the extent to which their remuneration depends on net profits.

A proposition to this effect is formally proved in the appendix (Proposition 3). However, the basic intuition is fairly easy to grasp. If each member's pay-off increases with the aggregate pay-off, his optimal strategy is clearly to work toward the maximization of aggregate benefits. Thus, in the bargaining game, each member's ideal policy is the one that maximizes aggregate profits. As a result, the equilibrium solution to the bargaining game will be the most efficient fisheries policy. Note that this applies to all possible dimensions of the fisheries policy including the management regime itself as well as the management measures. Moreover, since views regarding the maximization of aggregate benefits will differ only in so far as information sets and, perhaps, risk attitudes differ, the bargaining process will become unusually easy and the speed by which the equilibrium solution is reached is increased.

Interestingly, as is also proven in Proposition 3 in the appendix, if pay-offs are shares in aggregate profits, the same result applies even when the members of the fisheries community do not bargain but act in isolation as in competitive games.[10] The fundamental reason is the same. If each member's pay-off is increasing in the aggregate pay-off, his interest lies in employing his controls to maximize the aggregate pay-off independently of what the other players do. Thus, on the basis of his expectations as to what the other players will do, each agent will pick the policy that maximizes aggregate pay-offs. The only equilibrium to this game is the overall profit maximizing fisheries policy.

It is interesting to note that this is exactly the game situation the shareholders (owners) in limited (or incorporated) companies find themselves in. Their pay-offs depend entirely on the profitability of the company. Hence, it is in their common interest to try to maximize these profits and hence the market value of the company.

This suggests that one way to facilitate this process, is to organize the fisheries community as limited company with the members of the community as share-holders. Such a company would run the fishery as a business, setting its own TAC and either operating its own fishing fleets or contracting the harvesting operations out. In principle this should work. It should be noted, however, that compared to the conventional fishery, this company would be subject to the familiar management problems of creating the appropriate incentives for its employees or contractors and enforcing the necessary fisheries management rules.

It should also be noted that the a system of individual transferable quota shares, *i.e.* the ITQ system, has the property of making each member's pay-off an increasing function of aggregate profits. This is because, as long as the market for quotas is reasonably efficient, the value of each member's quotas will depend on the average profitability of each unit of quota share (Arnason, 1990). Therefore, each member's optimal strategy is to try to advocate fisheries policies that maximize the aggregate profits in the fishery. Notice, that the ITQ system, being decentralized, has certain management advantages over the

10. Perhaps voting may be regarded as a competitive game.

fisheries corporation.[11]

These results are clearly of great importance. They give what approximates sufficient conditions for fisheries communities to be economically efficient. The catch, however is that to achieve this particular set-up is itself a game. The fundamental pay-off in this game is the allocation of shares to individual players. While the actual allocation is no consequence for economic efficiency, it is of great consequence for individual players. Hence, it seems likely that this game will be played with great intensity and it may take a long time to reach an agreement. Indeed, referring to our earlier results, especially Proposition 2, there is no guarantee that this game will lead to a resolution.

In view of this, it seems advisable that the fisheries authority granting rights to the community attempt to impose a priori rules that either stipulate i) sharing of aggregate benefits and the individual shares or ii) procedures to determine the shares within a reasonable timeframe.

3.6 Practical guidance: Summary

The foregoing discussion has generated certain design principles for setting up fisheries communities for the purpose of fisheries management:

3.6.1 High quality rights

The fisheries rights awarded to the community should be as high quality property rights as possible. This means that they should be i) as secure, ii) as long term, iii) as exclusive and iv) as transferable between communities as possible.[12]

3.6.2 Decision making processes

Effective decision making processes are essential for the community fisheries management to work. Therefore, the government or any other body awarding the community rights should make it a precondition that appropriate decision making processes be in place in the community.

3.6.3 Inclusive membership

It should neither be possible to stay out of or opt out of the fisheries community. This means that in order to retain fishing rights, fishermen must be included in a fisheries community. If this is not possible, it is imperative that the activities of outside fishermen be constrained by other means.

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11. The fisheries corporation could, of course, actually adopt the ITQ system for its internal operations.
12. Regarding the proper interpretation of these attributes of property rights see section 2.1 and Arnason (2000, 2007).

3.6.3 Homogeneity

The membership of the communities should be as homogeneous as possible. This implies that the communities should, to the extent possible, only include fishermen or, preferably, vessel owners. Also, this means that the communities should not be to large, neither geographically nor socially (*i.e.* encompassing different social groups)

3.6.4 Individual benefits as a function-of aggregate benefits

To the extent possible, the fisheries communities should adopt rules that make individual benefits (pay-offs) depend positively on collective benefits. As discussed in section 2.5 this could be accomplished by organizing the community as a limited company with the members as share holders or the adoption of ITQs within the community. No doubt, other arrangements having similar effects could be thought of.

Notwithstanding these design principles, it is, of course, imperative to regard each case as unique and allow for its special features in the design of the community rights to be conferred.

Thus, in addition to the above design principles, the government or a more immediate authority dealing with the fishery and conferring the communal fishing rights should follow certain procedures. This involves:

- Laying down basic rules for the structure and decision making within the communities
- Signing a contract of rights and obligations with each community
- Providing expert (biological, economic and managerial) advice on running the communities and the fisheries
- Include the communities in centralized fisheries management decisions including the setting of overall TACs of stocks exploited by more than one community etc.

4. Practical application: Some thoughts

Although, apparently attractive there are certain problems with communal fishing rights in the many artisanal fisheries situations around the world. These problems have primarily to do with the exclusivity of the community fishing rights and the enforcement of these rights.

4.1 The problem of exclusivity

As already mentioned, most commercial fish stocks are quite migratory relative to the range of reasonably sized fishing communities. As a result, communities can hardly be given exclusive rights to fish stocks. In many places of the world, moreover, the geographical distance between coastal communities is often quite small. This means that the different local communities tend to harvest from the same stocks, even when stock migrations are minimal. This means that as far as stock exclusivity is concerned, it is normally not possible to define communal TURFs, at least not effectively. Communal TURFs, however, can work well to reduce gear conflict and crowding.[13]

For these reasons, it seems that many community fishing rights have to be, at least partly, defined in terms of community fishing quotas. Note that this does not exclude the possibility of the community having an exclusive TURF as well. It only means that as far as extraction rights are concerned, these would have to be based on communal quotas for all but the most sedentary species.

4.2 Enforcement of the quota constraint

Community fishing quotas must be enforced. If they are not, the situation quickly degenerates into the common property problem with the communities competing for shares in declining catches from dwindling fish stocks.

At first glance, it may appear that the need to enforce community fishing quotas reintroduces the need to monitor landings which was one of the reasons ITQs may not be feasible to begin with. In the case of community quotas, however, the enforcement problem is much simplified. Most importantly, with community quotas, it is possible to hold the community responsible for violations instead of its individual members. As a result, at least if the communal penalty is high enough, the community will force its members to adhere to its quota constraint. This has great advantages both in terms of the cost of monitoring — community members know each others catch rates, and individual penalties — the community can impose social penalties that are substantially more painful for the violator than a centralized fisheries authority can.

Let us, for the sake of argument assume that dockside monitoring is too expensive or infeasible for other reasons to be conducted. Then the following procedure for enforcing the quota constraint appears feasible.

13. In fact, I would be surprised if it was found that the current fishing communities have not imposed informal rules to reduce the problem of crowding and gear conflict between different communities of fishermen as well as within each community.

i) To obtain fishing rights the fishing community must sign a contract with the fisheries authority. This should have the status of a normal business contract, stipulating the rights and obligations of the parties. In the case of a quota right, the contract should stipulate procedures (such as reporting, verifying and possibly tagging landings) and penalties for violations.
ii) The community should be report landings daily by boat and buyer.
iii) The fisheries authority would do (inexpensive) spot checks.
iv) If a volume of catch that has not been reported is identified, the community as a whole would be subject to a penalty.
v) This penalty would be either financial or in terms of a quota reduction.
vi) The penalty should be high enough to make the expected value of individual violations highly negative to the community as a whole. Note that since the penalty is based on a business contract and it is the community, not individual fishermen, that is penalized it is much easier to make the penalty high enough.

Under these conditions, the community would be induced to enforce the quota constraint on its individual members. Hence all the advantages of decentralized control (virtually self-control) would be achieved.

4.3 Likely outcomes

A priori, it is of course very difficult to predict the outcome of this kind of an arrangement. Much depends on the execution of this system by the fisheries authority, the set-up of the fisheries communities and how their members would react to this new opportunity set. Assuming reasonably good execution and community set-up, a gradual movement toward economic efficiency within the communities seems the most likely outcome. Economic efficiency probably requires a radical restructuring of the fishery. The important point, however, is that this would occur over a period of time and, more importantly, at the pace chosen by the fisheries communities themselves.

5. Conclusions

Economic efficiency in fishing can only be achieved by appropriate fisheries management regime. Property rights-based regimes such as sole ownership, TURFs and ITQs have been found to lead to substantial improvement in the economic efficiency of fisheries. However, when these arrangements are not technically or socially feasible — and there are many examples of that — community fisheries management on the basis of

community fishing rights constitutes a promising alternative.

Community fisheries management exhibits several attractive properties. First, and most importantly, it may lead to lead to economically efficient fisheries within the confines of the community. In fact, given that the community set-up is in accordance with principles identified in this paper, this outcome is quite likely. Second, community management is highly likely to greatly reduce the costs of fisheries enforcement. Third, community fishing rights represents a decentralization that allows smaller government. Fourth, community fishing rights provides fisheries communities with a greater control of their own future.

However, the efficiency of community management of fisheries depends very much on the overall set up of the communities. First, and most importantly, the community rights must be high quality ones. Secondly, the community must be inclusive. Outsiders, unbound by community rules, can easily thwart community efforts to increase fisheries efficiency by expanding their operations. Thirdly, the fisheries community should be as homogeneous as possible. Preferably it should consist exclusively of vessel owners or individual fishing rights holders. Fourthly, it would be extremely helpful if it could be arranged that the benefits to individual members of the fisheries community be increasing functions of the aggregate benefits to the community as a whole. If this is the case, it is almost certain that the fishery will be as efficient as the quality of the communal property right allows.

The large and economically important artisanal fishing sector of the world, is often not very amenable to management on the basis of ITQs. It appears, on the other hand, to be well suited to community management on the basis of community fishing rights. However, for maximum benefits, the set-up for a community rights-based system must be carefully designed and the application tailored to each particular situation.

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Appendix

Basic Propositions

The decisions taken by the fisheries community may be regarded as the outcome of games that occur within the community. To make progress in analysing these games we need to specify the conditions. To focus on the essentials, we'll adopt a very simple framework.

A1. Each agent seeks to maximize his profits

A2. Each agent's profits are given by the concave function: $\Pi(q(i), x; i)$,

where the index i refers to the agent, $q(i)$ represents his harvest and x the biomass level.

A3. Biomass evolves according to equation $\dot{x} = G(x) - q$,

where $G(x)$ is the natural growth function of the biomass having the usual properties[14] and q denotes the aggregate harvest.

Lemma 1

All management that constrains individual harvest may be represented as a charge on harvest. Moreover, this charge is increasing in the marginal profits of harvest.

Proof:

When harvest is indirectly constrained by tax on harvest the result follows immediately from the expression:

$$\Pi(q(i), x; i) - \tau \cdot q(i)$$

where τ is the tax rate. Differentiating this expression w.r.t.. harvest establishes the second part of the lemma.

14. *I.e.* concave and dome-shaped.

When harvest is directly constrained, each company attempts to solve the problem:

$$\max_{q(i)} \int_0^{\infty} \Pi(q(i), x; i) \cdot e^{-rt} dt$$

where τ represents the constraint.

The necessary conditions for solving this problem (Pontryagin *et al*. 1962) include:

i) $\Pi_{q(i)} = \lambda(i) + \mu(i)$,

ii) $\bar{q}(i) = q(i) \Rightarrow \mu(i) > 0$[15] .

where $\lambda(i)$ represents the firm's evaluation of the shadow value of biomass and $\mu(i)$ the marginal cost of its harvest constraint.

Now, if the constraint on harvest is binding, ii) shows that $\mu(i)$ is positive. Therefore, by i), $\mu(i)$ can be regarded as the unit charge on harvesting, and an equivalent solution could be derived by writing the profit function without a constraint as:

$$\Pi(q(i), x, i) - \mu(i) \cdot q(i).$$

This establishes the first part of the lemma. Differentiating the above expression w.r.t. $q(i)$ establishes the second part.

Note: If the firm is operating at the maximum of it's average profit function (which would be the case for the marginal (least profitable) firm in the industry or all firms if they are equally efficient), average and marginal profits would be equal and $\mu(i)$ would be exactly the average profits of the firm.

Proposition 1

Let a fishery be managed by a fisheries community. Then, if the community is successful in managing the fishery, it benefits individual companies to leave the community provided only that i) the community does not collapse and ii) leaving does not incur any penalties.

Proof:

According to Lemma 1, if the management is successful, the harvesting constraint is equivalent to a positive charge on the harvest. Thus, if the two conditions of the proposition, *i.e*. conditions i) and ii) hold, profits can be increased by leaving the community. QED.

15. Provided of course, that the constraint is actually binding, *i.e*. $\Pi_{q(i)}(q_{\max}) - \lambda(i) > 0$

Proposition 2

If firms are not identical and benefits are not transferable between players, the Nash equilibrium bargaining solution will generally not lead to the most efficient fishery.

Proof:

We will prove this proposition in a simplified framework to two players and equilibrium biomass. Eextending the proof to N players and an evolving biomass is straight-forward but much messier.

Assume, without loss of generality, that the equilibrium biomass level has been agreed upon. This implies that the two players' equilibrium value functions (discounted future profits in equilibrium) depend on the allocated catch levels only. Write these two value functions respectively as $\Pi(q(1),\bar{x};1)$ and $\Pi(q-q(1),\bar{x};2)$, where, it will be recalled, q is the aggregate catch satisfying the condition = 0.

Now, the harvest allocation, *i.e.* level of $q(1)$, that maximizes aggregate profits is

$$\Pi_{q(1)}(1)-\Pi_{q(2)}(2)=0,$$

where $\Pi_{q(1)}(1)\equiv\partial\Pi(q(1),\bar{x};1)/\partial q(1)$ and $\Pi_{q(2)}(2)\equiv\partial\Pi(q(1),\bar{x};2)/\partial q(1)$.

However, there is no reason to expect that bargaining will ever reach this point. One easy way to see this is to note that aggregate profit maximization may easily entail that one of the firms has no harvest. Obviously, without transferable benefits, however, this can never constitute a bargaining solution.

To make the argument a bit more formal, us look at the Nash bargaining solution to this game. For convenience assume that each firm's threat point is to opt out, *i.e.* to harvest nothing. Then, according to the Nash bargaining solution (Nash 1953, Friedman 1986), the equilibrium solution to this game is defined by

$$\max_{q(1),q(2)}\ \Pi(q(1),\bar{x};1)\cdot\ \Pi(q(2),\bar{x};1)$$

Subject to the condition $q(2)=q-q(1)$.

This obviously implies

$$\Pi_{q(1)}(1)-(\Pi(1)/\Pi(2))\cdot\ \Pi_{q(2)}(2)=0.$$

So, comparing this to the aggregate profit maximization shows that at least Nash bargaining will not lead to an efficient solution unless $\Pi(2)=\Pi(1)$, *i.e.* the firms have identical profits at the bargaining solution. This happens, if the firms are identical but is virtually inconceivable otherwise.

Proposition 3

If all members of a fisheries community receive pay-offs that are monotonically increasing in the aggregate pay-off, then the Nash bargaining solution is economically efficient. Moreover, the Nash competitive solution and the Nash bargaining solutions are identical

Proof:

We will prove this proposition in a simplified framework similar to the one used in Proposition 2. Assume two players only. Assume also, without loss of generality that the equilibrium biomass level has been agreed upon. Write the corresponding two value functions respectively as $\Pi(q(1),\bar{x};1)$ and $\Pi(q-q(1),\bar{x};2)$, where q is the aggregate catch satisfying the condition that $G(x)-q=0$.

Given these specifications, aggregate profits are:

$$\Pi(q(1))=\Pi(q(1),\bar{x};1)+\Pi(q-q(1),\bar{x};2).$$

Obviously, maximization of aggregate profits implies

$$\Pi q(1)=0.$$

Now let the two allocation or sharing functions be $\psi(\Pi(q(1));1)$ and $\psi(\Pi(q(1));2)$ where both functions are monotonically increasing in the aggregate profits.

Under the circumstances defined, the Nash bargaining solution is defined by:

$$\max_{q(1)} \psi(\Pi(q(1));1)\cdot\ \psi(\Pi(q(1));2)$$

Solving this problem requires

$$[\psi_{\Pi}(\Pi(q(1));1)+\psi_{\Pi}(\Pi(q(1));2)]\cdot\ \Pi_{q(1)}=0$$

Since, both allocation functions are monotonically increasing, this obviously implies

$$\Pi_{q(1)}=0.$$

which, of course, is the condition for maximizing aggregate profits.

To prove the second part of the theorem note that the optimal strategy of each (or all players) is always to maximize aggregate profits. More formally, for (an arbitrary) fishing firm 1, the maximization problem is:

$$\max_{q(1)} \psi(\Pi(q(1));1)$$

But, since $\psi(\Pi(q(1));1)$ is monotonic, this implies the condition $\Pi_{q(1)} = 0$. QED

Note 1: The importance of the second part of the proposition is that if pay-offs are monotonically increasing in the aggregate pay-off bargaining is not even necessary. Competitive game-playing will lead to the jointly optimal bargaining outcome.

Note 2: The game-situation of shareholders in a limited company is very similar to the premises of Proposition 3.

Note 3: The game situation of holders of tradable share rights in a fishery such as ITQs, is very much along the lines of Proposition 3. However, a system of non-tradable shares, *i.e.* an IQ system, does not exhibit this property.