

Developing a Decision Support System to Manage Fisheries Externalities in New Zealand's Exclusive Economic Zone

Ken Hughey#, Ross Cullen#, Ali Memon#, Geoff Kerr# and Nick Wyatt*
Lincoln University. * Ministry of Fisheries
New Zealand

Abstract: New Zealand marine fishing activities create many types of environmental externalities. Legislation requires that the externalities be internalised and fisheries management agencies must choose from a wide range of instruments which are best suited to the task. Selection of best instruments can be aided by following a hierarchical decision process, which first screens the universe of instruments to produce a likely set, then tests that list against implementation criteria to establish the feasible set. Instruments in the feasible set can be evaluated against a range of environmental, Treaty of Waitangi, economic, socio-cultural and management criteria. This approach to selection can be formalised in decision support software to provide a useful tool for fisheries management agencies.

Key words – New Zealand, fisheries, internalising externalities, Decision Support System

1. INTRODUCTION

New Zealand has the fourth largest Exclusive Economic Zone in the world. In 1986, New Zealand introduced the quota management system as a tool to promote sustainable management of its fishery resources. New Zealand was amongst the first countries to do this on a universal basis. Even though the ITQ system has been successful in a number of respects, one of the major concerns that has become increasingly manifest during the last decade is environmental externalities associated with the activities of commercial fishers. Such concerns have led to a wider focus on the need for sustainable management of the marine environment within the EEZ. This is reflected in the purpose and principles of the recently reviewed Fisheries Act 1996 (Fig. 1).

The objective of our research project, commissioned by the Ministry of Fisheries, is to develop a Decision Support System (DSS) to assist the Ministry to select the best combination of 'instruments' for internalising the environmental externalities of commercial fishing. This paper provides an outline of the framework and process that has been followed to develop this system.

2. THE DECISION SUPPORT FRAMEWORK

Decision makers in fisheries management, when faced with environmental problems, have a logical sequence of decisions which they must work through before deciding on the policy instruments which are most likely to resolve the environmental problems. This sequence is as follows:

- Environmental impacts/externalities must be defined.
- Type of fishery within which the impact/externality occurs must be defined.

- Significance of the environmental impacts/externalities must be evaluated.
- Range of policy instrument(s) that will internalise the externality must be determined.
- Effectiveness of these instruments, in meeting the environmental aims of fisheries and other related legislation, needs determining.
- Instruments are selected that best meet a range of evaluation criteria.

This process is portrayed schematically in Figure 2.

3. BIOPHYSICAL ENVIRONMENTAL EXTERNALITIES IN NEW ZEALAND FISHERIES

One of the problems we faced in reviewing the literature on environmental externalities was how to determine the relative significance of externalities, i.e., how to express the extent of the externality problem in terms of indices such as species survival, sustainability, etc. While many authors have identified the types of externalities associated with particular fisheries, few have been able to report on their significance. Significance is important for several reasons:

- To meet the requirements of sections 8 (Sustainability) and 9 (Environmental principles) of the Fisheries Act 1996 (see Figure 1);
- To determine the relative ecological impacts of the different externalities so that priorities for remedial action can be determined.

Hughey et al (2000) identified the New Zealand fisheries in which 'significant' externalities occur as:

- Any bottom dredging fishery on a non silt/sand substrate, e.g., oyster and scallop;

- Any bottom trawl fishery on a non silt/sand substrate, e.g., snapper and orange roughy;
- Long line fisheries where there is the presence of non target fish species or seabirds in high numbers at the same fishing water level, e.g., tuna;
- Mid water trawl fisheries where marine mammals occur in ‘significant’ numbers, e.g., southern squid; and
- Gillnet fisheries where dolphins are present, e.g., rig and other small sharks and kahawai.

4. INSTRUMENTS FOR INTERNALISING FISHERIES EXTERNALITIES

4.1. Underlying rationale for internalising externalities

Negative externalities are costs imposed upon another person or firm where there is no contractual relationship between the two parties. The term externality is also widely used to describe situations where there is damage caused to part of the natural environment as a consequence of economic activities, including in some instances by fishing. In those cases costs are recognised by individuals who are concerned about the natural environment. Because of the absence of a contractual relationship between two parties, external costs can be ignored by the person or firm who creates them. The

outcome is that inefficient levels of production or consumption occur.

If fishing effort is identified as being at an inefficient level, actions can be proposed to internalise costs and reduce the externalities. Generally, externalities can only be reduced at some cost and there is an economically optimal level of externality reduction. The optimal level occurs where the marginal cost of externality reduction equals the marginal benefit from externality reduction (Pearce and Turner 1990).

Internalisation occurs when the external costs associated with fishing are ‘recognised’ by the firm creating the externality. A key point is the need to change fishing companies’ behaviour or their fishing-related activities, to avoid, remedy, or mitigate externalities. This can occur if the firms creating the external costs take any of the actions listed below, resulting in reduced incidence of the externality creating behaviour:

- Reduce or stop or change the pattern or timetabling of fishing in an area, or during certain times.
- Apply more caution during fishing to reduce risk of polluting, or causing damage by fishing in multi species areas, or trawling the sea floor.

Figure 1. Purpose and principles of the Fisheries Act 1996.

PART II: PURPOSE AND PRINCIPLES	
8. Purpose	– (1) the purpose of this Act is to provide for the utilisation of fisheries resources while ensuring sustainability. (2) In this Act- “Ensuring sustainability” means- (a) Maintaining the potential of fisheries resources to meet the reasonable foreseeable needs of future generations; and (b) Avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment: “Utilisation” means conserving, using, enhancing, and developing fisheries resources to enable people to provide for their social, economic, and cultural well-being.
9. Environmental principles	– All persons exercising or performing functions, duties, or powers under this Act, in relation to the utilisation of fisheries resources or ensuring sustainability, shall take into account the following environmental principles: (a) Associated or dependent species should be maintained above a level that ensures their long-term viability. (b) Biological diversity of the aquatic environment should be maintained. (c) Habitat of particular significance for fisheries management should be protected.
10. Information principles	– All persons exercising or performing functions, duties, or powers under this Act, in relation to the utilisation of fisheries resources or ensuring sustainability, shall take into account the following information principles: (a) Decisions should be based on the best available information: (b) Decision makers should consider any uncertainty in the information available in any case: (c) Decision makers should be cautious when information is uncertain, unreliable, or inadequate: The absence of, or any uncertainty in, any information should not be used as a reason for postponing or failing to take any measure to achieve the purpose of this Act.

- Change behaviour once fish have been caught and deal with non-target fish species, to reduce bycatch, and potential discards.
- Change behaviour once non-target species have been caught and deal with them as effectively as possible to minimise the externality.
- Invest in activities such as stock enhancement or habitat creation to offset the environmental effect.

To address the above we have surveyed a wide range of international literature covering a broad spectrum of environmental management issues.

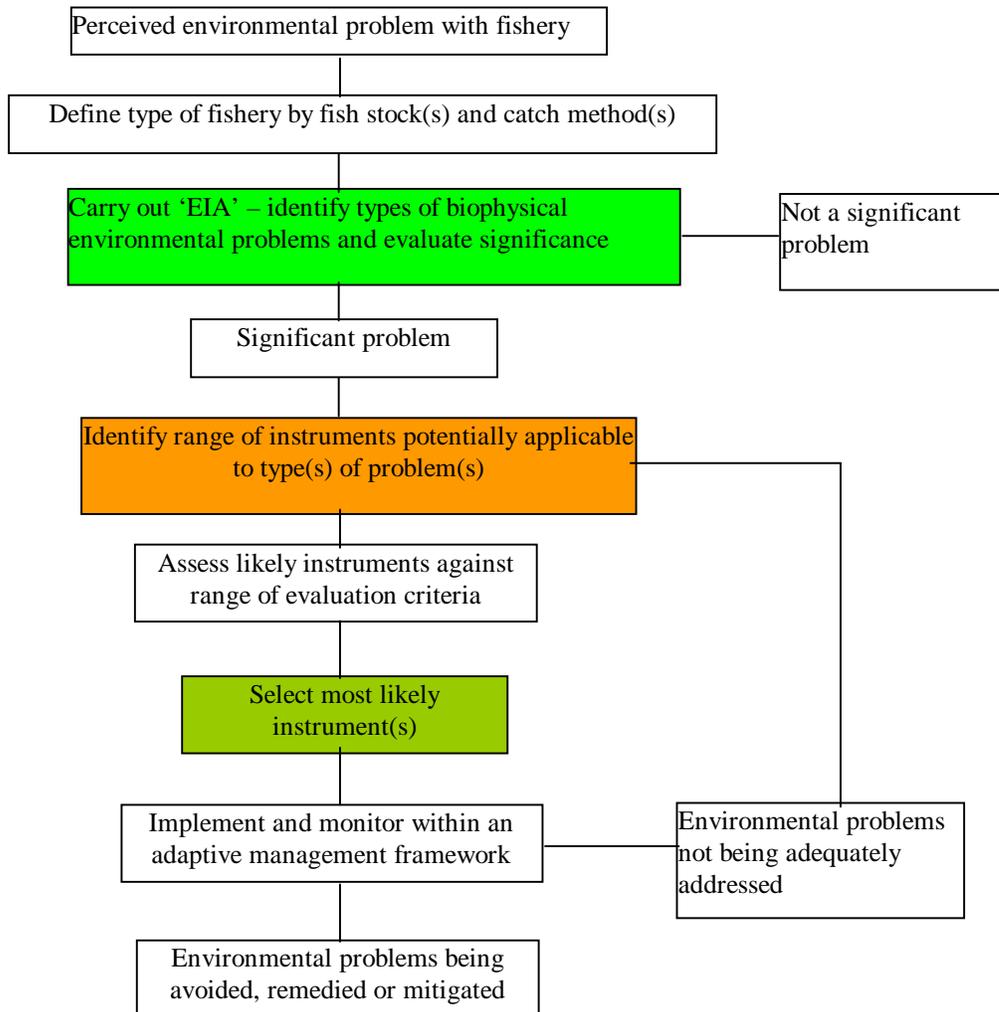
4.2. Instruments for internalising environmental externalities in fishing

Environmental externalities are associated with many economic activities and there is an extensive literature analysing types of externality, instruments for correcting

externalities, and criteria for evaluating those instruments (Verhoef 1999).

Fishing environmental externalities comprise a range of diverse events: marine pollution from ship’s discharges; bycatch of non-target fish species; damage and mortality to non-fish species; and destruction of fish habitat. While all of these externalities are undesirable, in few instances will they cause disastrous outcomes. If that is the case then society will typically tolerate some amount of the externalities. Only in some instances will society judge that fisheries externalities are unacceptable and strive to avoid them completely. The result is that in many cases society will find acceptable, instruments which reduce the level of externalities so long as the level achieved meets some minimum standards. In cases where any damage is unacceptable society will resort to instruments that target zero level of fisheries externality.

Figure 2. Preliminary framework for the Decision Support System.



Many instruments have been invoked and used in many countries, often in an attempt to reduce or prevent excessive harvesting of fish species. Some are used specifically to tackle fishing environmental externalities; others appear to have potential for use with internalising fisheries externalities. A large amount of literature exists exploring the effectiveness of various fisheries management policy tools and the requirements for their success (e.g., Hanna 1997, OECD 1997). Table 1 describes the attributes of the different policy instruments for internalising environmental externalities and their potential application to fisheries management.

5. EVALUATION CRITERIA

Determining which instruments are ‘best’ requires criteria to judge performance and data to evaluate performance of the instruments. However, and as noted by (Slooten and Dawson 1995), most evaluation studies of the performance of some of these instruments are at best limited. Consequently, clear and robust criteria are necessary to evaluate their performance as a basis for selecting appropriate management tools.

Table 1. A summary of the Instruments.

Instrument	Main world uses	Current NZ uses	Applicability to fishing
Regulatory			
No take zones	Protect juveniles, spawning areas etc	Hoki spawning areas	No fishing in specified zones means externalities not created
Marine Reserves	Protect juveniles, spawning areas etc protect habitat	Banks Peninsula, Long Bay etc	Area set aside for preservation of marine species
Closed seasons, areas	Protect juveniles, spawning areas etc	Near sub Antarctic islands.	No fishing during designated times and /or in prescribed areas.
Size or sex selectivity	Direct effort away from specified ages, sex individuals	Rock lobster, size requirement	Requirement for fishers to return to sea all prohibited catch
Bycatch Reduction Devices (BRD)	Reduce rate of bycatch of fish and other species	Pingers for Hector's Dolphin	Vary technology used while fishing to reduce bycatch of fish or other species
Technology ban	Prevent externalities associated with specific harvesting technologies	Drift netting ban	Reduce bycatch by only allowing techniques which cause few externalities
Input limitations	Reduce externalities associated with number of potlifts, boat days etc	Foveaux Strait oyster fishery	Reduce volume of fishing activity and associated externalities
Catch limitations	Reduce externalities associated with effort	Foveaux Strait oysters	Limit total harvesting and associated externalities
Retention and utilisation requirements	Reduce dumping of target and non -target species	CAAQ, FA AQ	Allow non target catch to be landed, not dumped
Financial systems			
Taxes	Provide incentive to reduce, eg, pollution	Conservation Services Levy, applied to some non-fish bycatch	Apply tax to variable inputs, boats, outputs, to reduce profits and externalities
Subsidies	Reduce costs of inputs	R&D assistance	Reduce costs of developing BRD
Environmental performance bonds	Provide financial incentive to avoid creating externalities	Mining, biodiversity protection	Provide incentive to not damage habitat or marine ecosystem
Financial inducements	Bribe to behave in desired way		Financial reward if do not create environmental externalities
<i>Rights based</i>			
IQ, ITQ, IVQ CDQ, Share fisheries	Reduce race to fish	NZ QMS	Creation of rights reduces need to race, provides incentive to maintain asset, so less externalities created

Voluntary approaches			
Co management	Right holders draw up operating systems	Challenger Scallop	Peer agreements reduce externalities
Codes of practice	Agreed behaviour which limits externalities	HSNO, Agchem	Industry develop, adopt, codes which limit or preclude externalities
Accredited environmental management systems	Industry develops systems - externally audited prior to accreditation	Marine Stewardship Council, ISO 14001	Industry develop, adopt, systems with environmental policy which aims to limit or preclude externalities
Conservation easements	Negotiated agreements restricting a parties behaviour	QEII Trust, Ducks Unlimited	Negotiated agreement to not take certain actions eg create externalities
Legal Remedies			
Tort law	Liability for pollution damages	RMA is a 'strict liability' law	Potential damages claims provide incentive to avoid creating externalities
Education Information supply			
Publications, guides, kits, etc	numerous	Numerous, e.g., biodiversity protection	Informed people change behaviour, not create externalities
Informal regulation e.g., environmental reporting	Toxics Release Inventory and corporate environmental reporting		Information release plus community pressure, modifies firm behaviour

The criteria presented below are in five sections. Criteria within each of the sections vary in terms of the strength of direction they give, i.e., the environmental and Treaty of Waitangi criteria are prescriptive because they are mandatory under existing legislation. Economic and social criteria are less prescriptive because policy advisors and decision-makers have greater latitude to consider these. Management criteria fall in between. In the main, they reflect attributes of good policy analysis.

5.1. Environmental criteria

The development of environmental criteria requires consideration of:

- Fisheries Act (1996) requirements
- Other relevant NZ legislative requirements
- NZ's international treaty obligations

- Government 'resource management/environmental' policy
 - Industry self-management environmental principles.
- Fortunately, following its recent review, the Fisheries Act has been developed in an integrated way. It draws on international conventions (e.g., UNCLOS Convention) and is complementary to related legislation (i.e., the RMA 1991) and policy (e.g., the Environment 2010 Strategy (MfE 1995)). Because of this approach to development of the legislation, it has been possible to integrate more recent environmental management considerations into development of fisheries policy and its implementation. Specifically, development of the Proposed Environmental Performance Indicators of the Marine Environment (MfE 1998) builds on key Fisheries Act requirements.

The following criteria, which more than meet the requirements of the Fisheries Act (1996), apply to the selection of policy instruments.

OVERALL ENVIRONMENTAL CRITERION:

- The Policy Instrument(s) safeguards the life supporting capacity of the marine environment in a healthy functioning state.

SPECIFIC ENVIRONMENTAL CRITERIA require that the policy instrument:

- contributes to maintaining 'utilised' fish stocks above a level that ensures their long-term viability
- assists with avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment
- ensures fishing related mortality of marine mammals or other wildlife is below a maximum allowable fishing-related mortality level
- will seek to support aims of the NZ Biodiversity strategy which are relevant to implementing the Environmental Principles of the Fisheries Act, specifically:
 - it will help ensure natural marine habitats and ecosystems maintained (including associated or dependent species) are in a healthy functioning state; and
 - it contributes to ensuring there are no human induced extinctions of marine species;
 - protects habitat of particular significance for fish.

5.2. Rights guaranteed under the Treaty of Waitangi: Treaty rights criteria

The Treaty of Waitangi 1840 is the founding document of New Zealand as a nation. It is part of the law of New Zealand to the extent that it is incorporated into statute. A number of statutes relating to the marine environment incorporate reference to the principles of the Treaty and to the values and traditional relations of Māori with natural places and resources.

By the Treaty, the Crown confirmed and guaranteed the existing rights of tangata whenua to land and resources, including rights in respect of intangible taonga. For this reason, it is imperative that the choice of policy instruments to avoid, remedy or mitigate environmental externalities associated with commercial fisheries is assessed in terms of their implications for Māori tribes, which have guaranteed to them under Article II the right to retain (and have restored to them if taken without consent) tribal resources and taonga, and the right to manage them according to their cultural preferences.

TREATY OF WAITANGI CRITERION:

- The policy instrument(s) chosen will protect Māori customary fishery rights and practices.

5.3. Economic criteria

There are five broad economic requirements for assessment of the performance of policy instruments to address environmental externalities:

1. Efficiency (including transaction costs)
2. Encouragement of innovation (dynamic efficiency)

3. Profitability/International competitiveness
4. Cost-effectiveness/Least cost policy
5. Internalisation (full cost principle).

The following 'overall' and 'specific' criteria are designed to reflect these requirements:

OVERALL ECONOMIC CRITERION:

- The Policy Instrument(s) maintains the economic viability of the fishery and downstream economic activities.

SPECIFIC ECONOMIC CRITERIA:

- The policy instrument is the least cost way to achieve the desired environmental objective
- The policy instrument forces the person causing the environmental externality to face all (or more) of the costs that they impose on the environment or on others
- Windfalls and wipeouts will be avoided as far as practicable
- The policy instrument minimises transaction costs
- The policy instrument does not result in undesirable changes in market power, either for buyers or seller.

Cullen et al (2000) identify what is meant by each of these criteria, and how they may be assessed in practice. The key requirement is to find the least economic cost way to achieve internalisation of the externalities, when

imposing the polluter pays principle. Impacts of each policy on transaction costs, market power and windfalls/wipeouts should also be considered.

5.4. Socio-cultural criteria

There are three major areas for criteria development here:

- a. Community
 - b. Protection of access to other users
 - c. Equity
- The suggested criteria are:

OVERALL SOCIO-CULTURAL CRITERION:

- The Policy Instrument(s) will not have undesirable social/cultural impacts on fisheries dependent communities.

SPECIFIC SOCIO-CULTURAL CRITERIA:

- The policy instrument(s) will not have adverse social impacts on fisheries dependent communities.
- The policy instrument will protect access by recreational fishers to adequate fish stocks to satisfy their needs
- The policy instrument(s) will safeguard the needs of future generations.

Community

Introduction of fisheries management policies can have significant effects on some communities which are heavily dependent on fishing for employment and income. The New Zealand Government acted precipitously in 1983 to remove part time fishers from the industry by declaring all fishers who received less than 80 percent of their income from fishing, to no longer be eligible to fish commercially. Selection of fisheries management policies in some instances must consider the impact on communities.

Recreational fishing

The rights of recreational fishers are different from those of commercial quota holders, and have not as yet been well defined. Compared to the QMS and the ITQ, and the recently established regulations for Māori customary fishing, the recreational sector has no equivalent framework for precisely determining rights in the marine resource. For many New Zealanders, however, the freedom to go fishing is considered a birthright. It is imperative that tools to manage environmental externalities associated with commercial fisheries are evaluated in terms of how they may impact on access by recreational fishers to fishery resources.

Equity

The concept of equity underpins the principle of sustainable management. Equity can be defined as intragenerational equity and intergenerational equity.

The recent environmental statutes in New Zealand, including the current fisheries legislation, have embraced the sustainability principle. This is a requirement to our generations to manage the resource base such that the average quality of life we ensure ourselves can potentially be shared by all future generations.

Equity questions arise not only on the consumption side of public policy (“Who benefits?”), but also on the production side (“Who pays?”). There is no clear right answer to what an appropriate distribution of such benefits and costs to society’s members should be. Unlike efficiency questions, which, despite a host of conceptual problems, often do have right answers, e.g., “This instrument to manage environmental externalities is the cheapest”- equity questions do not. There are, however, several principles that can guide consideration of equity issues in the decision making process.

5.5. Management criteria

Fisheries managers have limited resources available to achieve management’s objectives. They can be expected to search for internalisation mechanisms which can be implemented at moderate cost, are effective in achieving externality internalisation, including in less than optimal circumstances. Fisheries managers need to consider the following ‘managerial’ criteria when evaluating internalisation mechanisms.

OVERALL MANAGEMENT CRITERION:

- The Policy Instrument(s) is capable of being implemented within existing management constraints.

SPECIFIC MANAGEMENT CRITERIA:

- The policy instrument(s) is/are easy to introduce and readily modified
- The policy instrument(s) is/are low cost to administer
- The policy instrument(s) does not require specific infrastructure that is not available at an acceptable price or in reasonable time
- Application of the policy instrument(s) requires low levels of information about the state of the fishery, the activities of the fishing companies and the effectiveness of the internalisation mechanism
- The policy instrument's performance falls within optimal operating conditions
- The policy instrument(s) do not make unacceptable demands upon the skill, capability, safety, and health of fisheries management staff.

Introduction and modification

Some fisheries policies require new legislation to introduce. Others can be introduced and varied by a change of regulations – a much simpler process. Managers who want to achieve speedy improvement in situations where externalities are present will favour instruments that can be readily introduced and varied.

Administration costs

Answers to that question will be determined by the location of the fishery – inshore/mid water/deepwater; by the ease or difficulty in achieving compliance with the system; by the costs of monitoring fishing activities. Budgetary pressures will force fisheries managers to prefer low administration cost mechanisms.

Specific fisheries management infrastructure requirements

Some internalisation instruments may require that fisheries managers have specific items of equipment, e.g., for monitoring, or enforcement such as deepwater capability ships. Where these are not available to fisheries managers, alternative mechanisms must be selected to avoid the infrastructure requirement. A widely used alternative is to negotiate or require that fishing companies carry observers on board ships, or self report, to obviate the need for fisheries management vessels.

Information requirements

Regulatory authorities often have poor information supply about those items and this can restrict their ability to successfully apply internalisation instruments.

Where information availability is weak, fisheries managers will select internalisation instruments that make least information demands. Section 10 of the Fisheries Act deals with the Information Principles – good practice guidelines can be used here.

How well do the internalisation mechanisms perform in sub-optimal conditions?

A first best internalisation instrument in optimal conditions may perform poorly in sub optimal conditions. Fisheries managers often operate in second best worlds of limited resources, poor information availability, variable causes of externalities, etc. Their preference may be for versatile internalisation instruments which operate satisfactorily in many situations, rather than a mechanism which only performs well in ideal conditions. Is the internalisation instrument self funding? Some mechanisms have potential to be self-funding by requiring payment of fees by industry participants. This feature will increase their likelihood of acceptance by fisheries managers.

Pressure on fisheries management staff

Some fisheries internalisation instruments require frontline staff to tackle risky tasks, or to deal with unpleasant situations. These pressures require specially trained fisheries management staff, payment of higher wage rates, and their overall effect is to increase costs of fisheries management. Internalisation instruments which do not lead to confrontation, do not require specially trained staff, or expose fisheries staff to risk, are likely to be more attractive to fisheries managers.

6. JUDGING THE EFFECTIVENESS OF INSTRUMENTS

We have identified 7 types of fisheries: trawl netting, seining, set netting, dredging, line fishing, pot fishing and diving. For each type of fishing there is a range of possible environmental impact classes: bottom/sea bed disturbance, non-fish bycatch, non-target fish bycatch and pollution. Combining these classifications provides the following matrix (Table 2).

Table 2. Likely areas of concern for fisheries managers based on an analysis of combinations of fishing activity types and classification of impacts.

Type of fishing activity	Impact classification			
	Bottom/sea bed disturbance	Non-fish bycatch	Non-target fish bycatch	Pollution
• Trawl netting	*	*	*	*
• Seining	*	*	*	*
• Set netting	-	*	*	*
• Dredging	*	-	*	*
• Line fishing	-	-	*	*
• Pot fishing	-	-	*	*
• Diving	-	-	-	*
TOTAL POSSIBLE IMPACTS	3	4	6	7

KEY: * Fishing activity can cause a significant environmental impact
 - Fishing activity unlikely to cause a significant environmental impact

Analysis of the table indicates there is a total of 20 fishing activity-impact combinations. Each of these has a possible 21 internalisation instruments that can be applied to it. Clearly, this can be viewed as an imposing exercise. However, for most types of fishing activities it is unlikely there will be more than 2 potentially significant environmental impacts. Consequently, the array of instruments to choose from is much more manageable.

The criteria identified above need to be prioritised/weighted to reflect the project requirements and the aims of the Fisheries Act 1996. In the field of Environmental Impact Assessment, criteria are often:

- Differentially weighted;
- Subject to matrix analysis;
- Added, multiplied or subject to some other form of statistical treatment;
- Used in checklist form.

It is our view that a combination of approaches is necessary as shown in Figure 3, so that:

(a) Having completed an EIA and clearly defined the ‘type of fishery’ and its associated problem(s) then

instruments can be chosen and subjected to evaluation under the Environmental Criteria that are accorded the top priority. This is because the Fisheries Act concerns sustainable fisheries and sustainable fisheries are reliant upon successful achievement of section 9 of the Act. Environmental criteria are also context specific, i.e., not all criteria need be met in every circumstance.

(b) Subject to environmental criteria being met then Treaty of Waitangi needs should be considered next.

(c) Economic and socio-cultural criteria are next in importance – if the instrument is ‘uneconomic’ then it is pointless examining socio-cultural and management issues.

(d) Management criteria should be dealt with separately.

To improve manageability further we have gone the next step of determining, in a preliminary way, the potential effectiveness of each instrument within each of the combinations concerned (Table 3). Summing the effectiveness over the likely range of applicable instruments provides us with a means of identifying those most likely to internalise and correct the externality.

Figure 3. Hierarchical framework for considering instruments employed to internalise environmental externalities.

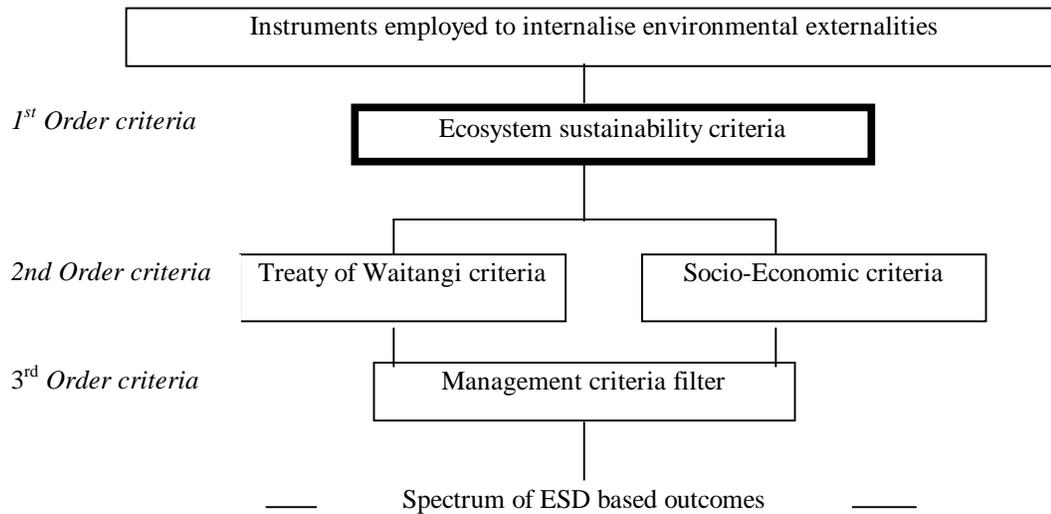


Table 3. Evaluation of the likely effectiveness of a range of policy instruments in addressing a significant line fishing-non fish bycatch problem.

Impact class	Instrument	Environmental criteria	Treaty of Waitangi criteria	Economic criteria	Socio-cultural criteria	Management criteria	Overall effectiveness rating
Non-fish bycatch	No Take Zones	100% in No Take area. Displaced fishing to other regions may result in bycatch	Could negatively impact on tangata whenua if they line fish species in the Zone	If No Take zone can be substituted by another fishing area, economic cost may be slight, and vice versa.	Likely high recreation costs in some areas	Requires monitoring to see if zero take occurs.	
	BRD, e.g., change in hook size to avoid bycatch	Could be 100% effective if change avoids bycatch	Nil	Cost of BR device	Nil	Monitoring to gauge impact of BRD, and if being used.	
	Technology ban/ codes of practice, e.g., timing of line set	Effectiveness will depend on uptake of change	Nil	Cost depends on amount it reduces profits	Nil	Monitoring	
	Taxes, on variable inputs, boats, output, catch – Conservation Services Levy	Effectiveness will depend on fishers responsiveness to tax, and the tax level	Some impact if tangata whenua line fish that species	Cost depends on amount it reduces profits	Nil	Need to estimate tax driver, e.g., variable inputs, to levy tax	

7. DEVELOPING THE DECISION SUPPORT SYSTEM

The final phase of our work, development of a Decision Support System and associated guidelines to make all of

this information manageable from the perspective of a policy analyst, will establish how this process can be operationalised.

An electronic Decision Support System provides a means of doing this. In developing this DSS there are 3 major issues:

- Gaining information about impacts of fishing at each site;
- Lack of knowledge of the relative and absolute effectiveness of instruments; and
- How to deal with multiple problems and synergy between instruments.

These challenges require the system to operate as an adaptive learning approach, providing a tool to aid policy analysts to choose the most likely combination of instruments for any particular circumstance.

For a specific fishery, and environmental externality, the DSS will lead the decision-maker through a multi-stage process, which will ultimately:

- Reduce the range of solutions
- Provide detailed application to a subset of solutions
- Few criteria will be assessed at the first stage
- Few solutions will be assessed at later stages
- Weighted matrix approach to scoring instruments
- Outputs are overall scores for each relevant instrument.
- A qualitative summary can then be provided.

The system makes substantial information requirements, but then this is consistent with Section 10 of the Fisheries Act. These requirements lie in three main areas:

1. Environmental Impacts of fishing
 - Information source, 'science'
2. Relative importance of impacts
 - Information source, managers and/or community
3. Effectiveness of instruments
 - Information source, managers and /or community.

In all cases it will be necessary to consider if combined use of instruments will produce a higher score than a single instrument. Researchers will provide indicative ratings, to generate scores for relevant instruments. DSS users will adjust the ratings, to generate new scores based upon expert knowledge and adaptive learning.

8. CONCLUSIONS

Potential mechanisms for internalising the externalities from commercial fishing have been identified. We have also identified and developed a wide range of criteria that can be used to determine which policy mechanisms are best suited to resolving the environmental externalities. The principal decision criteria are those based around section 9 of the Fisheries Act, i.e., the

Environmental Principles. Assuming there are mechanisms that can achieve these criteria then further criteria representing Treaty of Waitangi, economic, socio-cultural and management issues need to be implemented. A Decision Support System is being developed to help make all this information useful to decision-makers. The challenge will be to keep the system adaptive to the information requirements being generated within sustainable fisheries management.

ACKNOWLEDGEMENTS

We acknowledge the support of the Ministry of Fisheries which is funding this research under contract.

REFERENCES

- Cullen, R., Hughey, K.F.D., Memon, A., Kerr, G.N. (2000). Criteria for evaluate the application of policy instruments designed to internalise externalities from commercial fisheries. AERU Research Report 250: Lincoln University.
- Hanna, S. A. (1997). The new frontier of American fisheries governance. *Ecological Economics* 20, 221-233.
- Hughey, K.F.D., Cullen, R., Kerr, G.N., Memon, PA., Robb, C. (2000). Instruments for internalising the environmental externalities in the commercial fisheries. AERU Research Report 242: Lincoln University.
- Ministry for the Environment, (1995). *Environment 2010 Strategy - a statement of the Government's Strategy on the Environment*. Wellington: Ministry for the Environment.
- Office of the Parliamentary Commissioner for the Environment, (1999). *Setting Course for a sustainable Future*. Wellington.
- OECD, 1997. *Towards sustainable fisheries*. OECD: Paris.
- Pearce, D.W., Turner, R.K., (1990). *Economics of natural resources and the environment*. Hemel Hempstead: Harvester Wheatsheaf.
- Slooten, E., Dawson, S. M., (1995). Conservation of marine mammals in New Zealand. *Pacific Conservation Biology* 2, 64-76.
- Verhoef, E.T., (1999). *Handbook of environmental and resource economics*. Cheltenham: Edward Elgar.