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Protected Areas and the Management of Fisheries: An Institutional Perspective

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Abstract

Marine protected areas have been advocated as a useful tool in fisheries management. However, as protected areas they are a 'blunt' tool to manage fishery operations; in the sense that they do not alter the incentives of individual fishers, the outcomes from protected area creation are likely to be dependent on other management mechanisms which alter incentives. Implementing protected area management of fisheries has also been viewed as beneficial in the sense that they provide a low cost management tool. In this paper, the optimal fishery management structure, in light of transaction costs, and which integrates protected areas and effort controls as a mechanism used to control the extraction of fishery resources, is explored. The policy implications of the results are also discussed.

Keywords: Fisheries management, transaction costs, institutional economics, institutional design.

1. Introduction

Wild harvest fisheries are often managed to overcome the problems of open access identified by Gordon (1954). Open access conditions usually lead to the over exploitation of fish stocks, to the point where some fisheries collapse. To prevent this, societies have used a variety of controls to regulate fisheries. The objective of fishery regulation is to move the fishery from non-optimal exploitation arrangements closer to optimal arrangements. Optimal regulation can be viewed as the combination of government policy instruments which cause a change in the vessel and fleet operations from the open access to the optimal time pattern of exploitation (Anderson 2004, p. 92).

A variety of policy instruments have been advocated by economists to enable the sustainable and rent maximising control of fishery resources. Merrifield (1999) suggests that the usual approach to overcome open access problems in fisheries start with attempts to reduce effort through targeted gear restrictions, area closures, and shorter fishing seasons. These measures are later supplemented with entry barriers such as limited licensing schemes. Merrifield (1999) states that as these controls do not alter the incentives of fishers, they will not succeed, creating a need for incentive based controls.

Despite the need to adopt incentive based controls, such as individual tradeable quotas or Pigouvian taxes, these are rarely used in fisheries management (Merrifield 1999). For example, in Australia, of the 21 Commonwealth managed fisheries, the majority of the fisheries are managed through input controls (nine), six fisheries under tradeable output controls, with a further two managed via a combination of input and output controls. Further, three fisheries are managed via limiting the number of operators with one of these fisheries moving to spatial management controls (marine protected areas). Only one fishery currently has no controls on fishing activity. Similar management arrangements are in place in state fisheries (fisheries within three nautical miles of the coast), where for example, in NSW only two of the nine commercial wild-harvest fisheries are managed via tradeable output controls (Lobster and Abalone).

Much of the reason behind the lack of use of tools such as individual tradable quotas and Pigouvian taxes has been attributed to high transaction costs. Transaction costs will affect the return from the use of different policies, and their effectiveness in achieving desired fishery outcomes. Despite the potential benefits of incentive based measures, there are impediments faced by management organisations to create such institutional arrangements. In light of transaction costs, whether or not such policies should be implemented has not been examined. As with other forms of regulation, the policy analyst should be mindful of the benefits and costs that are involved with the use of various policy instruments.

Impediments to the use of certain policy instruments, outside the possible transaction costs of their use, may skew institutional structures. Both budgetary constraints and issues of public choice may lead to a non-optimal fisheries management structure. Such constraints on behaviour may lead to either second best choices, or public choice based policy outcomes.

In this paper, a theoretical model of institutional design is explored to examine the optimal mix of policy instruments in policy programmes, and the possible impediments to their use in fisheries management. Trade-offs exist in the use of different policy instruments in terms of their costs and benefits, and the goal of optimal management. That is to maximise the value of the fishery to society, both optimal management and maximum net benefit may be unattainable or even undesirable.

The structure of this paper is as follows. In the following section, the transaction costs faced by differing policy instruments are explored. In section 3, the model of an optimal institutional structure is presented, with an application to institutional design given in section 4. Policy implications and concluding comments are presented in section 5 and 6 respectively.

2. Fisheries Management: Benefits and Costs

Anderson (2004, p. 192) sets out five characteristics of optimal fisheries regulations. Firstly, regulation should encourage innovation and research into new fishing methods; secondly, it should be flexible enough to react to changes in the biological conditions of the fishery; thirdly, it should have the support of the majority of the fishermen to which it controls; fourthly, it should recognise the costs of negotiation, research, monitoring and enforcement necessary for the regulation to succeed; and fifthly, distributional effects and the effect on other management objectives (such as maintaining employment) should be considered. These characteristics can be used to identify the objectives of, and constraints faced, in determining optimal fisheries policy programmes. The benefits created through fisheries management occur as with the shift away from open access, generating rent from the underlying resource. This rent represents a benefit to society from the use of the fishery resources.

The management costs incurred in the management of a fishery are an important characteristic in determining the optimal fisheries management structure. For OECD nations, the total cost of managing fisheries totalled approximately $US 2.5 billion in 1999 (OECD 2003, p. 8) Of these cost, the largest share on average was the provision of enforcement services, close to 40 percent of the total costs (OECD 2003, p. 8). These costs generally only represented a relatively small percentage of the total fishery value. However, for small fleets with incentive based institutional structures such as in New Zealand, the management costs per vessel were relatively high.

Outside the administration or management costs associated with different policy instruments, are other transaction costs which will affect both policy performance and net benefits. Transaction costs, defined as the costs of forming contracts, bargaining or inspection of contracts between individual agents or resource managers (Challen 2000, p.28), associated with various fishery management programmes will play an important role in their success or failure. Several authors have suggested that a significant factor in the transaction costs of specific policy instruments is related to the heterogeneity of fishers (Johnson and Libecap 1982, Feeny *et al.* 1997, and Merrifield 1999). Fisher heterogeneity is believed to hinder the agreement on key aspects of fisheries management, because of possible conflicts between fishers, many policies do not receive support (Merrifield 1999). In these instances, the lack of support can lead to the failure of certain policy arrangements. This failure can be viewed as a prohibitive cost to the implementation of the policy.

The evolution of past fisheries policies may also play a role in determining outcomes of future changes in management. Merrifield (1999) states that given past management failures, fishers may oppose the introduction of new institutional arrangements as they do not believe that the new management arrangements will work. An implication of this is that given past management failures, institutional evolution is likely to be hampered, with better controls less likely to be adopted.

Certain policy instruments, such as input controls, have failed to achieve management objectives due to perverse incentives. Inputs controls create an incentive for fishers to substitute between controlled and uncontrolled inputs (Wilen 1979). In a study of the NSW Ocean Prawn Trawl Fishery, Greenville *et al.* (2006) found that controls placed on net and engine size had a detrimental effect on the technical efficiency of fishers. Similar effects on technical efficiency were found by Kompas *et al.* (2003) for Australia’s Banana Prawn Fishery. Such behaviour represents a cost to the choice of input controls to manage fishery resources as it reduces the efficiency of the production technology used to exploit the resource, a cost which would need to be considered in determining the optimal institutional structure for a fishery.

Fishers often hold the right to access more than one fishery. When this is the case, fishers may be able to shift effort levels between fisheries in response to changes in the management of one or more fisheries. This shift can impose external costs as a result of certain policy instruments, which can both reduce the effectiveness of the policy instrument, and also lead to greater opposition to changes in management. These effects have the potential to influence the adoption of certain policies, and may make certain policies undesirable from society's point of view as the costs imposed may reduce the benefits.

Most policy instruments will have different distributional effects on stakeholders. Although policies may achieve a similar objective, they may fail to be introduced due to political concerns over particular groups of stakeholders. Non-producer interests such as fish suppliers and processors may prevent selection of efficient management structures and require assistance packages to be used to get all stakeholders to adopt certain policies (Merrifield and Firoozi 1995).

Policy instruments which do not influence the incentives of fishers can be used to optimally manage fishery resources. Instruments such as marine protected areas have been shown to form part of optimal fisheries management arrangements under certain conditions (Grafton *et al.* 2005 and Greenville and MacAulay 2006). In terms of fisheries management, protected areas are an area of the fishery which is protected from consumptive pressures. Protected areas form a spatial management control which allows for the management of fishery resources on a finer scale.

As protected areas not only preserve biomass, but also habitat, they are believed to improve the resilience of marine ecosystems. The stocks that occur within protected area boundaries form a buffer source, and can increase yields when stock levels are highly exploited (Pezzey *et al.* 2000, Sanchirico and Wilen 2001, and Greenville and MacAulay 2004). Grafton *et al.* 2005 found that in the presence of a negative shock, protected areas allowed a fishery to return to a steady-state faster than without, improving the resource rent generated. Protected areas have also been found to reduce the variation in harvests (Conrad 1999, Pezzey *et al.* 2000 and Hannesson 2002). However, in a predator-prey fishery, protected areas were found to increase harvest and resource variation despite improvements in resource rent (Greenville and MacAulay 2006).

One of the significant advantages of protected area use as a tool for fisheries management is the low management costs involved. The low management costs can mean that protected area use is more practical in situations where there are limits to the regulatory budget. However, as Greenville and MacAulay (2006) state, protected areas are a 'blunt' policy instrument, and need to be used in conjunction with other control mechanisms to generate benefits to the fishery.

Protected areas may also face significant opposition as they represent a loss in access rights for fishers (Grafton and Kompas 2005). Despite potential benefits, fishers may oppose the use of such a policy instrument for fear of losing some of their traditional fishing grounds. Further, as shown in Greenville (2005), protected areas can have significant distributional effects on fisheries which target different species, due to the species interactions that occur within the protected area boundaries.

Given the costs involved with policy instruments used to manage fishery resources, it is necessary to examine the net benefit to society from the regulation of fisheries. If the maximisation of net benefit is considered a desirable outcome of fisheries management, provided sustainability constraints are satisfied, then a trade-off between the potential benefits of certain policies and their costs is inferred. In this sense, the goal of optimal management (say in the form of maximum resource rent), may be undesirable as to achieve such an outcome would impose extra costs on society and shift too many resources into fisheries management. The design of an optimal fisheries institutional structure needs to be mindful of the characteristics of the fishery itself. As these differ between fisheries, a blanket approach cannot be applied, however, a framework to analyse the potential optimal structure can be developed.

3. Institutional Considerations

The objective of institutional design for a fishery needs to be defined in order to analyse an optimal structure. Challen (2000, p.29) defines institutional efficiency as the institutional structure(s) that minimise the transaction costs involved with a particular set of allocation decisions. However, this definition does not allow for changes in allocation decisions based on differences in net benefits, and does not allow for the examination of trade-offs between different policies.

In formulating a structure for the optimal regulation of fisheries, Anderson's (2004, p. 192) five points can be classified into those which influence the objectives of society, costs of regulations and those which pose constraints. The underlying objective of fisheries regulation is to maximise the fisheries return to society. The return from fishery resources includes extractive values, such as resource rent, tourism values, and other non-use existence values which are generated from fishery resources.

If the objective is to maximise the resource rent in the fishery, managers have the ability to determine, or at least come close to determining, the optimal level of resource rent or the utility gained by society from fishery resources that could be generated in the fishery. However, the regulation of fisheries is subject to transaction costs, described by Anderson (2004, p.192) as the costs of negotiation, research, monitoring and enforcement necessary for the regulation to succeed. These are thus the costs for determining the optimal level of fisheries regulation.

Anderson (2004, p.192) pointed to the support of the fishers involved. This will directly affect the objective function as it will influence the costs of negotiation and the monitoring and enforcement of the policy used. Anderson's (2004, p.192) first, second and third points can be used to fully define the objective function for the optimal fisheries institutional design. Thus, the objective of fisheries management is to maximise the utility of the fishery resource with consideration to the other goals and aims of fisheries management; given that the regulations are sufficient to achieve their desired outcomes (that is, that they are flexible to changes in the biological conditions of the fishery and encourage innovation overtime).

The constraints to the development of an institutional structure are any that restrict the regulations away from the maximum net benefit (such as a budget constraint). Formally, the model can be set out as follows. The cost of differing regulatory controls can be expressed as a function of transaction costs, which include administration, monitoring, enforcement, and other transaction costs. The other transaction costs will be a function of many different aspects of the fishery, such as fisher heterogeneity, geographical dispersion and the number of fisheries in which fishers operate. These factors will all influence the costs of different policy instruments to fishers. For quota schemes, the geographical separation of individuals may increase the cost of exchange due to greater search costs. Fisher heterogeneity may mean that some groups who opposed the initial policy change do not participate in the market, making it harder to trade. The ability of fishers to shift their operations between fisheries may limit the overall objective of reforms in one fishery by creating an external cost in the form of a shift in effort to other fisheries. All these costs will influence the design of optimal fishery regulation.

To set up the objective function for optimal institutional design in a fishery, a few definitions are required. In this paper, it is assumed that the governing organisation forms part of a broader government. This organisation has the power to formulate and enforce various different policy mechanisms. In order to manage the fishery, the governing organisation will have to use certain instruments. A policy instrument (*PI*) is defined as a mechanism used by the governing organisation to manage the fishery and includes such controls as quotas, taxes, marine protected areas, amongst others.

The governing organisation can establish policy programmes (*PP*). A policy programme is defined as various combinations of policy instruments or levels thereof. The degree of use of certain policy instruments can be considered policy parameters. For example, a policy programme may be to use a protected area and a tax on effort to manage the fishery. Within this policy programme, the use of a protected area is set at 15 percent. In this analysis, the policy parameters are assumed fixed within the policy programme, such that there is a discrete set of policy programmes over various ranges of policy parameters.

Each of the policy instruments has different policy characteristics (*PC*). For example, a policy may either be a command and control instrument such as effort controls, or an incentive-based control such as a quota. These characteristics will influence both the return and cost to society of using a specific policy instrument.

The problem to determine the optimal regulation or institutional structure for the management authority, assuming that the policy programme choice is sufficient to achieve the desired objective, is given by:

$$
\begin{aligned}
\max U(FR) &= \sum_{k=1}^{K} U_k \left(RB - RC\right) - U\left(\text{admin}\right) \\
&= \sum_{k=1}^{K} U_k \left(\sum_i^n PP_i \left(RB - RC\right)\right) - U\left(\text{admin}\right) \\
&= \sum_{\text{k}=1}^{K} U_k \begin{pmatrix} \left[\sum_i^n h_i\left(PC_i\right)\cdot PI_i + \sum_{i\neq j}^n \beta_{ij}\cdot\left(h_i(\bullet)\cdot PI_i\right)\cdot\left(h_j(\bullet)\cdot PI_j\right)\right] \\ -\left[\sum_i^n f_i\left(V,G,E\right)\cdot PI_i + \sum_{i\neq j}^n \alpha_{ij}\left(f_i(\bullet)\cdot PI_i\right)\cdot\left(f_j(\bullet)\cdot PI_j\right)\right] \end{pmatrix} \\
&\quad - U\left(\text{admin}\right)
\end{aligned}
\qquad (1)
$$

where $U(FR)$ is the fishery return to society in terms of a social utility, RB the regulatory benefit, such as the level of resource rent and other non-use values generated, with RC the regulatory cost. The objective function is given by the sum of the net benefits from regulation to different stakeholder groups, k, less the administration costs of the regulation (*admin*). In this way, the regulatory net benefit to society from fisheries resources can be viewed as the sum of the individual net benefits of all the stakeholders. The administration costs of the policy include costs such as implementation, monitoring and enforcement costs associated with particular policy programmes.

The regulatory benefit will be a function of the policy programme. The policy programme is made up of different policy instruments (and degrees of use). The benefit from regulation is given by the sum of benefits over the policy instruments (PI) used, and is expressed as a function of the policy characteristics (PC), such that the unique benefit from policy i is given by $h_i(PC_i)PI_i$. Some policies will have joint benefits, and others will have either zero or negative interactions given by β_{ij}.

The regulatory cost of different policy programmes, denoted by $f_i(V,G,E)$, will differ for different stakeholders depending on the characteristics of the group. The cost of organising for a group will affect the benefit from different policy programmes. This cost of organising will be influenced by the heterogeneity (V) of the group and the geographical distribution G. Another significant influence on stakeholder costs will be the group's ability to exploit or access the resource. This ability to exploit or access the resource is termed the efficiency of the production technology, E. The more efficient the production technology, the greater the net benefit from a certain policy (and also the greatest opportunity cost if excluded). As for the benefits, some policy instruments will have joint costs denoted by α_{ij}.

The first order conditions derived for the model are given below, assuming that the utility function is a linear operator for mathematical convenience and illustrative purposes such that $U_k(h_i(PC_i)PI_i)=h_{ik}(PC_i)PI_i$. As the policy choice is binomial and there are n policy instruments, a policy programme is conducted (1) or not (0). Varying degrees of policy instruments cannot be analysed as they are assumed discrete for the purpose of this analysis. The choice of whether a policy is of benefit to society or not, is determined if the value of the policy exceeds the cost. The cross terms will influence the outcome since, if there is a large conflict (benefit) with another policy, then it is less (more) likely that this policy will be chosen. With the binomial choice of policies, for the model to yield an optimal mix of policies, sufficient policy choice is required. It is not the purpose of this analysis to present a full discussion of policy choice, but to demonstrate how the objective of implementing controls which maximise the value to society from a fishery may differ from the optimal policy mix or institutional design. The first-order condition is given in equation (2).

$$\frac{\partial U(\bullet)}{\partial PI_i} = \sum_{k=1}^{K}\left(h_{ki}(\bullet) - f_{ki}(\bullet) + \left[\sum_{i\neq j}^{n} PI_j\left[\beta_{kij}h_{ki}(\bullet)\cdot h_{kj}(\bullet) - \alpha_{kij}f_{ki}(\bullet)\cdot f_{kj}(\bullet)\right]\right]\right) = 0 \quad (2)$$

From the first-order condition, a policy instrument, PI_i, will increase the utility value of fishery resources to society if the sum of benefits exceeds the costs (assuming the net benefit is greater than the administration cost). The net benefit from a policy programme is made up of the individual benefit of a policy instrument less its costs, plus the interaction benefit less the interaction cost. The choice of whether PI_i should form part of the optimal institutional design for the fishery will depend on the relative benefits of all other policy instruments. If, for policy i:

$$\frac{\partial U(\bullet)}{\partial PI_i} \geq \frac{\partial U(\bullet)}{\partial PI_{j-i}} \quad (3)$$

that is, whether the marginal net benefit of instrument PI_i is greater, or as good as, the marginal net benefit of all other policies, then it should be included in the optimal set. If a market solution is considered as a policy instrument, in the absence of externalities, the net benefit of the market solution will always exceed the alternate policy instruments, making a market solution the default choice of policy instruments. In the case of a fishery, due to the potential rent dissipation under competitive market conditions without private property rights, there is a high cost to stakeholders from this policy instruments (in terms of production efficiency), thus reducing its value when compared with regulation. The first-order condition provides a criterion for the choice of policy programmes. An interesting implication of this can be seen in relation to the production efficiency of different stakeholders. Optimal policies will favour those groups who exploit (or access) fisheries resources relatively more efficiently than other groups, due to lower costs. Policy programmes should thus be directed to those groups with the best ability to exploit or access the resource to maximise the gain to society.

If policy programmes are directed to the most efficient users of the resource, an inequitable outcome may arise. If instead, the objective was to allow equitable use of the resource, then the optimisation problem would differ slightly. The optimal policy structure would occur when the net benefit of a policy programme is equal amongst all groups, that is:

$$\frac{\partial U(\bullet)}{\partial U_k} = \sum_{k=1}^{K} U_k '(\bullet) = 0 \tag{4}$$

In the context of heterogenous policy programmes, this condition may not be satisfied. However, it does provide a criterion for evaluating different policy programmes in an equity sense. If policy programmes are selected on this criterion, then it is likely that a potential Pareto improvement will exist. A potential Pareto improvement exists when the overall net benefit could be improved allowing a compensation scheme that would make all groups are at least as well off as under the equity solution.

So far two significant aspects of policies relating to fisheries management have been ignored. First, the influence of government and alternate use for the funds used to manage fisheries; and second, issues of public choice. The first is an issue of budgetary constraints on institutional design and can be incorporated as a constraint in the function. The revised function is given in equation (5):

$$\max U\left(FR\right)=\sum_{k=1}^{K}U_k\left(RB-RC\right)-\lambda\left(\text{admin}\leq B\right) \tag{5}$$

where B is the allowable expenditure and λ the shadow price for the budget constraint. The addition of the constraint will shift the choice of optimal policy programmes. It could be argued that under all circumstances, the entire budget will be spent (even if the allocation of funds is greater than what is needed to achieve the optimal policy mix). If the budget is greater than what is required for the optimal institutional structure, the rent seeking of individuals involved in the management organisation, or the setting of goals to maximise the value of the fishery in the absence of transaction costs, could lead to the use of policy instruments with strong monotonicity. In this situation, the fishery could become 'over managed' compared to the socially optimal institutional structure. If the budget is below what is required for optimal institutional design, then second-best policies may be enacted.

The influence of the constraint on institutional design is given in Figure 1. If $\boldsymbol{PP}^*$ is the optimal policy programme (or vector of policy instruments), given administration costs (*admin*) and net benefit, then the shift in the policy programme can be seen. If the budget is below what is optimal, then an institutional structure comprised of policy instruments in policy programme $\boldsymbol{PP}_1$ is chosen, with $\lambda>1$. Given strong monotonicity in the use of policy instruments and a budget greater than the level required for optimal institutional design, then a policy programme $\boldsymbol{PP}_2$ with $\lambda<1$ will be chosen.

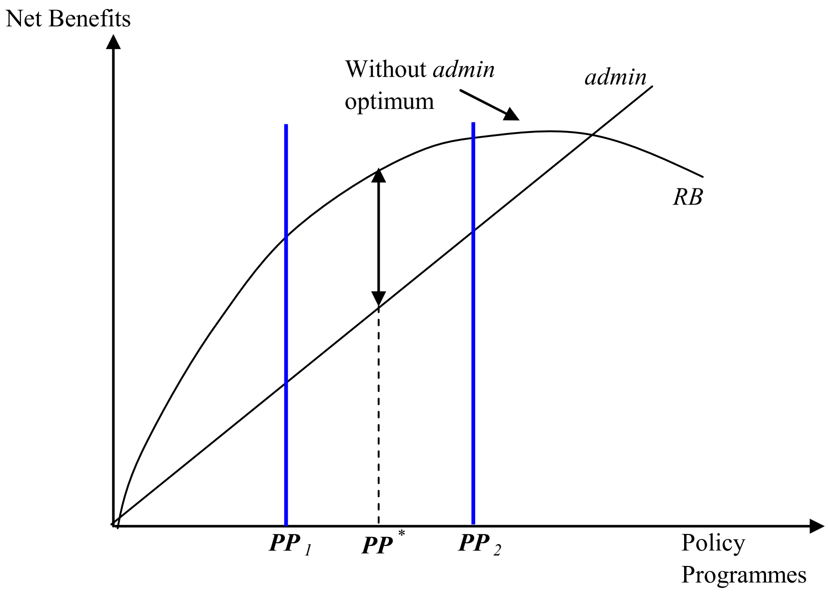


Figure 1: Institutional design with budget constraint

The presence of a limited budget for policy programmes is partly counter intuitive without consideration given to the rest of the economy. With a limited budget, the shadow price, λ, is greater than one, meaning that if an extra dollar was allocated to the development of fisheries policy programmes, the return to society would be greater than the initial outcome. As such, it would be illogical not to allocate additional funds. However, the fisheries management organisation may have to rely on funds from outside the sector to fund its policy programmes. If this is the case, then the central body responsible for the collection and allocation of public funds, for example treasury, would need to weigh up the potential benefits from regulations in a variety of sectors. This may lead to insufficient funds to develop fisheries policy programmes.

Public choice models of institutions do not include the assumption that individuals in the governing organisation make altruistic decisions in formulating policy programmes (Godden 1997, p. 42). In terms of fisheries management, the decisions made on what policy programmes to introduce are dependent on decisions based on the private interest of individuals in the governing organisation and not made in the public interest. As different policies will have different effects on stakeholder groups, it is possible, under certain circumstances, that the agency responsible for establishing the regulatory framework may be influenced by one group greater than another.

The influence on government polices can be depicted following Anderson (1992) in terms of the supply and demand for regulation. Anderson (1992) viewed the supply of regulation from government agencies in the form of support for industries in terms of the effective rate of support. The demand for support was based on the characteristics of the industry. The supply and demand functions were viewed as continuous functions, with the level of support given as the interaction between the supply and demand functions.

However, in the case of discrete policy programmes, the continuous nature of the supply and demand functions is not adequate in explaining the likely outcome for a public choice model of fishery management. Instead, policy makers may have a set of preferences over different programmes based on the level of lobbing. In a common property setting, Rausser and Zusman (1992) showed that the exploitation solution for a resource given a market for regulation and exogenous political preferences over policy programmes, lead to exploitation levels that lay between the pure self interest and optimal outcomes.

Issues of public choice arise in fisheries due to the vast differences in opinions over the best use of marine resources and the distributional effect of policies. The allocation of resources between competing uses can be affected by political concerns as policy makers are influenced by stakeholder groups. With a market for regulation, policy makers may be advantaged through the development of particular policy programmes over others. If this is the case, the agency may allocate welfare weights, δ, to different stakeholders, biasing the policy choice. The welfare weights are determined by the market for regulation. With welfare weights, the public choice institutional design system becomes:

$$
\begin{aligned}
\max U\left(FR \mid P\right) &= \sum_{k=1}^{K} \delta_k U_k \left(RB - RC\right) - U\left(\text{admin}\right) \\
&= \sum_{k=1}^{K} \delta_k U_k \left(\sum_i^n PP_i \left(RB - RC\right)\right) - U\left(\text{admin}\right) \\
&= \sum_{k=1}^{K} \delta_k U_k \left(\begin{array}{l} \left[\sum_i^n h_i\left(PC_i\right) \cdot PI_i + \sum_{i \neq j}^n \beta_{ij} \cdot \left(h_i\left(\bullet\right) \cdot PI_i\right) \cdot \left(h_j\left(\bullet\right) \cdot PI_j\right)\right] \\ -\left[\sum_i^n f_i\left(V, G, E\right) \cdot PI_i + \sum_{i \neq j}^n \alpha_{ij}\left(f_i\left(\bullet\right) \cdot PI_i\right) \cdot \left(f_j\left(\bullet\right) \cdot PI_j\right)\right] \end{array} \right) \\
&\quad - U\left(\text{admin}\right)
\end{aligned} \tag{6}
$$

where $U(FR|P)$ is the public choice utility derived from fishery resources. The welfare weight, δ, is the perceived private gain to policy makers (Rausser 1982). For individual stakeholders, lobbying will occur based on the stakeholders' perceived gain from being involved in the market for regulation. For policy makers, the welfare weight will be a function of lobbying and the private gain. As lobbying increases, the perceived private gain for policy makers will also increase. For example, fishers may lobby for a less restrictive quota due to differences in the private and public discount rates, leading to a welfare weight being placed on fisher's utility and thus causing a skew in the policy arrangements. If $\delta_k \neq \delta_K$, then a shift in institutional design will occur for a policy instrument not included in the optimal set, given:

$$
\frac{\partial U\left(\bullet\right)}{\partial PI_i} < \frac{\partial U\left(\bullet\right)}{\partial PI_{j-i}} \leq \frac{\partial U\left(\bullet \mid P\right)}{\partial PI_{j-i}} \leq \frac{\partial U\left(\bullet \mid P\right)}{\partial PI_i} \tag{7}
$$

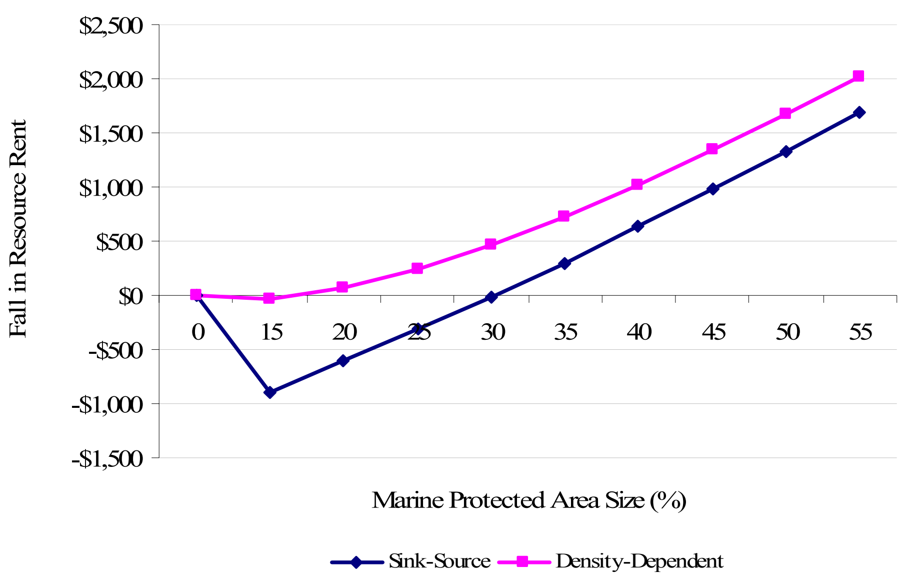
Thus, if the marginal benefit of the policy instrument is changed as a result of public choice behaviour from being outside the optimal set such that it is now greater than or equal to the marginal benefit of all other policies under public choice, it will become part of the institutional structure. Hence, it is possible for public choice effects to influence the policy outcome. The opportunity cost of the policy is given by the difference in utility from using the optimal vector of policy instruments, or policy programme (PP^*) and the set under public choice ($PP|P$):

$$
\text{Public Cost} = U\left(PP^*\right) - U\left(PP \mid P\right) \tag{8}
$$

4. Institutional Design

The model developed in the previous section will be applied to analyse the optimal institutional design for a hypothetical fishery. Two different policy instruments will be analysed; namely, marine protected areas and a Pigouvian tax on effort, with policy programmes comprising varying combinations of the two. Although there are many other policy instruments which could be examined, these were chosen to show the trade-offs that would occur in determining an optimal institutional structure.

The outcomes, in terms of resource rent for the policy instruments are taken from Greenville and MacAulay (2006) and are shown in Figure 2. In this study, a bioeconomic model was used to analyse protected area creation in a fishery which was subject to the risk of stock collapse. The protected area was assumed to offset the risk of stock collapse in the fishery due to the protection of both species and habitats. It was found that with a 5 percent chance of stock collapse (which was assumed to follow a Poisson distribution), protected areas of 15 and 20 percent of the fishery maximised the level of resource rent generated in the fishery under a tax on effort which led to optimal steady-state biomass and a tax which led to 75 percent of optimal steady-state biomass respectively.



Source: Greenville and MacAulay (2006).
Figure 2: Opportunity cost of protected area creation with stock collapse risk

The results are presented in Figure 2 for both density-dependent dispersal (where stocks move between the protected area and the surrounding fishing ground based on differences in relative stock densities) and sink-source dispersal (uni-directional flow from the protected area to the surrounding fishing grounds) systems in comparison to an Pigouvian tax on effort which led to optimal steady-state biomass levels. The curves in Figure 2 represent opportunity cost curves (lost resource rent due to protected area creation).

For simplicity, two stakeholder groups will be analysed. First, fishers and second 'conservationists' The group 'conservationists' is loosely used to define those who gain added utility from the fishery resources when unexploited. Initially, the net gain to fishers will be defined as the gain in terms of resource rent using the case of sink-source flows from the protected area to the surrounding fishing ground. The net gain to conservationists is set at a present value of $100 thousand for 15 percent of the fishery as a protected area and increasing proportionally thereafter.

While no data on costs were able to be obtained, it was assumed that the administration costs for a protected area are less than that for the tax. This assumption was made as it is likely that the tax on fishers' effort is relatively expensive to administer due to the reporting and monitoring and enforcement requirements for the tax to work effectively. For the protected area, the administration charge would be relatively lower as it requires the monitoring of the area and not the individual fisher activity. The cost of the protected area for 100 percent of the fishery was arbitrarily set at a net present value of $40 thousand, and at $100 thousand for an optimal tax placed on effort levels when fishers had access to the entire fishing ground. The cost of protected areas is assumed to change in proportion with the area protected, whereas the cost of the tax is assumed to change in proportion to effort levels relative to those under an optimal tax and full access to the fishery.

Optimal Institutional Design

With no welfare weights, the net benefits from a range of different policy programmes are shown in Figure 3. The policy programme which maximises the net benefit to society in this simple example is given by having a protected area of 30 percent of the fishery and using an optimal tax for the remaining effort in the fishing ground.

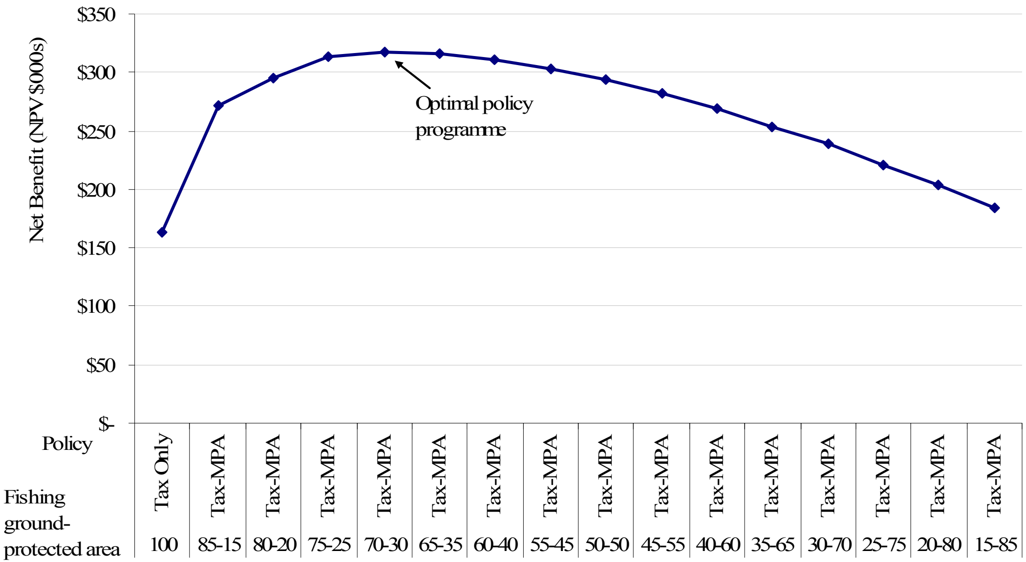


Figure 3: Net benefits from different policy programmes

Without the inclusion of transaction costs, a protected area of 15 percent of the fishery in conjunction with an optimal tax will maximise the value of fishery resources. As protected areas are a relatively low cost policy instrument, the optimal proportion of protected area with the inclusion of costs is greater than without. Without costs, the tax is relatively overused, as the extra benefit from controlling the fishery is less than the administration cost imposed.

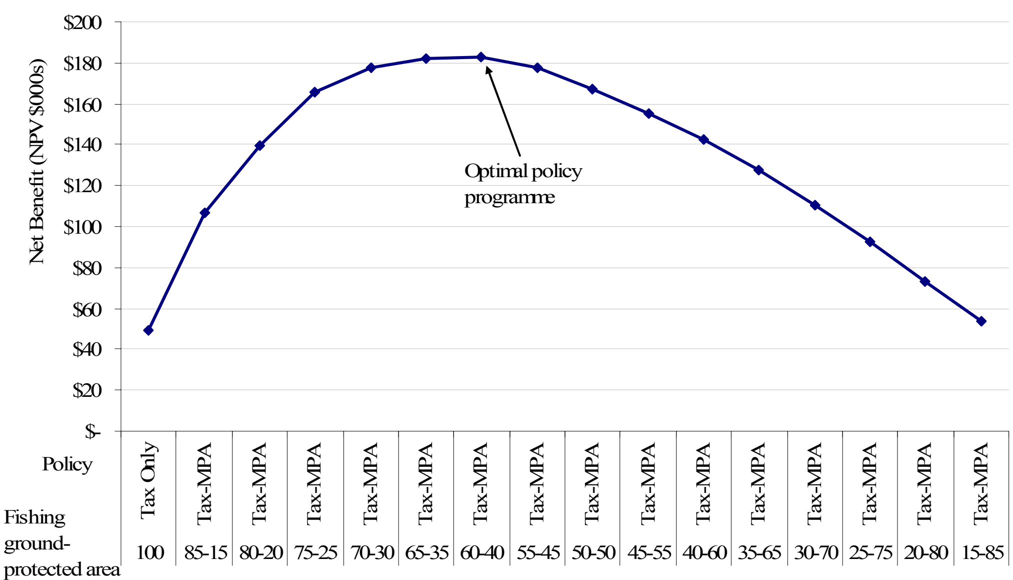


Figure 4: Net benefits from different policy programmes with sub-optimal tax

A similar result was obtained under tax controls which lead to biomass levels at 75 percent of the optimum level. With the inclusion of transaction costs, the optimal policy programme included the use of a protected area of 40 percent of the fishery in conjunction with the tax. This is compared with a protected area of 25 percent of the fishery and tax which maximised the value of fishery resources in the absence of cost. The value of various policy programmes with a tax rate set to achieve 75 percent optimal biomass is shown in Figure 4.

From the results for both forms of the tax, sole use of a protected area was not optimal. This result is sensitive to the benefits to accrue to the 'conservationist' stakeholder group. If these net benefits increased significantly, above $200 thousand net present value for a tax which results in biomass at 75 percent of optimal levels, then the optimal policy programme would be switched to the use of a protected are over the entire fishery. For the case of a tax which led to optimal steady-state biomass levels, the net benefit to the conservationist group would have to increase by 6.7×10^{13} percent for the optimal solution to switch to the sole use of a protected area.

Administration Budget Constraints

The cost curves for the policy programmes that include both the marine protected area and a tax on effort take the form of a quadratic curve. When a constraint is added in the form of an administration cost limit, for a range of costs there are two possible policy programmes which will satisfy the constraint given the assumption that the entire allocated budget would be spent. The cost curve and region of two policy programmes is shown on Figure 5.

Despite the different policy programmes jointly satisfying the budget constraint, if the management goal is to maximise the return from the fishery, then the programme which yields the greatest return will be selected. For example, given a budget constraint of $65 thousand in net present value terms, the policy programmes of a 25 percent of the fishery protected area and optimal tax would be chosen instead of policy programme which used a protected area of 80 percent of the fishery and an optimal tax which resulted in the same cost. However, in this example, the fishery was effectively over managed compared with the unconstrained case (cost of $56 thousand), with too much of the relatively more expensive control (tax) used, and too little of the relatively inexpensive (protected area) control used.

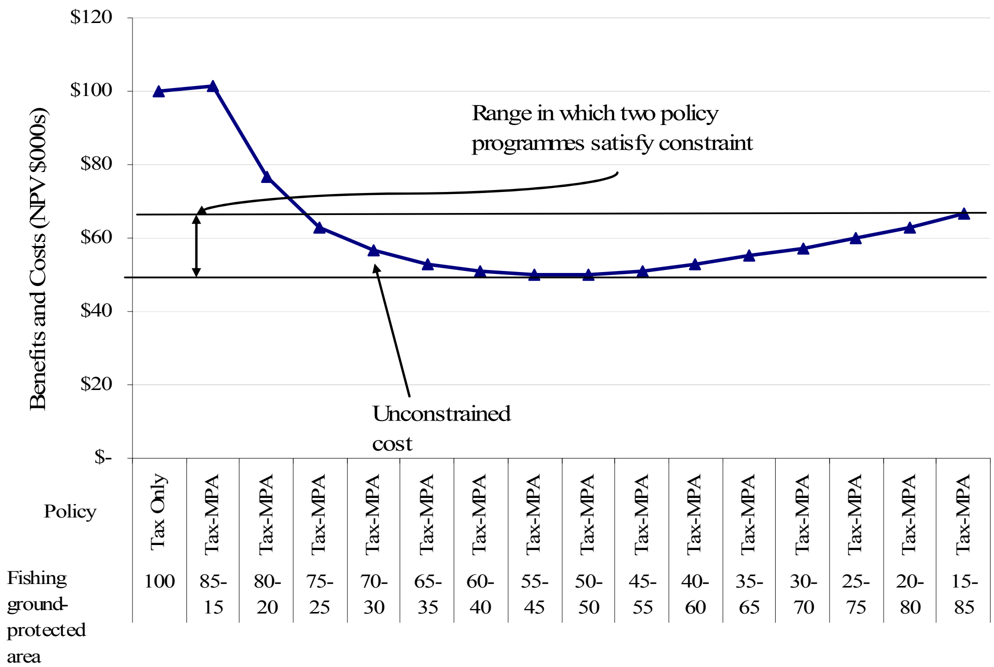


Figure 5: Cost curve for various policy programmes

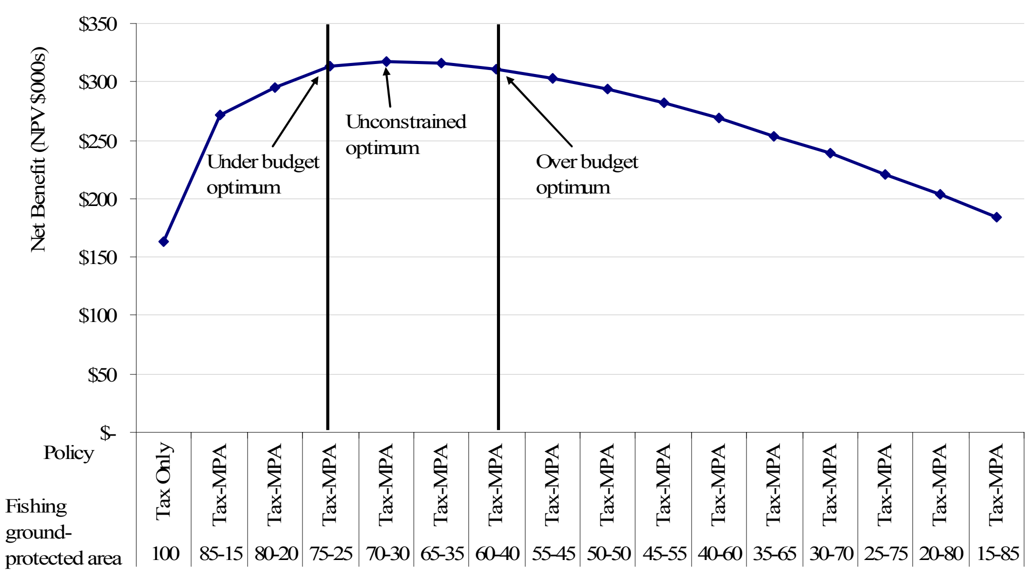


Figure 6: Net benefit curve with budget constraints and policy programmes

In the situation where the budget constraint was less than that required to optimally manage the fishery, the reverse outcome was obtained. That is, too much of the relatively inexpensive control (protected area) used, and too little of the relatively expensive (tax) control used. Given a budget constraint of $51 thousand, a policy of 40 percent protected area and tax was optimal. The over and under budget optimal controls are shown in Figure 6.

Public Choice

Welfare weights were added to the two stakeholders to examine the outcome given a market for regulation. Two scenarios were examined; first, were an arbitrary weight of two was added to fishers leaving conservationists weight neutral at one (2:1); and second, when the same arbitrary weight of two was added to conservationists leaving fishers weight at one (1:2). The results in terms of total discounted net benefit are shown in Figure 7. As expected, the welfare weights skewed the policy choice towards either less protected area for fishers, or more for conservationists.

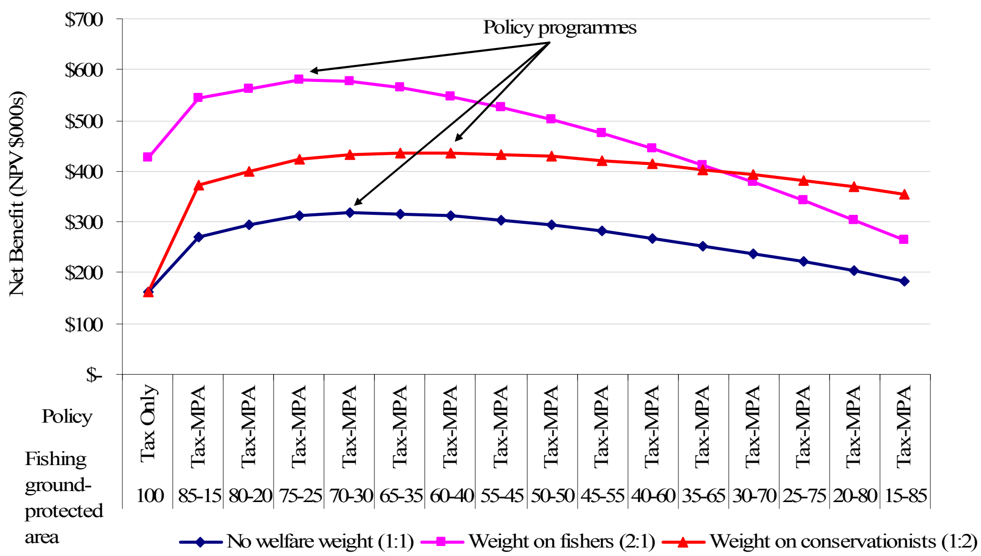


Figure 7: Policy programmes under public choice

The net costs of a policy environment where stakeholders can influence the choice of policy programmes can be determined. Given the welfare weight on fishers of two (2:1), the loss of total discounted net benefit was $4.7 thousand, and $6.6 thousand given a welfare weight of two on conservationists (1:2). Given these losses, a potential Pareto improvement exists.

5. Policy Implications

From the theoretical model of institutional design developed in this paper, several aspects of institutional design in fisheries were explored. When consideration was given to both the administration and stakeholder costs of different policy instruments, it was found that optimal policy programmes included a greater degree of less expensive policy instruments. These instruments were included despite the loss in fishery value. As a trade-off between extra value and the cost of a programme exists, the goal of maximising fishery value in the absence of these costs is non-optimal.

With benefits dependent on the production technology in use, optimal policies favour those stakeholders who are more efficient at accessing or exploiting the resource. If the cost of accessing the resource for certain groups is relatively high in comparison to the benefits that accrue, then policies should be skewed away from these groups. Despite this outcome, it is likely that the development of policies which favour efficient users of the resource is likely to be unequitable. Given the common property nature of most fisheries, fisheries management may instead be concerned with the equitable division of resources, and not in maximising the net benefit to society. However, if policy programmes are designed based in equitable division, a likely potential Pareto improvement exists.

In this paper, a theoretical model of institutional design was developed and illustrated using data obtained from Greenville and MacAulay (2006). The data were used to illustrate the outcomes from the model and are therefore not a complete representation of all possible policy programmes that are available in fisheries management. Despite this, the model does provide a means to analyse the application of policy programmes. One difficultly not easily overcome if applying this model is the availability of data, in particular on the costs of policy programmes. Whilst administration costs may be obtained, the net benefits to stakeholders are harder to obtain. Benefits in terms of resource rents may be modelled, however, marginal data on non-use values and the costs of contracting between individuals is very difficult to obtain and remains a major limitation of this approach.

From the comparative statics of the model, an insight into the uptake of economic policy tools can be obtained. As economic management tools are generally viewed as relatively expensive policy instruments, it is likely that they will be either used less extensively than is required to maximise the resource rent generated in the fishery, or under used in an environment of tight budgetary controls on the managing authority. In this way, the lack of uptake of economic management tools in fisheries can partly be explained.

An argument given for why management organisations have limited funds was that they have to compete with regulation requirements in other sectors of the economy. If the overall central funds are limited, this could lead to a shortfall in the required funds to manage the fishery despite the potential net gain of extra funds. If this is the case, policy instruments which collect revenue (such as taxes) may be favoured (if the funds go to the management authority), and improve the net return from the fishery.

Public choice issues were included in the analysis by the use of welfare weights. In a discrete policy environment, a continuous market for regulation cannot be defined, as stakeholders will attempt to influence policy programmes that improve their net utility. In a simple example, such policy weights lead to a net loss in the return from fishery resources and a bias in the use of instruments. In practice, such policy weights could be estimated and used to analyse public choice issues in fisheries management.

6. Conclusions

A theoretical model of institutional design was developed in this paper with reference to fisheries management. It was argued that tools aimed at maximising the value of fishery resources were not optimal without adequate consideration of the costs involved with those policies. In a two-policy instrument example, optimal policy programmes used the relatively cheaper and less effective policy instruments more intensively than the relatively more expensive and effective policies.

Further, it was argued that optimal policy programme design should favour those groups who could more efficiently access the resource. In this way, the greatest net benefit to society was generated as less value was transferred to cost. However, this outcome is likely to be unequitable, and may not be politically desirable.

A significant amount of further work is required to apply this model to observed data. The estimation of net benefits of individual stakeholder groups is required to apply the model. Despite this, the aim of the paper was to present a theoretical model of institutional design that could both identify optimal policy programmes and be used to explain why current programmes may differ from optimal. Three reasons for policies to differ from optimal programmes were identified; first, the misspecification of the objective function for the management authority; second, budget constraints placed on policy makers; and third, public choice. All these were shown to skew the choice of policy programmes.

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