Stakeholder evaluation of market based approaches towards managing the adverse impacts of commercial fishing on the marine environment

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Abstract

Over fishing, by-catch of non-target fish species, marine mammals, seabirds, and damage to benthic habitats remain serious problems in fisheries management. Management methods based on traditional command and control (CAC) approaches may meet with initial successes yet additional progress is often marginal, requiring managers to implement additional regulations to achieve improvements in environmental performance. Market-based instruments (MBI), particularly in the context of rights-based systems, are relatively new and potentially powerful instruments for addressing environmental externalities in the marine environment, yet few policymakers have embraced or actively experimented with them. A comprehensive literature review, a general survey on perceptions and attitudes, and workshops using policy relevant decision support frameworks were used to understand, educate and assist west coast fishery management participants in evaluating the strengths, weaknesses, and trade offs associated with the potential use of MBI compared to traditional CAC regulations in managing the adverse impacts of fishing on marine ecosystems. Survey results suggest that although there were some differences among the various stakeholder groups, fishery management participants are familiar, receptive and perceive MBI as an effective, potential way to manage the adverse environmental impacts of fishing on the west coast. Workshop results indicate that there was little difference among the diverse stakeholder groups in evaluating the different policy approaches towards managing the adverse environmental impacts of fishing on the west coast. An individual transferable bycatch quota of non-commercial fish species is a market-based policy option that had high criteria satisfaction, while managing the essential fish habitat through market based instruments was ranked low and had high uncertainties. The combination of a structured and participatory decision support system and a comparison of the potentials of MBI relative to traditional CAC regulations should assist policy makers and stakeholders in seeking more creative and effective approaches in managing the environmental impacts of fishing activities.
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Chapter 1
Introduction

Most federal and state agencies with fisheries responsibilities have embraced the concept of sustainability. Many agencies, however, struggle in developing management frameworks that can deliver sustainable fisheries. Overfishing, by-catch of non-target fish species, marine mammals, seabirds, and damage to benthic habitats remain serious fisheries problems. Management methods based on traditional “command and control” regulatory approaches such as closed areas, aggregate quotas for non-target fish stocks, mandated gear modifications, and restrictions on fishing methods have met with some success. But many of these “blunt instruments” are often inefficient and inflexible. In many cases, after an initial response, progress remains marginal, requiring managers to implement additional regulations in order to achieve improvements in environmental performance.

In contrast to the management of marine fisheries, terrestrial resource managers often use market-based policy approaches that provide incentives to drive policy actors to meet -- or even exceed -- environmental standards through technological innovation and market efficiency and entrepreneurship. Market-based instruments used in land-based environmental management include cap and trading schemes, environmental credits, trading ratios, cross-area mitigation, credit banking, credit retirement, and cross-externality trading (Van Beuren 2001; Sterner 2003).

A major contributing factor to the success of market-based environmental standards in terrestrial environments is the broad use of property rights. Most U.S. fisheries are managed under regulated open access using command and control rules or weak forms of harvest privileges (e.g., revocable permits or licenses). This reliance on top-down regulation has discouraged the use of innovative market-based approaches in fisheries management. Advancing the use of market-based systems is a priority in the Bush Administration’s Ocean Action Plan (U.S. President 2004) and is a key recommendation of the US Commission’s Oceans Policy Report (USCOP 2004). The emphasis in the Ocean Commission Report is on the use of weak to moderately strong forms of property rights known as “dedicated access privileges”—e.g., tradable but non-compensable Individual Fishing Quotas (IFQs). The 2006 amendments to the
Magnuson-Stevens Fishery Management and Conservation Act include provisions for limited access privileges. Although lacking all the characteristics of strong property rights found in terrestrial landscapes, these programs can create valuable private or community harvest asset rights that generate incentives to address environmental regulations that constrain the use of the asset. They also can function as models for structuring market-based approaches for addressing the constraining environmental problem.

**Environmental Impacts and Market Instruments**

The shortcomings of traditional command and control approaches to minimizing environmental impacts have been well documented (Andersen and Leal 2001; Heal 2000; Anderson 1997; National Research Council 1986), as have the potential benefits of market based instruments (NCEE 2001; Van Beuren 2001; Sterner 2003). In many cases market-based instruments have significant advantages relative to other policy approaches (NCEE 2001). For example, they generate incentives that harness forces of the market place that encourage and reward flexibility, adaptability, and creativity. Creative institutions can use market forces to reduce environmental externalities beyond levels set by traditional regulation while thwarting “perverse” incentives associated with government’s tendency to ratchet up the standards once they are achieved. These market forces also provide a mechanism to coordinate the activities of thousands of players (the “invisible hand”) and stimulate new technologies and innovations.

Market-based instruments such as cap and trading schemes are commonly employed to manage and reduce air pollution (EPA 2003). There are also many examples of the successful application of market based environmental standards to manage large scale ecosystem effects in freshwater aquatic environments including: 1) mitigation banking to protect wetlands (Markandya et al., 2002; Binning et al. 2000); nutrient trades to control pollutants entering watersheds (Nutrient Net 2003); and, 3) salinity trades to manage discharge of saline water into river systems (EPA 2003).

**Prospects and Opportunities for Market-based Standards for Fisheries Management**

Except in the case of IFQ-based property rights used for managing overfishing of commercially valuable stocks, there are few cases where regulators have developed market-based approaches
for controlling the environmental impacts of fishing. This institutional inertia is due to poorly
developed property rights for marine resources and habitats, institutional constraints, paucity of
relevant policy models, and lack of political will and institutional creativity. Developing rights–
based standards for large scale aspects of marine ecosystems including bycatch, spatial access,
and impacts to benthic habitats, while presenting socially beneficial opportunities, may be
perceived as technically too difficult, politically too challenging, and legally in conflict with
public trust doctrine. In contrast to the terrestrial environment, few policymakers in the marine
environment have embraced or actively experimented with market-based policy tools for
controlling fishing impacts to the marine environment.

Despite these barriers, market-based standards, particularly in the context of rights-based
systems such as dedicated access privileges, are potentially powerful instruments for addressing
environmental externalities. The consideration of these tools is particularly timely given the
development of policy approaches for managing essential fish habitat for West Coast groundfish,
and bycatch of overfished groundfish species such as yelloweye rockfish.

To demonstrate possible alternatives, Sylvia (2004) summarized five examples of fisheries which
have been described as somewhat successful in addressing the environmental impacts of fishing
(dolphin bycatch, seabird bycatch, salmon bycatch, benthic habitat impacts, and forage fish
management). In each case, the progress was being achieved using traditional command and
control regulation, best practices technology, and/or government mandated performance
standards. For each case, Sylvia proposed an alternative set of economic instruments using
property rights and market based incentives. These included 1) ITQ’s which incorporate penalty
functions for salmon bycatch, 2) environmental credits, trading ratios, and cross-externality
trading for managing dolphin and seabird bycatch, and 3) cross-area credit trading and mitigation
to control fishery impacts to benthic habitats. His analysis suggested that these instruments may
provide opportunities for equitably and more efficiently managing, trading, banking, and retiring
environmental impacts due to fishing relative to traditional regulation.

Regulators have rarely developed market-based standards to control the environmental impacts
of fishing. In most cases it is considered too costly or politically impractical (Sharp 2002).
These “impracticalities”, however, may be due as much to a lack of knowledge, experience, and a common vision, than any political or technical “transactions” cost. Because communities will tend to address environmental problems consistent with their history, cultures, and existing institutions, it is difficult to implement fundamental institutional change that may be efficient, but also less predictable (Miles et al. 2002). Conducting outreach education and instituting policy experiments are two strategies for overcoming institutional inertia and designing innovative approaches for managing environmental impacts.

In addition to the challenges inherent in their design and implementation, any system of rights-based performance standards must provide incentives for exploration, testing, and adaptation consistent with spatial and temporal scales (Sylvia 2004). The variation across habitats, fish stocks, and fisheries will require flexibility in the design of market instruments and incentive-based policy approaches. The process itself will need to compel research of the marine environment, and then drive analysis to measure the effectiveness of this research in improving for managing environmental impacts.

Relative to simpler and more traditional input/output and command/control policy approaches, property rights are relatively new and require a higher level of policy craftsmanship in order to achieve their objectives. Since market-based programs are not without their own inherent challenges, experts advocating these programs must demonstrate potential benefits relative to traditional regulatory approaches. Assessing and then demonstrating these benefits will require policy analysis, education, regulatory flexibility, and ultimately a willingness to take policy risks. Conducting comparative analysis and undertaking policy experiments and will be important strategies to support their adoption.

One way in which to assess the different policy approaches towards managing the adverse effects of fishing on the marine environment is through multi criteria analysis (MCA). MCA is used to determine overall preferences among alternative options, where the options accomplish several objectives. In MCA, desirable objectives are specified and corresponding attributes or indicators are identified. The measurement of indicators do not need to be in monetary terms, but are often based on the quantitative analysis (through scoring, ranking and weighting) of a wide range of
qualitative impact categories and criteria. Different environmental and social indicators may be
developed side by side with economic costs and benefits. Explicit recognition is given to the fact
that a variety of both monetary and nonmonetary objectives may influence policy decisions.
MCA provides techniques for comparing and ranking different outcomes, even though a variety
of indicators are used.

The overall goal of this project was to help stakeholders involved in the West Coast fishery
management process evaluate the strengths, weaknesses, and tradeoffs associated with the
current use of command and control instruments compared to the potential use of market-based
instruments in mitigating the potential adverse impacts of fishing on marine ecosystems. To
accomplish this, the following tasks were undertaken:

1. A comprehensive review of the literature identifying:
   a. Market-based approaches developed to manage terrestrial environmental externalities that
      have potential for managing the environmental impacts of fishing
   b. Market-based approaches currently employed in fisheries nationally and globally
   c. Evidence of institutional, legal, political and administrative barriers to the adoption of
      market-based environmental standards for fisheries management.

2. A survey of general perceptions and attitudes towards market-based instruments relative to
   traditional command and control approaches towards reducing the potential adverse impacts
   of fishing on the marine environment.

3. Engagement of representative fishery management stakeholders using specific case studies
   and a policy relevant decision support framework to evaluate the potential strengths,
   weaknesses and tradeoffs of market-based instruments relative to more traditional and widely
   used command and control approaches for reducing the environmental impacts of fishing on
   the west coast.

4. Evaluation of the benefits of using a structured decision support system to assess public
   policy alternatives for fisheries management.
Chapter 2
Literature Review

This literature review explores the use of market-based instruments for reducing the environmental impacts of fishing. Part of it is adapted from work previously done from Sylvia (2004) and a previous version of this review was presented at an international conference in 2006 and published in the conference proceedings (Appendix A). It begins with a discussion on the environmental impact of fishing. It then explores five conceptual policy models approaches towards managing environmental problems. The advantages of market based instruments for managing environmental impacts are explained followed by successful examples in the terrestrial and non-marine environment to manage wider ecosystem services. Key opportunities, issues, and challenges associated with the use of market-based instruments in the marine environment are reviewed before the paper concludes with, by way of example, two cases where we believe market-based mechanisms could potentially enhance the management for the environmental impacts of fishing on the West Coast.

ENVIRONMENTAL IMPACTS OF FISHING

The exploitation of marine fish and invertebrate resources provide many important benefits to society, including food, economic resources, employment, livelihoods and recreation. Historically, marine fishery resources were assumed to be limitless, and fishing was thought to have little impact on fish stock and marine ecosystems (NMFS 1998). However, during recent decades, concern about the condition of fisheries has increased. The negative biophysical externalities caused by commercial fishing activities can generally be ascribed to one or a combination of the following (Hughey 2000):

- Habitat damage as a result of dredging or bottom trawling
- Disruption to the food chain through excessive harvest of a predator or prey species
- Non-fish bycatch such as seals, dolphins and birds
- Non-target fish species bycatch impacting on these fisheries and on other types of fishers
- Discarding of undersized or non-commercial fish stocks
Table 2.1 Likely areas of concern for fisheries managers based on an analysis of combinations of fishing activity types and classification of impacts (adapted from Hughey 2000).

<table>
<thead>
<tr>
<th>Type of Fishing Activity</th>
<th>Impact Classification</th>
<th>Bottom/Sea bed disturbance</th>
<th>Non-fish bycatch</th>
<th>Non-target fish bycatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trawl netting</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Seining</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Set netting</td>
<td>-</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Dredging</td>
<td>*</td>
<td>-</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Line fishing</td>
<td>-</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Pot fishing</td>
<td>-</td>
<td>-</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Diving</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TOTAL POSSIBLE IMPACTS</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

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

According to a survey of various stakeholders in the fisheries management process, Chuenpagdee (2003) found that the highest level of habitat impacts are caused by bottom gear such as dredges and bottom trawls; high levels of shellfish and crab bycatch occur in dredge, pot, and trap fisheries; high levels of finfish bycatch are caused by bottom trawls, gillnets, and bottom longlines; high levels of shark bycatch are from midwater gillnets and pelagic longlines. High marine mammal bycatch occurs in gillnet fisheries; and bycatch of seabirds and sea turtles are highest in fisheries using midwater gillnets and pelagic longlines (see Figure 2.1).
Figure 2.1 Ratings of habitat and bycatch impacts for each gear class, as determined by participants of a workshop held in March 2002 in Seattle, WA (Morgan and Chuenpagdee 2003).

Fisheries of the west coast (coastal California, Washington, and Oregon) primarily target several species of groundfish and salmon, while anchovy, sardines, mackerel, shrimp, crab, squid and other shellfish and mollusks are also important fisheries. These fisheries are harvested using seven major methods – trawls, nets, dredges, traps and pots, hook and line, trolling, and miscellaneous – that produce about 410,000 metric tons (mt) annually, and bring in approximately $434 million in revenue (PacFIN 2006). Figure 2.2 breaks down the percentage of landings (by weight) of the fishing gears in the Pacific Fishery Management Council Region in 2006. Purse seine fisheries (under nets gear category), predominately target squid, constitute almost half of the total landings, with another 36% from trawls mainly targeting hake.
The combined effects of overfishing, bycatch, habitat degradation, and fishing-induced food web changes alter the composition of ecological communities and the structure, function, productivity, and resilience of marine ecosystems (Dayton et al. 2002).

**Effects of Fishing on the Ecosystem**

The act of fishing reduces the biomass of a fish species relative to its unfished condition. A marine ecosystem in an unfished state supports a specific number and complexity of fish species. As a marine area is fished, the qualities of the ecosystem change in relation to the number of fish of each species removed from the ecosystem and the effects of fishing gear on the habitat(s) of species using that area. After a number of years of fishing, the habitat quality and nature of that marine ecosystem might be significantly different from the unfished ecosystem. Habitat modified by fishing pressure would support a different set of fish species from those supported by undisturbed habitat for that same area (PFMC 2006).

**Overfishing**

Excessive fishing reduces spawning biomass below optimum levels and catches below the maximum sustainable yield. It can have unintended effects on target species' populations and the ecosystems that they inhabit. Excess removal of larger, older and more fecund individuals from a population depletes spawning stocks, thus reducing a population's ability to replenish itself.
Potential ecosystem impacts include changes in community structure and food chains. Removing a dominant species, for example, may allow competing or prey species to increase, or cause predator populations dependent on the harvested species to decline. Also, discarding of bycatch and processing waste may increase food availability for opportunistic scavengers, including other fish, crabs, and seabirds. These discards in deeper water could redistribute prey food away from midwater and bottom-feeding organisms to surface-feeding organisms; in low-current environments, these discharges can decompose and create anoxic bottom conditions (NMFS 1998; Dayton et al. 2002).

Worldwide, some 25 to 30 percent of all exploited populations experience some degree of overfishing, and another 40 percent is heavily to fully exploited (NRC, 1999). In the United States, approximately one-quarter of the fish stocks for which the status was known were either overfished or experiencing overfishing (NOAA 2005). A majority of the already overfished populations are still being fished unsustainably (Dayton et al. 2002). Of concern on the west coast is the groundfish fishery. In 2002 nine species of groundfish species were declared overfished by the PFMC (including four species of rockfish, bocaccio, cannary, darkblotched, and yelloweye) leading to the closure of the fishery that same year.

Bycatch
Bycatch is the discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct contact with fishing gear (NMFS 1998). This occurs when the fishing method used is not perfectly selective, in that it fails to result in the catch of exactly the desired sex, size, quality and quantity of the target species without causing other fishing-related mortality. With some exceptions, such as speargun and harpoon, the major trawl, gillnet, dredge, and seine fishing technologies are only moderately specialized to catch the desired sizes and quantities of target species. Bycatch includes inefficient choices of technology or gear (discarding undersized commercial and recreational species), de facto claims to harvest rights in competitive fisheries (discarding alleged non-target species as required by regulations), and accidental catches of uneconomic ‘trash’ fish (e.g. sea robins), protected species such as marine mammals (e.g. whales, seals, dolphins), threatened or endangered species (e.g., all sea turtles), and seabirds (Edwards 2003).
Bycatch is considered a serious problem because valuable living resources are wasted, populations of endangered and rare species are threatened, stocks that are already heavily exploited are further impacted, and important changes the ecosystem such as a change to the overall structure of trophic webs and habitat may result. Bycatch is also undesirable if it leads to discards and is thereby a waste of a potential food resource. As marine fisheries catches have plateaued and competition for increasingly depleted stocks has intensified, the moral and economic arguments to decrease bycatch have been received greater emphasis from policy makers, industry, and the general public (Harrington 2005).

Bycatch is also a serious concern for noncommercial marine wildlife. Dramatic declines of leatherback sea turtles, blue marlin, small tooth sawfish, and the barndoor skate suggest that, in extreme cases, bycatch may be the leading reason a species is in jeopardy (Dayton et al. 2000). Bycatch poses the most significant threat to U.S. sea turtle populations, all of which are either threatened or endangered (Hall 1999; NRC 1990). It has also seriously depleted a number of marine mammal populations, such as dolphins in the eastern tropical Pacific Ocean, and concern about its impact on seabirds is increasing. Most harmful to seabirds are the effect of longline bycatch on albatrosses, petrels, and shearwaters and the effect of gill nets on shearwaters and auks (Dayton et al. 2002).

In 159 distinct U.S. fisheries, bycatch discarding affects at least 149 species or species groups. Finfish, crustaceans and mollusks constitute a majority of these species or species groups, while protected species such as marine mammals, sea turtles and sea birds make up most of the remainder (NMFS 1998). In 2002, 1.06 million tones of fish were discarded and 3.7 million tones of fish were landed in the USA marine fisheries, giving a nationwide discard to landing ratio of 0.28, amongst the highest in the world. Regionally, west coast fisheries are amongst the lowest in the nation with a discard to landings ratio of 0.15 (Harrington 2005). Still, the groundfish and halibut fisheries have high ratios of discards to landings at 0.93 and 0.80 respectively. Groundfish bycatch includes flatfish, skates, halibut, whiting, and sharks. The halibut fishery bycatch includes rockfish, spiny dogfish, skates, sharks and sablefish. At the
other end of the spectrum, the coastal pelagic and whiting fisheries makes up 0.02 and 0.004
discard to landing ratio.

Table 2.2 Pacific regional overview of landings, discards and discard to landings ratios by
fishery (adopted from Harrington 2005)

<table>
<thead>
<tr>
<th>Fishery</th>
<th>Landings (mt)</th>
<th>Discards (mt)</th>
<th>d/l ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundfish</td>
<td>24,988</td>
<td>23,297</td>
<td>0.93</td>
</tr>
<tr>
<td>Halibut</td>
<td>26,065</td>
<td>20,929</td>
<td>0.80</td>
</tr>
<tr>
<td>Coastal Pelagics</td>
<td>123,138</td>
<td>2,560</td>
<td>0.02</td>
</tr>
<tr>
<td>Whiting</td>
<td>142,020</td>
<td>586</td>
<td>0.00</td>
</tr>
<tr>
<td>West Coast Region</td>
<td>316,211</td>
<td>47,372</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Habitat Disturbance

Any sort of mechanized harvesting that reduces habitat complexity can change species
composition, abundance, diversity, and the productivity of associated marine life (NRC 2002).
In general, marine habitats that have been less altered by fishing and other activities are more
complex in structure and more productive in lower level organisms such as worms and
crustaceans than highly altered habitats. Marine habitats with greater complexity at lower
trophic levels and with greater structural complexity tend to support a more complex mix of fish
species in greater abundances than altered habitats. In some cases, however, activities that add
nutrients to the system can increase total productivity but reduce complexity (PFMC 2006).

The habitat features associated with the bottom, for instance – the rocks, ledges, sponge gardens,
and shellfish beds – provide shelter for juvenile fishes and serve as a focal point for foraging or
spawning adults. In addition, ocean sediment supports complex communities of burrowing fish,
worms, and other invertebrates. Mobile fishing gear, such as bottom trawl and dredges, which
are towed along bottom to capture groundfish, shrimp and molluscan shellfish, can have
deleterious impacts these seafloor habitats (NMFS 1998). Plants, animals, sediments, rocks and
other substrates and structures attached to or living on the bottom can be disturbed, removed, killed or injured. Nutrient concentrations in near-bottom water can be increased, which may slightly increase phytoplankton productivity. Suspended solids concentrations can also be increased; these materials typically settle nearby, potentially impacting bottom-dwelling biota. Dissolved oxygen concentrations near-bottom waters can decrease due to the exposure of previously covered anoxic subsurface sediments. Sedimentation and reduced oxygen concentrations associated with mobile gear may affect sensitive larval shellfish and filter feeders, such as clams, scallops and oysters. All these factors have an impact on biodiversity with potentially broad adverse effects on ecosystem functions (as reviewed in NMFS 1998).

The total extent of habitat destruction by fishing gear is unknown, however its extent is far greater and it occurs more frequently than do most natural disturbances (Dayton et al. 2002). Resulting benthic troughs from bottom trawling can last as little as a few hours or days in mud and sand sediments over which there are strong tides or currents, to between a few months to over five years in sea beds with a mud or sandy-mud substrate at depths greater than 100 meters with weak or no current flow. Longline gear has similarly been observed to shear marine plants and sessile organisms from the bottom. Pot gear may damage demersal plants and animals as it settles, and longlined pots may drag through and damage bottom fauna during gear retrieval. Boat anchors also can inflict serious, though localized, impact in some areas (Sheehan 2001).

There is little information on the effects of fishing gears on the habitat of Pacific coast, although there are numerous theories and a great deal of speculation about the effects of various fishing gears on structural habitat. The available information on the effects of fishing gear on marine fish habitat comes from research that has been concentrated in heavily fished areas off the east coast of Canada and the United States, and in the North Sea. There are substantial differences in sea floor topography, other physical features, and biological characteristics between those regions and the Pacific coast of the United States. In addition, most research in those areas focused on trawl and dredge gears, with little information on the effects of non-mobile (fixed) gears. There is ongoing debate about the applicability of that research to the Pacific coast environment (PFMC 2006).
The Pacific coast groundfish species mix, with a high proportion of rockfish, is evidence that there are several remaining complex habitat areas. The numerous, long-lived rockfish species have evolved to take advantage of varied rock habitats along the length of the coast. As rockfish stocks have been fished down to lower levels, there is little evidence of new increases in stocks of short-lived species that do not rely on high habitat complexity. Thus, alterations to rockfish habitat may not be accompanied by improvements in stocks that are better adapted to the altered habitat. For this reason, protection of rockfish and rockfish habitat is extremely important to long-term sustainability of the groundfish fishery (PFMC 2006).

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 (Cullen et al. 2000).

MANAGING THE ENVIRONMENTAL IMPACTS OF FISHING

Institutional Models for Managing the Environmental Impacts of Fishing
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. The conceptual structure for managing environmental impacts is relatively straight-forward (Hughey 2000):

- Define environmental impacts
- Evaluate significance of environmental impact
- Determine management and environmental objectives
- Determine range of policy instrument(s) that will internalize the externality
- Select the rules, institutions, incentives and standards which best achieve management and environmental objectives;
Monitor, measure, and evaluate the effect of policy instrument in achieving environmental objective(s);
Revise and adapt if necessary.

However, there is less agreement on which type of policy approach would most effectively achieve environmental goals. The following section summarizes five alternative conceptual policy models for managing environmental impacts of fishing. To some extent these models are used as a heuristic devise to isolate the essential features of alternative institutional strategies – in the practical policy environment there will be considerable overlap between these approaches (Sylvia 2004).

Model 1 – Government regulated input or output standards (Command and Control)
The central government employs a scientific-bureaucratic model to dictate how, when, where and how much fishermen can fish for controlling environmental impacts. This approach generally relies on detailed prescriptive regulations followed up by a compliance regime based on at sea observers, port inspections and catch reporting. Types of command and control regulations include:

- Technology based standards that specify the method, and sometimes the actual equipment, that fishermen must use to comply with a particular regulation. Examples include restrictions on size and power of fishing vessels, and fishing gear restrictions on mesh size, hook size, trawl gear modifications, and the use of turtle excluder devices (TEDs).
- Temporal or spatial regulations that restrict when and where fishing can take place. Temporal examples include season restrictions. Spatial examples include rockfish conservation areas (RCA) and bottom trawl closures.

Model 2 – Government regulated performance standards
The central government employs a scientific-bureaucratic management model to dictate performance of fishermen in production of environmental externalities by setting a specific target for the environmental impact being managed. This usually allows some flexibility in how this target is met by fishermen. Common examples, in fisheries management are total allowable
catches for target stocks, bycatch allowances and maximum allowable limits for sea bird and marine mammal fishing-related mortality.

**Model 3 – Government employed economic incentives**

Government sanctioned financial tools to encourage efficient and cost effective environmental protection in managing the possible impacts of fishing on the marine environment. These policy instruments are often described as "harnessing market forces" because if they are well designed and implemented, they encourage individuals and companies to undertake efforts that are in their interest and that collectively meet policy goals. The various types of incentive-based economic policy instruments include:

- **Fees and Charges**: A schedule of fees and charges is set based on the potential impacts of different gear types of the marine environment. An example would be charging higher license fees for using bottom trawl gear compared to mid-water trawl gear. Fishermen would have an economic incentive to use gear types that have potentially less impact to the marine environment.

- **Subsidies**: The opposite of fees and charges — subsidies are special pricing, discounts, or payments for adopting specific fishing behaviors, actions, or activities that have a potentially reduced impact on the marine ecosystem. An example would be subsidies to adopt new gear technologies.

**Model 4 – Government sanctioned market based performance standards**

Institutions are structured to provide a form of legal property right, user right, or privilege to provide market discipline and economic efficiencies for managing the environmental impacts of fishing. The impacts can be narrowly focused on a single externality or species or broadly structured to incorporate habitats or ecosystems. Like the economic incentive approach of fees and subsidies, incentives are internally generated through the workings of a market system, allowing considerable flexibility across communities of interest and rights holders to achieve the performance standard. An example of a market based performance standard is tradable permits or “quotas”. Permits or quotas are awarded as a right to use or take an amount of a resource or to impact the marine environment. The number of permits/quotas depends on the total amount of a resource available for use or the acceptable level of the environmental impact. Permits/quotas
may be traded among individuals. An example would be a by-catch quota trade program that allows fishermen to sell unused by-catch quota to a fisherman who needs it.

**Model 5 – Community or industry designed voluntary performance standards**

Voluntary approaches allow the fishing industry to adopt and enforce their own measures and codes of conduct for managing the potential impacts of fishing on the marine environment. These voluntary approaches are not enforced through state or federal regulations, rather voluntary agreements can be enforced through civil contract and associated penalty. This model provides considerable flexibility across the community of interest. Incentives are derived through social structures rather than through the market like in models 3 and 4. Examples of voluntary approaches include industry agreements on time and space closures and the adoption of by-catch mitigation technologies such as gear modifications.

**Table 2.3: Relative strengths of institutional models for managing environmental problems**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptability</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate-High</td>
<td>High</td>
</tr>
<tr>
<td>Public Participation</td>
<td>Low-Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low-High</td>
<td>High</td>
</tr>
<tr>
<td>Economic Efficiency</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate-High</td>
<td>Moderate-High</td>
<td>Moderate-High</td>
</tr>
<tr>
<td>Equity</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low-High</td>
<td>High</td>
</tr>
<tr>
<td>Simplicity of Policy Process</td>
<td>Moderate-High</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low-High</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Table 2.3 illustrates that each of these policy models has strengths and weaknesses relative to some of the key attributes of successful policy institutions. In general, model 1, command and control models, tend to score low except for the simplicity of the process it employs. These low scores are a direct result of an institutional structure that places high value on centralized control and top-down rulemaking strategies.

The government mandated performance-based standards model tends to score moderately well in all categories since it is based on standards directly linked to controlling the environmental externality and involves greater public participation. However, although the standards model allows each fisherman to select the best individual approach for meeting the standard, it does not
provide opportunities for trade among heterogeneous fishermen that could lead to substantial improvements in efficiency and welfare.

Model 3 economic incentives, such as fees and charges, can result in substantial savings in the total cost of controlling the environmental externality as compared to the cost of all fishermen controlling to the exactly the same level. The challenge with charges is figuring out where to set the tax as policy makers have a difficult time knowing beforehand how fishermen will respond to a given level of taxation.

The market-based performance standards (model 4) can generate potentially greater efficiency, depending on the environmental goods, the extent of the rights, and number and heterogeneity of agencies and policy actors. Conversely, the approach can raise social-equity issues and generate contentious debate. Similar to model 5, however, it has significant potential for devolving the day-to-day management to the rights holders.

While the voluntary approach to standards has many advantages, it requires unique conditions for its development including a relatively small community of interests, effective community leaders, potential for significant gains (or minimum losses) for its members, and supportive public agencies.

Another approach for understanding the comparative strengths of standards-based models is the relative degree of economic efficiency and adaptability compared to policy predictability and centralized control. Input standards models demonstrate greater predictability but less efficiency. Conversely, efficient models tend to have significantly less centralized control. (Sylvia 2004).

With appropriate property rights, pricing incentives, and adjustment of national accounting frameworks to include environmental services, markets can be used to substantially manage environmental impacts. Successful markets to manage water and air pollution exist, particularly in the United States. This has important implications for each conceptual model. Because model 1 mandates inputs and/or outputs, it cannot take advantage of economic incentives and
opportunities for trade to efficiently and innovatively meet environmental impacts. In contrast, the performance standards of model 2 can be incorporated within a property rights structure if the performance is evaluated across the entire system rather than for each individual actor. Generally however, government mandated performance standards and economic incentives are mandated for each agent, which does not take advantage of market based trading to achieve efficient solutions for meeting environmental impact. Model 4 is based on market-based approaches for achieving an overall environmental impact for a species, habitat, or ecosystem. If appropriately designed, it can take full advantage of property rights systems to efficiently meet and even exceed the market-based environmental standards. And model 5, although having many attractive features that can work congruently with property rights systems, will only be effective if the achievement of managing the environmental impact is in the individual (or collective) interest, and if the property rights are sufficiently strong to provide agent(s) with the control needed to achieve the goal. If rights are relatively weak, or if achievement of the goal is not in individual and/or collective interest (although it may be in society’s interest) the approach can fail, or at best have only minor consequences. In addition, a collective voluntary system may not necessarily be efficient if it is not structured to take full advantage of opportunities for trades in achieving the standard (Sylvia 2004).

Current Management of the Environmental Impacts of Fishing on the West Coast
To date the regulatory responses to environmental impacts of fishing have been primarily model 1 command and control regulations that prohibit or prescribe particular fishing gears and methods in particular areas either year-round or at specific times.

Bycatch
In the United States one of the national standards for management of marine fisheries, the Magnuson-Stevens Fishery Conservation and Management Act of 2006 (MSFCMA), requires that “Conservation and management measures shall to the extent practicable to, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch” (MSFCMA Sec.301 (a)(9)). Sec. 303 of the MSFCMA expands on this requirement somewhat, stating that fishery management plans are required to “establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery, and
include conservation and management measures that, to the extent practicable and in the
following priority (A) minimize bycatch and (B) minimize the mortality of bycatch which cannot
be avoided” (16 U.S.C. § 1853(11)). In response, fisheries management policies have been
implemented to reduce bycatch.

A large number of marine species have been listed as threatened or endangered under the
Endangered Species Act (ESA) including several species of marine turtles, a variety of marine
mammals, a number of anadromous fish, one species of abalone and one species of seagrass.
The ESA requires the Federal government to protect and conserve species and populations that
are endangered, or threatened with extinction, and to conserve the ecosystems on which these
species depend. The bycatch reduction requirements of the ESA follow from Section 9(a)(1)(B)
and 9(a)(1)(C) of the ESA, which prohibit the take of endangered species within the United
States or the territorial sea of the United States, and on the high seas, respectively. “Take” is
defined by the ESA as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect,
or attempt to engage in any such conduct” (16 U.S.C. 1536(18)). ESA Sections 4, 6, 7, and 10
provide mechanisms for the limited take of ESA-listed species. Of particular relevance for
fisheries bycatch is Section 7, which provides that “Each Federal agency shall...insure that any
action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the
continued existence of any endangered species or threatened species or result in the destruction
or adverse modification of habitat of such species . . . “(16 U.S.C. §1536(a)(2)). For example,
Section 7 consultations and resulting biological opinions and reasonable and prudent alternatives
have resulted in fishery regulations to prevent bycatch of endangered and threatened sea turtles
in the Atlantic and Pacific Oceans.

Several seabird species are protected under the ESA as well. In cooperation with the Department
of the Interior’s U.S. Fish and Wildlife Service, the NMFS monitors and reports the bycatch of
these and other seabirds. Additionally, international conventions and treaties also play a
significant role in the national approach to bycatch management. For example, the Food and
Agriculture Organization of the United Nations, Committee on Fisheries, developed the
International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries.
This plan is being implemented by NMFS and other fishing countries via corresponding National Plans of Action.

The Marine Mammal Protection Act (MMPA) seeks to maintain populations of marine mammals at optimum sustainable population levels, principally by regulating the take of marine mammals. Although the MMPA prohibits the take of marine mammals, it provides exceptions to the prohibition for incidental mortality and serious injury in the process of commercial fishing activities. The MMPA also requires the implementation of take reductions plans that reduce incidental catch of marine mammals by commercial fishing to levels below the Potential Biological Removal (PBR) level within six months and to levels approaching zero mortality with seven years.

In general there are three possible means of bycatch reduction: modifying fishing methods including gear, timing, or location of fishing or other aspects of the methodology such as the introduction of bycatch reduction devices in shrimp fisheries; changing fishing gear or fishing methods entirely, such as the change from drift net gill fisheries to trolling for tunas or changing from trawls to traps for groundfish such as lingcod; and reducing effort and therefore the amount of fishing gear used overall (Chuenpagdee 2003).

Ongoing management measures and programs implemented by the Pacific Fisheries Management Council and NMFS that mitigate bycatch on the West Coast include (PFMC 2007):

- At-sea observer programs in both shore-delivery and sea-delivery groundfish fisheries, including groundfish limited entry trawl, limited entry fixed gear, and open access vessels.
- Large-scale closed areas to reduce protected salmon bycatch: Klamath and Columbia River Conservation Zones.
- Large-scale closed areas to reduce overfished species bycatch: Rockfish Conservation Areas, Cowcod Conservation Areas, Yelloweye Rockfish Conservation Areas.
- Large-scale closed areas to protect groundfish essential fish habitat: 51 new closed areas implemented off West Coast in June 2006.
- Vessel Monitoring System (VMS) requirements for the limited entry fleet to ensure compliance with closed area restrictions.
• Landings limits set for harvest of healthy stocks so that they constrain the incidental catch of overfished species that co-occur with those stocks.
• Season restrictions to reduce directed and incidental catch of overfished species.
• Trawl mesh size, chafing gear, and codend regulations to reduce juvenile fish bycatch.
• Trawl footrope size regulations to reduce access to rocky habitat and rockfish bycatch.
• Selective flatfish trawl regulations to reduce bycatch of rockfish in flatfish fisheries.
• Escape panel requirements for groundfish pots to prevent lost pots from ghost fishing.
• FMP Amendment 14 to reduce capacity in the limited entry fixed gear fleet.
• Trawl buyback to reduce capacity in limited entry trawl fleet.
• Geographically-based harvest guidelines where appropriate, especially in recreational fisheries.
• Total catch limits for canary, darkblotched, and widow rockfish in the non-tribal Pacific whiting sector.

Habitat
Under the Magnuson-Stevens Fishery Conservation and Management Act, the eight regional fishery management council are required to minimize the adverse impacts of fishing on “essential fish habitat” (EFH), which is “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (16 U.S.C. § 1853(11)). Interpretations by NMFS have clarified this definition: waters is defined as “aquatic areas and their associated physical, chemical, and biological properties that are used by fish,” and may include areas historically used by fish. Substrate means “sediment, hard bottom, structures underlying the waters, and associated biological communities;” necessary means “the habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem;” and spawning, breeding, feeding, or growth to maturity covers the full life cycle of a species.

The Pacific Fisheries Management Council has developed documents that describe and map EFH for coastal pelagic species, salmon, groundfish, and highly migratory species and suggest management measures to reduce impacts from fishing and non-fishing activities. The PFMC may use fishing gear restrictions, time and area closures, harvest limits, and other measures to lessen adverse impacts on EFH. When doing so, the Council considers whether the fishing activity is harming the habitat, the nature and extent of the damage, and whether management
measures can be enforced. The Council also considers the long-term and short-term costs and benefits to the fishery, fishing communities, and the habitat.

In addition to EFH, the MSFCMA encourages Councils to designate habitat areas of particular concern (HAPCs). These are specific habitat areas, a subset of the much larger area identified as EFH, that play a particularly important ecological role in the fish life cycle or that are especially sensitive, rare, or vulnerable. Designating HAPCs allows managers to focus their attention on conservation priorities during review of proposals, gives those habitats extra management protection, and gives the fish species within HAPCs an extra buffer against adverse impacts. HAPCs are identified differently from EFH. EFH is identified for each species and life stage; in contrast, HAPCs are identified on the basis of habitat-level considerations, including the importance of the ecological function provided by the habitat, the extent to which the habitat is sensitive to human-induced environmental degradation, whether and to what extent development activities are or will be stressing the habitat, and the rarity of the habitat type.

*Coastal Pelagic Species*

The coastal pelagic species (CPS) fishery includes four finfish (Pacific sardine, Pacific (chub) mackerel, northern anchovy, and jack mackerel), and market squid. CPS finfish generally live nearer to the surface than the sea floor. The definition of EFH for CPS is based on the temperature range where they are found, and on the geographic area where they occur at any life stage. This range varies widely according to ocean temperatures. The EFH for CPS also takes into account where these species have been found in the past, and where they may be found in the future. The east-west boundary of CPS EFH includes all marine and estuary waters from the coasts of California, Oregon, and Washington to the limits of the EEZ (the 200-mile limit) and above the thermocline where sea surface temperatures range between 10° and 26° C. The southern boundary is the U.S./Mexico maritime boundary. The northern boundary is more changeable and is defined as the position of the 10° C isotherm, which varies seasonally and annually (PFMC 1998).

Currently there is no evidence that a fishing activity is having an identifiable adverse effect on CPS EFH. But the PFMC may use fishing gear restrictions, time/area closures, harvest limits or
other applicable management measures to minimize adverse effects of EFH from fishing (PFMC 1998).

Salmon
The Pacific coast salmon fishery EFH includes those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (200 nautical miles) offshore of Washington, Oregon, and California north of Point Conception. In freshwater, the salmon fishery EFH includes all those streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon. Salmon EFH also includes aquatic areas above all artificial barriers except the impassible barriers (dams), however, activities occurring above impassable barriers that are likely to adversely affect EFH below impassable barriers are subject to the consultation provisions of the MSFCMA (PFMC 2003).

The Council is required to minimize the negative impacts of fishing activities on essential salmon habitat. The ocean activities that the Council is concerned with include the effects of fishing gear, removal of salmon prey by other fisheries, and the effect of salmon fishing on reducing nutrients in streams due to fewer salmon carcasses in the spawning grounds. The Council may use gear restrictions, time and area closures, and harvest limits to reduce negative impacts on salmon EFH (PFMC 2003).

The Council is also required to comment and make recommendations regarding other agencies’ actions that may affect salmon EFH. This usually takes the form of endorsing an enhancement program or other type of program, requesting information and justification for actions that might affect salmon habitat, and promoting the needs of the salmon fisheries. The Council works with many other agencies to identify cumulative impacts on salmon habitat, to encourage conservation, and to take other actions to protect salmon habitat (PFMC 2003).
Highly Migratory Species
Defining EFH for highly mobile species such as tuna, swordfish, and sharks is a challenging task. These species range widely in the ocean, both in terms of area and depth. Highly migratory species are usually not associated with the features that are typically considered fish habitat (such as seagrass beds, rocky bottoms, or estuaries). Their habitat may be defined by temperature ranges, salinity, oxygen levels, currents, shelf edges, and seamounts. Little is known about why highly migratory species frequent particular areas. Nevertheless, these species may be affected by actions close to shore or on land, such as fishing, dredging, wastewater discharge, oil and gas exploration and production, aquaculture, water withdrawals, release of hazardous materials, and coastal development (PFMC 2007).

Groundfish
The PFMC manages more than 82 species over a large and ecologically diverse area. Groundfish are fish such as rockfish, sablefish, flatfish, and Pacific Whiting that are often (but not exclusively) found on or near the ocean floor or other structures. The PFMC identified groundfish EFH along the West Coast as all waters form the high tide line to 3,500 meters in depth. As a result the Council adopted mitigation measures directed at the adverse impacts of fishing on groundfish EFH, including closed areas to protect sensitive areas. And now there are 34 bottom trawl areas that are closed to all types of bottom trawl fishing gear, a bottom trawl footprint closure area in the EEZ between 1,280 meters and 3,500 meters and 17 bottom contact areas that are closed to all types of bottom contact gear intended to make contact with bottom during fishing operations, which includes fixed gear, such as longline and pots (PFMC 2006).

INCENTIVES, PROPERTY RIGHTS AND ENVIRONMENTAL MARKETS

The Benefits of Economic and Market Incentives
The inefficiencies of command and control and performance standard policy models for controlling environmental externalities are well documented (Andersen and Leal, 2001; Heal 2000; Anderson 1997). Even voluntary “best practices” may be inefficient because they provide no financial incentive to improve beyond the minimum standard. In many cases economic
incentives and market based performance standards may have significant advantages relative to other policy approaches (NCEE 2001):

- Incentives harness forces of the market place;
- They support flexibility and creativity;
- Can be structured to reduce greater levels of pollution or environmental externalities relative to traditional regulation;
- Can be used to thwart perverse incentives associated with the tendency of government to ratchet up the standards once they are achieved;
- Provides mechanisms to coordinate activities of thousands of players without directly controlling behavior;
- Stimulates technologies and innovations.

Criteria, Design, and Implementation of a market system for environmental management

Haddad (1997) presents criteria that shed light on whether a marketable permit reform is appropriate in a given regulatory circumstance. Below is a general checklist for determining whether to pursue creation of marketable permit based system. A checklist of this sort should be used in the design and application of marketable permit scheme to reduce the environmental impacts of fishing on marine ecosystems.

- Is the regulatory goal clearly-stated, quantifiable, and adopted? If there is ambiguity, no deadline, a perceived willingness not to enforce the requirements, or a perception that penalties for non-compliance are trivial, then there will be minimal incentive to participate in a market. Companies or public agencies will not bother to trade.
- Do potential benefits exceed potential costs associated with decentralizing compliance decisions? Potential risks could be to public safety, the financial health of public or private institutions, human health, or environmental quality.
- Can a permit be identified that, if traded, would reduce the cost of compliance, or provide economic benefits? A marketable obligation to do something that is trivial or that companies or governments would do anyway does not lead to a meaningful cost savings.
- Is the object of trade divisible, measurable, and verifiable? There must be identifiable boundaries that can be used to apportion it among different owners. There has to be a low-
cost non-intrusive way for regulators to verify that the object of trade is being utilized in accordance with its ownership rights and duties, and regulatory constraints.

- Can potential permit purchasers or obligation transferors afford to pay the expected market price of the permit/obligations? Though hard to predict, this can be estimated through surveys and modeling.
- Can certain rights-holders afford not to sell their rights? The extent an area wishes to preserve certain historical ways of life, and simply absorb the loss of economic efficiency that results from leaving some historic property-rights and use patterns alone should be considered in the provisions of a marketable permit system.
- Are there sufficient numbers of traders to make market creation a worthwhile investment? Small numbers introduce the possibility of collusion on pricing or trading rules in order to limit entry into the market by new companies.
- Does the regulated entity have several alternative compliance paths? The marginal costs of compliance must be sufficiently different in order to create the opportunity for gains from trade.
- Can transaction costs be held down? Program designers should seek to minimize cost towards negotiations, execution agreements amongst firms and other costs necessary to transfer a good that is subject to public scrutiny (i.e., filling out applications, environmental impact assessments, attending meetings, etc.).
- Do market-oversight institutions have potential conflicts of interest with a trading program? The oversight body could have a regulatory requirement to dispose of the object of trade in a way different from trading or if valid trades are blocked, the market could lose its credibility among potential traders.
- Is there a regulatory authority with sufficient administrative and enforcement powers to carry out the program? Resource flows often ignore political boundaries. Coordination must be necessary in order to develop a program that benefits all participants.
Designing and implementing a marketable permit program is complex. On one hand the purpose is to achieve a regulatory goal which requires regulation and enforcement but on the other hand in order for a marketable permit system to succeed, it must generate private-sector-like conditions in which trading can take place. Other sources of design and implementation is the political nature of the undertaking. Also trading programs could be affected by legislative, executive and judicial decisions that were not made with the program in mind. In order for trading systems to function well a number of requirements must be satisfied. There are some key variables that influence the shape and form of a trading program (EPA 2001, VanBueren 2001, Haddad 1997):

**Specification of rights**

- The commodity being traded must be defined. The object of trade should help achieve the regulatory goal and it must be determined whether the commodity being traded is an emission permit or an offset credit.
- A well-defined commodity requires a baseline from which to calculate the emission reduction credits (or allowances) that may be traded. Establishing baselines require good historic data on emissions, input use, etc.
- The physical basis of the right should be determined such as a performance basis, input or output basis.
- The duration of the right of the right must be established. Emission permits or reduction credits may be valid for a finite period or given number of periods or they may be valid indefinitely. Administrators should create property rights with enough flexibility to evolve as the regulatory program evolves, but inflexible enough to have lasting value needed to provide an incentive to purchase them.

**Scope of the market**

- The minimum number of participants should be set. Simulations demonstrate that markets require at least 8 participants to function properly.
- Determining who can participate should be made. It may be necessary to place restrictions on transfer of rights to prevent a concentration of ownership. Also issues arise with
transferring emission rights to organizations that plan to retire the rights (e.g. conservation groups). In addition rulings must be established that apply towards the involvement brokers and speculators.

- Defining the level of allowable trading because depending on the program’s objectives, trades may be allowable between individual firms, groups of firms each operating within separate bubbles, or different countries.
- Specifying the geographic area. If sources are dispersed geographically, trading ratios other than one-to-one might have to be imposed to account for the distance between sources to ensure no degradation in environmental quality. Trading might be limited in order to avoid “hot spots” where externality concentrations increase. If the externalities occur seasonally, then trades might be allowed only during a portion of the year.

**Trading rules**

- Design elements must be determined (e.g. trading ratios, cross pollution trading, banking and borrowing, etc.).
- The design process should be “open but guided”. Open in that potential buyers, sellers, and other stakeholders should be included in the substantive discussion over all the aspects of the program creation but guided in that an open process could take years to reach an agreement by all sides.

**Organization of transfers**

- The institution that will administer trading must be determined (e.g. centralized permit exchanges, brokerage services).

**Monitoring and Enforcement**

- There is a need to ensure accountability of trades must not pose unacceptably high transaction costs. Early transactions should be studied for guidance in reducing future transaction costs.
- Performance feedback, evaluation, and incentive mechanisms should be created for the regulatory oversight bodies. Regulators must maintain an open attitude to suggestions and/or
criticisms from program participants and other interested parties. Processes and budgets for formal feedback and evaluation must be defined.

- A regulatory culture consistent with oversight of the market-based programs should be fostered.
- The program should provide meaningful penalties for non-compliance. Credible, significant penalties for non-compliance with the regulatory goals create the underlying incentive to find least-cost compliance solutions. If the underlying incentive is weakened, achievement of the regulatory goal may be put in jeopardy.
- The program should include a teaching component so regulated companies are aware of their options.
- Program participants should be allowed to retain a substantial portion of their gains from trade. Gains from trade can be expropriated by regulators either by matching the level of transaction fees to the estimated level of gains from trade, or by requiring that some additional increment of permits be retired without compensation in order to approve the transfer.
- Program administrators should refrain from instituting quick or unexpected changes in order to retain participants’ confidence in the program.

**Applying Environmental Market Instruments to Manage Large Scale Ecosystem Effects**

The following examples represent a range of environmental problems in terrestrial and freshwater environment which have been successfully addressed using market based approaches.

*Air Pollution*

There are many credit and cap and trade program used to manage and reduce air pollution. Credit programs include EPA’s emissions trading program and phase out of leaded gasoline. Cap and trade systems examples include EPA’s Acid Rain Trading Program, Southern California’s RECLAIM program, CFC trading, SO2 allowance trading system for acid rain control, Northeast Ozone transport, various state level NOx and VOC emissions trading programs (EPA 2001). Stavins (2003) notes particular attention to the lead trading and the SO2 allowance systems.
The purpose of the lead trading program, developed in the 1980s, was to allow gasoline refiners greater flexibility in meeting emission standards at a time when the lead-content of gasoline was reduced to 10 percent of its previous level. In 1982, EPA authorized inter-refinery trading of lead credits, a major purpose of which was to lessen the financial burden on smaller refineries, which were believed to have significantly higher compliance costs. If refiners produced gasoline with a lower lead content than was required, they earned lead credits. In 1985, EPA initiated a program allowing refineries to bank lead credits, and subsequently firms made extensive use of this option. In each year of the program, more than 60 percent of the lead added to gasoline was associated with traded lead credits, until the program was terminated at the end of 1987, when the lead phase down was completed (Stavins 2001).

The lead program was successful in meeting its environmental targets, although it may have produced some (temporary) geographic shifts in use patterns. The level of trading activity and the rate at which refiners reduced their production of leaded gasoline suggest that the program was relatively cost-effective. The high level of trading among firms far surpassed levels observed in earlier environmental markets. The EPA estimated savings from the lead trading program of approximately 20 percent below alternative programs that did not provide for lead banking, a cost savings of about $250 million per year. Furthermore, the program appears to have provided greater incentives for cost-effective technology diffusion than did a comparable non-tradable performance standard (Stavins 2001).

The most important application made of a market-based instrument for environmental protection has arguably been the SO$_2$ allowance program for acid rain control. Established under the Clean Air Act Amendments of 1990, the trading program was based on allocation of allowances to emit sulfur by electric utility, which are transferable across firms and location and that can be carried forward if not used. The intention was to reduce SO$_2$ emissions by 10 million tons below 1980 levels. The EPA was in charge of conducting annual auctions of emission allowances and to oversee a nationwide market in emission allowances traded between utilities. A robust market of bilateral SO$_2$ permit trading gradually emerged, resulting in cost savings on the order of $1 billion annually, compared with costs under likely command-and-control regulatory alternatives.
Although the program had low levels of trading in its early years, trading increased significantly over time. In addition, the allowance trading program had exceptionally positive welfare effects, with benefits being as much as six times greater than costs and consisting mostly of gains in human health. Despite its broadly acknowledged success, the SO\textsubscript{2} allowance trading program has encountered some criticism, mostly for a perceived failure to address spatial (upwind/downwind) concerns (Stavins 2001).

\textit{Water Quality Trading}

There are also many examples of the successful application of market based environmental standards to manage large scale ecosystem effects in freshwater aquatic environments through water quality trading and wetland mitigation banks. The United States is at the forefront in developing trading programs for controlling the discharge of effluent into waterways. Effluent trading is a system that sets a goal for the total amount of effluent which may enter a watershed and allocates this amount among polluting industries. The goal is usually expressed as a mandatory cap on the total quantity of effluent that may enter the water. This cap is the Total Maximum Daily Load (TMDL). Polluters may trade these allocations or credits among each other. An industry with low pollution reduction costs may discharge nutrients at an amount below cap levels, thus acquiring excess pollution credits. These credits may be traded to other firms with higher-pollution reduction costs (Nutrient Net 2006).

The Environmental Protection Agency was actively involved in the development or implementation of 35 effluent trading projects in California, Colorado, Connecticut, the District of Columbia, Florida, Iowa, Idaho, Massachusetts, Maryland, Michigan, Minnesota, North Carolina, New Jersey, Nevada, New York, Ohio, Pennsylvania, Virginia, and Wisconsin (Environmental Protection Agency 2001). The main forms of effluent being regulated in this way are nutrients, salts and pesticides from point sources – including sewage treatment plants, piggeries and industrial plants. More recently, efforts are being made to incorporate non-point sources, from agriculture, into the regulatory framework.

Compared to air emissions trading, effluent trading is more complicated to manage. Water pollutants entering the waterway at one location has a different environmental impact of an
equivalent unit discharged at another point along the waterway and ‘hotspots’ can exist if market rules are not carefully crafted. This problem can sometimes be overcome with trading ratios but these must be founded on a solid understanding of the biophysical relationship involved. Also non-point sources are difficult to incorporate into a trading program because, by definition, discharge form these sources is dispersed and often unobservable. Functional relationships are needed to establish between land use practices and the quantity of discharge. Even if these functional relationships are established, it can be costly to monitor non-point sources because they are dispersed across a wide geographic area (Whitten et al. 2004).

One of the most successful trading examples is the Long Island Sound Nitrogen Credit Trading Program in the State of Connecticut (Kieser and Fang 2005; http://www.dep.state.ct.us/wtr/lis/lisindex.htm). Connecticut established a 64% nitrogen reduction goal for 79 Publicly Owned Treatment Work (POTWS) in a phased Total Maximum Daily Load (TMDL) for nitrogen to remedy hypoxia in Long Island Sound by 2014. A General Watershed Permit allows for point source-point source trading through a state run program.

The design and implementation strategy of the Long Island Sound Nitrogen Credit Trading Program has become a model for other trading programs under development in the U.S. This program has been considered an early success: by using a general permit to include a high number of market participants; the Department of Environmental Protection serving ats the broker to simplify transactions for the buyers and sellers, and; establishment of a state law to protect participants from uncertainties regarding their property rights of the credits (Kieser and Fang 2005). Though it is still early, cost saving with trading have been projected at $200 million versus a traditional command-and-control strategy absent trading.

Wetland Mitigation Banking

Over 100 mitigation banks encompassing 50,000 hectares are used in 34 states and more are in advanced stages of planning (NCEE 2001). Wetland mitigation banking is a system in which the creation, enhancement, restoration, or preservation of wetlands generates compensation credits for the future development of other wetland sites. Large offsite wetland areas are designated and used to mitigate for numerous independent wetland conversions. Wetland mitigation banks are
created through a memorandum of understanding (MOU) among federal and state officials and a bank administrator. The MOU describes the responsibilities of each party, the physical boundaries of the bank, how mitigation credits will be calculated, and who is responsible for long term management of the bank. Developers can purchase credits from other developers who have “banked” credits from previous restoration projects. Credits, which are usually denominated in terms of acres of habitat values, may only be used to mitigate development within the same watershed. State regulations cover issues such as where mitigation credits can be used and the compensation ratios that would be required for various types of development. Existing banks vary from a few acres to over 7,000 acres (Markandya et al. 2002, NCEE 2001, Binning et al. 2000).

Mitigation banking offers several advantages over more traditional on-site mitigation activities (NCEE 2001; Van Bueren 2001):

- Environmental values are better protected in large-scale developments rather than the fragmented wetlands which often result from on-site rehabilitation efforts;
- Economies of scale can be achieved by creating, protecting, and enhancing large parcels of wetland;
- The cost of wetland mitigation actions can be made known to developers very early in the development process;
- Mitigation banking offers greater assurance of long-term management of the protected area;
- Allowing firms to purchase credits overcomes a problem of 'slippage’ which was experienced prior to the advent of mitigation banking. Slippage refers to the cumulative effects of many small individual losses in wetland functions which, on their own, were deemed to be impractical to offset.

The examples of tradable permit programs for water quality trading and wetland mitigation banks can be applied to managing environmental impact of fishing as they both are broader in terms of managing large scale ecosystem effects. A significant challenge is applying market instruments for achieving large-scale environmental and ecosystem public goods. Some analysts have noted that mitigation banking is a policy instrument suitable for addressing large scale ecosystem management objectives (VanBueren 2001; Anderson et al. 2001). The difficulties
Lessons Learned

In reviews of market-based environmental programs, below are some lessons learned and common characteristics of successful marketable permits based on case studies (Haddad 1997; Van Bueren 2001; Tietenberg 2002):

- **Enforceable caps are the key.** An enforceable cap or baseline level of environmental quality is the most effective way of stimulating demand for environmental services. However, the imposition of enforceable targets must be justified by a preliminary economic assessment that demonstrates the policy will lead to a net welfare gain after accounting for all costs and benefits.

- **Start from scratch.** When designing trading programs, the design process should start from scratch rather than make piecemeal changes to existing programs. Emphasis should be on developing a program that is simple to understand by all stakeholders and puts in place the correct incentives to address the externality problems.

- **Understand the market potential.** Assess the potential economic benefits to be gained from trading. This will depend on whether there are an adequate number of firms who would be interested in participating in the market and whether these firms are sufficiently heterogeneous in terms of their abatement costs.

- **Involve stakeholders.** Success of a trading program relies heavily on the extent to which interested parties are involved in the planning and design phase. There is a strong case for government to decentralize the day-to-day management of a trading scheme by passing the responsibility onto a community-based association.

- **Keep trading rules simple.** Unnecessarily complicated trading rules are a primary factor responsible for causing trading programs to fail. There must be sufficient transparency in the trading process and a minimum of bureaucratic intervention. Furthermore, restrictions on trade should be kept to a minimum.
Take into account physical features that affect the market. On the one hand, geographical restriction on trading limits the theoretical maximum gains from trade if everybody everywhere were invited into the market. On the other hand, the limits provide focus and manageability.

Limit access to the market. Curtailing access to a program limits theoretical gains from trade but facilitates both the policy goals behind the program as well as the market-like trading mechanism.

Markets may need not last forever. Program longevity is a design factor; if a reallocation is needed in the medium-term or longer, a market may be the instrument of choice but a short-run or one-time only reallocation may or may not be worth the trouble of creating the necessary institutions.

Have strong, credible regulatory enforcement measures. Compliance is the preferred option and cost reduction then becomes the focus of regulated entities. Similarly, successful programs have low-cost monitoring systems that preserve the autonomy of regulated entities while providing sufficient monitoring information. Clear rules, strict penalties, and good monitoring systems ease the administrator’s oversight burden.

Address distribution and other fairness issues effectively. A main element of controversy in tradable permit systems involves both the process for deciding the initial allocation and the initial allocation itself.

A Comparison of Economic Incentives versus Command and Control
Many factors enter into the decision to favor either policies that lean more toward economic incentives (EI) and toward command and control (CAC) policy. Underlying determinants include a country’s governmental and regulatory infrastructure, along with the nature of the environmental problem itself. Ever since the formation of comprehensive environmental policies, there has been a good deal of speculation and disagreement over the differences between EI and CAC instruments in practice. These discussions boil down to assertions or hypotheses about comparative advantages of each instrument. Harrington and Morgenstern (2004) compared the EI and CAC policies and their outcomes by analyzing six environmental problems that the United States and at least one European country dealt with differently. For each problem, one approach was more of an EI measure while the other relied more on CAC.
for a total of 12 case studies). Below is a summary of the six environmental problems that were compared:

1. SO₂ emissions from utility boilers: Permit market (United States) vs. sulfur emissions standards (Germany)
2. NOₓ emissions from utility boilers: Emission taxes (Sweden and France) vs. NOₓ New Source Performance Standards (United States)
3. Industrial water pollution: Effluent fees (Netherlands) vs. Effluent Guidelines and National Pollutant Discharge Elimination System permits (United States)
4. Leaded gasoline: Marketable permits for leaded fuel production (United States) vs. mandatory lead phase-outs plus differential taxes to prevent misfueling (most European countries)
5. Chlorofluorocarbons (CFC): Permit market (United States) vs. mandatory phase-outs (other industrial countries)
6. Chlorinated solvents: Source regulation (United States) vs. three distinct policy approaches (Germany, Sweden, Norway)

These 12 case studies were then analyzed against a list of hypotheses frequently made for or against EI and CAC. This included:

- **EI instruments are more efficient than CAC instruments: that is, they result in a lower unit of cost of abatement.** The cases they analyzed show that indeed economic incentive policies are generally more efficient in that they result in a lower unit cost of abatement. Substantial cost savings were proven in the U.S. program of marketable permits to lower SO₂ emissions and in the elimination of CFCs and lead in gasoline. However in instances where the regulations are so stringent that practically all available abatement measures must be taken, there is little scope for choosing the most cost-effective ones, and EI instruments do not achieve significant cost savings over CAC. EI also enjoys little advantage if all plants face similar abatement costs.

- **The real advantages of EI instruments are only realized over time, because they provide a continual incentive to reduce emissions, thus promoting new technology, and permit maximum flexibility in achieving emissions reductions.** In deed many of the cases studied by
Harrington and Morgenstren proved EI provide greater incentives than CAC for continuing innovation.

- **CAC policies achieve their objectives quicker and with greater certainty than EI policies.** Evidence from the case studies is mixed; several cases argue EI policies are more effective and two cases show that both approaches can result in significant environmental gains, but with undesirable longer-term side effects.

- **Regulated firms are more likely to oppose EI regulations than CAC because they fear they will face higher costs, despite the greater efficiency of EI instruments.** The cases showed that no government has put this hypothesis to the test which the authors signify that this shows strong support for the hypothesis. In nearly all cases governments eliminate the burden of EI instruments by returning fees to the firms.

- **CAC policies have higher administrative costs.** The cases studied showed no clear pattern because the evidence was mixed. Despite whether choosing to do CAC or EI policy, the analysis of the cases studied showed significant environmental results, with emissions falling by about two-thirds when compared to baseline estimates and outcomes either meeting or exceeding policymakers’ original expectations.

The cases show that EI instruments appear to appear to produce cost savings in pollution abatement, as well as innovations that reduce the overall cost. The concern that EI instruments are not as effective was not found in their analysis. However, the finding about EI’s economic efficiency is tempered by evidence that polluting firms prefer a CAC instrument because of its perceived lower costs to them. In all but one of the case studies, the actual or potential revenue raised by EI instruments had to be reimbursed in some way to the firms, meaning the revenues cannot be used for other purposes.

**Market Based Instruments in Combination with Other Environmental Policy Instruments**

In practice marketable permit systems almost always co-exist with other environmental policies. A mix of environmental policy instruments, rather than one single instrument may prove to be more effective when seeking to address environmental concerns in fisheries. Examples of this dependence include: the use of direct regulations in permit allocation or credit creation; the use of taxes or penalties to ensure compliance; and, the ‘voluntary nature of adherence to credit-and-
baseline schemes. For instance in the area of fisheries, it is quite common for individual transferable quota regimes to co-exist with technology-based regulations such as gear restrictions as well as spatial and temporal restrictions on fishing activity. The OECD (2003) identifies specific conditions under which the joint use of tradable permits in conjunction with other policy instruments may be preferable to the application of one or the other instrument on its own:

- *Dealing with spatial differentiation of impacts.* It has been shown that in order for tradable permit markets to function smoothly and efficiently, it is important that the permit market be very broad. However, for pollutants whose impacts vary by place of emission, this implies that the permit price will only be incidentally associated with marginal damages for most emitters. There is, therefore a trade-off between efficiency in the market for permits and the equalization of marginal abatement costs with marginal environmental damages. In order to mediate this trade-off it may be preferable to use direct regulations as constraints on trading.

- *Addressing technology market barriers and failures.* Under perfect market conditions, tradable permit regimes with target emissions will achieve the optimal rate and direct technological change to reduce impacts. However, if there are significant market failures which adversely affect the development of technologies for abatement, then it may be necessary to introduce complimentary policies such as subsidies and credits to overcome such failures if the environmental damages are to be reduced at least costs.

- *Expanding regulatory scope and reach.* The flexibility of tradable permit regimes allows them to play an important role in expanding the scope of the regulatory authority’s reach, particularly when used in conjunction with other instruments. For instance, effective combinations can be devised to allow for voluntary adherence to tradable permit systems or to encourage regulated firms to improve environmental performance in unregulated firms. Using tradable permits can be a lower-cost option than extending regulatory reach by expanding the scope of direct regulations to areas which are difficult to reach.

- *Reducing compliance cost uncertainty.* Tradable permits have the advantage over other instruments (including direct regulation) of achieving a particular environmental objective with certainty. However, they have uncertain cost implications. Using taxes as a cap on permit prices and subsidies as a floor, can reduce this uncertainty. By reducing risk, this can have benefits for both affected firms and for the regulatory authority.
However, in all cases the objective of each instrument must be clearly defined, and the relationship between the two instruments must be properly understood. If the objectives are the same, in almost all the cases on or the other instrument will be at best redundant, and at worst the combination will be inefficient and administratively costly. Thus in order for the use of an additional policy instrument to increase efficiency in the presence of a tradable permit system, the “complimentary” instrument must (OECD 2003):

• Meet a legitimate policy objective which cannot be met through the tradable permit system;
• Be the best instrument available to the regulatory authority if it is to meet the that policy objective;
• Be administratively feasible at reasonable cost; and,
• Be an effective complement to the tradable permit.

Political Economy of Regulatory Choices for Managing the Environment
The political economy of instrument choice in managing terrestrial pollution provides some useful insights into why command and control approaches have been favored and adoption of market-based approaches has been slow (Holland 2007). Command and control approaches have generally been predominant in managing pollution because they have been preferred by all of the major stakeholder groups: industry, environmental groups and government legislators and bureaucrats (Keohane et al. 1997, Oates and Portney, 2003; Stavins, 2001). There are a number of reasons for industry to favor input controls. First they can act as a barrier to entry for other firms, particularly if existing firms are grandfathered in with existing practices while any new producers are required to utilize state of the art pollution reduction technology. Firms may also fell they have more control over the form regulation will take and thereby reduce cost of them relative to output-oriented controls.

Environmental groups in the USA have mostly been hostile towards market based approaches. One reason has been a philosophical objection to ‘putting the environment up for sale’ (Oates and Portney 2003). Other reasons for opposition included concerns that damages from pollution were difficult or impossible to quantify and monetize, and that, once implemented, controls would be more difficult to tighten over time than command-and-control standards. Raising pollution tax rates would be politically difficult and reducing the number of permits might
require compensation if viewed as takings (Keohance et al. 1997). Opposition to market-based approaches has not been universal among environmental advocacy groups. Environmental Defense Fund (EDF) has consistently supported market-based approaches for pollution control, beginning with its support of the SO$_2$ trading allowance program in 1990. They have also been a consistent supporter of individual fishing quota systems.

Legislators also have reasons to prefer command and control approaches. Many are trained in law which may predispose them towards legalistic regulatory approaches (Stavins 2001), while the time needed to learn about approaches such as marketable permits or pollution taxes represents a significant opportunity cost (Keohane et al. 1997). Command-and-control approaches also tend to hide the costs of regulation and offer legislators greater control over the distributional impacts of regulation. Typically, legislators are more concerned with the distributions of costs and benefits than with total benefits and costs (Stavins 2001) and the same may be true with government bureaucrats who face lobbying from the different affected parties. Kirchgassner and Shneider (2003) argue that bureaucrats tend to favor command and control regulations because they increase their power and budgets. Finally, command and control approaches offer legislators and regulators an opportunity for ‘symbolic’ politics (Stavins 2001). Strict standards can be combined with exemptions or lax enforcement that reduces the cost of regulation to industry of particular segments of firms. In contrast an approach using tradable permits requires regulators to set an absolute limit on emissions and a failure to keep emissions within that limit may be readily visible.

Given the choice between a taxed-based approach and a tradable permit system, industry, environmental groups and government have, at least in the USA, tended to favor the later (Oates and Portney, 2003; Stavins, 2001). Tradable permits have generally been allocated to existing participants in proportion to their existing pollution levels. Therefore they do not represent an additional cost to existing firms unless total emission permits are reduced. However new firms need to purchase permits which acts as an additional barrier to entry protecting the competitive position of existing firms. In contrast, a tax represents an additional cost to the firm and does not create the same barrier to entry. Where market-based approaches have been used to manage target catches in fisheries, there has been virtual no use of tax-based approaches. Rather catch
right have been allocated in the form of individual quotas or allocations to cooperatives and producer organizations and allocations have been almost universally given free of charge to existing fishery participants. Some notable exceptions have occurred in New Zealand where much of the quota for new species introduced in recent years has been or will be auctioned off. Fishers also have the alternative to pay a per kilogram fee on catch they land as an alternative to purchasing quota. This system was designed to provide fishers and means and incentives to land unintended bycatch, but it effectively functions as a tax on catch

Environmental groups also have incentives to favor a tradable permit approach over a tax or charge-based approach. Environmental advocates have a strong incentive to avoid policy instruments that make the costs of environmental protection highly visible to consumer and voters and taxes make those costs more explicit than permits (Stavins 2001). Also, environmental advocates prefer permit schemes because they specify the quantity of pollution reduction that will be achieved, in contrast with the indirect effect of pollution taxes.

**Use of Market Based Instruments to Manage the Environmental Impacts of Fishing**

Over fishing, by-catch of non-target fish species, marine mammals, seabirds, and damage to benthic habitats remain serious fisheries problems. Management methods based on traditional “command and control” regulatory approaches such as closed areas, aggregate quotas for non-target fish stocks, mandated gear modifications, and restrictions on fishing methods have met with some success. But many of these “blunt instruments” are often inefficient and inflexible. In many cases, after an initial response, progress remains marginal, requiring managers to implement additional regulations in order to achieve improvements in environmental performance.

Regulators have rarely developed market-based standards to control the environmental impacts of fishing. In most cases it is considered too costly or politically impractical (Sharp 2002). These “impracticalities”, however, may be due as much to a lack of knowledge, experience, and a common vision, than any political or technical “transactions” cost. Because communities will tend to address environmental problems consistent with their history, cultures, and existing
institutions, it is difficult to implement fundamental institutional change that may be efficient, but also less predictable (Miles et al. 2002).

New Zealand’s use of deemed values to reduce the incentive for fishers to target fish stocks stock for which they do not hold catching rights (Sanchirico et al. 2005) is an exception to this paucity of market-based instruments. New Zealand does not generally allow the discarding of by-catch. Instead, all catch must be balanced with rights called Annual Catch Entitlements (ACE) by the middle the following month in which the fish were caught. If the fisher does have or can not buy ACE, they must pay a deemed value. The deemed value payment is refunded if the fisher acquires ACE to balance the catch within 15 days of the end of the fishing year. The revenues from the deemed value system go to the New Zealand Governments general fund.

Deemed value rates are set to discourage discarding at sea but at the same time to not encourage targeting of fish for which the fishers does not have rights. The deemed value system creates a catch management regime under which both the Total Allowable Catch for a stock and deemed values manage catch. It is important to note that deemed values are an administrative charge integral to the operation of the catch balancing system and are not considered to be a fine or over-fishing penalty. The revenues from the deemed value system go to the New Zealand Governments general fund. It is important to note that deemed values are an administrative charge and are not a considered a fine.

The use of market based instruments to manage damage to benthic habitat has not been used either, although Holland and Schnier (2006) propose an individual habitat quota (IHQ) system for habitat conservation that would utilize economic incentives to achieve habitat conservation goals cost-effectively, which is discussed later in the chapter.

In a study of senior decision makers in the Seychelles and their attitudes towards the importance of command and control and market mechanisms in the management of living marine resources, Payet (2006) found a preference for command and control approaches among 55% of those surveyed. The remainder supported the need to explore and move towards the greater use of market-based incentives. Market-based mechanisms were seen as being better at optimizing the
current levels of marine benefits gained form the marine environment compared to command and control approaches. They were also seen as a way of reducing dependence on Government transfers to the marine sector of the economy (Payet 2006).

**CHALLENGES AND OPPORTUNITIES FOR MARKET-BASED MECHANISMS IN THE MARINE ENVIRONMENT**

Designing, implementing, and managing market based approaches for managing the environmental impact of fishing on the West Coast is a complex and potentially expensive process. For the U.S., which relies on command and control regulatory tools, the policy changes may be relatively easy, but the loss in cultural, social, and economic wellbeing can be significant.

The following summary section highlights key opportunities, challenges, and risks for designing market-based mechanisms for managing the environmental impacts of fishing on the marine environment to enable the Pacific Fisheries Management Council to meet the requirements of the 2006 Magnuson-Stevens Fishery Conservation Act.

**Institutional Arrangements in the United States**

Any institutional design must first begin with relevant law and legal obligations that act to guide and constrain the design, implementation and management of legally sanctioned activities. The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) provides the legal foundation for designing market based ways of managing the environmental impacts of fishing. Other relevant laws include the Marine Mammal Protection Act and the Endangered Species Act. The following section briefly reviews some key sections of the 2006 MSFCMA and their relevance for managing the environmental impacts of fishing and the use of market-based instruments for managing the environmental impacts of fishing for fishery management.

As stated earlier one of the national standards set includes measures about bycatch. It reads “Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.
Two of the required provisions for any fishery management plan prepared by any Council, or by the Secretary for any fishery, address both essential fish habitat and bycatch: “they shall…describe and identify essential fish habitat for the fishery based on the guidelines established by the Secretary under section 305(b)(1)(A), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat;… establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery, and include conservation and management measures that, to the extent practicable and in the following priority— (A) minimize bycatch; and (B) minimize the mortality of bycatch which cannot be avoided”.

In addition one of the discretionary provisions of any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery must “include, consistent with the other provisions of this Act, conservation and management measures that provide harvest incentives for participants within each gear group to employ fishing practices that result in lower levels of bycatch or in lower levels of the mortality of bycatch.”

These portions of the Act provide flexibility in finding strategies to minimize bycatch and minimize the adverse effects of fishing on habitat. This degree of flexibility, however, ultimately depends on the intended meanings of words, phrases and concepts in the Act. For example, what is an adverse impact? Is adverse impact the destruction of a single organism or small habitat area, or conversely, is impact associated with the functioning of large-scale marine ecosystems? Although lawmakers may not have intended for adverse impacts to apply to small, non-cumulative, and isolated habitats, stocks, or species, there may be alternative interpretations that could affect the ability to reach consensus on developing an acceptable level.

An amendment in 2006 was a lift on the moratorium on ITQs and the implementation of limited access privilege programs which assign specific shares of the annual harvest quota to eligible fishermen, fishing communities, and regional fishery associations. While limited access programs deal with markets and rights based systems, it is vague when it comes to dealing with the environmental impacts of fishing. The requirements for limited access privileges (A) if established in a fishery that is overfished or subject to a rebuilding plan, assist in its rebuilding;
(B) if established in a fishery that is determined by the Secretary or the Council to have overcapacity, contribute to reducing capacity; (C) promote—(i) fishing safety; (ii) fishery conservation and management; and (iii) social and economic benefits (MSFCMA Sec. 303A (c)(1).”

The act appears to provide flexibility in meeting requirements on the environmental impacts of fishing. However, before stakeholders can develop effective environmental standards, they need clear and unambiguous interpretations of the relevant sections of the Magnuson-Stevens Fisheries Act. A fundamental challenge is balancing the requirements in the 2006 Fisheries Act. Market-based mechanisms in the marine environment must be structured consistent with the national standards. This requires that the law have clear, unambiguous, and consistent meanings. Ambiguities can ultimately undermine the development of policies consistent with legal obligations. This is particularly true if the process is structured to successfully engage public and private stakeholders. With the current amendments to the MSFCMA that promote more conservation towards sustainable fisheries and limited access privileges there is potential to develop market based approaches towards managing the environmental impacts of fishing.

**Pew Ocean Commission and USCOP Report**

The 2006 amendments to the MSFCMA that improves conservation efforts and promotes limited access privilege programs were in part due to the critiques in the management of the nation’s fisheries by The Pew Oceans Commission and U.S. Commission on Ocean Policy. To alleviate the “race for fish”, the U.S. Commissioners recommend that Congress amend the MSFCMA to affirm the rights of Regional Fisheries Management Councils to institute dedicated access privileges. The term “dedicated access privileges” rather than “fishing rights” is preferred, because it highlights that fishing is a privilege granted by the government and is vague enough to encompass several different types of access control tools (USCOP 2004; Sanchirico and Hanna 2004).

The Pew Report recommends that fishery management plans should change from a focus on harvested species and singles species stock assessments to plans that ensure that ecosystem function and productivity are not adversely affected. Accomplishing this goal would entail
setting policies to reduce habitat damage by mobile bottom gear, such as bottom trawling (which the Pew Commission recommends phasing out over time). Plans would also need to account for the incidental catches of marine mammals. Predator-prey relationships need to also be incorporated when setting catch levels to ensure that catches of one species do not affect the sustainability of others. The commissioners also suggest that a statutory goal to eliminate bycatch be set (Pew 2003). In addition, The Pew Commission acknowledges that current fishery management fails to address economic incentives and encourages the use of rights-based approaches (called privileges) under restrictions to protect small-scale operations and fishing communities. Building on the recommendation of the two reports, Sanchirico and Hanna believe that all fishery management plans need to explicitly address incentives that would ensure better resource stewardship, including developing approaches to pair responsibilities with rights through contracting and to broaden the application of incentive-based tools such as individual fishing quotas (2004).

**Structure and Transparency in the Process**

Undertaking a policy process for reducing the environmental impacts of fishing through market based instruments is a daunting task. Maligned problems, misaligned interests, and considerable uncertainty about environmental science, make it difficult to reach consensus (Miles et al. 2002). Without appropriate incentives, stakeholders may not participate and may actively undermine or circumvent the process. This is particularly true if there are significant uncertainties or high costs associated with the outcomes. For example, given the combined effects of uncertainty regarding a new policy process, definition of adverse impacts, inadequate science, and mandated cost recovery for efforts to avoid, remedy or mitigate adverse impacts, one would predict that various stakeholders user groups may be cautious, less than fully engaged, and prepared to use tactics that slow or impede the policy process. Or one could anticipate that and NGO group, with few resources and a cynical view regarding regulatory capture by industry, may decide to skip the process entirely and lobby for their interests at the executive level (Sylvia 2004).

In order to have a successful process, one must understand the motivations of the policy actors and provide appropriate incentives. Policy actors must be convinced that their expected welfare is improved by participating. For industry this means clear and consistent definitions, a
predictable policy roadmap, and a commitment to flexibility, adaptability, and efficiency on the part of the government in balancing utilization and sustainability requirements. For NGO’s, they must be convinced that the process is not captured by industry and that government is committed to meeting sustainability mandates. Whether groups choose to participate or not, they must be convinced that the outcome will be implemented, and that efforts to impede or circumvent the process will fail (Sylvia 2004).

In addition, unnecessary uncertainties associated with the policy process must be identified, reduced or eliminated. Many of the outcomes and strategies for addressing marine environmental issues may be uncertain, particularly when first implementing, but the process should be predictable. The PFMC must have a well-defined roadmap and identifiable strategies to address points of contention. As part of its process, the Council should anticipate these potential problems, and seek to eliminate them before the process begins (Sylvia 2004).

Also a process which encourages and rewards creative thinking and openness to new ideas has a greater likelihood of long term policy success. A process run by policymakers who favor command and control policy strategies is far less likely to encourage broad scale stakeholder participation than policymakers that embrace and reward efficient, innovative and flexible policy strategies (Sylvia 2004).

**Designing Environmental Management Consistent with the Spatial and Temporal Dimensions of the Marine Environment**

There are considerable challenges inherent in developing institutions for managing the complex process of sustainable development of the marine environment. In many case the challenges are greater than on terrestrial environments because terrestrial ecosystems (1) have undergone a longer institutional management experience, (2) are more thoroughly studied and researched, (3) have more sessile and less fugitive organisms, and (4) are characterized by better defined and secure property rights. Except for having possibly fewer policy actors and agencies, the marine environmental management problem poses a “messier” challenge than found on terrestrial landscapes and watersheds (Sylvia 2004).
Probably the most fundamental difference between terrestrial and marine ecosystems is the prevalence of the aquatic medium in which all marine organisms live. The properties of water have profound effects on the physical and biological characteristic of marine organisms. For instance, the transport of materials and organisms by the connective forces of ocean waves and currents extends the spatial scale of many processes, so that marine systems tend to be more ‘open’ (i.e., greater magnitudes and higher rates of import and export) than their terrestrial counterparts. Unlike land systems marine systems have endless boundaries, both in terms of definable limits of ecological communities, and population structure (Carr et al. 2004).

Most species in terrestrial ecosystems are distributed two dimensionally while marine ecosystems they are distributed three dimensionally. Due to the three dimensional nature of the marine environment, multiple uses of the same location, simultaneously or during different times and seasons, may be more relevant than for many areas on land. To a much greater extent than on land, the marine environment is also far more dynamic and unpredictable due to physical process. Control areas are often unavailable for scientific research in marine systems. Offshore access is sometimes difficult and dependent on weather conditions. The seabed is far less extensively mapped than land areas, and our knowledge of the marine environment as a whole, whilst increasing all the time, is still far from complete (Carr et al. 2004).

The attributes associated with fishery resources are huge in scope. Fishery resources are comprised of a myriad of biological (e.g., plankton, fish and mammal species), chemical (e.g., salinity, oxygen concentration, and physical (e.g., sediment type, currents, space) attributes which can be further differentiated by quantity, quality and relational attributes. For example, a species of fish could be defined by stocks, biomass, population, structure (age, size, sex), geographic location and scale, gene pool, disease, dynamics (life cycle, migration, fecundity, recruitment, growth rate, natural mortality), coexistence with other species, diet, habitat requirements and so forth. Many of these same attributes can also be used to describe different life stages, cohorts, or even individual fish (Edwards 2003). This list then can be expanded by the large number of species of finfish and shellfish landed by fishermen in Pacific Northwest.
These complex temporal and spatial dimensions of the marine environment pose significant challenges for managing environmental impacts relative to terrestrial environments. First, they pose significant costs for scientific exploration in understanding biology, habitats, and ecosystems. Second, even with relatively large investments in marine monitoring systems, it can take many years to understand changes in marine environments and ecosystems. One implication is substantial uncertainty in understanding fishing related impacts to the marine environment relative to natural variation.

Addressing these challenges suggests that any system for managing the environmental impacts of fishing must provide incentives for exploration, testing, and adaptation consistent with spatial and temporal scales. The variation across habitats, fish stocks, and fisheries will require flexibility in design of managing environmental impacts. The process itself must compel research of the marine environment, and then drive analysis to measure the effectiveness of this research in improving standards for managing environmental impacts (Sylvia 2004).

The large spatial scale and the diversity of habitats within three-dimensional space require that a system of standards be congruent with spatially defined classes of habitat. Fishing operations within one habitat type may have different impacts than the same operations in a different habitat. Developing standards as a function of spatial boundaries could result in management systems consistent with definitions of “marine protected areas.” It may also support development of rights-based environmental management structured within spatially defined areas. This does not imply that trades or mitigation of environmental impacts cannot occur across habitat types, but that the ratio of trades may vary by habitat type. It also may provide opportunities for using creative mitigation strategies for meeting environmental standards (Sylvia 2004).

If rapidly advancing technologies support spatial mapping and classification of habitats, ecosystems, and stocks, then environmental management will continue to be more precisely defined by habitat type. This suggests two possibilities related to developing and managing the environmental impacts of fishing. The first is that devolution of environmental management by private entities could be organized around habitat classification rather than a single fishery.
Second, that refined maps of natural habitats can be overlaid with dynamic maps of fishing activities in order to evaluate environmental impacts at relatively fine spatial scales. The resulting information could then be used to manage fisheries and environmental impacts by refined habitat classifications. The ability to manage fisheries within relatively small areas could reduce the need for larger-scale marine closures and reserves (Sylvia 2004).

**Risk and Uncertainty**

Risk and uncertainty are fundamental characteristics of fisheries management and the public and private management process including policymaking, resource monitoring and assessment, and fishing strategies. Risk analysis plays a fundamental role in determining strategies to protect the marine environment. Any program designed to manage the environmental effects of fishing should incorporates risk and uncertainty and can efficiently increase predictability, should be an objective of any program designed to manage the environmental impacts of fishing.

Although risk and uncertainty are related concepts, they have fundamentally different definitions. Risk is defined as a random variable (or systems of variables and their relationships) with known mean(s) and probability distribution(s). In contrast, uncertainty is represented by variables (and unknown systems of variables) with unknown means and distributions. The probabilities cannot be scientifically calculated using known data and facts. These uncertain variables and relationships, however, are often transformed into “risky” variables and relationships through the use of subjective “expert” opinion (Sylvia 2004).

To a significant extent, marine environmental management is based on uncertainty analysis and subjective estimates of risks. The role of experts in defining risk, therefore, is fundamental to any standards-setting process. It is critical, however, that the process of risk analysis be structured with its own set of clearly articulated rules and standards. For example, for a relatively simple environmental standards-setting process involving only a single externality or impact, and supported with a reasonable amount of scientific research, a panel of scientific experts could evaluate the research and make reasonable calculations of the risk estimates (Morgan 1993). However, for more complex environmental management problems with considerable uncertainty, experts will include stakeholders and other members of the public.
many risk assessment processes, including those used in fisheries, not only will these experts provide subjective estimates of risks, but they will be invited to incorporate their personal values within the risk assessment process (Standards Australia and Standards New Zealand 1999; URS 2002). Whether intended or not, in the absence of objective definitions of adverse impact, it is inevitable that subjective values will be incorporated within the risk assessment process. This can result in arbitrary risk assessment in which one environmental fisheries risk assessment process estimates high risks and damages, while another process for a fisheries with similar environmental effects, estimates low risks and impacts.

Because risk assessment is the core process for determining environmental impacts, the designers of the risk assessment process must carefully evaluate their choices. In particular, they need to determine whether they build a simultaneous or sequential process that estimates the 1) probability of impacting some component of the marine ecosystem 2) determining whether the impact meets the legal definition of adverse and, 3) if found adverse, the relative degree of adversity relative to sustainability requirements. They also need to determine whether the same group of expert panelists evaluates each component of risk analysis, and whether these experts are also involved with designing management actions to address the impacts. They need to determine the criteria for being considered an expert, and the information which experts should be provided before participating in the process. And finally they need to consider how management concepts associated with risk and uncertainty such as decision makers should be cautious will be addressed, if at all, within the risk assessment process. In many third party fisheries certification audits, the “precautionary approach” is integrated within the risk assessment process (for example, Alaskan pollock [SCS 2002]).

Although risk and uncertainty are important concepts during the risk assessment stage of the standards process, they are also important for developing research and management strategies, and achieving both utilization and sustainability requirements. For example, a key utilization objective for many fisheries is to increase fishery stability. Because stability and predictability are complementary needs, the ability of the standards process to increase predictability can enable industry to provide for greater utilization, while meeting sustainability requirements.
Role of Technology

Technology plays a multidimensional role in developing efficient environmental standards. GIS mapping allows industry behavior and performance to be mapped within spatially defined ecosystems and habitats. Electronic logbooks allow industry to efficiently collect environmental information and use that information to manage environmental impacts. Digital technologies that support real time data collection and analysis, provides opportunities for industry to collect information on their interactions with marine ecosystems, and to analyze that information to reduce environmental impacts. Technology also allows industry to analyze their performance data in order to improve collective efficiency while reducing fishing effort and associated effort and habitat impacts.

Technology is also critical in developing environmental markets. Technology can reduce transaction and enforcement costs. The combined effects of technological improvements is to reduce the market price of an environmental good and in a rights-based environmental market make it easier for the government or a third party to purchase the good and retire the right.

The importance of technology must be explicitly recognized within any environmental impacts plan. The plan should recognize the role of incentives in accelerating technological improvements and decreasing the costs for reducing impacts. Approaches that use environmental property rights will more efficiently promote technological innovations relative to the other three policy approaches. In turn technological improvements will reduce the costs of developing, testing, implementing and managing market based approaches (Sylvia 2004).

Individual Habitat Quotas for Fisheries

As fishery managers in the US are required to identify and limit adverse consequences of fishing on essential fish habitat because of amendments to the MSFCMA, Holland and Schnier (2006) propose an individual habitat quota (IHQ) system for habitat conservation that would utilize economic incentives to achieve habitat conservation goals cost-effectively. Individual quotas of habitat impact units (HIU) would be distributed to fishers with an aggregate quota set to maintain a target habitat “stock”. HIU use would be based on proxy for marginal habitat damage that the habitat incurs form a discrete fishing event and would vary depending on the ecological
characteristics of the region fished as well as the amount of fishing that has recently occurred within the region. The HIU used by a vessel might differ with the type of gear and would be based on empirical studies of the marginal physical damage associated with fishing particular gears in particular types of habitat. Fishers would be charged fewer HIU for fishing in areas that have been more heavily and recently fished while they would incur high HIU charges for fishing in pristine areas or areas that have not been fished for some time.

The total quantity of HIU distributed each year would be set to maintain a given level of habitat protection as measure by the total remaining virtual habitat stock. This virtual habitat stock would be made up of a combination of totally and partially regenerated areas. The quantity of HIU allocated each year would depend on the assumed regeneration rate of habitat, the standing stock of habitat and the target level of the habitat stock.

HIU use could be monitored using a VMS system. For example, trawlers might be charged HIU any time they are in fishable areas moving within a range of speeds feasible for fishing. More sophisticated system could be developed using sensors on gear. To be effectively used by fishers, the system would require real-time updating of the state of the habitat. This would not be the true physical state of habitat but the virtual habitat stock used as a proxy. This information would have to be available to fishermen in real time so that they could decide whether fishing in a particular location was worth the HIU they would use to fish.

Holland Schnier (2006) use dynamic, explicitly spatial fishery and habitat simulation models to explore the cost-effectiveness of achieving specified habitat conservation targets with a habitat quota system versus fixed or rotating MPAs. These simulations suggest that a fixed MPA covering 20% of the overall fishery could reduce Catch Per Unit Effort (CPUE) by 15-75% over the range of the fish movement rates modeled. Reductions in CPUE and average habitat quality are greater, the lower the fish movement rate. In contrast, the CPUE was reduced by less than 1% under the habitat quota over the same range of movement rates and achieved a higher average habitat quality.
SUBSTITUTING COMMAND AND CONTROL WITH MARKET BASED APPROACHES: TWO CASES

Two case studies demonstrate that progress is being made in addressing the environmental impacts of fishing. In each case, however, the “progress” is being achieved using traditional command and control regulation, best practices technology, or government mandated performance standards. Property-rights and market-based incentives have not been used to address the environmental management of fishing on the West Coast. For each case study market-based mechanisms to enhance the mandated environmental standards are suggested.

Yelloweye Rockfish
Concern over the take or bycatch of non-target species in fishing has grown over the last decade. Generally, fishermen use their skills and experience to take the catch with the highest value. In many fisheries, however, some species that are not targeted are also harvested. While some of this non-targeted catch is commercially valuable and is retained by fishermen, some is returned to the water either because it has little value or because regulations preclude it from being retained.

Both target and non-target fish species must be managed effectively as part of specific fisheries management arrangements. The management of yelloweye rockfish (Sebastes ruberrimus) on the west coast by the Pacific Fisheries Management Council is an extreme example of the way in which bycatch management can constrain an entire fishery worth many millions of dollars. In 2006, total catch for yelloweye was 14.4 metric tons (mt), below the target catch set by the fisheries managers at 27 mt. Recent stock assessments suggest that allowable catches in future years may have to be set much closer to the current total commercial catch. Yelloweye is principally managed with area-closures because they are relatively sedentary and managers have a reasonably good idea of their depth, latitude, and associated habitats.

The yelloweye rockfish case study demonstrates the use of area closures to manage non-target by-catch. Though one possible approach to rebuilding yelloweye stocks, there may be other market incentive and voluntary approaches to managing by-catch that create greater management
flexibility while maintaining mandated rebuilding rates. The following are potential examples to stimulate thinking about possible alternatives to the current command and control management approach. The examples are generic and indicative only and are not intended to be specific proposals to manage the bycatch of yelloweye rockfish.

**Market Incentives**

Market incentives to reduce yelloweye by-catch could take many forms. The basic strategy is to reward fishing strategies that avoid yelloweye. For example, The Pacific Fisheries Management Council is currently considering a rationalization of the groundfish trawl sector. One of the goals of this rationalization is to achieve individual accountability of catch and bycatch. Two common market instruments used elsewhere to achieve such bycatch accountability are tradable bycatch allowances and financial penalties for catching amounts exceeding individual vessel bycatch allowances.

In the case of tradable bycatch quotas, all active groundfish vessels could either be allocated an individual share of the incidental by-catch allowance or have the opportunity to purchase by-catch allowance at auction. If a vessel reaches its individual bycatch allowance it must buy additional allowances either from a periodic auction or unused allowances from other active groundfish vessels, or stop fishing. This allows individual vessels to keep fishing so long as they do not exceed their vessel allowance or as long as they can buy unused by-catch allowances from other vessels or from auction. It further rewards vessels avoiding yelloweye by-catch by enabling the sale of unused by-catch allowances to vessels that have reached their limits.

Financial penalties work by penalizing vessels that exceed a set by-catch allowance for the vessel. All incidental by-catch of yelloweye must be landed and if this exceeds the allowable limit (either per trip or in aggregate for a season) an automatic and significant financial penalty is imposed. The penalty could vary depending on the amount by which a vessel’s by-catch allowances is exceeded and the status of the by-catch stock. For example, in cases where a vessel is well over its allowance and the by-catch stock is at critically low levels, a penalty equivalent to the ex-vessel value of the entire catch for that trip could be imposed. This creates an incentive for vessels to avoid areas where excessive yelloweye by-catch could occur.
Because of this incentive effect, financial penalties for excess by-catch might reduce the need for extensive rockfish conservation areas.

Voluntary by-catch mechanisms
Rather than impose relatively inflexible command and control mechanisms such as RCAs and total yelloweye catch limits that penalize the entire groundfish fleet for the actions of possibly a few fishermen, agencies could exempt members of by-catch cooperatives from these rules. The by-catch cooperatives would put in place alternative voluntary rules and demonstrate compliance with these rules through civil contracts and agreements between members and between the cooperative and management agencies.

For example, vessels that are members of a by-catch cooperative could be allowed to fish in the RCA if they abide by “voluntary” gear or by-catch harvest restrictions while fishing in the RCA. Independent, industry-funded observers or other relatively “fool-proof” mechanisms would monitor these harvest restrictions. Violations would be reported to the cooperative that would have the responsibility to enforce civil sanctions against the offending member. Excessive or persistent breaches of the voluntary agreement would see individual members expelled from the cooperative. Expelled members would then become subject to the standard command and control regime. If the cooperative breaches overall by-catch levels, the cooperative loses its exemption from the command and control regulations.

Essential Fish Habitat
The potential impact of commercial fishing on marine habitats is becoming a major issue for fishery managers and the fishing industry. The Magnuson-Stevens Fishery Conservation and Management Act requires the Pacific Fisheries Management Council (PFMC) to describe “essential fish habitat” (EFH), which is “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity”. The Council is also required to minimize impacts on this essential habitat from fishing activities.

Many different gear types are used to target the more than 90 different species of groundfish managed by the Pacific Fisheries Management Council. Although the trawl fishery harvests
most groundfish, they can also be caught with troll, longline, hook and line, pots, gillnets, and other gears. Although there are numerous theories and a great deal of speculation about the effects of these various fishing gears on EFH, there is little information on the effects of fishing gears on the habitat of Pacific coast groundfish.

The PFMC identified groundfish EFH as all waters from the high tide line to 3,500 meters in depth. The Council is also required to minimize impacts on this essential habitat from fishing activities. As a result the Council adopted mitigation measures directed at the adverse impacts of fishing on groundfish EFH, including closed areas to protect sensitive areas known as Habitat Areas of Particular Concern. There are 34 bottom trawl areas that are closed to all types of bottom trawl fishing gear (covering 11,787 square miles), a bottom trawl footprint closure area in the EEZ between 1,280 meters and 3,500 meters (covering 246,062 square miles) and 17 bottom contact areas that are closed to all types of bottom contact including fixed gear, such as longline and pots (covering 1,668. square miles). In total, these gear restrictions protect some 259,517.6 square miles of area along the West Coast.

The West coast groundfish EFH example demonstrates the widespread use of closed areas to some or all gear types to manage the impacts of fishing on EFH. Closed areas can lead to more fishing effort, greater cost and even more overall habitat impacts in open fishing areas because fishermen can no longer fish traditional areas where their catch is concentrated. Fisheries managers also often lack the information to determine:

- “habitats of particular concern”
- the degree to which these areas, if any, need to be protected
- the costs of closing a fishing area and how these costs will change overtime because of closures.

Given the high degree of uncertainty about the costs and benefits of closed areas to protect EFH, are there are other approaches, or mixes of approaches that could achieve a balance between habitat conservation and lost fishing opportunities?

*Market Instruments*
Market incentives to reduce the potential impacts of fishing on EFH could take many forms. The basic strategy is to reward fishing strategies that avoid or minimize impacts on EFH. Two possible schemes out of many possibilities are 1) variable fees charged to vessels for fishing with bottom contacting gear in areas zoned as sensitive marine habitats and 2) tradable “seabed contact” allowances.

A fee system would work by levying a fee proportionate to the time spent fishing in areas sensitive to the impacts of fishing. The more sensitive the habitat to the effects of fishing, the higher the fee. The use of fees would increase the costs of fishing in some designated areas of EFH. Increased costs of fishing would encourage fishermen to fish elsewhere. Money collected from this scheme could be paid in compensation to fishermen for lost fishing opportunities from the establishment of no-take Marine Protected Areas designed to protect very sensitive and/or rare marine habitats. Fees would not be applied in areas that were not sensitive to the potential impacts of fishing.

 Tradable seabed contact allowances would be based on research establishing the sensitivity of EFH to the impacts of fishing. Total seabed contact tolerance limits would be set for each zone in terms of time in contact or perhaps area of contact. These limits would be subdivided between vessels using bottom contact gear. Once a vessel had reached its allowance it would have to leave the fishing zone. The time spent fishing in the zone would be verified by a vessel monitoring system (VMS). Alternatively, rather than VMS alone, gear sensors in combination with cameras could measure and record seabed contact. A vessel could purchase unused seabed contact allowances from other vessels to continue fishing in a particular zone. This would make fishing in the zone relatively expensive for vessels choosing to fish in the area while rewarding vessels that choose not to fish in areas sensitive to the effects of fishing. Markets for seabed contacts could provide for permanent retiring of impacts or trading impacts across habitats with different levels of sensitivities. The management scheme could be structured to increase fishing opportunities in sensitive areas to vessels demonstrating low impact technologies and practices.

Different variations of these approaches are possible. Each approach sends clear signals to fishermen about the incentives to avoid EFH areas sensitive to the possible impacts of fishing.
Because no one approach is likely to meet all economic and ecological objectives some possible mix of command and control and market incentives may be optimal depending on management objectives. What is important is that a full range of tools is available to address the challenge of balancing habitat conservation with loss of fishing opportunities.

**Voluntary Mechanisms**

Scientific information about the sensitivity of EFH to the impacts of fishing is incomplete and uncertain in many cases. This is especially true in regard to specific fishing grounds. Fishermen could agree to fund or support research into determining the extent of impacts associated with alternative fishing technologies and practices. In return, managers would open areas for gear testing. This would allow the collection of data to create much greater certainty about the impacts of alternative fishing technologies and potential impacts in the short, medium and long term. Such research would help achieve management objectives and reward fishermen for improving science and those technologies which reduce environmental impacts.

Another voluntary approach would allow fishermen to place some areas of EFH suspected to be vulnerable to fishing impacts off limits to bottom contact gear or any fishing. Fishermen who agree to avoid these areas could be rewarded with access to other less sensitive areas of EFH that are off limits to vessels that haven’t signed the voluntary agreement. This system rewards fishermen who proactively take action to conserve sensitive EFH ahead of a longer more contentious period of research, debate and potential litigation.

**CONCLUSION**

Many individuals remain unconvinced that market or voluntary approaches can work, particularly for managing large-scale and diverse environmental public goods problems. They remain skeptical that institutions can be developed to efficiently or equitably redirect the behavior of those who helped create the problem. Presently, there is no worldwide consensus, and policy experiments and empirical research are needed to design, demonstrate, and evaluate effective market-based institutional approaches to managing the environmental impacts of fishing.
Relative to simpler and more traditional input/output and command/control policy approaches, property rights are relatively new and require a higher level of policy craftsmanship in order to achieve their objectives. Since market-based programs are not without their own inherent challenges, experts advocating these programs must demonstrate potential benefits relative to traditional regulatory approaches. Assessing and then demonstrating these benefits will require policy analysis, education, regulatory flexibility, and ultimately a willingness to take policy risks. Conducting comparative analysis and undertaking policy experiments and will be important strategies to support their adoption.

The overview of issues associated with the use of market-based instruments in fisheries management is part of this project to help west coast fishery management stakeholders evaluate the strengths, weaknesses, and tradeoffs associated with the potential use of market-based approaches in mitigating the adverse impacts of fishing on marine ecosystems compared to the use of traditional command and control - based approaches. The other key components of this study include:

- Surveying participants to assess perceptions and attitudes towards market-based instruments relative to traditional command and control approaches for managing the environmental impact of marine fisheries.
- Engaging representative fishery management stakeholders using specific case studies and a policy relevant decision support framework to identify and evaluate alternative policy approaches for reducing the environmental impacts of fishing.
- Evaluating the benefits of using a structured decision support system to assess public policy alternatives for fisheries management.
Chapter 3

Survey

The goal of the survey was to determine general perceptions and attitudes of people involved with the West Coast fisheries management process (i.e. fisheries managers, policy makers, fishermen, stakeholders, and environmental organizations) towards the current use of “command and control” regulatory methods and potential use of market-based policy approaches towards mitigating the adverse impacts of fishing on marine ecosystems. More specifically, the purpose was to establish baseline attitudes and perceptions that were to help evaluate 1) preconceived notions of market-based approaches relative to more traditional regulatory approaches, and 2) results of the decision support workshop to determine whether the collective result of the evaluation differs from the individual perspectives held prior to participation in the project. Note that before the survey was conducted, participants did not formally discuss alternative policy approaches for addressing the fisheries management scenarios.

Specifically there were a number of key research questions:

- What are fishery management stakeholder’s views on market based instruments (MBI) towards reducing the environmental impacts of fishing?
  - Are they familiar with MBI used in environmental policy in general?
  - Do they perceive MBI to be effective towards managing the environmental impacts of fishing?
  - Are they receptive towards the use of MBI towards managing the environmental impacts of fishing?
  - How feasible do they perceive it would be to implement MBI with the goal of managing the environmental impacts of fishing?

- Is there a difference in receptiveness, effectiveness and feasibility responses with respect to familiarity of MBI?

- Do different fisheries management participants have different value systems and does this lead to differences in survey responses between the sectors?

- How well do MBI compare to command and control (CAC) regulations in their potential ability to manage the potential environmental impacts of fishing?
METHODS

Surveys can be a powerful and useful tool for collecting data on human characteristics, attitudes, thoughts, and behavior. The survey for this project mix-mode and was conducted using the Tailored Design Method (TDM) (Dillman 2007). The TDM attempts to identify and utilize knowledge of sponsorship, the survey population, and the nature of the survey situation in an effort to maximize quality and quantity of response.

Participants were mailed the survey and given the option to complete the questionnaire by paper or online through a web based survey. A copy of the questionnaire can be found in Appendix B. Mail-back questionnaires provide an opportunity to reach a much broader audience than many other survey methods. A greater portion of the general population possesses a mailing address than a telephone or Internet access. Cost, printing and postage is generally less expensive than the time of telephone surveys and the time and travel expenses of interviews. Also it allows and participants to have a greater understanding of the questions since they are read first hand. Though mail-back questionnaires are convenient for respondents, the researcher must wait a longer time for results and take measure to maximize response raters by sending additional surveys and reminder mailings. There also is no opportunity for clarification if a respondent doesn’t understand a question. For our survey we made sure to include contact information in case any respondent needed clarification. Current names and addresses are also necessary for adequate participation and response.

Web surveys gather respondent information via the Internet. An advantage of web surveys is that responses are automatically compiled and outputs are automatically generated. Besides time efficiency, other advantages of web surveys include reduction in paper and printing costs, and convenience for respondents, who can complete the survey at their convenience. The greatest detriments to web surveys are that respondents must possess basic typing and information technology skills, obtain access to a computer with web access, and, in most cases, have an e-mail account. Additionally, creation of the survey instrument must comply with the constraints of the electronic system used to deliver the instrument.
The online survey was built using the Oregon State University’s Business Group Solutions survey tool. The thirteen-question survey was designed to collect information on participant perceptions regarding the current use of “command and control” regulatory methods and the potential use of market-based policy approaches towards mitigating the adverse impacts of fishing on marine ecosystems. Each question was based on a 5-point Likert Scale, with a possible “No-opinion” response. An average respondent should have been able to complete the survey in 15 minutes.

The survey was divided into four different sections. The first section asked demographic questions, such as the sector that the respondent represents in West Coast fisheries and length of time involved in the fishery management process. The second section related to how participants perceived the issue of the potential adverse impacts of fishing on marine ecosystems along the West Coast. The third section asked questions on the current use of command and control regulations towards reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast. The fourth section looked at the potential use of market based instruments towards reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast.

When undertaking any survey, it is essential that data is obtained from people that are as representative as possible of the group that is being studied. For this survey non random purposive sampling was used in an attempt to obtain a sample that appeared to be representative of the population. The survey population was people who are involved in or are directly affected by state or federal fishery management processes. It was created by consulting various members involved in the fishery management process (fishermen, university professors, Sea Grant extension staff, those representing fishery industry groups).

RESULTS
A total of 229 unique individuals were compiled and mailed the surveys; 95 from the fishing industry including fishermen, captains, boat owners, processors, and those representing fishing industry groups; 84 who work as state or federal agency staff; 24 who represent environmental non-governmental organizations (ENGO); 19 from academia; and 7 from tribal groups. Eighty
five individuals responded to the survey either by mail or the web, resulting in a total response rate of 37%. Thirty four of those were from the fishing industry (36% response rate), 25 from state or federal agency staff (29% response rate), 13 from ENGO (54% response rate), 10 from academia (56% response rate), and 3 from tribal groups (43% response rate).

![Survey Participants by Sector](image)

Figure 3.1: Survey Participants by Sector

A summary of survey results was sent to participants (Appendix C).

**Time Involved**

The average length of time that a participant was involved in the fishery management process was 19 years. Industry had the highest with an average of over 23 years of experience while the ENGO sector only averaged 11 years of experience participating in the fishery management process. The agency and academia sectors both averaged 19 years.

**The Issue**

**Adversity of Impacts**

A majority of the survey participants felt that disturbance of benthic habitats and bycatch of non-commercial fish species have either a moderate or major adverse impact on the marine environment along the West Coast (71% & 64%, respectively). Opinion on the bycatch of marine mammals, sea turtles and sea birds (non-fish species) was mixed with 47% indicating that
there is no adverse or minor adverse impact and 40% indicating a moderate or major adverse impact.

![Figure 3.2 Adversity of three fishing impacts on the marine environment along the west coast](image)

A Kruskal-Wallis nonparametric one-way analysis of variance test was used to determine if there was a difference in responses between the fishery management sectors. The Kruskal-Wallis one-way analysis of variance by ranks test is used to determine whether three or more independent groups are the same or different on some variable of interest when an ordinal level of data or an interval or ratio level of data is available (Kruskal and Wallis 1952). Kruskal-Wallis does not assume normal distribution but it does assume that the observations in each group come from populations with the same shape of distribution. The results of this test showed that the difference was statistically significant (damage to benthic habitats two sided p-value < 0.05, bycatch of non-commercial fish species two-sided p-value < 0.05, bycatch of non-fish species two-sided p-value < 0.05).

The mean scores for each sector and for each impact are presented in the table below. Industry responses were consistently lower for all of the environmental impacts than the rest of the sectors. Meanwhile the ENGO sector represented the highest mean sector scores for each of the issues. The agency and academia sector scores were in the middle.
Figure 3.3: Average score for each sector on the adversity of fishing impacts on the marine environment along the west coast

Adequate Science

There was mixed reaction from respondents when asked to what degree they either agreed or disagreed with the following statement “Overall there is adequate scientific evidence to determine that fishing adversely impacts the marine environment”, with half of the respondents agreeing and the other half disagreeing. This was especially apparent with how the different sectors responded to the question. 76% of industry respondents either “strongly disagreed” or “somewhat disagreed” with the statement (mean 2.03). At the opposite end of the spectrum, every reply from the ENGO sector had either “somewhat” or “highly agreed” (mean 4.77). Agency staff (mean 3.85) and academia (mean 3.30) had mixed reactions with only slightly more agreeing. There was a statistically significant difference in the responses between the different sectors (Kruskal Wallace two-sided p-value < 0.05).
Command and Control Regulations

Effectiveness
Overall a majority of survey respondents felt that the current use of command and control regulations were either somewhat effective or highly effective towards reducing the environmental impacts of fishing to bycatch of non-fish species (mean 3.80), disturbance of benthic habitats (mean 3.17), and bycatch of non-commercial fish species (mean 3.08).
The next question asked how receptive they thought the different stakeholder groups are towards the use of command and control regulations in meeting the goals of reducing the environmental impacts of fishing on marine ecosystems along the west coast. Overall, a majority of the respondents perceived that policy makers (86%, mean 4.18), agency staff (88%, mean 4.22), and environmentalists (70%, mean 3.88) are all somewhat or highly receptive towards the use of command and control regulations in meeting the goals of reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast. Meanwhile they thought most fishermen are somewhat or highly unreceptive (52%, mean 2.86). Forty percent of the responses for the general public were undecided (mean 3.56).

![Figure 3.6: Perceived receptiveness of different groups towards the use of command and control regulations in meeting the goals of reducing the environmental impacts of fishing on marine ecosystems along the west coast.](image)

**Market Based Instruments (MBI)**

*Familiarity and Effectiveness*

Seventy four percent of respondents were either somewhat familiar or very familiar with using market based instruments (MBI) in environmental policy (mean 3.76).
A difference in the scores among the sectors was not statistically significant (two-sided p-value = 0.099) but it was found ENGO’s had the highest mean score at 4.46, while the Industry sector had the lowest mean score of 3.41. Academia and Agency sectors mean scores were about the same (3.80 and 3.84, respectively).

Familiarity with market based instruments was not correlated with the length of time involved in fisheries management issues (r-squared = 0.016).

Of the 74% that were familiar with MBI in environmental policy, 79% indicated that market based instruments are either somewhat effective or highly effective at managing environmental
problems (mean score 3.90). There was no evidence to suggest that there was a difference in the scores of the groups (two sided p-value = 0.64).

Figure 3.9: Perceived effectiveness of market based instruments towards managing environmental problems for those that are familiar with market based instruments used in environmental policy.

Also a majority of those already familiar with market based instruments, considered that MBI could be an effective approach towards managing possible adverse environmental impacts of fishing on marine ecosystems along the West Coast especially for bycatch of non-commercial fish species (71%, mean 3.71) and bycatch of non-fish species (59%, mean 3.40). For disturbance to benthic habitats it wasn’t as convincing as only 52% (mean 3.22) thought market based instruments would be effective towards managing the possible adverse environmental impact of fishing. There was no evidence to suggest that there was a difference in the scores of the sectors (two sided p-value = 0.22, 0.22, and 0.45, respectively).

Figure 3.10: Perceived effectiveness of market based instruments towards the environmental impacts of fishing for those that are familiar with market based instruments used in environmental policy.
Those that were not familiar with using market based instruments in environmental policy were then given definitions and examples of what market based instruments are and how they could be used to minimize the adverse impacts of fishing on the marine environment. They were also asked if using market-based tools could be an effective approach in managing the possible adverse environmental impacts of fishing on marine ecosystems along the West Coast. Fifty five percent felt MBI could be a somewhat or highly effective approach towards managing bycatch of non-commercial fish species (mean 3.24). Disturbance to benthic habitats (41%, mean 3.19) and bycatch of non-fish species (41%, mean 3.00) were met with mixed results. There was no evidence to suggest that there was a statistically significant difference among sectors.

Figure 3.11: Perceived effectiveness of market based instruments towards the environmental impacts of fishing for those that are not familiar with market based instruments used in environmental policy.

A Wilcoxon rank-sum test was used to compare the effectiveness scores for those who were familiar with use of market based instruments compared to those who were not familiar. A Wilcoxon rank-sum test, an alternative to the two-sample t-test, is a non-parametric test for assessing whether two samples of observations come from the same distribution when ordinal data is available (Wilcoxon 1945). In general, the effectiveness scores for those not familiar with MBI were lower for all three impact issues than those that were familiar with MBI, although the results were not statistically significant (two sided p-values = 0.19, 0.31 and 0.77, respectively).
A Wilcoxon rank-sum test was also used to compare the effectiveness scores for the potential use of market based instruments to reduce the possible adverse impacts of fishing on the marine environment compared towards the use of command and control regulations. The effectiveness of market based instruments to reduce the bycatch on non-commercial fish species were higher than the effectiveness scores towards the current use of command and control regulations (one-sided p-value < 0.05). Meanwhile it was the opposite for reducing the possible adverse impacts on non-fish species; there was statistically significant evidence that the effectiveness scores of the current use of command and control regulations were greater than the effectiveness of potentially using market based instruments (one-sided p-value < 0.05). There was no statistically significant difference in the effectiveness scores for the potential use of market based instruments and the current use of command and control regulations to reduce the disturbance of benthic habitats (two-side p-value = 0.88). Mean scores of effectiveness for both command and control regulations and market based instruments are in the figure below.
Figure 3.13: Average perceived effectiveness scores of market based instruments and command and control instruments for managing the environmental impacts of fishing on the marine environment along the west coast.

Feasibility

Sixty one percent of survey participants felt that it would be somewhat feasible or highly feasible to implement MBI with the goal of reducing environmental impacts of fishing on marine ecosystems (mean 3.48). There was no statistical evidence to suggest that there was a difference in scores between the fishery management sectors (two sided p-value = 0.14) nor a difference between those familiar with MBI and those not familiar (two sided p-value = 0.15).

Figure 3.14: Perceived feasibility to implement market based instruments with the goal of reducing the environmental impacts of fishing on the marine environment along the west coast.
Receptiveness

Forty five percent of respondents were highly receptive (and another 32% were somewhat receptive) towards the use of MBI with the goal of reducing environmental impacts of fishing on West Coast marine ecosystems (mean 4.00).

Figure 3.15: Perceived receptiveness towards the use of market based instruments with the goal of reducing environmental impacts of fishing on west coast marine ecosystems.

There was statistically significant evidence that there were differences in the fishery management stakeholder sectors (two-sided p-value < 0.05). The agency sector had the highest mean score at 4.46, while industry posted the lowest mean score of 3.61. The ENGO and academia sectors responded similarly with mean scores of 3.92 and 4.00.

Figure 3.16: Average receptiveness score by sector towards the use of market based instruments with the goal of reducing the environmental impacts of fishing on west coast marine environments.
In addition it was found that there was a statistically significant difference in the receptiveness for those that were familiar versus those not familiar with market based instruments. The average receptiveness score for those familiar was 4.22, while the average receptiveness score for those not familiar was 3.30.

Survey participants were then asked how receptive they thought the different stakeholder groups would be towards the use of market based instruments in meeting the goals of reducing the environmental impacts of fishing on marine ecosystems along the west coast. A majority of the responses considered that policy makers (69%, mean 3.62), agency staff (59%, mean 3.44), fishermen (59%, mean 3.50) and environmentalists (70%, mean 3.57) would be receptive towards the use of MBI with the goal of reducing any possible adverse environmental impacts of fishing on marine ecosystems along the West Coast. 48% of the responses regarding the general public were undecided (mean 3.16).

![Figure 3.17: Perceived receptiveness of fishery management sectors towards the use of market based instruments with the goal of reducing the environmental impacts of fishing on west coast marine ecosystems.](image)

The perceived receptiveness of policy makers, agency staff, environmentalists and the general public towards the current use of command and control regulations to reduce any possible adverse environmental impacts on the marine environment was higher than compared to the potential use of market based instruments (rank sum one-sided p-values = 0, 0, 0.032 and 0.0036). Whereas, the perceived receptiveness scores of fishermen was higher towards the potential use of market based instruments compared to the current use of command and control...
regulations to reduce any possible adverse environmental impacts on the marine environment (one-sided p-value = 0).

![Figure 3.18: Average perceived receptiveness scores of each sector towards the use of command and control regulations and market based instruments with the goal of reducing the environmental impacts of fishing on west coast marine ecosystems.]

**Comments**

**Broad Context and Generalizations**

Dealing with the adverse environmental impacts of fishing is a very complicated issue to deal with. In order to simplify the complexities we tried to make generalizations and broad statements because overall that is what the survey was seeking. Despite this, some participants had issues with the survey because it lumped all the various fisheries, gear types, and federally and state managed fisheries off the West Coast together. This broad generalization made it difficult for some survey participants to answer. One wrote, “All of the questions are based on the assumption that fishing has an environmental impact on the marine ecosystem to an equal degree; some fisheries where real damaging and others where self controlling except for man's impact.” Also “There are many sustainable and low impact fisheries, so I strongly disagree that fishing in general has an adverse impact - but at the same time would strongly agree that some kinds of fishing have adverse environmental consequences.”

Others found the generalization of command and control regulations and of market based instruments to be inhibiting. One participant wrote, “Found survey difficult to respond to given it lumped all MBI together in a generic way…” Another one said “It was difficult to generalize for all fisheries (state and federal) and areas. I have assumed with federal groundfish
management in mind. It has used CAC and MBI more extensively than other fisheries I am familiar with.” In addition, “There is a spectrum of market-based approaches being addressed here, ranging from well-established tools like ITQs to more speculative tools like transferable habitat impact limits. Feasibility will depend on which tool we are referring to.” Although participants may have struggled with the generalizations, that was what was intended.

**Sample Bias**

The survey used a purposive sample in that only those involved or affected by the state or fishery management process along the west coast were contacted to participate. It was an observational survey so the results can only be interpreted for this sample not to some broader context. In addition, it was not a randomized experiment so statistical inferences of cause-and-effect relationships cannot be made. The survey only had a 37% response rate, it could have been biased towards people who have an interest in market based instruments. But these results do suggest what participants in the West Coast fisheries management participants feel about different policy approaches towards managing the potential adverse environmental impacts from fishing.

**Adverse Impact**

One of the issues that the survey did not address is the definition of an adverse impact of fishing on the marine environment. The MSFMCA includes the minimization of adverse impacts but it does not define what an adverse impact is. The interpretation by survey participants was subjective. What a fisherman may think of as an adverse impact may be completely different than what an environmentalist or agency staff person may think it is. There may be alternative interpretations that could affect the ability to reach consensus on developing an acceptable level.

**Adequate Science**

The question on whether there is enough adequate science to address this issue was the most divisive issue on the survey. While those from the ENGO sector thought there was adequate enough science to determine fishing has an adverse impact on the marine environment, the fishing industry did not think there was enough adequate science. Ultimately this issue is up to
NMFS and the PFMC to decide but in order for the issue on adverse impacts of fishing to move forward, stakeholders need to reach consensus addressing this issue.

High Familiarity Rates
An increase in familiarity of market based instruments may be due to the proposed groundfish Trawl Rationalization Program. Introduced in 2003, the PFMC is currently considering alternatives that would rationalize the trawl fishery either through a Trawl Individual Quota (TIQ) program for all trawl sectors, or co-ops for the whiting sectors. The trawl individual quota program would be based on individual fishing quotas (IFQs). This is the first attempt by the PFMC to propose a market based instrument for their fisheries.

Experimental limitations and suggestions for improvement
The survey was done utilizing the Tailored Design method which involved a mail survey and a web survey. A telephone survey could have been used as an alternative approach or as a follow up to the first round of questionnaires (i.e. in conjunction with mail and web based surveys) sent out in order to improve response rates. People can usually be contacted faster over the telephone than through the other methods. Interviewing participants over telephone would have ensured that all the survey questions were answered completely and that questions about the survey would have been answered. Also the presence of an interviewer encourages sample participants to respond, leading to a higher response rate. The disadvantages of this method is the time and cost involved in collecting the data. The data may also be affected by characteristics of the interviewers such as their motivation, personality, skills, and experience. And there may be interviewer bias, where the interviewer unwittingly influences the responses through verbal or non-verbal cues indicating ‘correct’ answers. In addition, respondents may feel their answers are not anonymous and be less forthcoming or open.

CONCLUSION
According to the survey results, market based instruments are potentially a policy option that could be used on the west coast in order to reduce the potential adverse environmental impacts of fishing on the marine ecosystem. Not only were a majority of respondents familiar with MBI, but they perceived them to be effective towards mitigating bycatch of non-commercial fish
species, non-fish species and disturbance to benthic habitats. Even those that were not initially familiar with market based instruments thought that MBI could be effective towards mitigating the adverse environmental impacts of fish, although to a lesser extent than those already familiar. In addition survey participants perceived that MBI would be feasible to implement. They were also receptive towards using them as well as perceiving there fellow participants to be receptive towards them.
Chapter 4
Workshops

The survey portion of this project looked at general perceptions and attitudes. In addition to this, another objective of this project was to engage fisheries management participant stakeholders with the analysis and selection of policy approaches to managing the environmental impacts of fishing on the west coast using two specific case studies applicable to west coast fishermen and to use a decision support system to assist in the process. The decision support system uses computer software to facilitate group-based analysis on the relative importance and desirability of alternative policy approaches in managing the environmental impacts of fishing. Policy support documentation was developed consisting of selection of policy evaluation criteria, scoring of policy options against criteria, conduct of sensitivity analyses, and interpretation and policy application of the results of the analysis. A more detailed analysis of the methodology is discussed in the next chapter.

The workshop had two major research questions:

- How satisfied are fishery management participants towards the use of market based policy approaches compared to command and control regulations in order to manage the environmental impacts of fishing on the marine environment?
- Are there differences in responses among the fishery management sectors?

Background
At the end of March and beginning of April 2008 three workshops were held in Portland, San Francisco and Newport. To make the workshops relevant to West coast fishermen, agencies and other stakeholders, two case studies of the possible fishing impacts on the marine environment based on an existing regional example were chosen. Though simplified so as to be widely and quickly accessible, the case studies were real enough so that consequences of the different approaches were apparent and relevant to workshop participants.

For the Portland and Newport workshops the incidental bycatch of yelloweye rockfish as the case study was chosen (Appendix D). Concern over the take or bycatch of non-target species in
fishing has grown over the last decade. Generally, fishermen use their skills and experience to
take the catch with the highest value. In many fisheries, however, some species that are not
targeted are also harvested. While some of this non-targeted catch is commercially valuable and
is retained by fishermen, some is returned to the water either because it has little value or
because regulations preclude it from being retained.

Both target and non-target fish species must be managed effectively as part of specific fisheries
management arrangements. The management of yelloweye rockfish (Sebastes ruberrimus) on
the West coast by the Pacific Fisheries Management Council is an extreme example of the way
in which bycatch management can constrain an entire fishery worth many millions of dollars. In
2006, total catch for yelloweye was 14.4 metric tons (mt), below the target catch set by the
fisheries managers at 27 mt. Recent stock assessments suggest that allowable catches in future
years may have to be set much closer to the current total commercial catch. Yelloweye is
principally managed with area-closures because they are relatively sedentary and managers have
a reasonably good idea of their depth, latitude, and associated habitats.

The yelloweye rockfish case study demonstrated the use of area closures to manage non-target
by-catch. Though one possible approach to rebuilding yelloweye stocks, there may be other
market incentive and voluntary approaches to managing by-catch that create greater management
flexibility while maintaining mandated rebuilding rates. The question asked to participants was
whether or not they believed that the use of alternative management approaches relative to those
currently used would lead to better or worse economic and environmental outcomes for the
management of yelloweye bycatch.

For the San Francisco workshop, the potential impacts of fishing on essential fish habitat was the
case study used (Appendix E). The potential impact of commercial fishing on marine habitats is
becoming a major issue for fishery managers and the fishing industry. The Magnuson-Stevens
Fishery Conservation and Management Act requires the Pacific Fisheries Management Council
(PFMC) to describe “essential fish habitat” (EFH), which is “those waters and substrate
necessary to fish for spawning, breeding, feeding, or growth to maturity”. The Council is also
required to minimize impacts on this essential habitat from fishing activities.
Many different gear types are used to target the more than 90 different species of groundfish managed by the Pacific Fisheries Management Council. Although the trawl fishery harvests most groundfish, they can also be caught with troll, longline, hook and line, pots, gillnets, and other gears. Although there are numerous theories and a great deal of speculation about the effects of these various fishing gears on EFH, there is little information on the effects of fishing gears on the habitat of Pacific coast groundfish.

The PFMC identified groundfish EFH as all waters form the high tide line to 3,500 meters in depth. The Council is also required to minimize impacts on this essential habitat from fishing activities. As a result the Council adopted mitigation measures directed at the adverse impacts of fishing on groundfish EFH, including closed areas to protect sensitive areas known as Habitat Areas of Particular Concern. There are 34 bottom trawl areas that are closed to all types of bottom trawl fishing gear (covering 11,787 square miles), a bottom trawl footprint closure area in the EEZ between 1,280 meters and 3,500 meters (covering 246,062 square miles) and 17 bottom contact areas that are closed to all types of bottom contact including fixed gear, such as longline and pots (covering 1,668. square miles). In total, these gear restrictions protect some 259,517.6 square miles of area along the West Coast.

The West coast groundfish EFH example demonstrates the widespread use of closed areas to some or all gear types to manage the impacts of fishing on EFH. Closed areas can lead to more fishing effort, greater cost and even more overall habitat impacts in open fishing areas because fishermen can no longer fish traditional areas where their catch is concentrated. Fisheries managers also often lack the information to determine:

- “habitats of particular concern”
- the degree to which these areas, if any, need to be protected
- the costs of closing a fishing area and how these costs will change overtime because of closures.

Given the high degree of uncertainty about the costs and benefits of closed areas to protect EFH, participants were asked whether or not they believe there are other approaches, or mixes of
approaches that could achieve a balance between habitat conservation and lost fishing opportunities?

All three workshops were composed of 26 people involved in the fishery management process representing fishing industry (fishermen, processors, etc.), federal and state agencies, environmental groups, and academia. The breakdown in the number of workshop participants by sector can be seen below:

![Number of workshop participants by sector](image)

### Results
The following are results from the workshops. The results of the workshop were also sent to participants (Appendix F).

### The Issue
The first major task was to develop an issue statement that workshop participants believe best represented the management challenge being explored. The policy problem had to be specific because imprecise or partial specification would mean that subsequent steps in the analysis may multiply the initial error several fold through flow-on effects. As simple as that may seem, getting the group to agree on the issue in writing and how to word them, proved to be a valuable exercise in the process.

- For the Portland workshop, the issue was: How to best manage rebuilding of yelloweye rockfish?
- For the San Francisco workshop, the issue was: How to best manage essential fish habitat?
• For the Newport workshop, the issue was: What management strategy has the best potential to allow us to continue fishing while rebuilding yelloweye rockfish?

Management Alternatives

Each workshop identified various management alternatives towards their respective issues based on the five major policy approaches outlined in Chapter 2 (see pages 18-22). The table below illustrates the management alternatives from each workshop.

Table 4.1: Management alternatives by workshop

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Newport</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Individual transferable bycatch quota</td>
<td>2. Tradable EFH impact credits</td>
<td>2. Area specific total allowable catch</td>
<td></td>
</tr>
<tr>
<td>4. Volunteer closed areas</td>
<td>4. Subsidies not to impact EFH</td>
<td>4. Full retention with consequences</td>
<td></td>
</tr>
<tr>
<td>5. Higher fees</td>
<td>5. Gear specific EFH area permit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For simplicity and comparison purposes the management alternatives can be grouped into five different types:

• Command and Control (Gear restrictions, vessel restrictions, area closures, time closures, etc.)

• Performance Standard (Total Allowable Catch (TAC), bycatch allowances, quotas, etc.)

• Economic Incentives (Fees, penalties, subsidies, etc.)

• Tradable Permit Scheme (Individual tradable bycatch quotas, Tradable EFH impact credits, etc.)

• Voluntary Approaches (Co-ops, co-management, etc.)

Decision Criteria

The management alternatives for each of the issues were assessed against some performance criteria. The following were the criteria decided upon for each workshop.
Although each workshop came up with their own unique and different number of criteria to use for their issue, each workshop developed criteria that could be generally classified into four categories:

- Economic – (profitability, administrative costs, socio economic impacts on fishing communities/sectors, etc.)
- Environmental – (conservation effectiveness/benefits, stock knowledge, etc.)
- Management – (flexibility, enforceability, adaptability, feasibility, measurability, etc.)
- Social – (equity, acceptability, community heritage, etc.)

Weighing the Criteria

Having decided which criteria to use to evaluate the management alternatives, the next step was to determine the relative importance of the criteria relative to each other, by ranking them from most important to least important. In general industry representatives weighed profitability and social equity criteria high. Meanwhile representatives from environmental groups ranked

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Newport</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High profitability</td>
<td>1. Low additional cost to fisheries enterprise</td>
<td>1. Generates broad ecosystem benefits</td>
<td></td>
</tr>
<tr>
<td>3. Cost effective</td>
<td>3. Low socio-economic impact on sectors</td>
<td>3. Maintains or increases economic value</td>
<td></td>
</tr>
<tr>
<td>4. High ecosystem conservation effectiveness</td>
<td>4. High political feasibility</td>
<td>4. Creates access to healthy resources</td>
<td></td>
</tr>
<tr>
<td>5. High biological understanding of yelloweye rockfish</td>
<td>5. High administrative effectiveness</td>
<td>5. High operating flexibility for all</td>
<td></td>
</tr>
<tr>
<td>8. Low bycatch rate</td>
<td>8. High enforceability</td>
<td>8. Incentivizes individual stewardship</td>
<td></td>
</tr>
<tr>
<td>9. Low impact on user group viability</td>
<td>9. High conservation benefit for benthic habitats</td>
<td>9. Low impact on community heritage</td>
<td></td>
</tr>
<tr>
<td>11. High accountability</td>
<td>11. High knowledge creation and collection</td>
<td>11. Promotes area management</td>
<td></td>
</tr>
<tr>
<td>12. Builds stock knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although each workshop came up with their own unique and different number of criteria to use for their issue, each workshop developed criteria that could be generally classified into four categories:
environmental criteria relatively high. Both agency and academic representatives had mixtures of management and environmental criteria ranked relatively high.

**Individuals Evaluate Alternatives**

Stakeholders independently rated their knowledge and estimate of each management alternative to meet each criterion. Each participant had to decide two things: (1) How well does the management alternative do compared to the evaluation criteria? (2) How certain are they that if implemented, the management alternative would do as well as they have indicated? The facilitator merged all the data from the participants (the criteria weightings plus the criteria scored against the alternatives) and the computer support tool produced an overall scoring of the management alternatives. The alternative with the highest score is the most satisfactory alternative. An alternative with a satisfaction value of 100% means that the team is fully satisfied with it. Satisfaction can be interpreted both relatively and absolutely. Relatively, the highest score is the best, but this should be checked from many viewpoints to insure team consensus. Absolutely, there is a minimum level of satisfaction that should be obtained to warrant commitment to a specific alternative. There is no set value for this minimum, but a value below 65% for an alternative implies that the team is not very confident in its success. The results of the team, the evaluation for all viewpoints were calculated and displayed numerically.

**Results**

The two different issues compared for the three workshops had different trends in satisfaction scores of policy alternatives. In both the yelloweye rockfish case studies the stakeholders collectively rated the performance standard (area total allowable catch) policy approach as having the highest total satisfaction. Second in order of satisfaction was the individual transferable bycatch quota. The third highest policy alternative satisfaction score was economic incentives. Command and control, which was only used in one of the yelloweye rockfish workshops, scored as the fourth highest policy approach. And finally voluntary co-ops was the policy alternative with the least high score. This trend is illustrated in the graph below.
Despite minor individual variance among sectors, the average ranking satisfaction scores of the different policy approaches were fairly consistent across all the sectors compared with the overall scores. Like the average total satisfaction score, performance standard and tradable permit were scored as the top two policy alternatives to satisfy the criteria by every sector. Economic incentive was the third highest policy approach for the industry sector. For the environmental, and academia sectors economic incentives and command and control tied for the third highest management alternative. As for the academia sector, command and control scored just slightly higher than the economic incentive approach. The lowest alternative score to satisfy the criteria for all the sectors was the voluntary co-operative policy approach. The graph below documents this.
Figure 4.2: Bycatch of yelloweye rockfish case study average sector satisfaction scores for each management alternative

For the management of essential fish habitat case study the trends were different. The stakeholders collectively rated the status quo (command and control regulations) policy approach as having the highest satisfaction. The second highest satisfaction score was the voluntary cooperative policy approach. This was followed by economic incentive, tradable permit, and finally, performance standard. Below is a graph that confirms the above description.

Figure 4.3: Essential fish habitat case study average total satisfaction score for each management alternative
All three sectors in the essential fish habitat case study scored the status quo command and control regulation as the highest policy alternative to satisfy the 11 criteria. In addition all three sectors scored the voluntary co-op as the second highest alternative. It was the final three alternatives in which there were differences. The industry sector had the economic incentive policy alternative ranked as their third. The ENGO sector tied economic incentive and tradable permit as their third highest. The agency sector had tradable permit as their third highest management alternative. All three sectors had performance standard as their least highest satisfaction score. This can be seen in the graph below.

Figure 4.4: Essential fish habitat case study average sector satisfaction score for each management alternative

In all three workshops, the policy approaches that have not been used much in west coast fisheries management, especially voluntary approaches and to some extent tradable permit schemes and economic incentives, consistently rated with higher uncertainty when scoring the criteria to the alternative as compared to the other, more widely used policy alternatives such as the currently used command and control regulations.
Comments

*Complex Case Study*

Many workshops participants found the case studies to be too complex to introduce in a one day workshop. The usefulness of the case study to help evaluate the different approaches to managing the possible effects of fishing on the marine environment was met with mixed results. Both management of essential fish habitat and bycatch of yelloweye rockfish are extremely complicated issues. As one participant said “Interesting case study but it almost too complex to deal with in a short workshop”. There are many variables involved in the decision making process of those two issues and it takes a while to discuss, explain and evaluate the various alternatives and criteria associated with them. Participants would tend to get bogged down in the details due to their difficult nature. One participant expressed “There is too much history; there are too many hidebound opinions, to make using a real example - especially one as contentious as yelloweye - provide much in the way of constructive results. Workshop participants spent too much time arguing over contemporary (or historical issues), which in turn influenced selection of both criteria and alternatives.” Another participant wrote “For so short a meeting, the problem was overly complex. We had some misunderstanding of what the criteria and alternatives were. Maybe introducing the approach with a simpler problem would have been more appropriate.” This sentiment was carried by another participant “… (We) needed a lot more time to look closely at alternatives and criteria.”

One of the options for doing this workshop was to do a hypothetical example but it was concluded that there wouldn’t be as much incentive to participate if there wasn’t a real issue to discuss and could be viewed as a waste of participants’ time. There was no expectation to solve the management challenges in a single workshop given the complexity of the issues. But the issue was intended to be as realistic as possible in recognizing both the opportunities and problems that face managers and the commercial fishing sector in addressing complex and contentious environmental issues.
Lack of Time

As a result of the complexities of the case studies, a common complaint was that the participants needed more time in order to deal with such a complex issue. Running a one day workshop to discuss these issues and introducing this decision support method posed a significant tradeoff between detail and time. Ideally when dealing with these multifaceted issues in the policy arena, the process would be spread out over multiple days so that all of the participants universally understand the process and comprehend the various criteria and different management alternatives. More specifically, participants expressed that there was far too much time spent on background and explanation and not enough time actually spent evaluating the different management alternatives.

Conclusion

According to the survey results, market based instruments were perceived to be more effective towards reducing the bycatch of non-commercial fish species than the current use command and control regulations. The opposite was reflected in the workshop. In both the yelloweye rockfish case studies the stakeholders collectively rated the performance standard (area total allowable catch) policy approach higher than the tradable permit alternative (individual transferable bycatch quota). But there still is potential to use market based approaches to manage the bycatch of non-commercial fish species because the tradable permit alternative scored higher than economic incentives, command and control, and voluntary co-op. Participants scored economic (profitability) and management (adaptability, flexibility, enforceability, accountability) criteria high for the tradable permit scheme alternative. Even one workshop scored the ecological criteria relatively high while the other didn’t. Social and equity concerns were the criteria that scored much lower and fishery management participants were concerned about.

Looking at the potential of market based instruments to reduce disturbance to benthic habitats, the survey found that it was the environmental impact scenario that scored lowest for effectiveness among the environmental impacts for both those that were familiar and those not familiar with market based instruments. The lower scores were also reflected in the workshop on how to best manage essential fish habitat. The tradable permit scheme (tradable EFH impact credits) scored the fourth highest alternative out of five alternatives. Overall when participants
scored how well the criteria met the management alternative, there was relatively high uncertainty. In addition the tradable permit scheme was scored low on having a low additional cost to fisheries enterprises, low socio-economic impact on fishing communities, high political feasibility, and high administrative effectiveness. It was recognized however that a tradable permit scheme to manage essential fish habitat would be have high flexibility and high benthic, water column, and forage conservation.
Chapter 5
Multi Criteria Analysis

The last two decades have seen increasing recognition that many decision problems, especially in an environmental context, are multi-dimensional. The management of natural resources can have several conflicting objectives involving economic, environmental and social issues. They often involve many different stakeholders with different priorities or objectives. Behavioral research has shown humans are poorly equipped to solve these problems unaided. Most people, when confronted with such problems, will attempt to use intuitive or heuristic approaches to simplify the complexity until the problem seems more manageable. In the process, important information may be lost, opposing points of view may be discarded, and elements of uncertainty may be ignored. In addition, group process decision making are susceptible to the tendency to establish entrenched positions (defeating compromise initiatives) or to prematurely adopt a common perspective that excludes contrary information (Kiker et al. 2005; McDaniels et al. 1999).

For environmental management projects, decision makers often receive four generalized types of technical input: the results of modeling and monitoring studies, risk assessment, cost-benefit analysis, and stakeholder preferences. However, current decision processes typically offer little guidance on how to integrate or judge the relative importance of information from each source. Also, information comes in different forms. While modeling and monitoring results are usually presented as quantitative estimates, risk assessment and cost-benefit analyses may incorporate a higher degree of qualitative judgment by the project team. Structured information about stakeholder preferences may not be presented to the decision maker at all and may be handled in an ad hoc or subjective manner that exacerbates the difficulty of defending the decision process as reliable and fair. Moreover, where structured approaches are employed, they may be perceived as lacking the flexibility to adapt to localized concerns or faithfully represent minority viewpoints. A systematic methodology to combine both quantitative and qualitative inputs from scientific studies of risk, cost, and benefit, as well as stakeholder views and values to rank project alternatives, has yet to be fully developed for environmental decision making. As a result, decision makers are prevented from identifying all plausible alternatives and from making full
use of all available and necessary information in choosing between identified project alternatives (Kiker et al. 2005).

In response to current decision making challenges, decision makers have turned to operational methods and theories oriented to the multi-objective and multi-dimensional character of many decision problems that can be applied to assess value judgments of individual decision makers or multiple stakeholders (Giaoutzi and Nijkamp 1994; Janssen 1992; Nijkamp et al. 1995, van Pelt 1993). Multi-criteria analyses (MCA) are designed to overcome the problems of multiple criteria, incommensurate units, and the occurrence of both qualitative and quantitative information. In general, multi-criteria methods are not based on monetary valuations, but on a more general weighting system. The weighting system reflects political priorities regarding the outcomes of the decision criteria for the alternative plans. A multi-criteria analysis attempts to select the most desirable alternative out of a series of alternatives. The selection is based on multiple policy objectives or criteria, including intangibles, represented in their own dimensions. This makes possible the consideration of quantitative and qualitative, and monetary and non-monetary effects and tradeoffs within the same analytical framework, thus better reflecting the policy development process (Harte 2000).

The particular strength of MCA is that it aids in the evaluation of prior specified alternatives that are characterized by multiple and often conflicting criteria (Munda et al. 1994). Multi-criteria evaluation situations are the norm in natural resource policy analysis. Moreover, the criteria being considered are in many instances measured in non-commensurate units and are often a mixture of qualitative and quantitative measurements. The combined problem of incommensurate units and qualitative data makes the evaluation procedure complex (Harte 2000).

Data measured on nominal or ordinal (qualitative) scales presents a particular problem to the decision maker because this type of data cannot be aggregated in a mathematically valid manner (Nijkamp and Rietveld 1982). Further, criteria weights (measures reflecting the importance of one criterion to another) are almost always based on qualitative data. MCA has the ability to provide a logical and comprehensive tool for the evaluation of social costs. Many of these costs
cannot be measured in monetary or even cardinal units, since many of them are only of a qualitative or ordinal nature. In other words, MCA can incorporate the many dimensions of social wellbeing (Nijkamp et al. 1990).

Hajkowicz (2007) compared 55 MCA assisted decisions to unaided decision-making in an environmental management context. The results of the study showed that: (1) Unaided decisions did not make explicit use of critical evaluation criteria. In other words, did make good use of available information. (2) MCA improves the decision process through better learning, clarification, transparency and accountability. MCA has many advantages over informal judgment unsupported by analysis (Department for Communities and Local Government 2000):

- it is open and explicit;
- the choice of objectives and criteria that any decision making group may make are open to analysis and to change if they are felt to be inappropriate;
- scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross-referenced to other sources of information on relative values, and amended if necessary;
- performance measurement can be sub-contracted to experts, so need not necessarily be left in the hands of the decision making body itself;
- it can provide an important means of communication, within the decision making body and sometimes, later, between that body and the wider community; and
- scores and weights are used, it provides an audit trail.

One limitation of MCA is that it cannot show that an action adds more to welfare than it detracts. Unlike CBA, there is no explicit rationale or necessity for a Pareto Improvement rule that benefits should exceed costs. Thus in MCA, as is also the case with cost effectiveness analysis, the 'best' option can be inconsistent with improving welfare, so doing nothing could in principle be preferable.

**The Use of MCA in Fisheries Management**

MCA based decision support systems have been used in policy development for several fisheries. Mardle and Pascoe (1999) list 38 applications of multi-criteria decision making for fisheries.
Kjaergaard (2007) cites 55 publications over a 28 year period applying multi-criteria decision making (MCDM) to fisheries management. Crutchfield (1973), one of the first to advocate incorporating multiple objectives in fisheries management, pointed out the need for public intervention in fisheries management and argued why objectives should move from “maximum sustained yield” to multiple social welfare functions. In addition Healy (1984) suggests that the traditional guiding principle Maximum Sustainable Yield (MSY) should be replaced by the concept of optimum yield (OY), which takes into account a range of biological, economic and social factors.


The application of MCA within fisheries management has many methods including lexicographic programming, weighted sum programming, generating techniques, goal programming, minmax programming, multi-attribute theory and analytic hierarchy process (Kjaersgaard 2007). Upon reviewing the applications of MCA to fisheries to management Kjaergaard concludes that:

“The articles show that the possibilities for applying multi-criteria decision management (MCDM) to fisheries management are wide-ranging. Different case studies reveal that numerous objectives exist within fisheries management and they can be considered simultaneously. Generally, the analyses were concluded to be successful and capable of contributing with valuable information to managers. Many of the applications have stakeholder involvement and results represent optimality.
from the perspective of a decision maker. This interaction with a decision maker is fruitful and natural way to establish a link between researchers and managers. It is not easy to conclude much about how often the analyses actually influence decision-making. However, the managers’ involvement and the fact that many of the analyses are carried out with financial support from government agencies indicate and interest in MCDM. Most often, the analyses are meant to provide guidance, and it is not the exact numerical solutions that are to be taken literally.”

Despite the positive attributes that MCA brings to fisheries management, there hasn’t been widespread use of the technique. Leung (2006) offers that it may be due to the heavy temporal and financial commitments in the development and implementation of many of these MCA techniques. A MCA-based decision support fishery system usually includes a time-intensive step-wise learning process between analysts and the users. In addition, many fishery managers are concerned with the immediate short term issues which usually cannot wait until a full-blown fishery management decision support system can be developed.

Different Methods
At least 40 to 50 different multi-criteria methods are documented in the decision support and evaluation literature (Maclaren 1985, Nijkamp 1989, RAC 1992). The choice of method depends on the way in which a particular policy problem has been constructed. Some methods such as the weighted summation approach, multi-attribute utility theory, ideal point and concordance analysis require quantitative information measured at the interval or ratio level. In contrast to CBA this quantitative information does not have to valued in monetary units. Other methods such as Regime and the Permutation method require the use of qualitative data measured at the nominal or ordinal level. Evamix and the Analytic Hierarchy Process are two methods use both quantitative and qualitative information (Harte 2000). The various MCA techniques include (Kjaersgaard 2007; Hajkowicz 2007:

- Weighted summation. Involves transforming performance measures into commensurate units, multiplying by criteria weights, then summing to attain an overall performance score for each objective.
• Lexicographic ordering. Places objectives at different levels such that objectives on level one are infinitely more important than objectives on level two, etc.

• Generating techniques. Produces a series of non-dominated criterion vectors through solving the weighted program with parametric variation of weights or by including some objectives in the constraints with minimum requirement levels or by both.

• Goal programming. A target level is related to each objective and the distance from the target is minimized.

• Multi-attribute theory. A set of relevant attributes is identified to measure the utility related to the decisions. The aim is to maximize the overall utility with respect to a set of attributes.

• Analytical hierarchy process. Constructs a hierarchy of objectives. Pair wise comparisons of one objective relative to another (for all pairs) are used to compute a weighting (ranking) of the objectives.

• ELECTRE. This approach involves comparing every pair of objectives through concordance-discordance analysis to compute overall performance score.

• Evamix. This approach separates cardinal and ordinal data in the performance matrix, applying algorithms suited to each level of measurement. Evamix makes paired comparisons for the projects and combines the ordinal and cardinal scores to attain an overall performance score.

For this project the software used was Accord, based on the mathematical method Bayesian Team Support (BTS). BTS is an extension of Bayesian Decision Theory, a computational theory for applying general knowledge to individual situations characterized by uncertainty and risk. BTS supports a team in making a decision as it collects evidences that supports or refutes alternative courses of action. BTS method assumes that the information collected will be uncertain, incomplete, inconsistent, and evolving. As evidence accumulates, the degree of belief in one of the alternatives will indicate the best choice. To help bring decision making in the face of uncertainty, BTS provides graphical and textual feedback to the decision makers using value of information and what to do next analyses to guide deliberation (Ullman 2006).

*The multi-criteria analysis using BTS is a nine-step process:*
First, the policy problem must be defined. Participants must develop an issue statement that they believe best represents the decision being explored. The issue statement has to be specific because imprecise or partial specification means that subsequent steps in the analysis may multiply the initial error several fold through flow-on effects. The decision support software provides a free-text window in the application to capture the issue. As simple as this may seem, getting a group to agree on the issue in writing and how to word them proves to be a valuable exercise in the process.

Second, identify the stakeholders. The various classes of stakeholders who benefit or incur a cost from the policy option(s) under consideration are identified. All persons who benefit or incur a cost from the policy under considerations should be included in the analysis including current and future generations. For fisheries management issues this includes management agencies, commercial and recreational fishers, environmental groups with interests in fisheries, academia and other stakeholders.

Third, identify the alternatives. The software is useful in keep track of each alternative and helping decision groups remain focused upon the ultimate objective. It is also usefully in weeding out inferior choices.

Fourth, define and characterize the decision criteria. Evaluation criteria or attributes against which to assess policy alternatives are specified. Criteria against which to assess the alternatives must be:

- Complete and comprehensive- if two alternatives have the same score for each criterion then it must be agreed that the two alternatives are equivalent. In other words there should be no other basis for distinguishing between the criteria. The criteria should encompass the whole range of relevant outcomes, both those sought from the policy or action, and those arising as a consequence.

- Directional – scoring or ranking of criteria should be able to reflect the direction of an outcome, to distinguish between a negative outcome and a positive one. On a simple ranking, a negative outcome will typically be ranked lower than a positive one, but it is important that the nature of the outcome is reflected whenever possible.
• Operational – the set of criteria must be able to be used in a meaningful way in subsequent analysis.

• Understandable – each criterion should be interpreted in the same way by a range of people with different backgrounds.

• Decomposable – Each criterion should be independent. For example, if criteria include job creation and labor costs and an increase in jobs is considered desirable when it results in unemployed people being employed but undesirable because it pushes up the cost of labor for people already employed. The two criteria are not decomposable because job creation cannot be evaluated independently of labor costs. In practice, it is important to recognize that many criteria are functionally related, and that the decomposable test may not be met. Nevertheless, it may be preferable to the non-decomposable criteria, since acknowledgement of both criteria is more important than eliminating the co-dependence of the criteria. For this, it is especially important to understand the processes through which policies or actions will have effect, and the nature of the relationships among criteria.

• Non-redundant – No aspect of the problem should be accounted for more than once.

• Minimal – There should be no smaller set of criteria satisfying the preceding conditions.

• Simple – Criteria containing a number of different aspects should be avoided if the combination of elements complicates interpretation and application of the criteria.

Fifth, weights are assigned to the criteria. Assigning weights to the criteria is a valuable aspect of multi-criteria analysis. It allows different views to be incorporated and their impacts on ranking of alternatives to be expressed explicitly. It is also important that the weighting procedure be done subsequent to the selection of criteria, and prior to the evaluation of alternatives. There are methods for weighing criteria importance such as independent, fixed sum, ranking, and pairwise comparison. For this project, weights were assigned using a ranking method, where decision makers rank the criteria and then weights are automatically set according to their ranking. Pairwise comparison, used in the Analytical Hierarch Process, compares multiple alternatives relative to each other, one criterion at a time. It is widely used but was not applied in this project due to its time consuming and laborious nature plus there is no proof that the added work improves the results (Ullman 2006).
Sixth, individuals evaluate alternatives. Stakeholders independently rate their knowledge and estimate values of each management alternative indicating its performance in relation to each criteria. Scores can be obtained by measuring quantitative attributes such as the dollar cost of gear modifications to avoid an adverse environmental impact or the expected reduction in fishing related mortality of marine mammals, or they can be constructed using qualitative data. Independent evaluation allows participants to maintain individual values, helps avoid groupthink, and potential personality conflicts. This evaluation is accomplished graphically by placing a point a simple decision matrix, also known as a belief map.

Seventh, is the “synthesis”. The facilitator merges all the data from the participants (the criteria weightings plus the criteria scored against the alternatives) and the computer support tool produced an overall scoring of the management alternatives. The alternative with the highest score is the most satisfactory alternative. An alternative with a satisfaction value of 100% means that the team is fully satisfied with it. Satisfaction can be interpreted both relatively and absolutely. Relatively, the highest score is the best, but this should be checked from many viewpoints to insure team consensus. Absolutely, there is a minimum level of satisfaction that should be obtained to warrant commitment to a specific alternative. There is no set value for this minimum, but a value below 65% for an alternative implies that the team is not very confident in its success.

Eighth, a sensitivity analysis is conducted. In the sensitivity analysis, various weights or aspects of the multi-criteria problem (scores, weights, evaluation method, etc.) were varied systematically to determine their effect on the satisfaction of the management alternatives. For example, it is possible to determine to what degree a particular weight or criteria score must change before the satisfaction of the alternatives changes. Participants could decide to re-weight criteria or change their scoring of alternatives against criteria. This reevaluation stage was guided by an assessment of what-to-do-next analysis. This is a decision technique that explicitly evaluates the benefit of collecting additional information to reduce or eliminate uncertainty. Combined with the level of team consensus, level of knowledge and weighting of criteria, it
generates statements that guide the team to the most effective next set of actions. The what to do next suggestion are:

- **Build Consensus** – Evaluations that are important and where the team evaluations are not consistent are listed first in the what-to-do-next report. These require the least expense to resolve if they are resolvable with the information that is available. Consensus values range from 0% to 100% to show the level of agreement among the members in their evaluation of the selected alternative featured.

- **Increase team knowledge** – Increasing team knowledge usually means performing more research, analysis, simulations or including more expertise on the team.

- **Refine criterion** – Qualitative criterion are flagged to be refined if they are critical to the decision.

Finally the results are presented. The objective of a decision support system is to assist the decision making process. Presentation of the results in a form understandable to key audiences is critical.

**Evaluation of the Use of MCA towards this project**

Participants in the policy evaluation workshop implementing the decision support system were asked to complete a short written questionnaire seeking their views on using a structured approach to fisheries policy analysis. The survey was thirteen questions, 4 questions evaluating the workshop itself and 9 questions evaluating the decision support software tool. Participants were asked to evaluate the questions on a five point satisfaction Likert Scale with “1” meaning “Not At All” and “5” meaning “Extremely”. The results of this survey will help in evaluating the contribution of this project to fisheries policy development in particular, and the likely benefit of continued development of the decision support framework for fisheries policy development for West Coast fisheries, in general.

Overall participants were satisfied with the workshop (mean score of 3.69). As one participant expressed “This was an excellent workshop and an excellent tool for decision making. In fisheries the problem is everyone is dug in with their opinion. This tool moves you off your position by just the exercise of identifying options and criteria. I could use this tool in my work.”
Another person noted the importance of having all the various stakeholders represented and having them knowledgeable in the subject in order for the workshop to be effective: “Interesting process if focus groups are a good representative, cross section of all stakeholders and interested parties the process has potential. It remains very important to include informed and knowledgeable focus group.”

Not only did the participants find that the decision support approach allowed for uncertainty (mean score 3.69) but it also allowed for socio, economic and cultural information about the impacts of fishing on the marine environment to be incorporated in the evaluation process (mean score 3.81). On the flip side participants didn’t think that the decision support approach allowed scientific information about the impacts of fishing on the marine environment to be incorporated into the evaluation process very well (mean score 2.96). The decision support software and methodology can support quantitative data but for these workshops it was not used due to time constraints and to facilitate ease of use. A participant recognized this, stating “(I) understand the application can handle quantitative data but we didn't use that function. A better understanding of this function could make me rate this higher.”

Participants especially felt that the decision support approach contributed to constructive discussion of the management alternatives by workshop participants (mean score 4.08). Participants also felt that the decision support tool was easy to use in the workshop (mean score 3.80). According to the survey results, the decision support tool helped to create common ground among participants on the management of possible adverse effects of fishing on the marine environment (mean score 3.32). A majority of respondents were satisfied with the results of the evaluation process (mean score 3.62). In addition, participants indicated that there is a potential of the decision support tool in stakeholder discussions about other contentious fisheries management issues (mean score 3.54). As one participant said “(The) support tool appears to have a significant potential for collaborative resolution of fishery management problems.”
Chapter 6
Conclusion

Designing, implementing, and managing market based approaches for managing the environmental impact of fishing on the West Coast poses opportunities, challenges and risks. Under many circumstances, market based instruments can generally achieve the same social benefits than government command and control systems while effectively communicating public values to industry for environmental improvement. In turn industry can use market trading to find the lowest costs to address these values. In addition society can use incentives and market pressures to induce private firms to invest in environmental public goods even above levels that exceed mandatory level.

However, relative to simpler and more traditional command and control policy approaches, market based approaches are relatively new and require a higher level of policy craftsmanship to achieve their objectives. In addition they may result in lengthy and complicated public negotiations over major policy elements including goals and objectives, the structure of rights, the types of standards, analysis of tradeoffs, and public versus private research and management responsibilities including monitoring, enforcement, and analysis. And given equity concerns and differing social, political, and environmental values, attempts to design a rights-based approach to manage environmental impacts may be met with considerable caution, cynicism, or outright hostility by some stakeholder groups.

The experience over the last 15 years suggests that with increasing experience and rapidly improving technologies, market based approaches offer considerable promise. But achieving that promise requires education, flexibility, and a willingness to take policy risks. Undertaking policy experiments and conducting comparative analysis are important strategies to direct criticism and develop support for their adoption.

The overall goal of this project was to help stakeholders involved in the West Coast fishery management process evaluate the strengths, weaknesses, and tradeoffs associated with the current use of command and control instruments compared to the potential use of market-based
instruments in mitigating the potential adverse impacts of fishing on marine ecosystems. To accomplish this, the following tasks were undertaken:

1. A comprehensive review of the literature identifying:
   a. Market-based approaches developed to manage terrestrial environmental externalities that have potential for managing the environmental impacts of fishing
   b. Market-based approaches currently employed in fisheries nationally and globally
   c. Evidence of institutional, legal, political and administrative barriers to the adoption of market-based environmental standards for fisheries management.

2. A survey of general perceptions and attitudes towards market-based instruments relative to traditional command and control approaches towards reducing the potential adverse impacts of fishing on the marine environment.

3. Engagement of representative fishery management stakeholders using specific case studies and a policy relevant decision support framework to evaluate the potential strengths, weaknesses and tradeoffs of market-based instruments relative to more traditional and widely used command and control approaches for reducing the environmental impacts of fishing on the west coast.

4. Evaluation of the benefits of using a structured decision support system to assess public policy alternatives for fisheries management.

According to the survey results, market based instruments are a policy option that could be used on the west coast in order to reduce the potential adverse environmental impacts of fishing on the marine ecosystem. Not only were a majority of respondents familiar with MBI, but they perceived them to be effective towards mitigating bycatch of non-commercial fish species, non-fish species and disturbance to benthic habitats. Even those that were not initially familiar with market based instruments thought that MBI could be effective towards mitigating the adverse environmental impacts of fish, although to a lesser extent than those already familiar. In addition survey participants perceived that MBI would be feasible to implement. They were also receptive towards using them as well as perceiving there fellow participants to be receptive towards them.
However as expected the workshops, focused on specific applications, produced more mixed results. The survey results indicated that market based instruments were perceived to be more effective towards reducing the bycatch of non-commercial fish species than the current use command and control regulations. The opposite was reflected in the workshop. In both the yelloweye rockfish case studies the stakeholders collectively rated the performance standard policy approach higher than the tradable permit alternative. But there still is potential to use market based approaches to manage the bycatch of non-commercial fish species because the tradable permit alternative scored higher than economic incentives, command and control, and voluntary co-op. Participants scored economic and management criteria high for the tradable permit scheme alternative. One workshop scored the ecological performance of ecological approaches relatively high while the others did not. With respect to social and equity concerns market based approaches scored much more poorly than the other policy alternatives.

Looking at the potential of market based instruments to reduce disturbance to benthic habitats, the survey found that it was the environmental impact scenario that scored lowest for effectiveness among the environmental impacts for both those that were familiar and those not familiar with market based instruments. The lower scores were also reflected in the workshop on how to best manage essential fish habitat. The tradable permit scheme (tradable EFH impact credits) scored the fourth highest alternative out of five alternatives. Overall when participants scored how well the criteria met the management alternative, there was relatively high uncertainty. In addition the tradable permit scheme was scored low on having a low additional cost to fisheries enterprises, low socio-economic impact on fishing communities, high political feasibility, and high administrative effectiveness. It was recognized however that a tradable permit scheme to manage essential fish habitat would be have high flexibility and high benthic, water column, and forage conservation.

The results of this study also show that the use of multi-criteria analysis could be beneficial in the west coast fishery management process. The Pacific Fishery Management Council would benefit from improved transparency, better problem structuring and decision maker learning. Even if decision makers disagree with MCA’s output, it can still provide a valuable input to the decision procedure. Those that use it can better understand the trade-offs and appreciate the
consequences of alternative preference-positions. It improves the decision procedure by making choices analytically robust, accountable and auditable.

The outcomes of this study can potentially influence whether market-based approaches become a policy option commonly employed for managing the environmental impacts of fishing on west coast marine ecosystems. Policymakers, industry, NGOs and other stakeholders will benefit from a wider range of policy tools to promote sustainable fisheries. Participation of stakeholders in their design, testing, and use in managing the environmental impacts of fishing facilitates sustainable outcomes through education and awareness of the benefits and weaknesses of market-based management approaches among stakeholders. The combination of a structured and participatory decision support system and a comparison of the potentials of market-based instruments compared to traditional command and control regulations should assist policy makers and stakeholders in seeking more creative and effective approaches in managing the environmental impacts of fishing activities. This project is a potential first step in establishing a decision support center specifically focused for marine resource management policy analysis.
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MARKET BASED ENVIRONMENTAL STANDARDS FOR SUSTAINABLE FISHERIES

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ABSTRACT

Many fisheries management agencies struggle with developing management frameworks that can deliver sustainable fisheries. Overfishing, by-catch of non-target fish species, marine mammals, seabirds, and damage to benthic habitats remain serious problems. Management methods based on traditional command and control approaches may meet with initial successes yet additional progress is often marginal requiring managers to implement additional regulations to achieve improvements in environmental performance. In contrast to the terrestrial environment, few policymakers in the marine environment have embraced or actively experimented with market-based policy tools for controlling fishing impacts to the marine environment. This institutional inertia is due to poorly developed property rights for marine resources and habitats, institutional constraints, paucity of relevant policy models, and lack of political will and institutional creativity. Developing rights based standards for large scale aspects of marine ecosystems may be perceived as technically too difficult, politically too challenging, and legally in conflict with public trust doctrine. Despite these barriers, market-based standards, particularly in the context of rights-based systems such as dedicated access privileges, are potentially powerful instruments for addressing environmental externalities in the marine environment. This paper identifies market-based approaches used in terrestrial contexts that have potential for managing the environmental impacts of fishing. It explores key issues in the use of market based environmental standards in fisheries management and demonstrates through case studies how the use of market-base approaches can enhance traditional command and control approaches to environmental standards for fisheries.

Keywords: Market-based standards, Environmental impacts of fishing

INTRODUCTION

Fisheries managers almost universally use sustainability, the use of natural resources to meet present needs without compromising the needs of future generations, as the guiding principle of fisheries policy. However, fisheries managers struggle in developing management frameworks that can achieve ecologically sustainable and profitable fisheries. Part of the problem is that the output of harvesting fish includes environmental “externalities” to environment such as over-fishing, by-catch of non-target fish species, marine mammals, and seabirds, and damage to benthic habitats. Managers cannot directly influence the state of the fishery resource but they can influence the actions of those exploiting the resource.

A standards-based approach is a coherent framework for building a successful environmental policy process. The major components of this approach include 1) an environmental goal; 2) input, process, or performance standards whose achievement correlates with goal achievement; 3) incentives and strategies which compel managers and policy actors to achieve standards; 4) evaluation; and, 5) revision and adaptation. A credible standards-based
approach must also be consistent with relevant policies and legal mandates, achieve its goals at the lowest cost or greatest benefits, and be fair and equitable. An effective standards process will include analysis of the success of the process in meeting these objectives.

There is less agreement, however, on which type of policy approach would most effectively incorporate standards and achieve environmental goals. The major approaches can be categorized into four classes: 1) government regulated input or output standards (Model 1); government regulated performance standards (Model 2); government sanctioned market-based performance standards (Model 3); and, community or industry voluntary performance standards (Model 4). The regulatory input/output model is the most predictable and often the most commonly employed in managing marine environmental impacts and it tends also to be the most inefficient. Although government regulated performance standards are usually more efficient than input-output standards, among world leaders in environmental management there is increasing testing and adoption of Models 3 and 4 given their significant advantages in harnessing market and social forces for achieving environmental goals.

Except in the case of ITQ’s for commercial fisheries, few management regimes have embraced or actively experiment with market-based policy tools for controlling fishing impacts to the marine environment. This institutional inertia is due to poorly developed property rights for marine resources and habitats, institutional constraints, paucity of relevant policy models, inadequate and costly science, and lack of political will and institutional creativity.

Nevertheless, there are a variety of market-based policy instruments developed for terrestrial and non-marine environments that could be used for managing the environmental effects of fishing. This paper explores the use of market-based instruments for achieving environmental standards in fisheries. It begins with a discussion of environmental standards and the use environmental markets in designing standards. It then explores four conceptual policy models that incorporate standards based approaches to managing environmental problems. Key issues and challenges associated with the use of market-based standards in the marine environment are reviewed before the paper concludes with, by way of example, two cases where we believe market-based mechanisms could potentially enhance the performance of existing environmental standards for the environmental impacts of fishing.

ENVIRONMENTAL STANDARDS

The development and use of standards is fundamental to any management or regulatory process designed to protect the environment. In fact a standard – or its synonyms criterion, target, norm, value, benchmark, rule – is fundamental to any systematic process designed to achieve some measurable goal. Associated with achieving an environmental goal (e.g., potable and fishable water quality) is a set of standards in which the performance of an individual, household, firm, industry, or community is evaluated according to its progress in achieving the goal. The performance is evaluated in terms of specific quantifiable targets or “standards” that have a functional relationship with the environmental goal (e.g., controlling the level of nitrogen or phosphorous in effluent). In many cases standards may also be prescribed for the types of inputs which can be used (e.g., fertilizer applications rates per hectare) or the type of technology (e.g., timing and method of applying fertilizers). Standards may also be prescribed for the environmental management process itself (process standards) which are used to provide quantifiable targets (e.g., quality and timeliness of information and analyses) in meeting policy objectives. For the typical environmental management policy process, there will be a system of standards to guide, evaluate, motivate and/or constrain the behavior of economic and policy actors who directly or indirectly influence the success of meeting the environmental goals.

A successful standards approach is based on an institutional and management process which 1) is consistent with relevant policies and legal mandates, 2) achieves its goals at the lowest cost (i.e., cost effectiveness) or greatest net benefits (economic efficiency), and 3) is fair and equitable. Planning and designing a standards process must include analysis of the success of the process in meeting these broad objectives.

Designing standards for evaluating effects of human behavior on species, habitats, or ecosystems is more challenging than measuring a single chemical pollutant. This is particularly true in the marine environment where it is difficult to determine the status and fundamental processes of species and habitats. Because direct measurements are costly, indirect indicators that may be correlated with anthropogenic effects are used to represent changes in the marine environment (McNeil 2003). Often a single indicator may not be adequate to represent the status of the
health of a habitat, environment, or ecosystem and multiple indicators will be structured to produce an index of environmental or ecosystem health. An index score can then be used to represent the progress in achieving the long run environmental goal. Standards will be structured to motivate and evaluate progress of economic or policy actors in collectively moving toward that goal. Reference points are specific levels of an indicator or that are used for comparative purposes or to trigger new policies or standards (Restrepo et al. 1998).

**INCENTIVES, PROPERTY RIGHTS AND ENVIRONMENTAL MARKETS**

**The Benefits of Economic and Market Incentives**
The inefficiencies of input/output and command and control policy models for controlling environmental externalities are well documented (Andersen and Leal, 2001; Heal 2000; Anderson 1997). Even voluntary “best practices” standards may be inefficient because they provide no financial incentive to improve beyond the minimum standard. In many cases economic incentives may have significant advantages relative to other policy approaches (NCEE 2001):
- Incentives harness forces of the market place;
- They support flexibility and creativity;
- Economic incentives can be structured to reduce greater levels of pollution or environmental externalities relative to traditional regulation;
- Positive incentives can be used to thwart perverse incentives associated with the tendency of government to ratchet up the standards once they are achieved;
- Provides mechanisms to coordinate activities of thousands of players without directly controlling behavior;
- Stimulates technologies and innovations.

**Types of Incentives and Market Systems**
There are various types of incentive-based economic policy instruments (Van Beuren 2003; Sterner 2003):
- **Fees, charges, and taxes**: These instruments impose an explicit price for an environmental service or resource. They may change a polluter’s behavior by providing price signals that more fully reflect the cost of using environmental resources and services. These instruments can generate revenue to fund environmental management.
- **Subsidies**: A direct transfer or pricing and tax policy that favors certain economic activities.
- **Deposit-refund systems**: A scheme that requires a deposit to be paid upon the purchase of potentially polluting products. The deposit is refunded if the product or its residues are returned for disposal or recycling.
- **Marketable permits (e.g., cap and trade or credit systems)**: Permits represent the right to extract, impact, or pollute a given quantity of resource, organism, or chemical. The number of permits allocated depends on the total amount of resource deemed acceptable to use or impact. Permits may be sold or traded among individuals.
- **Liability (e.g., performance bonds)**: Payments to authorities that take place prior to an activity that is potentially environmentally harmful. The payment is refunded if environmental regulations are met, and forfeited if they are not.
- **Environmental accreditation**: A process by which an outside source audits the environmental performance of a company, industry, or public management program.
- **Information disclosures**: Voluntary or legally mandated disclosure of product or service-related environmental information. Information disclosure can take on many forms including labeling, public disclosure, or rating and certification.
- **Voluntary eco-labeling**: A type of information disclosure in which identifiable labels on product packaging inform consumers about the environmental effects of product related production, consumption, and waste. The labels are granted by a public or private body on the basis that the products are generally less destructive to the environment than competitive products.

There are four basic classes of marketable permit systems (Heal 2000):
- **Cap and trade**: Establishment of a ceiling on the total allowable pollution or extraction of a resource. Tradable permits (to either pollute or extract) are allocated to industries that are an absolute or relative proportion of this allowance.
- **Baseline and credit**: Firms are allowed a certain pollution level or environmental impact that may be generated with no penalty. If they produce less than this, they create emission or impact reduction credits; if they emit or impact more than the baseline, they must purchase credits equal to the excess.
- **Bubble programs**: A feature of emissions trading systems which can be used to ensure that over a geographical area, average exposure to a certain pollutant or environmental impact is reduced. The aim is to prevent total emissions from an area (thought to be contained in an imaginary glass dome or bubble) rising above a certain level. Emission credits can be traded between companies within the same area.

- **Emissions averaging**: Firms (or industries) are allowed to purchase credits to generate an emission or impact. However, they may exceed the standard at a specific location as long as the average emissions or impact generated by the firm (or industry) from all locations meets the regulatory standard.

These marketable permit systems can be designed and adjusted to accommodate other policy instruments. For example, cap and trade systems can incorporate an allowance to purchase or retire pollution effects to meet standards associated with third party certification schemes (Anderson and Leal 2001). Trading ratios can be designed to control and reduce overall emissions or environmental impacts by requiring that the purchaser of a unit of credit receive the right to only use some proportion of that credit according to the trading ratio formula. *Cross pollution (or cross externalities) trading* for different types of pollution or environmental effects can be allowed based on specified trading ratios. *Banking and borrowing* can encourage firms to invest in new pollution or environmental impact control technologies, and gain from their investment through the use of various tradable credit schemes. Credits can then be awarded and banked when pollution or impacts are lowered below permitted levels.

**Designing Environmental Standards**

The conceptual structure of any standards process for managing environmental impacts is relatively straightforward:

- Determine management and environmental objectives;
- Analyze potential economic behavior and effects on these objectives relative to alternative institutional designs;
- Select the rules, institutions, incentives and standards which best achieve management and environmental objectives;
- Monitor, measure, and evaluate the effect of 1) incentives for achieving the standards and 2) standards in achieving environmental objective(s);
- Revise and adapt if necessary.

This conceptual structure embeds the key components of any system of standards including objectives, behavioral relationships, incentives, enforceable standards, measurement, accountability, learning, and adaptation.

The broad elements of this approach have been used for most environmental problems, particularly in controlling air and water point-source pollution. It is also the basic framework for ISO 14000 and related Eco-Management and Audit Schemes for meeting firm-level environmental standards (Mech and Young 2001). These schemes have been used by thousands of private firms to increase profitability while simultaneously reducing environment effects (Gilbert and Gould 1998).

Van Bueren (2003) summarizes key features of any standards-based market system for environmental management:

- Defining what is traded;
- Determining units and physical basis of trades;
- Determining the duration of the rights;
- Defining the minimum number of participants;
- Determining who can participate;
- Defining the level of allowable trading;
- Specifying the geographic area;
- Determining design elements (e.g., trading ratios, cross pollution trading, banking and borrowing, etc.);
- Selecting which institution will administer trading;
- Specifying the forms of monitoring;
- Determining who monitors and assesses;
- Designing the enforcement mechanisms;
- Calculating the costs of monitoring and enforcement and determining who pays.

Haddad (1997) outlines a general checklist for determining whether to pursue creation of marketable permit based system:

- Is the regulatory goal clearly-stated, quantifiable, and adopted?
- Do potential benefits exceed potential costs associated with decentralizing compliance decisions?
• Can a permit be identified that, if traded, would reduce the cost of compliance, or provide economic benefits?
• Is the object of trade divisible?
• Is the object of trade measurable?
• Is the object of trade verifiable?
• Can potential permit purchasers or obligation transferors afford to pay the expected market price of the permit/obligations?
• Can certain rights-holders afford not to sell their rights?
• Are there sufficient numbers of traders to make market creation a worthwhile investment?
• Does the regulated entity have several alternative compliance paths?
• Can transaction costs be held down?
• Do market-overight institutions have potential conflicts of interest with a trading program?

A standards approach is most easily used when there is a discrete environmental problem involving relatively few players, and when cause and effect are known. This approach, however, can break down for large and “messy” public policy environmental problems (Dorcey 1986). “Messy” problems are characterized by: 1) numerous and heterogeneous policy participants, 2) multiple agencies, 3) vague laws and legal standards, 4) lack of consensus on environmental management objectives, 5) multi-dimensional environmental objectives involving many species, habitats, and ecosystems, 6) significant uncertainty about the natural environment, 7) an unpredictable and unstable policy environment, 8) lack of economic-policy information on causal relationships, 9) insufficient funding, and 10) inadequate policy leadership.

INSTITUTIONAL MODELS USING ENVIRONMENTAL STANDARDS

There are considerable challenges inherent in developing standards-based institutions for managing the complex process of sustainable development of the marine environment. In many case the challenges are greater than on terrestrial environments because terrestrial ecosystems 1) have undergone a longer institutional management experience, 2) are more thoroughly studied and researched, 3) have more sessile and less fugitive organisms, and 4) are characterized by better defined and secure property rights. Except for having possibly fewer policy actors and agencies, the marine environmental management problem poses a “messier” challenge than found on terrestrial landscapes and watersheds.

The following section summarizes four alternative institutional models that which employ a standards-based approach for managing environmental problems. To some extent these models are used as a heuristic devise to isolate the essential features of alternative institutional strategies – in the practical policy environment there will be considerable overlap between these approaches.

Four Policy Models

There are four conceptual policy models which incorporate standards-based approaches for managing environmental problems:

Model 1 -- Government regulated input or output standards: Central government employs a scientific-bureaucratic model to dictate inputs, technology, and/or output of goods and services (of household, firm, or community) for controlling environmental impacts. Standards are developed to define the minimum or maximum inputs, technology, or outputs. Although there may be some consultation there is little direct public involvement. The government may employ various incentives to achieve standards. Government coercion is used to enforce the standard.

Model 2 -- Government regulated performance standards: Central government employs a scientific-bureaucratic management model to dictate performance of individual firms/communities/households in production of environmental externalities. Standards focus on maximum target level of environmental pollution or damages for each entity. Allows flexibility in choice of inputs and outputs of goods and services. Tends to involve higher degree of public consultation. May employ various incentives to achieve standards. Government coercion used to enforce the performance standard.

Model 3 – Government sanctioned market based performance standards: Institutions are structure to provide a form of legal property right, user right, or privilege to provide market discipline and economic efficiencies for achieving an environmental performance standard. Can be narrowly focused on a single externality or species or broadly structured to incorporate habitats or ecosystems. Allows considerable flexibility across communities of interest and
Model 4 -- Community or industry designed voluntary performance standards: Standards based process which is developed, owned, and managed by groups of households, firms, or communities in response to collective need for improving the environment. Often driven by potential gain/loss of utility and profits associated with product/service market demand or potential regulation by the state. Provides considerable flexibility across community of interest. Can include incentives and cooperative rights structures. There is a significant degree of consultation by community members. Incentives are internally generated through social structures. Government coercion and enforcement not directly relevant but implicit threats of government action may be a contributing motivation.

Table 1 illustrates that each of these policy models has strengths and weaknesses relative to some of the key attributes of successful policy institutions. In general, model 1 (input/output regulatory models (also known as “command and control” -- see next section) tends to score low except for the simplicity of the process it employs. These low scores are a direct result of an institutional structure that places high value on centralized control and top-down rulemaking strategies. In general, a process that embraced other attributes would be unlikely to select input/output controls. The government mandated performance-based standards model tends to score moderately well in all categories since it is based on standards directly linked to controlling the environmental externality and involves greater public participation. However, although the standards model allows each “polluter” to select the best individual approach for meeting the standard, it does not provide opportunities for trade among heterogeneous “polluters” that could lead to substantial improvements in efficiency and welfare. Conversely, while the market-based performance standards (model 3) can generate potentially greater efficiency, depending on the environmental goods, the extent of the rights, and number and heterogeneity of agencies and policy actors, the approach can raise social-equity issues and generate contentious debate. Similar to model 4, however, it has significant potential for devolving the day-to-day management to the rights holders. While the voluntary approach to standards has many advantages, it requires unique conditions for its development including a relatively small community of interests, effective community leaders, potential for significant gains (or minimum losses) for its members, and supportive public agencies.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
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<tbody>
<tr>
<td>Adaptability</td>
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<td>Moderate-High</td>
<td>High</td>
</tr>
<tr>
<td>Public Participation</td>
<td>Low-Moderate</td>
<td>Moderate</td>
<td>Low-High</td>
<td>High</td>
</tr>
<tr>
<td>Economic Efficiency</td>
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<td>Moderate</td>
<td>Moderate-High</td>
<td>Moderate-High</td>
</tr>
<tr>
<td>Equity</td>
<td>Low</td>
<td>Moderate</td>
<td>Low-High</td>
<td>High</td>
</tr>
<tr>
<td>Simplicity of Policy Process</td>
<td>Moderate-High</td>
<td>Moderate</td>
<td>Low-High</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

**Table 1: Relative strengths of standards-based institutional models for managing environmental problems.**

Another approach for understanding the comparative strengths of standards-based models is shown in Figure 1. The position and shape of each model indicates the relative degree of economic efficiency and adaptability compared to policy predictability and centralized control. Input standards models demonstrate greater predictability but less efficiency. Conversely, efficient models tend to have significantly less centralized control. As indicated by the intensity of shading, input/output regulatory models are the most common approach for controlling environmental impacts. The arrow indicates, however, increasing experimentation and adoption of more efficient institutional models over time.

With appropriate property rights, pricing incentives, and adjustment of national accounting frameworks to include environmental services, that markets can be used to substantially manage environmental impacts. Successful markets to manage water and air pollution exist, particularly in the United States. This has important implications for each conceptual model. Because Model 1 mandates inputs and/or outputs, it cannot take advantage of economic
incentives and opportunities for trade to efficiently and innovatively meet environmental standards. In contrast, the performance standards of Model II can be incorporated within a property rights structure if the performance is evaluated across the entire system rather than for each individual actor. Generally however, government mandated performance standards are mandated for each agent, which does not take advantage of market based trading to achieve efficient solutions for meeting environmental standards. Model III is based on market-based approaches for achieving an overall environmental standard for a species, habitat, or ecosystem. If appropriately designed, it can take full advantage of property rights systems to efficiently meet and even exceed the market-based environmental standards. And Model IV, although having many attractive features that can work congruently with property rights systems, will only be effective if the achievement of the standard is in the individual (or collective) interest, and if the property rights are sufficiently strong to provide agent(s) with the control needed to achieve the standard.

Figure 1. A relative comparison of economic efficiency versus centralized control for four types of standards-based environmental management policy models. The intensity of shading indicates the relative use of the policy model. The arrow indicates the adoption of more efficient and adaptable models over time.

If rights are relatively weak, or if achievement of the standard is not in individual and/or collective interest (although it may be in society’s interest) the approach can fail, or at best have only minor consequences. In addition, a collective voluntary system may not necessarily be efficient if it is not structured to take full advantage of opportunities for trades in achieving the standard.

Mix of Policy Instruments

In practice tradable permit systems almost always co-exist with other environmental policies, so a mix of environmental policy instruments, rather than one single instrument may prove to be more effective when seeking to address environmental concerns in fisheries. Examples of this dependence include: the use of direct regulations in permit allocation or credit creation; the use of taxes or penalties to ensure compliance; and, the ‘voluntary nature of adherence to credit-and-baseline schemes. For instance in the area of fisheries, it is quite common for individual transferable quota regimes to co-exist with technology-based regulations such as gear restrictions as well as spatial
and temporal restrictions on fishing activity. The OECD (2003) identifies specific conditions under which the joint use of tradable permit sin conjunction with other policy instruments may be preferable to the application of one or the other instrument on its own: dealing with spatial differentiation of impacts, addressing technology market barriers and failures, expanding regulatory scope and reach, and reducing compliance cost uncertainty.

USE OF MARKET BASED INSTRUMENTS TO REGULATE ENVIRONMENTAL IMPACTS OF FISHING

Over fishing, by-catch of non-target fish species, marine mammals, seabirds, and damage to benthic habitats remain serious fisheries problems. Management methods based on traditional “command and control” regulatory approaches such as closed areas, aggregate quotas for non-target fish stocks, mandated gear modifications, and restrictions on fishing methods have met with some success. But many of these “blunt instruments” are often inefficient and inflexible. In many cases, after an initial response, progress remains marginal, requiring managers to implement additional regulations in order to achieve improvements in environmental performance.

Regulators have rarely developed market-based standards to control the environmental impacts of fishing. In most cases it is considered too costly or politically impractical (Sharp 2002). These “impracticalities”, however, may be due as much to a lack of knowledge, experience, and a common vision, than any political or technical “transactions” cost. Because communities will tend to address environmental problems consistent with their history, cultures, and existing institutions, it is difficult to implement fundamental institutional change that may be efficient, but also less predictable (Miles et al. 2002).

New Zealand’s use of deemed values to reduce the incentive for fishers to target fish stocks stock for which they do not hold catching rights (Sanchirico et al. 2005) is an exception to this paucity of market-based instruments. New Zealand does not generally allow the discarding of by-catch. Instead, all catch must be balanced with rights called Annual Catch Entitlements (ACE) by the middle the following month in which the fish were caught. If the fisher does have or can not buy ACE, they must pay a deemed value. The deemed value payment is refunded if the fisher acquires ACE to balance the catch within 15 days of the end of the fishing year. The revenues from the deemed value system go to the New Zealand Governments general fund.

Deemed value rates are set to discourage discarding at sea but at the same time to not encourage targeting of fish for which the fishers does not have rights. The deemed value system creates a catch management regime under which both the Total Allowable Catch for a stock and deemed values manage catch. It is important to note that deemed values are an administrative charge integral to the operation of the catch balancing system and are not considered to be a fine or over-fishing penalty. The revenues from the deemed value system go to the New Zealand Governments general fund. It is important to note that deemed values are an administrative charge and are not a considered a fine.

In a study of senior decision makers in the Seychelles and their attitudes towards the importance of command and control and market mechanisms in the management of living marine resources, Payet (2006) found a preference for command and control approaches among 55% of those surveyed. The remainder supported the need to explore and move towards the greater use of market-based incentives. Market-based mechanisms were seen as being better at optimizing the current levels of marine benefits gained form the marine environment compared to command and control approaches. They were also seen as a way of reducing dependence on Government transfers to the marine sector of the economy (Payet 2006).

ISSUES, CHALLENGES AND OPPORTUNITIES FOR MARKET-BASED MECHANISMS IN THE MARINE ENVIRONMENT

Environmental “Club” and “Local” Goods: Three Classes of Adverse Impacts

Creating marine resource property rights generates positive and negative incentives that can be exploited to develop, implement, and manage environmental standards. These incentives stem from the 1) actions by resource users, 2) the effects of these actions on the marine environment, and 3) the impact of these effects on the rights holders and other marine resource user groups (consumptive and non consumptive). These effects are represented by three classes of adverse impacts which result from the actions of the users of these property rights (e.g., fishing quota holders) or changes to the asset value of their rights:
- Class I: Adverse impacts are caused by a user group’s collective “club” good or “local” public good activities which reduces the productivity of the resource and lowers the asset value of their user right. [Note: for this discussion the concept of “club” good is used loosely to indicate a mixture of private and public good elements held by a common group of rights holders or “club” members—the environmental good, however, may have some elements of rivalry and could more generally be referred to as a “local” public good.]
- Class II: Adverse impacts are caused by a second party’s activities (e.g., a second group of rights-holders) that reduce the productivity of the resource and lowers the asset value of the primary group’s property right.
- Class III: Adverse impacts are caused by a user group’s activities but do not influence the productivity of the resource, nor directly lower the asset value of their user right.

For Class I impacts, it is in the collective interest of the club members to internalize the externality and voluntarily reduce the adverse environmental impact to levels which maximizes the asset value; i.e., where the marginal benefits of reducing the impact are just offset by the marginal opportunity costs from the loss of use of the resource. If the club is the only recipient of value from the environmental good, then that good is a “club good” in which the impacts or the good itself could be owned and managed by the club.

For Class II impacts, the primary party being impacted may have legal standing to seek compensation from the second party. In most cases, however, the environmental good is a public good and held in public trust; in this case the primary affected party would seek redress through the political process. If the primary and secondary parties hold similar types of user rights then the “super” club representing all related rights holders could assist the parties in voluntary arbitration and equitable and efficient settlements which internalize the externality. If the only parties affected by the adverse impact are members of the “super” club, then it is in the interest of the “super” club to voluntarily manage the adverse impacts. If the members of the “super” club are the only recipients of value from the environmental good, then the good could be a local or club good owned and managed by the “super”. With appropriate rights structure within spatially defined areas, a broad range of resource user groups and their environmental effects could be managed by an “environmental management company” that efficiently optimizes and internalizes the environmental externalities (McClurg 2003).

For Class III impacts, the adverse environmental impacts have no direct effect on the asset value of the user right. Unless markets compensate resource users for reducing the adverse impact (e.g., eco-labeled products, third party certification), users will not voluntarily reduce the level of adverse impacts. In order to internalize the externality, it will be government’s responsibility to develop a standards process to avoid, remedy or mitigate the impact using policy approaches that maximize social welfare and balance utilization and sustainability mandates.

Table 2 summarizes the relationships between the classes of adverse impacts and the alternative institutional policy models presented previously. The table demonstrates that when the adverse environmental impacts primarily affect club members, they will voluntarily internalize the externality and manage the environment to reduce the impacts to an “optimal” level. In this case, it is in society’s interest to create an environmental property right to facilitate the club’s efficient management of that right using economic incentives. Conversely, when the user’s activities produce adverse impacts that only affect non-club members, government should establish institutions which internalize the externality. Consistent with the analysis in this report, the position of the X’s indicate that unless there are significant transactions costs, performance-based environmental property rights (Model 3) offers the most promise for environmental management consistent with balancing utilization and sustainability requirements.

Given the complex and diffuse nature of environmental impacts, in the actual world of marine resource management...

<table>
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<tr>
<th>Impact Class</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
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</thead>
<tbody>
<tr>
<td>Class I Club Good Externality</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-class Ip Club Good Externality &amp; Property Right</td>
<td></td>
<td></td>
<td>XXXX</td>
<td></td>
</tr>
<tr>
<td>Class II Super Club Good Externality</td>
<td></td>
<td></td>
<td></td>
<td>XXXX</td>
</tr>
<tr>
<td>Sub-class Ilp Super Club Good Externality &amp;</td>
<td></td>
<td></td>
<td></td>
<td>xxxxx</td>
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</tbody>
</table>
Table 2. Policy models associated with five classes of environmental impacts. The four classes of policy models are Regulatory Command & Control (Model 1), Regulated Performance (Model 2), Market Based (Model 3), and Voluntary (Model 4). The number of X’s indicate relative degree of relevancy and efficiency. The small x’s indicates relevancy and efficiency when the environmental good is privatized and managed by club members

Designing Environmental Management Consistent with the Spatial and Temporal Dimensions of the Marine Environment

Compared to most natural resource-based terrestrial activities, fishing occurs over large spatial areas that can display wide diversity in habitats and ecosystems. The resources which fishermen harvest can also migrate over vast distances. The biological stock can demonstrate significant variation in size and movement within and between years. The resource may also be relatively long lived—in some cases 100 years or longer. And the underlying physical and biological dynamics of the ocean environment will often demonstrate significant inter-decadal variation that can influence habitats, resource-stock size, and spatial behavior.

These complex temporal and spatial dimensions of the marine environment pose significant challenges for developing standards relative to terrestrial environments. First, they pose significant costs for scientific exploration in understanding biology, habitats, and ecosystems. Second, even with relatively large investments in marine monitoring systems, it can take many years to understand changes in marine environments and ecosystems. One implication is substantial uncertainty in understanding fishing related impacts to the marine environment relative to natural variation.

Addressing these challenges suggests that any system of standards must provide incentives for exploration, testing, and adaptation consistent with spatial and temporal scales. The variation across habitats, fish stocks, and fisheries will require flexibility in design of environmental standards. The standards process itself must compel research of the marine environment, and then drive analysis to measure the effectiveness of this research in improving standards for managing environmental impacts.

The large spatial scale and the diversity of habitats within three-dimensional space require that a system of standards be congruent with spatially defined classes of habitat. Fishing operations within one habitat type may have different impacts than the same operations in a different habitat. Developing standards as a function of spatial boundaries could result in management systems consistent with definitions of “marine protected areas.” It may also support development of rights-based environmental management structured within spatially defined areas. This does not imply that trades or mitigation of environmental impacts cannot occur across habitat types, but that the ratio of trades may vary by habitat type. It also may provide opportunities for using creative mitigation strategies for meeting environmental standards.

If rapidly advancing technologies support spatial mapping and classification of habitats, ecosystems, and stocks, then environmental management will continue to be more precisely defined by habitat type. This suggests two possibilities related to developing and managing standards. The first is that devolution of environmental management by private entities could be organized around habitat classification rather than a single fishery. Second, that refined maps of natural habitats can be overlaid with dynamic maps of fishing activities in order to evaluate environmental impacts at relatively fine spatial scales. The resulting information could then be used to manage fisheries and environmental impacts by refined habitat classifications. The ability to manage fisheries within relatively small areas could reduce the need for larger-scale marine closures and reserves.

Risk and Uncertainty

Risk and uncertainty are fundamental characteristics of fisheries management. In most standards-setting processes, “risk” analysis plays a fundamental role in determining strategies to protect the marine environment. Risk and uncertainty are also fundamental characteristics of the public and private management process including policymaking, resource monitoring and assessment, and fishing strategies. Developing a standards-process that
operationally incorporates risk and uncertainty, and can efficiently increase predictability, should be a core objective of any program designed to manage the environmental effects of fishing.

To a significant extent, marine environmental management is based on uncertainty analysis and subjective estimates of risks. The role of “experts” in defining risk, therefore, is fundamental to any standards-setting process. It is critical, however, that the process of risk analysis be structured with its own set of clearly articulated rules and standards. For example, for a relatively “simple” environmental standards-setting process involving only a single “externality”, and supported with a reasonable amount of scientific research, a panel of scientific experts could evaluate the research and make reasonable calculations of the risk estimates (Morgan 1993). However, for more complex environmental management problems with considerable uncertainty, “experts” will include stakeholders and other members of the public. In many risk assessment processes, including those used in fisheries, not only will these experts provide subjective “estimates” of risks, but they will be invited to incorporate their personal values within the risk assessment process (Standards Australia and Standards New Zealand 1999; URS 2002). Whether intended or not, in the absence of objective definitions of adverse impact, it is inevitable that subjective values will be incorporated within the risk assessment process. This can result in arbitrary risk assessment in which one environmental fisheries risk assessment process estimates high risks and damages, while another process for a fisheries with similar environmental effects, estimates low risks and impacts.

Because risk assessment is the core process for determining environmental impacts, the designers of the risk assessment process must carefully evaluate their choices and standards. In particular, they need to determine whether they build a simultaneous or sequential process that estimates the 1) probability of impacting some component of the marine ecosystem 2) determining whether the impact meets the legal definition of adverse and, 3) if found adverse, the relative degree of adversity relative to sustainability requirements. They also need to determine whether the same group of “expert” panelists evaluates each component of risk analysis, and whether these “experts” are also involved with designing management actions to address the impacts. They need to determine the criteria for being considered an “expert”, and the information which “experts” should be provided before participating in the process. And finally they need to consider how management concepts associated with risk and uncertainty such as decision makers should be cautious will be addressed, if at all, within the risk assessment process. In many third party fisheries certification audits, the “precautionary approach” is integrated within the risk assessment process (for example, New Zealand hoki [URS 2002] and Alaskan pollock [SCS 2002]).

SUBSTITUTING COMMAND AND CONTROL WITH MARKET BASED APPROACHES: TWO CASES

Two case studies demonstrate that progress is being made in addressing the environmental impacts of fishing. In each case, however, the “progress” is being achieved using traditional command and control regulation, best practices technology, or government mandated performance standards. Property-rights and market-based incentives have not been used to address the environmental management of fishing. For each case study market-based mechanisms to enhance the mandated environmental standards are suggested.

Case I: Eastern Tropic Pacific (ETP) Purse-Seine Yellowfin Tuna Fishery

Issue: Dolphin bycatch
Existing Standard: 5,000 dolphins/year fleet-wide; individual vessel bycatch levels determined by number of qualified vessels. Meeting “zero bycatch standard” qualifies as “dolphin free”

The ETP yellowfin tuna fishery is conducted over an eight million square mile area of the Pacific Ocean. It produces roughly 800 million pounds of skipjack and yellowfin tuna per year, supplying 20 to 25 percent of the world’s canned tuna supply (Platt 1996). Many nations participate in the ETP fishery, including Costa Rica, Ecuador, El Salvador, Honduras, Mexico, Nicaragua, Panama, Peru, the United States, and Venezuela. Millions of dolphins live in the ETP, about 10 million of which are commonly found swimming in association with yellowfin tuna. Of these 10 million, three species – the northern offshore spotted, eastern spinner, and coastal spotted dolphins – are considered “depleted” under the Marine Mammal Protection Act (MMPA) (NOAA 2003).

In the 1950’s, fishermen discovered that yellowfin tuna were likely to be found swimming 200 feet below dolphin stocks. Fishing methods were consequently developed using purse seines which encircled both dolphins and tuna. This method resulted in the deaths of hundreds of thousands of dolphins in the early years of the fishery. By the
1970’s public pressure and citizen boycotts caused Congress to amend the MMPA to address the dolphin bycatch issue. Throughout the next 20 years Congress continued to amend the MMPA imposing stricter regulations on both U.S. fishermen and the importation of foreign tuna. By 1990 the U.S. fleet’s participation in the ETP tuna fishery declined to less than ten vessels. The decline was due to economic opportunities in the Western Pacific Ocean and MMPA prohibitions in the ETP.

Since 1990, several substantial international dolphin conservation efforts have resulted in a dramatic reduction in dolphin mortality (NOAA 2003). The La Jolla Agreement in the fall of 1992 placed voluntary limits on the number of dolphins that could be incidentally killed in the tuna purse seine fishery. It also lowered the maximum number each year over seven years, with a goal of eliminating dolphin deaths in the fishery. In 1995, the United States agreed to import tuna from other countries and signed the Panama Declaration, an international agreement to continue long-term dolphin protection through participation in the international dolphin conservation program (NOAA 2003).

In 1999, the current international environmental standard for dolphin mortality was set by the Agreement on the International Dolphin Conservation Program (IDCP). The Agreement limits the total incidental dolphin morality limit (DML) in the purse-seine tuna fishery to no more than five thousand annually. At sea-observer coverage and support of research to improve gear design, deployment, and retrieval are among measures required by the Agreement to help reach this goal. Through the IDCP, observed dolphin deaths have been cut from 133,000 in 1986 to fewer than 2,000 annually since 1998 (Agreement on the International Dolphin Conservation Program 1998).

Two percent of the total DML are managed separately, leaving 4,800 dolphin to be allocated among all vessels (in all countries) participating in the ETP tuna fishery. The two percent is considered “reserve” and is managed at the discretion of the Inter-American Tropical Tuna Commission (IATTC). Vessels that do not normally participate in the tuna fishery may request allocation of the reserve.

Every year, each country submits a list of vessels to The Inter-American Tropical Tuna Commission that they believe are qualified to receive dolphin mortality quota. Qualified vessels are determined through examination of criteria such as performance records (past infractions, fishing history, etc.), carrying capacity, and crew certification in dolphin release and rescue techniques. The IATTC closely monitors all vessel request lists and has authority to determine the eligibility of each vessel’s DML. By November 1 of each year, all countries submit their lists of vessels requesting DML to the Commission. Once qualified vessels are approved, the total allowed dolphin mortality (4800) is divided by the total fleet-wide number of qualified vessels. This number is referred to as the ADML (average individual vessel DML). This number is then multiplied, on a per country basis, by the number of vessels requesting DML (e.g., if a list of 100 fleet-wide vessels is approved, the ADML=4800/100= 48. If a country has two qualified vessels, their DML =2*48= 96. The country may split this dolphin mortality between the vessels evenly, or divide it up at their discretion, with one vessel receiving more DML than another (Bratton-personal communication).

**Proposed Alternative Policy Instruments and Standards**

By any reasonable “standard”, the reduction by the ETP fleet in dolphin bycatch has been a significant environmental achievement. Although there are some concerns that the tightening restrictions have compelled “dirty” operators to target tuna located beneath floating logs and attractors with unregulated and disproportionately higher bycatch, in general the program has met or exceeded its specific goals. Today, dolphin bycatch is less than 2% of the 1986 bycatch and less than 40% of the existing aggregate bycatch cap. The program is considered a model of successful international cooperation in research and management for controlling environmental effects of fishing. Tuna caught in individual seine sets that meet a zero bycatch standard may be sold and labeled as “dolphin free.” In addition the program adopted the relatively progressive step of allocating individual quotas per vessel which has been a key incentive in reducing and managing bycatch.

The fishery, however, stopped short of adopting potentially more effective and flexible policy instruments including transferable dolphin bycatch quotas. Given that the aggregate dolphin cap is not binding (i.e., total bycatch is less than 40% of the total quota), but vessel quotas are binding for some individual vessels, there exist opportunities for trade among vessels. Although trading could increase total bycatch in early years of the program (although still below the aggregate fleet wide cap), trading ratios could be used to permanently retire some of the bycatch credits and therefore permanently lower the total fleet allowable bycatch cap. As an example, assume that each dolphin...
was assigned 10 credits and a four to one trading ratio was required. If vessel “A” exceeded its initial bycatch by one dolphin it would be required to purchase 40 credits (e.g., to avoid paying a substantial penalty). Thirty credits would then be permanently retired from the system, effectively lowering the total allowable bycatch cap by three dolphins (from 5,000 to 4,997).

This system could also be used to improve protection of “depleted” species of dolphins by using the concept of cross-externality trading ratios. For example, rather than allocating an annual dolphin bycatch to each vessel, the vessel would be allocated dolphin credits. Assume that each vessel was assigned 400 credits. Also assume that undepleted dolphin species “A” was 10 credits but depleted species “B” was 100 credits. If a vessel had used up its allocated credits and then captured depleted species “B” it would need to purchase 400 credits (assuming a four to one trading ratio) that would effectively retire 300 credits (the equivalent of thirty dolphin from our previous example). One would assume that as the total credits retired from the system began to substantially increase, the trading ratios would begin to reduce until they reached a one to one balance (that is, the aggregate quota was binding or met a specified target).

One could potentially improve the efficiency of the credit system by designing credits as a permanent property right or asset. Rather than having only an annual value they would become a valuable long-term asset. The market could be expanded to include any buyer or seller including non governmental organizations and international agencies that desired to purchase or retire the credits and, therefore, permanently reduce dolphin bycatch. Such a market would provide powerful incentives to further reduce dolphin bycatch and reward harvesters who develop bycatch innovations.

These are examples of possible market and standards-based approaches that use monetary incentives to reduce bycatch by “rewarding” low bycatch vessels and “punishing” high-bycatch vessels. These are also systems that provide considerable flexibility, reduce bycatch over time, and create special incentives to reduce fishing-related mortality of depleted or threatened stocks. Of course, depending on specific goals and issues, these examples may not represent the “best” approach; for example, a permanent cap and trade system for each bycatch species may be even more efficient. These examples, however, illustrate the range of potential policy instruments, incentives, and rights based systems which could reduce environmental impacts over time while simultaneously meeting utilization and sustainability requirements.

**New England scallop fishery**

**Issue:** Benthic habitat impacts  
**Existing standard:** Area closures based on biomass and harvest potential–rotational area management and area closure schedules currently being developed by NEFMC

The impacts of dredging on scallop habitat have only been examined in the last 20 years. The possible impacts of fishing activities on benthic habitat in the New England fishery became a major concern in the mid-1990’s. In 1994, three large areas covering 17,000 km² of the seabed were closed to help recovery of groundfish. By 2000 it was found that the closures effectively protected many less active species such as flatfishes, skates, and scallops (Kaiser 2001).

Excluding scallop dredges in the closed areas resulted in a 14-fold increase in scallop biomass. Because of this success, fishery managers are now considering managing scallop areas by rotational closures every 4-5 years (Kaiser 2001). The Scallop Fishery Management Plan (FMP), published by the New England Fishery Management Council (NEFMC) is currently under revision. Public hearings were held during May 2003 to gather comments regarding rotation closures (included in Amendment 10 to the FMP) and the NEFMC is now reviewing comments on Amendment 10 alternatives. Amendment 10 would introduce spatial scallop management, “taking advantage of local differences to improve yield and minimize adverse impacts on other fisheries and the marine environment” (NEFMC 2003).

Conservation measures currently required by the Scallop FMP such as days-at-sea allocations, gear restrictions to improve escapement of juvenile scallops and finfish, and reductions in other inputs have provided limited spatial management outside the closed areas since the mid-1990's. Amendment 10 would retain these strategies while meeting objectives that would rebuild the scallop resource and minimize bycatch and habitat impacts, while
ensuring “equitability and regulatory flexibility.” The preferred alternative for Amendment 10 consists of adaptive rotations with flexible boundaries. Five types of closures have been proposed: 1) multi-year scallop closures to postpone fishing mortality on strong year classes, 2) controlled access areas that re-open after a scallop rotation closure, 3) open scallop fishing areas where customary limited access and general category rules apply, 4) seasonal closures to avoid unacceptable bycatch, and 5) indefinite, long-term closures to protect sensitive and vulnerable habitat or to avoid unacceptable bycatch. These closures would apply to vessels fishing under the day-at-sea rules and other general rules (i.e. non-day-at-sea rules). The initial scallop rotation area management program will begin in 2004 and run for a three year duration (NEFMC 2003).

The decision to close or reopen fishing areas depends on the expected potential biomass. All area rotation alternatives of Amendment 10 are based on a pre-defined criteria or standard of potential biomass growth rate for scallops. The closure criterion ranges from 25-40% biomass growth per year and a re-opening criteria when growth decreases to 10-25%. Closures in each of the five New England sea scallop management regions (Gulf of Maine, Georges Bank, South Channel, Hudson Canyon and Southern) may not close more than 50 percent of all scallop fishing areas, or 75 percent of the biomass, whichever is less. The proposed target fishing mortality rate for scallops is different for different areas, ranging from F=.20-.40. The TAC for each area is based on the target mortality rate. Target mortality rates will increase each year consistent with the area rotation closures (NEFMC 2003).

Alternative Policy Instruments and Standards

The New England scallop case study demonstrates the importance of spatial and temporal strategies for managing benthic related species and habitats. For the case of New England scallops, it took area closures designed to rebuild groundfish stocks – stocks that were over-harvested in part due to poorly defined property rights – to discover this important management principle.

The concern, however, is that this “discovery” and a myopic focus on a powerful “regulatory” tool could limit the policymaker’s vision for other potentially more beneficial concepts and strategic alternatives. The fundamental issue is understanding the impacts of benthic gear to the productivity of the marine environment; that is, the “performance” of the gear with respect to “adverse” benthic impacts. Armed with this knowledge, policymakers could design management approaches that effectively balance utilization and sustainability. Strict reliance on a relatively coarse policy tool of temporal and spatial closures based on biological species growth, may not provide industry with the flexibility to address variation in industry’s individual and collective needs and differences, and changes in technology, input or output markets, and the marine environment.

As one alternative or complement to rotational strategies, consider a market-based performance standard using a “benthic impact credit” trading scheme. The scheme would be based on the assumption that benthic environmental impacts are a function of gear size, design, operation, and frequency of use. Based on scientific research, performance standards would be designed for each gear within each habitat. For example, within a specific spatially defined habitat, scientific analysis would determine that no more that 10,000 “credits” of impact could be sustained per year (or some other relevant time period) in order to meet management goals and balance utilization and sustainability requirements. Based on objective field tests, a “high” impact dredge may be assigned 10 credits per nautical mile of tow, a “medium” impact dredge 5 credits, and a “low” impact dredge 1 credit. Industry would report information from gear sensors and other recording instruments (e.g. GPS-- date, location, tow path, tow duration), in order to account for, and track credits over time, plus record other relevant management and scientific information. Credits could be leased or bought and sold within an “environmental benthic credit market.” Benthic habitat more easily damaged or considered more productive or essential would require a higher level of credits per unit effort (for example, instead of 10 “credits” per nautical mile, “high” impact gear would be assigned 50 “credits”). Credits across different habitat types could then be traded. Credits would be totaled across all habitats to produce a total credit level (e.g., 1,000,000 benthic credits) Caps within each habitat area could maintain some “flex” (e.g., up to 20% above the habitat-specific target level) in order to provide for flexibility in utilizing highly valuable commercial resources that may be found within any given habitat. Any increase in benthic impacts in one area, however, would be compensated or “mitigated” by a decrease in other areas; that is, total allowable benthic impacts to all areas could never exceed 1,000,000 credits. Unused credits could also be banked for future use and/or retired over time. For example, user groups could collectively bank “excess” credits and retire them in exchange for financial incentives from government or NGO’s.
SUMMARY AND ONGOING RESEARCH

Many individuals remain unconvinced that market or voluntary approaches can work, particularly for managing large-scale and diverse environmental public goods problems. They remain skeptical that institutions can be developed to efficiently or equitably redirect the behavior of those who helped create the problem. Presently, there is no worldwide consensus, and policy experiments and empirical research are needed to design, demonstrate, and evaluate effective market-based institutional approaches to managing the environmental impacts of fishing.

Relative to simpler and more traditional input/output and command/control policy approaches, property rights are relatively new and require a higher level of policy craftsmanship in order to achieve their objectives. Since market-based programs are not without their own inherent challenges, experts advocating these programs must demonstrate potential benefits relative to traditional regulatory approaches. Assessing and then demonstrating these benefits will require policy analysis, education, regulatory flexibility, and ultimately a willingness to take policy risks. Conducting comparative analysis and undertaking policy experiments and will be important strategies to support their adoption.

The overview of issues associated with the use of market-based environmental standards in fisheries management is part of an ongoing project to help managers, policymakers, and the public evaluate the strengths, weaknesses, and tradeoffs associated with the potential use of market-based environmental standards in mitigating the adverse impacts of fishing on marine ecosystems compared to the use of traditional command and control - based approaches. The key components of this study, focusings on fisheries on the west coast of the USA, include:

- Completing a comprehensive review of the literature on alternative market-based approaches that could be used to set environmental standards for marine fisheries.
- Developing a policy relevant decision support framework to evaluate the potential efficiency, effectiveness, and acceptability of market-based environmental standards relative to more traditional and widely used command and control approaches.
- Using the decision support model engage representative stakeholders and the public in the identification and evaluation of alternative policy models for setting environmental standards, with particular emphasis on the development of incentives and market-based standards for addressing fisheries issues of significance.
- Surveying participants at the beginning and end of the project to assess perceptions and attitudes towards market-based environmental standards relative to traditional command and control approaches to setting environmental standards for marine fisheries.

The results of this research will be reported at a future IIFET conference.

REFERENCES

Bratton, D. Personal communication, September 2003. Inter-American Tropical Tuna Commission, La Hoya, California.


APPENDIX B
SURVEY INVITATION AND QUESTIONNAIRE

2030 SE Marine Science Drive, Newport, OR 97365 (541) 867-0345

We invite you to participate in a research project being conducted by Oregon State University’s Coastal Oregon Marine Experiment Station and Marine Resource Management Program. The project, Market Based Environmental Standards for Sustainable Fisheries, is funded by Oregon Sea Grant. The purpose of the project is to evaluate the strengths, weaknesses, and tradeoffs associated with the current use of “command and control” regulatory methods and potential use of market-based policy approaches towards mitigating any possible adverse impacts of fishing on marine ecosystems. We are inviting you to participate because you are involved in or affected by state or federal fishery management processes.

You can help us in our research by taking 15 minutes to respond to a questionnaire. You can complete the questionnaire in two ways: (1) You can take the online version by connecting to http://oregonstate.edu/dept/trainfishmgr/survey.html and logging on using this password: or (2) You can complete and mail back the paper version included with this letter in the stamped return envelope provided. Your responses will remain completely confidential. Your participation in this study is voluntary and you may refuse to answer any question(s) for any reason. Only a small group of fishery stakeholders will be invited to complete this questionnaire. Your participation is important and will provide vital information to the research team. We will provide you results of the study upon completion. If for some reason you prefer not to respond, please let us know by returning the blank questionnaire in the enclosed stamped envelope.

We would also like you to consider being part of a more in-depth component of the study. This would involve two half-day meetings with approximately 10 other people, identifying and evaluating alternative policy models for setting environmental standards to address fisheries issues of significance to the West Coast. These meetings will be held at various locations along the West Coast. As a participant you will receive travel reimbursement and lunch and snacks will be provided. If you are willing to consider participating in this phase of the study please indicate your willingness by checking off the box on the enclosed card and returning the card.

If you have any questions about the survey or project, please contact Gil Sylvia (541-867-0284; gil.sylvia@oregonstate.edu) or Michael Harte (541-602-1960; mharte@coas.oregonstate.edu). If you have questions about your rights as a participant in this research project, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator at (541) 737-4933 or by email at IRB@oregonstate.edu.

Thank you for your help. We appreciate your cooperation.

Sincerely,
Gil Sylvia
Superintendent
Coastal Oregon Marine Experiment Station

Michael Harte
Director
Marine Resource Management,
Oregon State University

Brycen Swart
Graduate Research Assistant
Marine Resource Management, Oregon State University
Market Based Environmental Standards for Sustainable Fisheries Survey

1. Please select the sector(s) which you represent or have represented in West Coast fisheries (please check all that apply)

☐ Federal management process participant  
☐ Regional management process participant  
☐ State management process participant  
☐ Local management process participant  
☐ Federal government agency staff  
☐ State government agency staff  
☐ Local government agency staff  
☐ University faculty/professor  
☐ University student  
☐ Fish processor  
☐ Vessel owner  
☐ Captain/Skipper  
☐ Crewman  
☐ Fishery Industry Group  
☐ Environmental Non Governmental Organization  
☐ Other Non Governmental Organization  
☐ Other _________________________________

2. How long have you been involved in the fisheries management process (including local, state, regional, and federal)?

_______ years

3. Besides the possible biological or ecological impacts due to “overfishing” of target species, please indicate the degree that the following fishing impacts have had on marine ecosystems along the West Coast. For each type of possible impact please indicate on a scale from 1 to 5 where “1” is “No Adverse Impact” to the marine environment and “5” is “Major Adverse Impact” to the marine environment (please circle one number for each possible impact).

<table>
<thead>
<tr>
<th>Impact</th>
<th>No Adverse Impact</th>
<th>Minor Adverse Impact</th>
<th>Undecided</th>
<th>Moderate Adverse Impact</th>
<th>Major Adverse Impact</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bycatch of non-commercial fish species</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Bycatch of marine mammals, seabirds, or sea turtles</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Disturbance of benthic (bottom) habitats</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
</tbody>
</table>
4. Using the scale below, please indicate how strongly you agree or disagree with the following statement:

**Overall there is adequate scientific evidence to determine that fishing adversely impacts the marine environment along the West Coast.**

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Undecided</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
</tbody>
</table>

**Section 2: Command and Control Regulations**

Conventional approaches to regulating the adverse environmental impacts of fishing are referred to as “command and control” (CAC) regulations. These regulatory arrangements use mandatory rules to control the behavior of fishermen. As the name implies, a CAC mechanism consists of a ‘command’ that sets a rule and a ‘control’ for monitoring and enforcing that rule. Although CAC regulations vary among regions and fisheries, common types include:

- **Technology based regulations** that specify the method, and sometimes the actual equipment, that fishermen must use to comply with a particular regulation. Examples include restrictions on the size and power of fishing vessels and fishing gear restrictions on mesh size, hook size and the use of turtle excluder devices (TEDs).
- **Performance based regulations** that set a uniform control target for fishermen, while allowing some latitude in how this target is met. Examples include restrictions on the area where fishing is allowed, the time during which fishing is allowed, controlling total catch, vessel catch per fishing trip, number of fishing trips and catch characteristics (e.g. minimum fish size).

5. Based on your overall experience across all fisheries, please rate the effectiveness of current command and control regulations towards reducing the following adverse environmental impacts of fishing on marine ecosystems along the West Coast.

<table>
<thead>
<tr>
<th></th>
<th>Highly Ineffective</th>
<th>Somewhat Ineffective</th>
<th>Undecided</th>
<th>Somewhat Effective</th>
<th>Highly Effective</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bycatch of non-commercial fish species</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Bycatch of marine mammals, seabirds, or sea turtles</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Disturbance of benthic (bottom) habitats</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
</tbody>
</table>
6. In your opinion, how receptive are the following groups towards the use of command and control regulations in meeting the goal of reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast?

<table>
<thead>
<tr>
<th>Group</th>
<th>Highly Unreceptive</th>
<th>Somewhat Unreceptive</th>
<th>Undecided</th>
<th>Somewhat Receptive</th>
<th>Highly Receptive</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Policy Makers (e.g. council members, commissioners, etc.)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Agency Staff</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Fishermen</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Environmentalists</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>General Public</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
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</tbody>
</table>

Section 3: Market-Based Instruments

7. Using the scale below, please indicate your degree of familiarity with the use of market-based instruments in environmental policy.

<table>
<thead>
<tr>
<th>Familiarity</th>
<th>Very Unfamiliar</th>
<th>Somewhat Unfamiliar</th>
<th>Undecided</th>
<th>Somewhat Familiar</th>
<th>Very Familiar</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>

IF YOU ANSWERED 4 OR 5 PLEASE CONTINUE TO QUESTION 8.

IF YOU ANSWERED 1, 2, OR 3 PLEASE SKIP TO QUESTION 10.

8. If you are familiar with market-based instruments: Overall, how effective do you think market-based instruments are in helping to achieve their environmental outcomes?

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Highly Ineffective</th>
<th>Somewhat Ineffective</th>
<th>Undecided</th>
<th>Somewhat Effective</th>
<th>Highly Effective</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>
9. How effective do you think market-based instruments would be in meeting the goal of reducing the following adverse environmental impacts of fishing on marine ecosystems along the West Coast?

<table>
<thead>
<tr>
<th>Impact Description</th>
<th>Highly Ineffective</th>
<th>Somewhat Ineffective</th>
<th>Undecided</th>
<th>Somewhat Effective</th>
<th>Highly Effective</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bycatch of non-commercial fish species</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Disturbance of benthic (bottom) habitats</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
<td>99</td>
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</table>

NOW PLEASE SKIP TO QUESTION 11.

10. If you are not familiar with market-based instruments, please read the definition before proceeding

**Market-based instruments** are regulations that encourage good environmental performance through economic incentives. These policy instruments are often described as "harnessing market forces" because if they are well designed and implemented, they encourage people and companies to undertake efforts that both are in their interest and that collectively meet policy goals. Some examples of various types of incentive-based economic policy instruments include:

- **Marketable quotas and permits**: Quotas and permits are given as a right to use or take an amount of a resource or for the right to cause environmental impacts of some specified amount. The number of permits and quotas given depends on the total amount of a resource available for use or the acceptable total impact level. Permits and quotas may be traded among individuals. An example of this would be an individual bycatch quota program for non-commercial fish species such as sharks.
- **Fees, Charges, and Taxes**: A monetary charge that changes a user’s behavior to better reflect the true cost of using an environmental resource. An example would be charging higher license fees for using bottom trawl gear compared to mid-water trawl gear.
- **Subsidies**: The opposite of taxes; special pricing, discounts, or money transfers for specific behaviors, actions, or activities that have a reduced impact on the marine ecosystem. An example would be subsidies to adopt new gear technologies.

Based on what you have read above, how effective do you think market-based instruments would be in meeting the goal of reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast?

<table>
<thead>
<tr>
<th>Impact Description</th>
<th>Highly Ineffective</th>
<th>Somewhat Ineffective</th>
<th>Undecided</th>
<th>Somewhat Effective</th>
<th>Highly Effective</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bycatch of non-commercial fish species</td>
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<td>2</td>
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<td>5</td>
<td>99</td>
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</tbody>
</table>
11. In your opinion, how feasible would it be to implement market-based instruments with the goal of reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast?

<table>
<thead>
<tr>
<th>Highly Infeasible</th>
<th>Somewhat Infeasible</th>
<th>Undecided</th>
<th>Somewhat Feasible</th>
<th>Highly Feasible</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>99</td>
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</table>

12. Please indicate your “receptiveness” to the use of market-based instruments with the goal of reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast?

<table>
<thead>
<tr>
<th>Highly Unreceptive</th>
<th>Somewhat Unreceptive</th>
<th>Undecided</th>
<th>Somewhat Receptive</th>
<th>Highly Receptive</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
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</table>

13. In your opinion, how receptive would the following groups be towards the use of market-based instruments with the goal of reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast?

<table>
<thead>
<tr>
<th></th>
<th>Highly Unreceptive</th>
<th>Somewhat Unreceptive</th>
<th>Undecided</th>
<th>Somewhat Receptive</th>
<th>Highly Receptive</th>
<th>No Opinion</th>
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<tbody>
<tr>
<td>Senior Policy Makers (e.g. council members, commissioners, etc.)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Agency Staff</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>Fishermen</td>
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<td>99</td>
</tr>
<tr>
<td>Environmentalists</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td>General Public</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>99</td>
</tr>
</tbody>
</table>

Please provide any additional comments on the back.

Thank you for completing the survey, we appreciate your help. If you have questions or comments about the survey, please feel free to contact Gil Sylvia at 541-867-0284, gil.sylvia@oregonstate.edu or Michael Harte at 541-602-1960, mharte@coas.oregonstate.edu.
APPENDIX C
Survey Results Sent to Participants

Market Based Environmental Standards for Sustainable Fisheries Survey

Last summer you took part in an Oregon Sea Grant funded survey being carried out by researchers at Oregon State University. The goal of the survey was to determine perceptions and attitudes of people involved with the West Coast fisheries management process (i.e. fisheries managers, policy makers, fishermen, stakeholders, and environmental organizations) towards the existing use of “command and control” regulatory methods and the potential use of market-based policy approaches towards mitigating the possible adverse impacts of fishing on marine ecosystems.

The study had a number of key research questions.

- **What are fishery management stakeholder’s views on the ability of market based instruments (MBI) to help manage any possible adverse environmental impacts of fishing?**
  - Are they familiar with MBI used in environmental policy?
  - Do they perceive MBI to be effective towards managing the environmental impacts of fishing?
  - Are they receptive towards the use of market based instrument towards managing the environmental impacts of fishing?
  - How feasible do they perceive it would be to implement MBI with the goal of managing the environmental impacts of fishing?

- **Is there a difference in receptiveness, effectiveness and feasibility responses with respect to familiarity of MBI?**

- **Do different fisheries management participants have different value systems and does this lead to differences in survey responses between the sectors?**

- **How well do MBI compare to command and control (CAC) regulations in their potential ability to manage the potential environmental impacts of fishing?**

**BACKGROUND**

Fishermen and managers are required by state, federal and international laws to address the possible adverse effects of fishing on the marine environment. This is despite the fact that the science about these impacts is often incomplete and uncertain and that actions to regulate these possible impacts can have major financial consequences for commercial fisheries and the communities they support. Potential impacts include 1) by-catch of non-target fish species, marine mammals, seabirds, and 2) gear impacts to benthic habitats and bottom dwelling marine organisms.
On land, a diversity of approaches is used to manage the environmental impacts of economic activities. These range from strict regulation to voluntary compliance with industry codes of conducts. Because the issues addressed are often contentious, the range of management approaches provides agencies with a larger toolkit to promote the sustainable and profitable use of natural resources.

The toolkit available to fisheries managers is more limited. This occurs for a number of reasons ranging from lack of familiarity with the broader range of tools used in terrestrial environments to poorly defined privileges and responsibilities in the marine environment. However, no matter what the reasons, this means that fishermen and managers are often poorly placed to adopt win-win approaches to address the possible impacts of fishing on the marine environment.

The goal of the survey was to explore fishery management participants’ general perceptions and attitudes of different approaches for managing the possible impacts of fishing on the marine environment. With this knowledge managers will be better positioned to advise fishermen and agencies on the best ways of addressing these issues that have such high stakes for the fishing industry, coastal communities, and other stakeholders.

METHODS
Surveys can be a powerful and useful tool for collecting data on human characteristics, attitudes, thoughts, and behavior. For this survey, non random purposive sampling was used to obtain a sample to be representative of the population. The survey population included people involved in or are directly affected by state or federal fishery management processes. The survey mailing list was created by consulting various members involved in the fishery management process (fishermen, university professors, Sea Grant extension staff, those representing fishery industry groups) and asking them for the names of other participants in the management process.

Participants were mailed the survey and given the option to complete the questionnaire by paper or online through a web based survey. The thirteen-question survey was designed to collect information on participant perceptions regarding the current use of “command and control” regulatory methods and the potential use of market-based policy approaches towards mitigating the adverse impacts of fishing on marine ecosystems. Each question was based on a 5-point Likert Scale, with a possible “No-opinion” response. An average respondent should have been able to complete the survey in 15 minutes.

The survey was divided into four different sections. The first section asked demographic questions, such as the sector that the respondent represents in West Coast fisheries and length of time involved in the fishery management process. The second section related to how participants perceived the issue of the potential adverse impacts of fishing on marine ecosystems along the West Coast. The third section asked questions on the current use of CAC regulations towards reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast. The fourth section looked at the potential use of MBI towards reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast.
RESULTS
A total of 229 unique individuals were identified and mailed the surveys; 95 from the fishing industry including fishermen, captains, boat owners, processors, and those representing fishing industry groups; 84 who work as state or federal agency staff; 24 who represent environmental non-governmental organizations (ENGO); 19 from academia; and 7 from tribal groups. Eighty five individuals responded to the survey either by mail or the web, resulting in a total response rate of 37%. Thirty four of those were from the fishing industry (36% response rate), 25 from state or federal agency staff (29% response rate), 13 from ENGO (54% response rate), 10 from academia (56% response rate), and 3 from tribal groups (43% response rate).

![Figure 3.1: Survey Participants by Sector](image)

**Time Involved**
The average length of time that a participant was involved in the fishery management process was 19 years. Industry had the highest with an average of over 23 years of experience while the ENGO sector only averaged 11 years of experience participating in the fishery management process. The agency and academia sectors both averaged 19 years.

**The Issue**

*Severity of Impacts*
A majority of the survey participants felt that disturbance of benthic habitats and bycatch of non-commercial fish species have either a moderate or major adverse impact on the marine environment along the West Coast (71% & 64%, respectively). Opinion on the bycatch of marine mammals, sea turtles and sea birds (non-fish species) was mixed with 47% indicating that there is no adverse or minor adverse impact and 40% indicating a moderate or major adverse impact.
A Kruskal-Wallis nonparametric one-way analysis of variance test was used to determine if there was a statistically significant difference in responses between the fishery management sectors. The results of this test showed that the difference was statistically significant (damage to benthic habitats two-sided p-value < 0.05, bycatch of non-commercial fish species two-sided p-value < 0.05, bycatch of non-fish species two-sided p-value < 0.05).

The mean scores for each sector and impact are presented in the table below. Industry responses were consistently lower for all of the environmental impacts than the rest of the sectors. The ENGO sector represented the highest mean sector scores for each of the issues. The agency and academia sector scores were in the middle.
Adequate Science

There was mixed reaction from respondents when asked to what degree they either agreed or disagreed with the following statement “Overall there is adequate scientific evidence to determine that fishing adversely impacts the marine environment”, with half of the respondents agreeing and the other half disagreeing. This was especially apparent with how the different sectors responded to the question. 76% of industry respondents either “strongly disagreed” or “somewhat disagreed” with the statement (mean 2.03). At the opposite end of the spectrum, the ENGO sector either “somewhat” or “highly agreed” (mean 4.77). Agency staff (mean 3.85) and academia (mean 3.30) had mixed reactions with only slightly more agreeing. There was a statistically significant difference in the responses between the different sectors (Kruskal Wallac e two-sided p-value < 0.05).

![Figure 3.4: Adequate scientific evidence to determine that fishing adversely impacts the marine environment by fishery management sector](image)

Command and Control (CAC) Regulations

Effectiveness

Overall a majority of survey respondents felt that the current use of CAC regulations were either somewhat effective or highly effective towards reducing the environmental impacts of fishing to bycatch of non-fish species (mean 3.80), disturbance of benthic habitats (mean 3.17), and bycatch of non-commercial fish species (mean 3.08).
Figure 3.5: Perceived effectiveness of CAC regulations towards managing the environmental impacts of fishing on marine ecosystems along the west coast.

Receptiveness

The next question asked how receptive they thought the different stakeholder groups are towards the use of CAC regulations in meeting the goals of reducing the environmental impacts of fishing on marine ecosystems along the west coast. Overall, a majority of the respondents perceived that policy makers (86%, mean 4.18), agency staff (88%, mean 4.22), and environmentalists (70%, mean 3.88) are all somewhat or highly receptive towards the use of CAC regulations in meeting the goals of reducing the adverse environmental impacts of fishing on marine ecosystems along the West Coast. Meanwhile they thought most fishermen are somewhat or highly unreceptive (52%, mean 2.86). Forty percent of the responses for the general public were undecided (mean 3.56).

Figure 3.6: Perceived receptiveness of different groups towards the use of CAC regulations in meeting the goals of reducing the environmental impacts of fishing on marine ecosystems along the west coast.
Market Based Instruments (MBI)

*Familiarity and Effectiveness*

Seventy four percent of respondents were either somewhat familiar or very familiar with using MBI in environmental policy (mean 3.76).

![Figure 3.7: Familiarity of MBI used in environmental policy](image)

A difference in the scores among the sectors was not statistically significant (two-sided p-value = 0.099) but it was found the ENGO sector had the highest mean score at 4.46, while the Industry sector had the lowest mean score of 3.41. Academia and Agency sectors mean scores were about the same (3.80 and 3.84, respectively).

![Figure 3.8: Average familiarity score of MBI used in environmental policy by sector.](image)

Familiarity with MBI was not correlated with the length of time involved in fisheries management issues (r-squared = 0.016).

Of the 74% that were familiar with MBI in environmental policy, 79% indicated that MBI are either somewhat effective or highly effective at managing environmental problems (mean score 3.90). There was no statistical evidence to suggest that there was a difference in the views of the different groups (two sided p-value = 0.64).
Figure 3.9: Perceived effectiveness of MBI towards managing environmental problems for those that are familiar with MBI used in environmental policy.

Also a majority of those already familiar with MBI, considered that MBI could be an effective approach towards managing possible adverse environmental impacts of fishing on marine ecosystems along the West Coast especially for bycatch of non-commercial fish species (71%, mean 3.71) and bycatch of non-fish species (59%, mean 3.40). For disturbance to benthic habitats it was not as convincing as only 52% (mean 3.22) thought MBI would be effective towards managing the possible adverse environmental impact of fishing. There was no evidence to suggest that there was a difference in the scores of the sectors (two sided p-value = 0.22, 0.22, and 0.45, respectively).

Figure 3.10: Perceived effectiveness of MBI towards the environmental impacts of fishing for those that are familiar with MBI used in environmental policy.

Those that were not familiar with using MBI in environmental policy were given definitions and examples of what MBI are and how they could be used to minimize the adverse impacts of fishing on the marine environment. They were also asked if using market-based tools could be an effective approach in managing the possible adverse environmental impacts of fishing on marine ecosystems along the West Coast. Fifty five percent felt MBI could be a somewhat or highly effective approach towards managing bycatch of non-commercial fish species (mean 3.24). Disturbance to benthic habitats (41%, mean 3.19) and bycatch of non-fish species (41%,
mean 3.00) were met with mixed results. There was no evidence to suggest that there was a statistically significant difference among sectors.

Figure 3.11: Perceived effectiveness of MBI towards the environmental impacts of fishing for those that are not familiar with MBI used in environmental policy.

A Wilcoxon rank-sum test was used to compare the effectiveness scores for those who were familiar with the use of MBI compared to those who were not familiar. A Wilcoxon rank-sum test, an alternative to the two-sample t-test, is a non-parametric test for assessing whether two samples of observations come from the same distribution when ordinal data is available. In general, the effectiveness scores for those not familiar with MBI were lower for all three impact issues than those that were familiar with MBI, although the results were not statistically significant (two sided p-values = 0.19, 0.31 and 0.77, respectively).

Figure 3.12: Average scores of perceived effectiveness scores of MBI towards reducing the environmental impacts of fishing for those who are and are not familiar.

A Wilcoxon rank-sum test was used to compare the effectiveness scores for the potential use of MBI to reduce the possible adverse impacts of fishing on the marine environment compared towards the use of CAC regulations. The effectiveness of MBI to reduce the bycatch on non-
commercial fish species were higher than the effectiveness scores towards the current use of CAC regulations (one-sided p-value < 0.05). Meanwhile it was the opposite for reducing the possible adverse impacts on non-fish species; there was statistically significant evidence that the effectiveness scores of the current use of CAC regulations were greater than the effectiveness of potentially using MBI (one-sided p-value < 0.05). There was no statistically significant difference in the effectiveness scores for the potential use of MBI and the current use of CAC regulations to reduce the disturbance of benthic habitats (two-side p-value = 0.88). Mean scores of effectiveness for both CAC regulations and MBI are in the figure below.

![Figure 3.13: Average perceived effectiveness scores of MBI and CAC instruments for managing the environmental impacts of fishing on the marine environment along the west coast.](image)

Feasibility
Sixty one percent of survey participants felt that it would be somewhat feasible or highly feasible to implement MBI with the goal of reducing environmental impacts of fishing on marine ecosystems (mean 3.48). There was no statistical evidence to suggest that there was a difference in scores between the fishery management sectors (two sided p-value = 0.14) nor a difference between those familiar with MBI and those not familiar (two sided p-value = 0.15).

![Figure 3.14: Perceived feasibility to implement MBI with the goal of reducing the environmental impacts of fishing on the marine environment along the west coast.](image)
Receptiveness
Forty five percent of respondents were highly receptive (and another 32% were somewhat receptive) towards the use of MBI with the goal of reducing environmental impacts of fishing on West Coast marine ecosystems (mean 4.00).

![Figure 3.15: Perceived receptiveness towards the use of MBI with the goal of reducing environmental impacts of fishing on west coast marine ecosystems.](image)

There was statistically significant evidence that there were differences in the fishery management stakeholder sectors (two-sided p-value < 0.05). The agency sector had the highest mean score at 4.46, while industry posted the lowest mean score of 3.61. The ENGO and academia sectors responded similarly with mean scores of 3.92 and 4.00.

![Figure 3.16: Average receptiveness score by sector towards the use of MBI with the goal of reducing the environmental impacts of fishing on west coast marine environments.](image)

In addition it was found that there was a statistically significant difference in the receptiveness for those that were familiar versus those not familiar with MBI. The average receptiveness score for those familiar was 4.22, while the average receptiveness score for those not familiar was 3.30.
Survey participants were then asked how receptive they thought the different stakeholder groups would be towards the use of MBI in meeting the goals of reducing the environmental impacts of fishing on marine ecosystems along the west coast. A majority of the responses considered that policy makers (69%, mean 3.62), agency staff (59%, mean 3.44), fishermen (59%, mean 3.50) and environmentalists (70%, mean 3.57) would be receptive towards the use of MBI with the goal of reducing any possible adverse environmental impacts of fishing on marine ecosystems along the West Coast. 48% of the responses regarding the general public were undecided (mean 3.16).

Figure 3.17: Perceived receptiveness of fishery management sectors towards the use of MBI with the goal of reducing the environmental impacts of fishing on west coast marine ecosystems.

The perceived receptiveness of policy makers, agency staff, environmentalists and the general public towards the current use of CAC regulations to reduce any possible adverse environmental impacts on the marine environment was higher than compared to the potential use of MBI (rank sum one-sided p-values < 0.05). Whereas, the perceived receptiveness scores of fishermen was higher towards the potential use of MBI compared to the current use of CAC regulations to reduce any possible adverse environmental impacts on the marine environment (one-sided p-value < 0.05).
Figure 3.18: Average perceived receptiveness scores of each sector towards the use of CAC regulations and MBI with the goal of reducing the environmental impacts of fishing on west coast marine ecosystems.

CONCLUSION
According to the survey results, MBI are potentially a policy option that could be used on the west coast in order to reduce the potential adverse environmental impacts of fishing on the marine ecosystem. Not only were a majority of respondents familiar with MBI, but they perceived them to be effective towards mitigating bycatch of non-commercial fish species, non-fish species and to a lesser extent, disturbance to benthic habitats. Even those that were not initially familiar with MBI, thought that market based approaches could be effective towards mitigating the adverse environmental impacts of fish, although to a lesser extent than those already familiar. In addition survey participants perceived that MBI would be feasible to implement. They were also receptive towards using them as well as perceiving there fellow participants to be receptive towards them.
Contact Us
If you have any questions about or comments on this summary report, please do not hesitate to contact us, Gil Sylvia (541-867-0284; gil.sylvia@oregonstate.edu), Michael Harte (541-602-1960; mharte@coas.oregonstate.edu) or Brycen Swart (bswart@coas.oregonstate.edu).

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Sustainability and Profitability: New ways of managing the possible impacts of commercial fishing on the marine environment

Background Material
Questions and Feedback

If you have any questions about this workshop or wish to provide feedback please feel free to contact Gil Sylvia (541-867-0284; gil.sylvia@oregonstate.edu), Michael Harte (541-602-1960; mharte@coas.oregonstate.edu) or, Brycen Swart (831-345-0809; bswart@coas.oregonstate.edu).

Thank you for your interest and participation in this project.

Sincerely,

Gil Sylvia
Superintendent
Coastal Oregon Marine Experiment Station
Oregon State University

Michael Harte
Director, Marine Resource Management,
Oregon Sea Grant
Oregon State University

Brycen Swart
Graduate Research Assistant
Marine Resource Management, Oregon State University
## Agenda

<table>
<thead>
<tr>
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<th>Session</th>
</tr>
</thead>
<tbody>
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<td>9:00 – 9:05 pm</td>
<td>Welcome (Gil Sylvia)</td>
</tr>
<tr>
<td>9:05 – 9:10 pm</td>
<td>Purpose of the Pilot Workshop (Michael Harte)</td>
</tr>
<tr>
<td>9:15 – 10:00 pm</td>
<td>Explanation of workshop process and decision support software (David Ullman)</td>
</tr>
<tr>
<td>10:00 – 10:30 pm</td>
<td>Discussion of yelloweye rockfish case study (Michael Harte)</td>
</tr>
<tr>
<td>10:30 – 10:45 pm</td>
<td>Discussion of problem statement (Michael Harte/David Ullman)</td>
</tr>
<tr>
<td>10:45 – 11:00 pm</td>
<td>Break (Michael Harte)</td>
</tr>
<tr>
<td>10:45 – 11:00 pm</td>
<td>Discussion of management alternatives (Gil Sylvia)</td>
</tr>
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<td>11:00 – 11:30 pm</td>
<td>Discussion of evaluation criteria (David Ullman)</td>
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<tr>
<td>11:30 – 12:30 pm</td>
<td>Lunch (David Ullman)</td>
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<tr>
<td>12:30 – 1:00 pm</td>
<td>Weighting of criteria (David Ullman)</td>
</tr>
<tr>
<td>1:00 – 1:15 pm</td>
<td>Scoring alternatives against criteria (David Ullman)</td>
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<tr>
<td>1:15 – 2:30 pm</td>
<td>Break (David Ullman)</td>
</tr>
<tr>
<td>2:30 – 2:45 pm</td>
<td>Review of evaluation results and sensitivity analysis (David Ullman)</td>
</tr>
<tr>
<td>2:45 – 4:00 pm</td>
<td>Evaluation of computer-based decision support approach (Michael Harte)</td>
</tr>
<tr>
<td>4:00 – 4:30 pm</td>
<td>Evaluation of computer-based decision support approach (Michael Harte)</td>
</tr>
</tbody>
</table>
Sustainability and Profitability: New Ways of Managing the Possible Impacts of Commercial Fishing on the Marine Environment

Thank you for agreeing to take part in our workshop. This workshop is part of an Oregon Sea Grant funded project being carried out by researchers at Oregon State University.

The project and this workshop has two objectives:

First, we want to help West coast & Oregon fishery managers, fishermen and stakeholders evaluate different approaches that potentially promote both sustainability and profitability in managing the possible impacts of commercial fishing on the marine environment.

Second, we want to determine how well the use of a decision support computer tool to address this fisheries management challenge does or does not work in aiding the discussion of contentious management issues among diverse stakeholders.

By pursuing these objectives we want to identify forward-looking management options that are new and innovative, ways that may effectively promote both the sustainability and profitability of commercial fisheries. Given the complexity of the issues, we don’t expect to solve the management challenges in a single workshop. But we will strive to be as realistic as possible in recognizing both the opportunities and problems that face managers and the commercial fishing sector in addressing complex and contentious environmental issues.

Please take time to read this overview before coming to the workshop. It outlines the key parts of the workshop and importantly contains a case study (Appendix I) that will be the basis for comparing different management approaches to see how well they promote both the sustainability and profitability of commercial fisheries. A glossary of terms that are used in this background material or could be used by participants at the workshop can be found in Appendix II.

Workshop Context

Fishermen and managers are required by state, federal and international laws to address the possible adverse effects of fishing on the marine environment. This is despite the fact that the science about these impacts is often incomplete and uncertain and that actions to regulate these uncertain impacts can have major financial consequences for commercial fisheries and the communities they support. Potential impacts include 1) by-catch of non-target fish species, marine mammals, seabirds, and 2) gear impacts to benthic habitats and bottom dwelling marine organisms.

On land, a diversity of approaches is used to manage the possible environmental impacts of economic activities. These range from strict regulation to voluntary compliance with industry codes of conducts. Although the issues addressed are also often contentious, the range of management approaches provides agencies with a large toolkit to promote the sustainable and profitable use of natural resources.

The toolkit available to fisheries managers is more limited. This occurs for a number of reasons ranging from lack of familiarity with the broader range of tools used in terrestrial environments to poorly defined privileges and responsibilities in the marine environment. However, no matter what the reasons, this means that fishermen and managers are often poorly placed to adopt win-win approaches to address the possible impacts of fishing on the marine environment.

During this workshop we want to explore participants’ perceptions of the strengths and weaknesses of different tools for managing the possible impacts of fishing on the marine environment. With this knowledge we will be better positioned to advise fishermen and agencies on the best ways of addressing these issues that have that have such high stakes for the fishing industry, coastal communities, and other stakeholders.
The Decision Support Computer Tool

This workshop uses a decision support computer tool. This tool, while easy to use, is useful in helping diverse groups collectively evaluate different alternatives. Importantly, this approach explicitly recognizes and retains individual values, perceptions, and knowledge throughout the process.

Details of the decision support software called Accord and marketed by Robust Decisions Incorporated can be found at: www.robustdecisions.com.

Workshop Case Study

To make the workshop relevant to West coast fishermen, agencies and other stakeholders we have chosen a case study of possible fishing impacts on the marine environment based on an existing regional example. Though simplified so as to be widely and quickly accessible, the case study must be real enough so that consequences of the different approaches are apparent and relevant to workshop participants.

For this workshop we have chosen to use the incidental bycatch of yelloweye rockfish as the case study. Concern over the take or bycatch of non-target species in fishing has grown over the last decade. Generally, fishermen use their skills and experience to take the catch with the highest value. In many fisheries, however, some species that are not targeted are also harvested. While some of this non-targeted catch is commercially valuable and is retained by fishermen, some is returned to the water either because it has little value or because regulations preclude it from being retained.

Both target and non-target fish species must be managed effectively as part of specific fisheries management arrangements. The management of yelloweye rockfish (*Sebastes ruberrimus*) on the West coast by the Pacific Fisheries Management Council is an extreme example of the way in which bycatch management can constrain an entire fishery worth many millions of dollars. In 2006, total catch for yelloweye was 14.4 metric tons (mt), below the target catch set by the fisheries managers at 27 mt. Recent stock assessments suggest that allowable catches in future years may have to be set much closer to the current total commercial catch. Yelloweye is principally managed with area-closures because they are relatively sedentary and managers have a reasonably good idea of their depth, latitude, and associated habitats. The yelloweye case study is outlined in much more detail in the Appendix.

For the yelloweye rockfish case study we are asking whether or not participants believe that the use of alternative management approaches relative to those currently used would lead to better or worse economic and environmental outcomes for the management of yelloweye bycatch.

Workshop Structure

Creating an issue statement

Our first major task to is to develop an issue statement that workshop participants believe best represents the management challenge being explored. For example, it could be something like:

What management approaches will enable us to maintain a profitable harvest of healthy groundfish stocks while rebuilding stocks of yelloweye rockfish?

Identifying alternative management approaches

Most approaches to managing the possible adverse effects of fishing on the marine environment will be a mixture of tools. In this workshop we are concerned with the dominant philosophy behind the overall approach. Table 1 describes the alternative management approaches discussed at the workshop. These approaches are described in general terms and could be implemented in many different ways in the context of a specific fishery management challenge.
Table 1 Alternative Management Approaches

| Command and control | Command and control regulations focus on reducing potential environmental impacts by specifying how, when, where and how much fishermen can fish. This approach generally relies on detailed prescriptive regulations followed up by a compliance regime based on at sea observers, port inspections and catch reporting. Types of command and control regulations include:
| Types of command and control regulations include:
|   |   |
|   | Technology based standards that specify the method, and sometimes the actual equipment, that fishermen must use to comply with a particular regulation. Examples include gear restrictions such as mesh size restrictions, trawl gear modifications, hook size restrictions, and vessel power restrictions. |
|   | Temporal or spatial regulations that restrict when and where fishing can take place. |
| Performance based standards | Performance based standards that set a specific target for the environmental impact being managed. This usually allows some flexibility in how this target is met by fishermen. Common examples, in fisheries management are total allowable catches for target stocks, bycatch allowances and maximum allowable limits for sea bird and marine mammal fishing-related mortality. |
| Economic approaches | Economic incentive-based approaches rely on financial tools to encourage efficient and cost effective environmental protection in managing the possible impacts of fishing on the marine environment. These policy instruments are often described as "harnessing market forces" because if they are well designed and implemented, they encourage individuals and companies to undertake efforts that are in their interest and that collectively meet policy goals. The various types of incentive-based economic policy instruments include:
| Types of incentive-based economic policy instruments include:
|   | Fees and Charges: A schedule of fees and charges is set based on the potential impacts of different gear types of the marine environment. Fishermen would have an economic incentive to use gear types that have potentially less impact to the marine environment. |
|   | Subsidies: The opposite of fees and charges — subsidies are special pricing, discounts, or payments for adopting specific fishing behaviors, actions, or activities that have a potentially reduced impact on the marine ecosystem. |
|   | Tradable permits or “quotas”: Permits or quotas are awarded as a right to use or take an amount of a resource or to impact the marine environment. The number of permits/quotas depends on the total amount of a resource available for use or the acceptable level of the environmental impact. Permits/quotas may be traded among individuals. An example would be a by-catch quota trade program that allows fishermen to sell unused by-catch quota to a fisherman who needs it. |
| Voluntary approaches | Voluntary approaches allow the fishing industry to adopt and enforce their own measures and codes of conduct for managing the potential impacts of fishing on the marine environment. These voluntary approaches are not enforced through state or federal regulations. Voluntary agreements can be enforced through civil contract and associated penalty. Examples of voluntary approaches include industry agreements on time and space closures and the adoption of by-catch mitigation technologies such as gear modifications. |

Selecting criteria for evaluating the alternatives

The management alternatives for the reducing the potential impacts of fishing on the marine environments must be assessed against some performance criteria. Table 2 contains representative criteria that could be used in this workshop. Note that these criteria are not final and can be amended, new criteria added or removed during the workshop. Also the decision support tool allows us to indicate our relative certainty about the impacts of a potential approach for each of the measures/criteria we choose.
**Weighting the criteria**

Having decided which criteria we want to use to evaluate the management alternatives we now need to determine the relative importance of the criteria relative to each other. For example, should low impact on fishing communities be ranked in importance higher or lower than high consistency with state and federal fisheries legislation? This step is called weighting the criteria. Participants will likely have different views on the importance of different criteria and the decision support computer tool is designed to allow for these differences to be incorporated into the evaluation process.

The most straightforward way to arrive at criteria weightings is for each participant to rank the criteria from the most important to least important.

**Scoring alternatives against evaluation criteria**

The major task left for participants is to now score each of the management alternatives against the chosen criteria. For example, how well do command and control approaches perform when evaluated against the criteria of high industry profitability? How well do command and control approaches perform when evaluated against the criteria of high conservation effectiveness?
Our decision support computer program does this graphically using a belief map. Each participant has to decide two things:

- How well does the management alternative do compared to the evaluation criteria?
- How certain are they that if implemented, the management alternative would do as well as they have indicated?

**Table 2: Possible Evaluation Criteria**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High profitability</td>
<td>What is the impact or risk to fisheries profitability from the management approach?</td>
</tr>
<tr>
<td>Low impact on fishing communities</td>
<td>What is the likely impact of the management approach on fishing communities including processing and fisheries dependent employment and community identity?</td>
</tr>
<tr>
<td>Low administration cost</td>
<td>What is the likely cost of administering the management approach?</td>
</tr>
<tr>
<td>High conservation effectiveness</td>
<td>What is the likely effectiveness of the approach for managing potential impacts of fishing on the marine environment?</td>
</tr>
<tr>
<td>High environmental information availability</td>
<td>Does sufficient environmental information exist now or can be obtained at reasonable cost to design, implement and monitor the performance of the management approach so that we know that it is being effective?</td>
</tr>
<tr>
<td>High consistency with state and federal fisheries legislation</td>
<td>Is the management approach compatible with state and federal legislation that manage fisheries and its impact on the marine environment such as the Magnuson-Stevens Act, Marine Mammal Protection Act, and Endangered Species Act?</td>
</tr>
<tr>
<td>High flexibility</td>
<td>How well can the policy adapt to changes in knowledge and information about the fishery over time?</td>
</tr>
<tr>
<td>High innovation</td>
<td>Does the approach encourage experimentation and change and provide ongoing incentives for improvement in industry profitability and environmental improvement beyond a set target?</td>
</tr>
<tr>
<td>High enforceability</td>
<td>Can compliance with management approach be effectively monitored and enforced?</td>
</tr>
<tr>
<td>High stakeholder acceptability</td>
<td>Is the management approach likely to receive support from most stakeholders participating in the Pacific Fisheries Management Council process?</td>
</tr>
</tbody>
</table>
Combining the evaluations and criteria weightings

Once all the alternatives have been scored against the alternatives the decisions support decision computer tool takes all the information from the participants, factors in the evaluation criteria weightings and produces an overall scoring of the management alternatives. This is shown in Figure 1, a screenshot from an earlier trial of this process.

**Figure 1  Illustrative Example of Output from the Decision Support Tool**

Once this step is complete, participants can decide to re-weight criteria or change their scoring of alternatives against criteria. This reevaluation stage can be guided by an assessment of what-to-do-next analysis. This is a decision technique that explicitly evaluates the benefit of collecting additional information to reduce or eliminate uncertainty. Combined with the level of team consensus, level of knowledge and weighting of criteria, it generates statements that guide the team to the most effective next set of actions. These actions will support evaluation of different approaches that potentially promote both sustainability and profitability in managing the possible impacts of commercial fishing on the marine environment.
Evaluating the Workshop & The Decision Support Computer Tool

One of our research objectives is to determine how well the use of a decision support computer tool does or does not work in aiding the discussion of contentious management issues among diverse stakeholders. At the end of the workshop you will be asked to complete the following short survey that covers both the workshop and the use of the computer tool.

For each question below, circle the number to the right that best fits your opinion. Feel free to provide any written comments. The survey is anonymous.

<table>
<thead>
<tr>
<th>Question</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Please indicate your overall satisfaction with the workshop.</td>
<td>Not At All</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. How useful was the background information about the workshop and issues we discussed?</td>
<td>Not At All</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. How useful was the case study in evaluating the different approaches for managing the possible effects of fishing on the marine environment?</td>
<td>Not At All</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4. Has participating in the workshop given you greater understanding of the range of approaches that could be used to manage fishing’s possible adverse impacts on the marine environment?</td>
<td>Not At All</td>
</tr>
<tr>
<td></td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Comments:

________________________________________________________________________
________________________________________________________________________
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________________________________________________________________________
Now turning to the use of the decision support approach, please answer the following questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Indicate your satisfaction with the amount of time it took to evaluate the alternative management approaches.</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>6. To what degree did the decision support approach allow resource, social, economic and cultural information to be incorporated into the evaluation process?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>7. How well did the decision support approach allow scientific information about the impacts of fishing on the marine environment to be incorporated into the evaluation process?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>8. How well did the decision support approach allow for uncertainty to be taken into account in the evaluation process?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>9. How well did the decision support approach contribute to constructive discussion of the management alternatives by workshop participants?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>10. How easy was it to participate in using the decision support approach in a workshop setting?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>11. To what extent did the decision support approach create common ground among participants on the management of possible adverse effects of fishing on the marine environment?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>12. How satisfied are you with the results of the evaluation process?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
<tr>
<td>13. Indicate the potential of the decision support tool in stakeholder discussions about other contentious fisheries management issues?</td>
<td>Not At All: 1 2 3 4 5</td>
</tr>
</tbody>
</table>

Comments:

________________________________________________________________________
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Appendix I

Workshop Case Study: Managing the Bycatch of Yelloweye Rockfish

Introduction

Concern over the take or bycatch of non-target species in fishing has grown over the last decade. Generally, fishermen use their skills and experience to take the catch with the highest value. In many fisheries, however, some species that are not targeted are also harvested. While some of this non-targeted catch is commercially valuable and is retained by fishermen, some is returned to the water either because it has little value or because regulations preclude it from being retained.

Both target and non-target fish species must be managed effectively as part of specific fisheries management arrangements. An example of this situation is the management of yelloweye rockfish (Sebastes ruberrimus) on the West coast by the Pacific Fisheries Management Council.

The yelloweye rockfish case study demonstrates the use of command and control approaches to manage non-target by-catch. Trip limits, total catch limits and area closures are currently in place to rebuild yelloweye stocks.

Yelloweye Rockfish

Yelloweye rockfish is a species of West Coast groundfish considered “overfished” by NOAA Fisheries. Yelloweye rockfish are relatively low in abundance, extremely long-lived (aged up to 120 years), late maturing, and slow growing. They inhabit rocky areas and have been found at depths between 15 and 550m.

In 2002, following a first ever stock assessment for yelloweye rockfish, they were declared overfished. The stock was estimated to be smaller than 25% of its unfished biomass. The assessment concluded that yelloweye rockfish biomass is about 7% of unfished biomass in northern California, and 13% of unfished biomass in Oregon. Trip and bag limits were significantly reduced following completion of the 2002 yelloweye stock assessment. Commercial retention of yelloweye rockfish was prohibited except for a 300-pound trip limit in the trawl fishery so that yelloweye that were landed dead could be retained.

In addition to restrictive trip limits for yelloweye, managers instituted Rockfish Conservation Areas (RCAs) in 2002. These areas are large coastal closure areas intended to protect overfished rockfish species. The boundaries of the RCAs and landings limits external to the boundaries have varied by year, gear type, and season. The seaward boundary of the trawl RCA has ranged from 150-250 fathoms, while the shoreward boundary has ranged from 100 fathoms to the shore. Trawl gear that is used shoreward of the RCA is required to have small footropes (< 8” diameter), which increases the risk of gear loss in rocky areas and diminishes incentive to fish close to these areas. Reductions in landings limits for other shelf rockfish species have also reduced incentives to fish in rocky areas shoreward of the RCA thus reducing the bycatch of yelloweye.

Current Management of Yelloweye Rockfish

Overfished stocks in general are managed in the commercial fishery with a suite of command and control management tools including: trip limits for those overfished species; trip limits on groundfish species associated with overfished stocks; gear restrictions; area closures, total catch bycatch limits in the whiting fishery that require the closure of the fishery if they are reached; and public education and outreach.
In 2006, total catch for yellow eye was 14.4 metric tons (mt) below the target catch set by the fisheries managers at 27 mt. Recent stock assessments suggest that allowable catches in future years may have to be set much closer to the current total commercial catch (Table 1).

Table 1. Yelloweye rockfish management performance and rebuilding projections for future years

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Catch (metric tons)</th>
<th>Optimal Yield (metric tons)</th>
<th>Acceptable Biological Catch (metric tons)</th>
<th>Year</th>
<th>Total Catch (metric tons)</th>
<th>Optimal Yield (metric tons)</th>
<th>Acceptable Biological Catch (metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>13.0</td>
<td>22</td>
<td>52</td>
<td>2011</td>
<td>-</td>
<td>10.3</td>
<td>NA</td>
</tr>
<tr>
<td>2003</td>
<td>10.8</td>
<td>22</td>
<td>52</td>
<td>2012</td>
<td>-</td>
<td>10.5</td>
<td>NA</td>
</tr>
<tr>
<td>2004</td>
<td>15.7</td>
<td>22</td>
<td>52</td>
<td>2013</td>
<td>-</td>
<td>10.7</td>
<td>NA</td>
</tr>
<tr>
<td>2005</td>
<td>15.7</td>
<td>26</td>
<td>54</td>
<td>2014</td>
<td>-</td>
<td>10.9</td>
<td>NA</td>
</tr>
<tr>
<td>2006</td>
<td>14.4</td>
<td>27</td>
<td>55</td>
<td>2015</td>
<td>-</td>
<td>11.1</td>
<td>NA</td>
</tr>
<tr>
<td>2007</td>
<td>-</td>
<td>23</td>
<td>NA</td>
<td>2016</td>
<td>-</td>
<td>11.3</td>
<td>NA</td>
</tr>
<tr>
<td>2008</td>
<td>-</td>
<td>20</td>
<td>NA</td>
<td>2017</td>
<td>-</td>
<td>11.5</td>
<td>NA</td>
</tr>
<tr>
<td>2009</td>
<td>-</td>
<td>17</td>
<td>22.9</td>
<td>2018</td>
<td>-</td>
<td>11.6</td>
<td>NA</td>
</tr>
<tr>
<td>2010</td>
<td>-</td>
<td>14</td>
<td>23.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Yelloweye is principally managed with area-closures because they are relatively sedentary and managers have a reasonably good idea of their depth, latitude, and associated habitats. The commercial fixed gear fishery for sablefish is closed shoreward of 100 fathoms north of Cape Mendocino predominately to protect yelloweye. The commercial fixed gear fishery for nearshore species is required to fish shoreward of 30 fathoms off Oregon (though this can vary), predominately because of yelloweye and canary rockfish concerns. Recreational fisheries are also restricted to RCA boundaries that sometimes vary depending on the need. Specific closures were also implemented in more recent years to protect yelloweye, including the Stonewall bank area, and yelloweye conservation areas off Washington.

Other Possible By-catch Management Approaches

The Yelloweye rockfish case study demonstrates the use of area closures to manage non-target by-catch. Though one possible approach to rebuilding yelloweye stocks, there may be other market incentive and voluntary approaches to managing by-catch that create greater management flexibility while maintaining mandated rebuilding rates. The following are potential examples to stimulate thinking about possible alternatives to the current command and control management approach. The examples are generic and indicative only and are not intended to be specific proposals to manage the bycatch of yelloweye rockfish.

Market Incentives

Market incentives to reduce yelloweye by-catch could take many forms. The basic strategy is to reward fishing strategies that avoid yelloweye. For example, The Pacific Fisheries Management Council is currently considering a rationalization of the groundfish trawl sector. One of the goals of this rationalization is to achieve individual accountability of catch and bycatch. Two common market instruments used elsewhere to achieve such bycatch accountability are tradable bycatch allowances and financial penalties for catching amounts exceeding individual vessel bycatch allowances.

In the case of tradable bycatch quotas, all active groundfish vessels could either be allocated an individual share of the incidental by-catch allowance or have the opportunity to purchase by-catch allowance at auction. If a vessel reaches its individual bycatch allowance it must buy additional allowances either from a periodic auction or unused allowances from other active groundfish vessels, or stop fishing. This allows individual vessels to keep fishing so
long as they do not exceed their vessel allowance or as long as they can buy unused by-catch allowances from other vessels or from auction. It further rewards vessels avoiding yelloweye by-catch by enabling the sale of unused by-catch allowances to vessels that have reached their limits.

Financial penalties work by penalizing vessels that exceed a set by-catch allowance for the vessel. All incidental by-catch of yelloweye must be landed and if this exceeds the allowable limit (either per trip or in aggregate for a season) an automatic and significant financial penalty is imposed. The penalty could vary depending on the amount by which a vessel’s by-catch allowances is exceeded and the status of the by-catch stock. For example, in cases where a vessel is well over its allowance and the by-catch stock is at critically low levels, a penalty equivalent to the ex-vessel value of the entire catch for that trip could be imposed. This creates an incentive for vessels to avoid areas where excessive yelloweye by-catch could occur. Because of this incentive effect, financial penalties for excess by-catch might reduce the need for extensive rockfish conservation areas.

Voluntary by-catch mechanisms
Rather than impose relatively inflexible command and control mechanisms such as RCAs and total yelloweye catch limits that penalize the entire groundfish fleet for the actions of possibly a few fishermen, agencies could exempt members of by-catch cooperatives from these rules. The by-catch cooperatives would put in place alternative voluntary rules and demonstrate compliance with these rules through civil contracts and agreements between members and between the cooperative and management agencies.

For example, vessels that are members of a by-catch cooperative could be allowed to fish in the RCA if they abide by “voluntary” gear or by-catch harvest restrictions while fishing in the RCA. Independent, industry-funded observers or other relatively “fool-proof” mechanisms would monitor these harvest restrictions. Violations would be reported to the cooperative that would have the responsibility to enforce civil sanctions against the offending member. Excessive or persistent breaches of the voluntary agreement would see individual members expelled from the cooperative. Expelled members would then become subject to the standard command and control regime. If the cooperative breaches overall by-catch levels, the cooperative loses its exemption from the command and control regulations.
Appendix II

Glossary of Terms that could be used at the Workshop

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptable biological catch</td>
<td>A scientific calculation of the sustainable harvest level of a fishery and is used to set the upper limit of the annual total allowable catch. It is calculated by applying the estimated (or proxy) harvest rate that produces maximum sustainable yield to the estimated exploitable stock biomass (the portion of the fish population that can be harvested).</td>
</tr>
<tr>
<td>Allocation</td>
<td>Distribution of fishing opportunity among user groups or individuals.</td>
</tr>
<tr>
<td>Benthic</td>
<td>Refers to organisms that live on or in the ocean floor.</td>
</tr>
<tr>
<td>Bycatch</td>
<td>Fish that are captured in a fishery, but that are discarded (returned to the sea) rather than being sold, kept for personal use, or donated to a charitable organization. Bycatch plus landed catch equals the total catch or total estimated fishing mortality.</td>
</tr>
<tr>
<td>Closed areas</td>
<td>Area where form of restriction applies. For example, some areas may be closed to all fishers to protect juvenile fish and local reef species. Others areas may be closed to certain types of commercial bulk fishing methods eg trawling, but not to other more targeted types of fishing such as longlining.</td>
</tr>
<tr>
<td>Closed seasons</td>
<td>Some areas are closed for a specific time to protect the fish stocks by reducing the opportunities people have to fish them.</td>
</tr>
<tr>
<td>Command and control</td>
<td>Command and control regulations focus on reducing potential environmental impacts by specifying how, when, where and how much fishermen can fish. This approach generally relies on detailed prescriptive regulations followed up by a compliance regime based on at sea observers, port inspections and catch reporting.</td>
</tr>
<tr>
<td>Commercial fishing</td>
<td>Fishing in which the fish harvested, either whole or in part, are intended to enter commerce through sale, barter, or trade.</td>
</tr>
<tr>
<td>Demersal</td>
<td>Living near, and depending on, the sea floor. For example, cods, groupers, and halibut are demersal.</td>
</tr>
<tr>
<td>Decision Support Tool</td>
<td>A Decision Support Tool is a computerized system for helping people make decisions. A decision is a choice between alternatives based on scoring the alternatives against a set of criteria. These criteria can be weighted to reflect their relative importance to different stakeholders.</td>
</tr>
<tr>
<td>Economic Incentives</td>
<td>Economic incentive-based approaches rely on financial tools to encourage efficient and cost effective environmental protection in managing the possible impacts of fishing on the marine environment.</td>
</tr>
<tr>
<td>Ecosystem services</td>
<td>Ecosystem services are the processes through which the natural and biological resources comprising marine ecosystem, including all marine life and the oceans, seas, coastal areas, intertidal areas, estuaries, sustain human and non-human life. Marine ecosystem services include food production, carbon dioxide sequestration, the dilution of pollutants, climate regulation and the provision of medicines.</td>
</tr>
<tr>
<td>Fish stock</td>
<td>A group of individuals of the same species which are living together in the same area and can intermingle and interbreed freely. Different stocks of the same species, e.g. Snapper, can be genetically different.</td>
</tr>
<tr>
<td>Fishery</td>
<td>A general term for the combination of fishers, vessels and fishing gear involved in catching fish from a stock, as well as the fishing grounds and the catch.</td>
</tr>
<tr>
<td>Fishery management council</td>
<td>A fisheries management body established by the Magnuson-Stevens Act to manage fishery resources in designated regions of the United States. Membership varies in size depending on the number of states involved. There are eight regional Councils, including the Pacific Council.</td>
</tr>
<tr>
<td><strong>Fishing</strong></td>
<td>The catching, taking, or harvesting of fish; the attempted catching, taking, or harvesting of fish; any other activity that can reasonably be expected to result in the catching, taking, or harvesting of fish; any operations at sea in support of, or in preparation for, any of these activities. This term does not include any activity by a vessel conducting authorized scientific research.</td>
</tr>
<tr>
<td><strong>Fishing effort</strong></td>
<td>Is the amount of fishing gear of a specific type used in a fishery over a given time period e.g. Hours trawled per day.</td>
</tr>
<tr>
<td><strong>Fishing rights</strong></td>
<td>The right to harvest a defined amount of a fish stock or to the right to operate a certain amount of fishing effort in a fishery.</td>
</tr>
<tr>
<td><strong>Fishing community</strong></td>
<td>A community which is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs. Includes fishing vessel owners, fishing families, operators, crew, recreational fishers, fish processors, gear suppliers, and others in the community who depend on fishing.</td>
</tr>
<tr>
<td><strong>Fixed gear</strong></td>
<td>Fishing gear that is stationary after it is deployed (unlike trawl or troll gear which is moving when it is actively fishing). Within the context of the groundfish limited entry fleet, “fixed gear” means longline and fishpot (trap) gear. Within the context of the entire groundfish fishery, fixed gear includes longline, fishpot, and any other gear that is anchored at least at one end.</td>
</tr>
<tr>
<td><strong>Gear restriction</strong></td>
<td>These are usually imposed to protect young fish, e.g. mesh size restrictions, net size restriction and restrictions on how a net can be set, or to limit by-catch problems.</td>
</tr>
<tr>
<td><strong>Habitat</strong></td>
<td>Where organisms live.</td>
</tr>
<tr>
<td><strong>Habitat areas of particular concern</strong></td>
<td>Subsets of essential fish habitat (see EFH) containing particularly sensitive or vulnerable habitats that serve an important ecological function, are particularly sensitive to human-induced environmental degradation, are particularly stressed by human development activities, or comprise a rare habitat type.</td>
</tr>
<tr>
<td><strong>Harvest specifications</strong></td>
<td>The detailed regulations that make up management measures – for example, trawl footrope size, depth limits, net mesh size, etc.</td>
</tr>
<tr>
<td><strong>Incidental catch or incidental species</strong></td>
<td>Species caught when fishing for the primary purpose of catching a different species.</td>
</tr>
<tr>
<td><strong>Incidental take</strong></td>
<td>The “take” of protected species (such as listed salmon, marine mammals, sea turtles, or sea birds) during fishing. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct.</td>
</tr>
<tr>
<td><strong>Individual transferable quota</strong></td>
<td>The right to harvest a defined amount of a fish stock in a defined area, it can be bought or sold.</td>
</tr>
<tr>
<td><strong>Marine Ecosystem</strong></td>
<td>The natural systems of interacting aquatic life within the biological and physical marine environment.</td>
</tr>
<tr>
<td><strong>Marine Environment</strong></td>
<td>The natural and biological resources comprising any marine ecosystem, including all marine life and the oceans, seas, coastal areas, intertidal areas, estuaries, where marine life exists.</td>
</tr>
<tr>
<td><strong>Marine life</strong></td>
<td>Any species of plant or animal life, whether living or dead, which at any stage in its life history, must inhabit the marine environment.</td>
</tr>
<tr>
<td><strong>Maximum sustainable yield</strong></td>
<td>An estimate of the largest average annual catch or yield that can be continuously taken over a long period from a stock under prevailing ecological and environmental conditions. Since MSY is a long-term average, it need not be specified annually, but may be reassessed periodically based on the best scientific information available.</td>
</tr>
<tr>
<td><strong>Mixed stock exception</strong></td>
<td>In “mixed-stock complexes,” many species of fish swim together and are caught together. This becomes a problem when some of these stocks are healthy and some are overfished, because even a sustainable harvest of the healthy stocks can harm the depleted stock. In order to avoid having to shut down all fisheries to protect one particular overfished stock, the national standard guidelines allow a “mixed-stock” exception to the “overfished”</td>
</tr>
</tbody>
</table>
definition. This would allow higher catches of some overfished species than ordinarily allowed in order to avoid severe hardship to fishing communities.

**Optimum yield**
The amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems. The OY is developed on the basis of the Maximum Sustained Yield from the fishery, taking into account relevant economic, social, and ecological factors. In the case of overfished fisheries, the OY provides for rebuilding to a level that is consistent with producing the Maximum Sustained Yield for the fishery.

**Overfished**
Any stock or stock complex whose size is sufficiently small that a change in management practices is required to achieve an appropriate level and rate of rebuilding. The term generally describes any stock or stock complex determined to be below its overfished/rebuilding threshold. The default proxy is generally 25% of its estimated unfished biomass; however, other scientifically valid values are also authorized.

**Performance based standards**
Performance based standards that set a specific target for the environmental impact being managed. This usually allows some flexibility in how this target is met.

**Quota**
A specified numerical harvest objective, the attainment (or expected attainment) of which causes closure of the fishery for that species or species group.

**Quota shares**
Share of the Total Allowable Catch (TAC) allocated to an operating unit such as a vessel, a company or an individual fisherman (individual quota) depending on the system of allocation. Quotas may or may not be transferable, inheritable, and tradable. While generally used to allocate total allowable catch, quotas could be used also to allocate fishing effort or biomass.

**Rebuilding plan**
A document that describes policy measures that will be used to rebuild a fish stock that has been declared overfished.

**Rockfish conservation area**
A geographic area defined by coordinates expressed in latitude and longitude, created and enforced for the purpose of contributing to the rebuilding of overfished west coast groundfish species.

**Sustainability**
Maintaining a population at levels so that exploitation does not affect its reproductive ability and genetic diversity.

**Total allowable catch**
The total regulated catch from a stock in a given time period, usually a year.

**Vessel monitoring system**
A satellite communications system used to monitor fishing activities—for example, to ensure that vessels stay out of prohibited areas. The system is based on electronic devices (transceivers), which are installed on board vessels. These devices automatically send data to shore-based “satellite” monitoring system.

**Voluntary approaches**
Voluntary approaches allow the fishing industry to adopt and enforce their own measures and codes of conduct for managing the potential impacts of fishing on the marine environment.

Source: Adapted from http://www.pcouncil.org/acronyms.html
Sustainability and Profitability: New ways of managing the possible impacts of commercial fishing on the marine environment

Background Material

San Francisco - March 28, 2008
Hotel Whitcomb
1231 Market Street
San Francisco, CA 94103
(415) 626-8000
www.hotelwhitcomb.com
Questions and Feedback

If you have any questions about this workshop or wish to provide feedback please feel free to contact Gil Sylvia (541-867-0284; gil.sylvia@oregonstate.edu), Michael Harte (541-602-1960; mharte@coas.oregonstate.edu) or, Brycen Swart (831-345-0809; bswart@coas.oregonstate.edu).

Thank you for your interest and participation in this project.

Sincerely,

Gil Sylvia  
Superintendent  
Coastal Oregon Marine Experiment Station  
Oregon State University

Michael Harte  
Director, Marine Resource Management,  
Oregon Sea Grant  
Oregon State University

Brycen Swart  
Graduate Research Assistant  
Marine Resource Management, Oregon State University
Agenda

Welcome  Gil Sylvia  9:00 – 9:05 pm
Purpose of the Pilot Workshop  Michael Harte  9:05 – 9:10 pm
Explanation of workshop process and decision support software  David Ullman  9:15 – 10:00 pm
Discussion of groundfish essential fish habitat case study  Michael Harte  10:00 – 10:30 pm
Discussion of problem statement  Michael Harte/David Ullman  10:30 – 10:45 pm
Break
Discussion of management alternatives  Gil Sylvia  11:00 – 11:30 pm
Discussion of evaluation criteria  David Ullman  11:30 – 12:30 pm
Lunch
Weighting of criteria  David Ullman  1:00 – 1:15 pm
Scoring alternatives against criteria  David Ullman  1:15 – 2:30 pm
Break
Review of evaluation results and sensitivity analysis  David Ullman  2:45 – 4:00 pm
Evaluation of computer-based decision support approach  Michael Harte  4:00 – 4:30 pm
Thank you for agreeing to take part in our workshop. This workshop is part of an Oregon Sea Grant funded project being carried out by researchers at Oregon State University.

The project and this workshop has two objectives:

First, we want to help West coast & Oregon fishery managers, fishermen and stakeholders evaluate different approaches that potentially promote both sustainability and profitability in managing the possible impacts of commercial fishing on the marine environment.

Second, we want to determine how well the use of a decision support computer tool to address this fisheries management challenge does or does not work in aiding the discussion of contentious management issues among diverse stakeholders.

By pursuing these objectives we want to identify forward-looking management options that are new and innovative, ways that may effectively promote both the sustainability and profitability of commercial fisheries. Given the complexity of the issues, we don’t expect to solve the management challenges in a single workshop. But we will strive to be as realistic as possible in recognizing both the opportunities and problems that face managers and the commercial fishing sector in addressing complex and contentious environmental issues.

Please take time to read this overview before coming to the workshop. It outlines the key parts of the workshop and importantly contains a case study (Appendix I) that will be the basis for comparing different management approaches to see how well they promote both the sustainability and profitability of commercial fisheries. A glossary of terms that are used in this background material or could be used by participants at the workshop can be found in Appendix II.

Workshop Context

Fishermen and managers are required by state, federal and international laws to address the possible adverse effects of fishing on the marine environment. This is despite the fact that the science about these impacts is often incomplete and uncertain and that actions to regulate these uncertain impacts can have major financial consequences for commercial fisheries and the communities they support. Potential impacts include 1) by-catch of non-target fish species, marine mammals, seabirds, and 2) gear impacts to benthic habitats and bottom dwelling marine organisms.

On land, a diversity of approaches is used to manage the possible environmental impacts of economic activities. These range from strict regulation to voluntary compliance with industry codes of conducts. Although the issues addressed are also often contentious, the range of management approaches provides agencies with a large toolkit to promote the sustainable and profitable use of natural resources.

The toolkit available to fisheries managers is more limited. This occurs for a number of reasons ranging from lack of familiarity with the broader range of tools used in terrestrial environments to poorly defined privileges and responsibilities in the marine environment. However, no matter what the reasons, this means that fishermen and managers are often poorly placed to adopt win-win approaches to address the possible impacts of fishing on the marine environment.

During this workshop we want to explore participants’ perceptions of the strengths and weaknesses of different tools for managing the possible impacts of fishing on the marine environment. With this knowledge we will be better positioned to advise fishermen and agencies on the best ways of addressing these issues that have that have such high stakes for the fishing industry, coastal communities, and other stakeholders.
The Decision Support Computer Tool

This workshop uses a decision support computer tool. This tool, while easy to use, is useful in helping diverse groups collectively evaluate different alternatives. Importantly, this approach explicitly recognizes and retains individual values, perceptions, and knowledge throughout the process.

Details of the decision support software called Accord and marketed by Robust Decisions Incorporated can be found at: www.robustdecisions.com.

Workshop Case Study

To make the workshop relevant to West coast fishermen, agencies and other stakeholders we have chosen a case study of possible fishing impacts on the marine environment based on an existing regional example. Though simplified so as to be widely and quickly accessible, the case study must be real enough so that consequences of the different approaches are apparent and relevant to workshop participants.

For this workshop we have chosen the potential impacts of fishing on essential fish habitat as the case study. The potential impact of commercial fishing on marine habitats is becoming a major issue for fishery managers and the fishing industry. The Magnuson-Stevens Fishery Conservation and Management Act requires the Pacific Fisheries Management Council (PFMC) to describe “essential fish habitat” (EFH), which is “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity”. The Council is also required to minimize impacts on this essential habitat from fishing activities.

Many different gear types are used to target the more than 90 different species of groundfish managed by the Pacific Fisheries Management Council. Although the trawl fishery harvests most groundfish, they can also be caught with troll, longline, hook and line, pots, gillnets, and other gears. Although there are numerous theories and a great deal of speculation about the effects of these various fishing gears on EFH, there is little information on the effects of fishing gears on the habitat of Pacific coast groundfish.

The PFMC identified groundfish EFH as all waters form the high tide line to 3,500 meters in depth. The Council is also required to minimize impacts on this essential habitat from fishing activities. As a result the Council adopted mitigation measures directed at the adverse impacts of fishing on groundfish EFH, including closed areas to protect sensitive areas known as Habitat Areas of Particular Concern. There are 34 bottom trawl areas that are closed to all types of bottom trawl fishing gear (covering 11,787 square miles), a bottom trawl footprint closure area in the EEZ between 1,280 meters and 3,500 meters (covering 246,062 square miles) and 17 bottom contact areas that are closed to all types of bottom contact including fixed gear, such as longline and pots (covering 1,668. square miles). In total, these gear restrictions protect some 259,517.6 square miles of area along the West Coast. The groundfish essential fish habitat case study is outlined in more detail in the Appendix.

For the groundfish essential fish habitat case we are asking whether or not participants believe that the use of alternative management approaches relative to those currently used would lead to better or worse economic and environmental outcomes for the essential fish habitat and habitat areas of particular concern.

Workshop Structure

Creating an issue statement

Our first major task to is to develop an issue statement that workshop participants believe best represents the management challenge being explored. For example, it could be something like:

- What management approaches will enable us to maintain a profitable harvest of healthy groundfish stocks while sustaining marine ecosystems and the services they provide?
Identifying alternative management approaches

Most approaches to managing the possible adverse effects of fishing on the marine environment will be a mixture of tools. In this workshop we are concerned with the dominant philosophy behind the overall approach. Table 1 describes the alternative management approaches discussed at the workshop. These approaches are described in general terms and could be implemented in many different ways in the context of a specific fishery management challenge.
Table 1 Alternative Management Approaches

| Command and control | Command and control regulations focus on reducing potential environmental impacts by specifying how, when, where and how much fishermen can fish. This approach generally relies on detailed prescriptive regulations followed up by a compliance regime based on at sea observers, port inspections and catch reporting. Types of command and control regulations include:
- Technology based standards that specify the method, and sometimes the actual equipment, that fishermen must use to comply with a particular regulation. Examples include gear restrictions such as mesh size restrictions, trawl gear modifications, hook size restrictions, and vessel power restrictions.
- Temporal or spatial regulations that restrict when and where fishing can take place. |

| Performance based standards | Performance based standards that set a specific target for the environmental impact being managed. This usually allows some flexibility in how this target is met by fishermen. Common examples, in fisheries management are total allowable catches for target stocks, bycatch allowances and maximum allowable limits for sea bird and marine mammal fishing-related mortality. |

| Economic approaches | Economic incentive-based approaches rely on financial tools to encourage efficient and cost effective environmental protection in managing the possible impacts of fishing on the marine environment. These policy instruments are often described as “harnessing market forces” because if they are well designed and implemented, they encourage individuals and companies to undertake efforts that are in their interest and that collectively meet policy goals. The various types of incentive-based economic policy instruments include:
- Fees and Charges: A schedule of fees and charges is set based on the potential impacts of different gear types of the marine environment. Fishermen would have an economic incentive to use gear types that have potentially less impact to the marine environment.
- Subsidies: The opposite of fees and charges — subsidies are special pricing, discounts, or payments for adopting specific fishing behaviors, actions, or activities that have a potentially reduced impact on the marine ecosystem.
- Tradable permits or “quotas”: Permits or quotas are awarded as a right to use or take an amount of a resource or to impact the marine environment. The number of permits/quotas depends on the total amount of a resource available for use or the acceptable level of the environmental impact. Permits/quotas may be traded among individuals. |

| Voluntary approaches | Voluntary approaches allow the fishing industry to adopt and enforce their own measures and codes of conduct for managing the potential impacts of fishing on the marine environment. These voluntary approaches are not enforced through state or federal regulations. Voluntary agreements can be enforced through civil contract and associated penalty. Examples of voluntary approaches include industry agreements on time and space closures and the adoption of benthic impact mitigation technologies such as gear modifications. |

Selecting criteria for evaluating the alternatives

The management alternatives for the reducing the potential impacts of fishing on the marine environments must be assessed against some performance criteria. Table 2 contains representative criteria that could be used in this workshop. Note that these criteria are not final and can be amended, new criteria added or removed during the workshop. Also the decision support tool allows us to indicate our relative certainty about the impacts of a potential approach for each of the measures/criteria we choose.
**Weighting the criteria**

Having decided which criteria we want to use to evaluate the management alternatives we now need to determine the relative importance of the criteria relative to each other. For example, should low impact on fishing communities be ranked in importance higher or lower than high consistency with state and federal fisheries legislation? This step is called weighting the criteria. Participants will likely have different views on the importance of different criteria and the decision support computer tool is designed to allow for these differences to be incorporated into the evaluation process.

The most straightforward way to arrive at criteria weightings is for each participant to rank the criteria from the most important to least important.

**Scoring alternatives against evaluation criteria**

The major task left for participants is to now score each of the management alternatives against the chosen criteria. For example, how well do command and control approaches perform when evaluated against the criteria of high industry profitability? How well do command and control approaches perform when evaluated against the criteria of high conservation effectiveness?
Our decision support computer program does this graphically using a belief map. Each participant has to decide two things:

- How well does the management alternative do compared to the evaluation criteria?
- How certain are they that if implemented, the management alternative would do as well as they have indicated?

### Table 2: Possible Evaluation Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High profitability</td>
<td>What is the impact or risk to fisheries profitability from the management approach?</td>
</tr>
<tr>
<td>Low impact on fishing communities</td>
<td>What is the likely impact of the management approach on fishing communities including processing and fisheries dependent employment and community identity?</td>
</tr>
<tr>
<td>Low administration cost</td>
<td>What is the likely cost of administering the management approach?</td>
</tr>
<tr>
<td>High conservation effectiveness</td>
<td>What is the likely effectiveness of the approach for managing potential impacts of fishing on the marine environment?</td>
</tr>
<tr>
<td>High environmental information availability</td>
<td>Does sufficient environmental information exist now or can be obtained at reasonable cost to design, implement and monitor the performance of the management approach so that we know that it is being effective?</td>
</tr>
<tr>
<td>High consistency with state and federal fisheries legislation</td>
<td>Is the management approach compatible with state and federal legislation that manage fisheries and its impact on the marine environment such as the Magnuson-Stevens Act, Marine Mammal Protection Act, and Endangered Species Act?</td>
</tr>
<tr>
<td>High flexibility</td>
<td>How well can the policy adapt to changes in knowledge and information about the fishery over time?</td>
</tr>
<tr>
<td>High innovation</td>
<td>Does the approach encourage experimentation and change and provide ongoing incentives for improvement in industry profitability and environmental improvement beyond a set target?</td>
</tr>
<tr>
<td>High enforceability</td>
<td>Can compliance with management approach be effectively monitored and enforced?</td>
</tr>
<tr>
<td>High stakeholder acceptability</td>
<td>Is the management approach likely to receive support from most stakeholders participating in the Pacific Fisheries Management Council process?</td>
</tr>
</tbody>
</table>
Combining the evaluations and criteria weightings

Once all the alternatives have been scored against the alternatives the decisions support decision computer tool takes all the information from the participants, factors in the evaluation criteria weightings and produces an overall scoring of the management alternatives. This is shown in Figure 1, a screenshot from an earlier trial of this process.

Figure 1  Illustrative Example of Output from the Decision Support Tool

Once this step is complete, participants can decide to re-weight criteria or change their scoring of alternatives against criteria. This reevaluation stage can be guided by an assessment of what-to-do-next analysis. This is a decision technique that explicitly evaluates the benefit of collecting additional information to reduce or eliminate uncertainty. Combined with the level of team consensus, level of knowledge and weighting of criteria, it generates statements that guide the team to the most effective next set of actions. These actions will support evaluation of different approaches that potentially promote both sustainability and profitability in managing the possible impacts of commercial fishing on the marine environment.
Evaluating the Workshop & The Decision Support Computer Tool

One of our research objectives is determine how well the use of a decision support computer tool does or does not work in aiding the discussion of contentious management issues among diverse stakeholders. At the end of the workshop you will be asked to complete the following short survey that covers both the workshop and the use of the computer tool.

For each question below, circle the number to the right that best fits your opinion. Feel free to provide any written comments. The survey is anonymous.

<table>
<thead>
<tr>
<th>Question</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Please indicate your overall satisfaction with the workshop.</td>
<td>1</td>
</tr>
<tr>
<td>15. How useful was the background information about the workshop and issues we discussed?</td>
<td>1</td>
</tr>
<tr>
<td>16. How useful was the case study in evaluating the different approaches for managing the possible effects of fishing on the marine environment?</td>
<td>1</td>
</tr>
<tr>
<td>17. Has participating in the workshop given you greater understanding of the range of approaches that could be used to manage fishing’s possible adverse impacts on the marine environment?</td>
<td>1</td>
</tr>
</tbody>
</table>

Comments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
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________________________________________________________________________
Now turning to the use of the decision support approach, please answer the following questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not At All</td>
</tr>
<tr>
<td>18. Indicate your satisfaction with the amount of time it took to evaluate the alternative management approaches.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>19. To what degree did the decision support approach allow resource, social, economic and cultural information to be incorporated into the evaluation process?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>20. How well did the decision support approach allow scientific information about the impacts of fishing on the marine environment to be incorporated into the evaluation process?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>21. How well did the decision support approach allow for uncertainty to be taken into account in the evaluation process?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>22. How well did the decision support approach contribute to constructive discussion of the management alternatives by workshop participants?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>23. How easy was it to participate in using the decision support approach in a workshop setting?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>24. To what extent did the decision support approach create common ground among participants on the management of possible adverse effects of fishing on the marine environment?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>25. How satisfied are you with the results of the evaluation process?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>26. Indicate the potential of the decision support tool in stakeholder discussions about other contentious fisheries management issues?</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Comments:

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Appendix I

Workshop Case Study: Managing Potential Impacts of Fishing on Essential Fish Habitat

Introduction
The potential impact of fishing on marine habitats is becoming a major issue for fishery managers and the fishing industry. The Magnuson-Stevens Fishery Conservation and Management Act requires the Pacific Fisheries Management Council (PFMC) to describe “essential fish habitat” (EFH), which is “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity”. The Council is also required to minimize impacts on this essential habitat from fishing activities.

Potential Impacts of Fishing on Essential Fish Habitat
Many different gear types are used to target the more than 90 different species of groundfish managed by the Pacific Fisheries Management Council. Although the trawl fishery harvests most groundfish, they can also be caught with troll, longline, hook and line, pots, gillnets, and other gears. Although there are numerous theories and a great deal of speculation about the effects of these various fishing gears on EFH, there is little information on the specific effects of fishing gears on the habitat of Pacific coast groundfish.

Potential impacts from trawl gear, particularly doors and foot ropes, to EFH may include changes to physical characteristics of the sea floor such as leveling of rock formations, impacts to benthic flora and fauna, re-suspension of sediments, and other disturbances. These potential effects and their severity depend on towing speed, substrate type, strength of tides and currents, and gear configuration. Longline gear may also disturb or remove marine plants, corals, and sessile organisms. Although there has been no research conducted on pot gear effects on habitat along the Pacific coast, pot gear may impact plants and animals as it settles, and longlined pots may drag through and impact bottom fauna during gear retrieval. Similarly, anchoring the pot lines or the ends of the longlines could have crushing or dragging effects.

The available information on the effects of fishing gear on EFH is based on research that has been concentrated in heavily fished areas off the east coast of Canada and the United States, and in the North Sea. There is ongoing debate about the applicability of that research to the Pacific coast environment. There are substantial differences in sea floor topography, other physical features, and biological characteristics between those regions and the Pacific coast of the United States. In addition, most research in those areas focused on trawl and dredge gears, with little information on the effects of fixed gears.

Current Management of Fishing Impacts on EFH for Groundfish
The Pacific Fisheries Management Council identified groundfish EFH as all waters form the high tide line to 3,500 meters in depth. The Council is also required to minimize impacts on this essential habitat from fishing activities. As a result the Council adopted mitigation measures directed at the adverse impacts of fishing on groundfish EFH, including closed areas to protect sensitive areas known as Habitat Areas of Particular Concern (see map).
EFH area closures to protect Pacific Coast groundfish habitat - Coastwide.
There are 34 bottom trawl areas that are closed to all types of bottom trawl fishing gear (covering 11,787 square miles), a bottom trawl footprint closure area in the EEZ between 1,280 meters and 3,500 meters (covering 246,062 square miles) and 17 bottom contact areas that are closed to all types of bottom contact including fixed gear, such as longline and pots (covering 1,668 square miles). In total, these gear restrictions protect some 259,517.6 square miles of area along the West Coast.

In addition to EFH closures there are other area closures in the groundfish fishery including Rockfish Conservation Areas (RCAs). Intended to help the rebuilding of overfished rockfish species the RCAs cover thousands of square miles of water closed to groundfish trawling and fixed-gear fishing from the Canadian to Mexican borders.

**Other Possible Management Approaches**

The West coast groundfish EFH example demonstrates the widespread use of closed areas to some or all gear types to manage the impacts of fishing on EFH. Closed areas can lead to more fishing effort, greater cost and even more overall habitat impacts in open fishing areas because fishermen can no longer fish traditional areas where their catch is concentrated. Fisheries managers also often lack the information to determine:

- “habitats of particular concern”
- the degree to which these areas, if any, need to be protected
- the costs of closing a fishing area and how these costs will change overtime because of closures.

Given the high degree of uncertainty about the costs and benefits of closed areas to protect EFH, are there other approaches, or mixes of approaches that could achieve a balance between habitat conservation and lost fishing opportunities?

**Market Instruments**

Market incentives to reduce the potential impacts of fishing on EFH could take many forms. The basic strategy is to reward fishing strategies that avoid or minimize impacts on EFH. Two possible schemes out of many possibilities are 1) variable fees charged to vessels for fishing with bottom contacting gear in areas zoned as sensitive marine habitats and 2) tradable “seabed contact” allowances.

A fee system would work by levying a fee proportionate to the time spent fishing in areas sensitive to the impacts of fishing. The more sensitive the habitat to the effects of fishing, the higher the fee. The use of fees would increase the costs of fishing in some designated areas of EFH. Increased costs of fishing would encourage fishermen to fish elsewhere. Money collected from this scheme could be paid in compensation to fishermen for lost fishing opportunities from the establishment of no-take Marine Protected Areas designed to protect very sensitive and/or rare marine habitats. Fees would not be applied in areas that were not sensitive to the potential impacts of fishing.

 Tradable seabed contact allowances would be based on research establishing the sensitivity of EFH to the impacts of fishing. Total seabed contact tolerance limits would be set for each zone in terms of time in contact or perhaps area of contact. These limits would be subdivided between vessels using bottom contact gear. Once a vessel had reached its allowance it would have to leave the fishing zone. The time spent fishing in the zone would be verified by a vessel monitoring system (VMS). Alternatively, rather than VMS alone, gear sensors in combination with cameras could measure and record seabed contact. A vessel could purchase unused seabed contact allowances from other vessels to continue fishing in a particular zone. This would make fishing in the zone relatively expensive for vessels choosing to fish in the area while rewarding vessels that choose not to fish in areas sensitive to the effects of fishing. Markets for seabed contacts could provide for permanent retiring of impacts or trading impacts across habitats with different levels of sensitivities. The management scheme could be structured to increase fishing opportunities in sensitive areas to vessels demonstrating low impact technologies and practices.

Different variations of these approaches are possible. Each approach sends clear signals to fishermen about the incentives to avoid EFH areas sensitive to the possible impacts of fishing. Because no one approach is likely to meet all economic and ecological objectives some possible mix of command and control and market incentives may be optimal depending on management objectives. What is important is that a full range of tools is available to address the challenge of balancing habitat conservation with loss of fishing opportunities.

**Voluntary Mechanisms**
Scientific information about the sensitivity of EFH to the impacts of fishing is incomplete and uncertain in many cases. This is especially true in regard to specific fishing grounds. Fishermen could agree to fund or support research into determining the extent of impacts associated with alternative fishing technologies and practices. In return, managers would open areas for gear testing. This would allow the collection of data to create much greater certainty about the impacts of alternative fishing technologies and potential impacts in the short, medium and long term. Such research would help achieve management objectives and reward fishermen for improving science and those technologies which reduce environmental impacts.

Another voluntary approach would allow fishermen to place some areas of EFH suspected to be vulnerable to fishing impacts off limits to bottom contact gear or any fishing. Fishermen who agree to avoid these areas could be rewarded with access to other less sensitive areas of EFH that are off limits to vessels that haven’t signed the voluntary agreement. This system rewards fishermen who proactively take action to conserve sensitive EFH ahead of a longer more contentious period of research, debate and potential litigation.
Appendix II

Glossary of Terms that could be used at the Workshop

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptable biological catch</td>
<td>A scientific calculation of the sustainable harvest level of a fishery and is used to set the upper limit of the annual total allowable catch. It is calculated by applying the estimated (or proxy) harvest rate that produces maximum sustainable yield to the estimated exploitable stock biomass (the portion of the fish population that can be harvested).</td>
</tr>
<tr>
<td>Allocation</td>
<td>Distribution of fishing opportunity among user groups or individuals.</td>
</tr>
<tr>
<td>Benthic</td>
<td>Refers to organisms that live on or in the ocean floor.</td>
</tr>
<tr>
<td>Bycatch</td>
<td>Fish that are captured in a fishery, but that are discarded (returned to the sea) rather than being sold, kept for personal use, or donated to a charitable organization. Bycatch plus landed catch equals the total catch or total estimated fishing mortality.</td>
</tr>
<tr>
<td>Closed areas</td>
<td>Area where form of restriction applies. For example, some areas may be closed to all fishers to protect juvenile fish and local reef species. Others areas may be closed to certain types of commercial bulk fishing methods eg trawling, but not to other more targeted types of fishing such as longlining.</td>
</tr>
<tr>
<td>Closed seasons</td>
<td>Some areas are closed for a specific time to protect the fish stocks by reducing the opportunities people have to fish them.</td>
</tr>
<tr>
<td>Command and control</td>
<td>Command and control regulations focus on reducing potential environmental impacts by specifying how, when, where and how much fishermen can fish. This approach generally relies on detailed prescriptive regulations followed up by a compliance regime based on at sea observers, port inspections and catch reporting.</td>
</tr>
<tr>
<td>Commercial fishing</td>
<td>Fishing in which the fish harvested, either whole or in part, are intended to enter commerce through sale, barter, or trade.</td>
</tr>
<tr>
<td>Demersal</td>
<td>Living near, and depending on, the sea floor. For example, cobs, groupers, and halibut are demersal.</td>
</tr>
<tr>
<td>Decision Support Tool</td>
<td>A Decision Support Tool is a computerized system for helping people make decisions. A decision is a choice between alternatives based on scoring the alternatives against a set of criteria. These criteria can be weighted to reflect their relative importance to different stakeholders.</td>
</tr>
<tr>
<td>Economic Incentives</td>
<td>Economic incentive-based approaches rely on financial tools to encourage efficient and cost effective environmental protection in managing the possible impacts of fishing on the marine environment.</td>
</tr>
<tr>
<td>Ecosystem services</td>
<td>Ecosystem services are the processes through which the natural and biological resources comprising marine ecosystem, including all marine life and the oceans, seas, coastal areas, intertidal areas, estuaries, sustain human and non-human life. Marine ecosystem services include food production, carbon dioxide sequestration, the dilution of pollutants, climate regulation and the provision of medicines.</td>
</tr>
<tr>
<td>Fish stock</td>
<td>A group of individuals of the same species which are living together in the same area and can intermingle and interbreed freely. Different stocks of the same species, e.g. Snapper, can be genetically different.</td>
</tr>
<tr>
<td>Fishery</td>
<td>A general term for the combination of fishers, vessels and fishing gear involved in catching fish from a stock, as well as the fishing grounds and the catch.</td>
</tr>
<tr>
<td>Fishery management council</td>
<td>A fisheries management body established by the Magnuson-Stevens Act to manage fishery resources in designated regions of the United States. Membership varies in size depending on the number of states involved. There are eight regional Councils, including the Pacific Council.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fishing</td>
<td>The catching, taking, or harvesting of fish; the attempted catching, taking, or harvesting of fish; any other activity that can reasonably be expected to result in the catching, taking, or harvesting of fish; any operations at sea in support of, or in preparation for, any of these activities. This term does not include any activity by a vessel conducting authorized scientific research.</td>
</tr>
<tr>
<td>Fishing effort</td>
<td>Is the amount of fishing gear of a specific type used in a fishery over a given time period e.g. Hours trawled per day.</td>
</tr>
<tr>
<td>Fishing rights</td>
<td>The right to harvest a defined amount of a fish stock or to the right to operate a certain amount of fishing effort in a fishery.</td>
</tr>
<tr>
<td>Fishing community</td>
<td>A community which is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs. Includes fishing vessel owners, fishing families, operators, crew, recreational fishers, fish processors, gear suppliers, and others in the community who depend on fishing.</td>
</tr>
<tr>
<td>Fixed gear</td>
<td>Fishing gear that is stationary after it is deployed (unlike trawl or troll gear which is moving when it is actively fishing). Within the context of the groundfish limited entry fleet, “fixed gear” means longline and fishpot (trap) gear. Within the context of the entire groundfish fishery, fixed gear includes longline, fishpot, and any other gear that is anchored at least at one end.</td>
</tr>
<tr>
<td>Gear restriction</td>
<td>These are usually imposed to protect young fish, e.g. mesh size restrictions, net size restriction and restrictions on how a net can be set, or to limit by-catch problems.</td>
</tr>
<tr>
<td>Habitat</td>
<td>Where organisms live.</td>
</tr>
<tr>
<td>Habitat areas of particular concern</td>
<td>Subsets of essential fish habitat (see EFH) containing particularly sensitive or vulnerable habitats that serve an important ecological function, are particularly sensitive to human-induced environmental degradation, are particularly stressed by human development activities, or comprise a rare habitat type.</td>
</tr>
<tr>
<td>Harvest specifications</td>
<td>The detailed regulations that make up management measures – for example, trawl footrope size, depth limits, net mesh size, etc.</td>
</tr>
<tr>
<td>Incidental catch or incidental species</td>
<td>Species caught when fishing for the primary purpose of catching a different species.</td>
</tr>
<tr>
<td>Incidental take</td>
<td>The “take” of protected species (such as listed salmon, marine mammals, sea turtles, or sea birds) during fishing. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct.</td>
</tr>
<tr>
<td>Individual transferable quota</td>
<td>The right to harvest a defined amount of a fish stock in a defined area, it can be bought or sold.</td>
</tr>
<tr>
<td>Marine Ecosystem</td>
<td>The natural systems of interacting aquatic life within the biological and physical marine environment.</td>
</tr>
<tr>
<td>Marine Environment</td>
<td>The natural and biological resources comprising any marine ecosystem, including all marine life and the oceans, seas, coastal areas, intertidal areas, estuaries, where marine life exists.</td>
</tr>
<tr>
<td>Marine life</td>
<td>Any species of plant or animal life, whether living or dead, which at any stage in its life history, must inhabit the marine environment.</td>
</tr>
<tr>
<td>Maximum sustainable yield</td>
<td>An estimate of the largest average annual catch or yield that can be continuously taken over a long period from a stock under prevailing ecological and environmental conditions. Since MSY is a long-term average, it need not be specified annually, but may be reassessed periodically based on the best scientific information available.</td>
</tr>
<tr>
<td>Mixed stock exception</td>
<td>In “mixed-stock complexes,” many species of fish swim together and are caught together. This becomes a problem when some of these stocks are healthy and some are overfished, because even a sustainable harvest of the healthy stocks can harm the depleted stock. In order to avoid having to shut down all fisheries to protect one particular overfished stock, the national standard guidelines allow a “mixed-stock” exception to the “overfished”</td>
</tr>
</tbody>
</table>
definition. This would allow higher catches of some overfished species than ordinarily allowed in order to avoid severe hardship to fishing communities.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimum yield</td>
<td>The amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems. The OY is developed on the basis of the Maximum Sustained Yield from the fishery, taking into account relevant economic, social, and ecological factors. In the case of overfished fisheries, the OY provides for rebuilding to a level that is consistent with producing the Maximum Sustained Yield for the fishery.</td>
</tr>
<tr>
<td>Overfished</td>
<td>Any stock or stock complex whose size is sufficiently small that a change in management practices is required to achieve an appropriate level and rate of rebuilding. The term generally describes any stock or stock complex determined to be below its overfished/rebuilding threshold. The default proxy is generally 25% of its estimated unfished biomass; however, other scientifically valid values are also authorized.</td>
</tr>
<tr>
<td>Performance based standards</td>
<td>Performance based standards that set a specific target for the environmental impact being managed. This usually allows some flexibility in how this target is met.</td>
</tr>
<tr>
<td>Quota</td>
<td>A specified numerical harvest objective, the attainment (or expected attainment) of which causes closure of the fishery for that species or species group.</td>
</tr>
<tr>
<td>Quota shares</td>
<td>Share of the Total Allowable Catch (TAC) allocated to an operating unit such as a vessel, a company or an individual fisherman (individual quota) depending on the system of allocation. Quotas may or may not be transferable, inheritable, and tradable. While generally used to allocate total allowable catch, quotas could be used also to allocate fishing effort or biomass.</td>
</tr>
<tr>
<td>Rebuilding plan</td>
<td>A document that describes policy measures that will be used to rebuild a fish stock that has been declared overfished.</td>
</tr>
<tr>
<td>Rockfish conservation area</td>
<td>A geographic area defined by coordinates expressed in latitude and longitude, created and enforced for the purpose of contributing to the rebuilding of overfished west coast groundfish species.</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Maintaining a population at levels so that exploitation does not affect its reproductive ability and genetic diversity.</td>
</tr>
<tr>
<td>Total allowable catch</td>
<td>The total regulated catch from a stock in a given time period, usually a year.</td>
</tr>
<tr>
<td>Vessel monitoring system</td>
<td>A satellite communications system used to monitor fishing activities—for example, to ensure that vessels stay out of prohibited areas. The system is based on electronic devices (transceivers), which are installed on board vessels. These devices automatically send data to shore-based “satellite” monitoring system.</td>
</tr>
<tr>
<td>Voluntary approaches</td>
<td>Voluntary approaches allow the fishing industry to adopt and enforce their own measures and codes of conduct for managing the potential impacts of fishing on the marine environment.</td>
</tr>
</tbody>
</table>

Source: Adapted from http://www.pcouncil.org/acronyms.html
Sustainability and Profitability: New ways of managing the possible impacts of commercial fishing on the marine environment

Introduction
At the end of March and beginning of April 2008 three workshops were held in Portland, San Francisco and Newport as part of an Oregon Sea Grant funded project being carried out by researchers at Oregon State University. The project and workshops had two objectives:

1) To assist west coast & Oregon fishery managers, fishermen and stakeholders evaluate different approaches that potentially promote both sustainability and profitability in managing the possible impacts of commercial fishing on the marine environment.

2) To determine how well the use of a decision support computer tool to address this fisheries management challenge does or does not work in aiding the discussion of contentious management issues among diverse stakeholders.

By pursuing these objectives we wanted to identify forward-looking management options that are new and innovative, ways that may effectively promote both the sustainability and profitability of commercial fisheries. Given the complexity of the issues, we didn’t expect to solve the management challenges in a single workshop. But we strove to be as realistic as possible in recognizing both the opportunities and problems that face managers and the commercial fishing sector in addressing complex and contentious environmental issues.

Background
Fishermen and managers are required by state, federal and international laws to address the possible adverse effects of fishing on the marine environment. This is despite the fact that the science about these impacts is often incomplete and uncertain and that actions to regulate these uncertain impacts can have major financial consequences for commercial fisheries and the communities they support. Potential impacts include 1) by-catch of non-target fish species, marine mammals, seabirds, and 2) gear impacts to benthic habitats and bottom dwelling marine organisms.

On land, a diversity of approaches is used to manage the possible environmental impacts of economic activities. These range from strict regulation to voluntary compliance with industry codes of conducts. Although the issues addressed are also often contentious, the range of management approaches provides agencies with a large toolkit to promote the sustainable and profitable use of natural resources.

The toolkit available to fisheries managers is more limited. This occurs for a number of reasons ranging from lack of familiarity with the broader range of tools used in terrestrial environments to poorly defined privileges and responsibilities in the marine environment. However, no matter what the reasons, this means that fishermen and managers are often poorly placed to adopt win-win approaches to address the possible impacts of fishing on the marine environment.
The goal of the workshops was to explore fishery management participants’ perceptions of the strengths and weaknesses of different tools for managing the possible impacts of fishing on the marine environment. With this knowledge we will be better positioned to advise fishermen and agencies on the best ways of addressing these issues that have that have such high stakes for the fishing industry, coastal communities, and other stakeholders. To assist in this endeavor, we used a decision support computer tool in the workshops. This tool, while easy to use, is useful in helping diverse groups collectively evaluate different alternatives. Importantly, this approach explicitly recognizes and retains individual values, perceptions, and knowledge throughout the process.

**Problem**

To make the workshops relevant to west coast fishermen, agencies and other stakeholders a case study of possible fishing impacts on the marine environment based on an existing regional example was chosen. Though simplified so as to be widely and quickly accessible, the case study was real enough so that consequences of the different approaches were apparent and relevant to workshop participants.

For the **Portland and Newport** workshops we chose to use the incidental bycatch of yelloweye rockfish as the case study. Concern over the take or bycatch of non-target species in fishing has grown over the last decade. Generally, fishermen use their skills and experience to take the catch with the highest value. In many fisheries, however, some species that are not targeted are also harvested. While some of this non-targeted catch is commercially valuable and is retained by fishermen, some is returned to the water either because it has little value or because regulations preclude it from being retained.

Both target and non-target fish species must be managed effectively as part of specific fisheries management arrangements. The management of yelloweye rockfish (*Sebastes ruberrimus*) on the west coast by the Pacific Fisheries Management Council is an extreme example of the way in which bycatch management can constrain an entire fishery worth many millions of dollars. In 2006, total catch for yelloweye was 14.4 metric tons (mt), below the target catch set by the fisheries managers at 27 mt. Recent stock assessments suggest that allowable catches in future years may have to be set much closer to the current total commercial catch. Yelloweye is principally managed with area-closures because they are relatively sedentary and managers have a reasonably good idea of their depth, latitude, and associated habitats.

The question we asked was whether or not participants believe that the use of alternative management approaches relative to those currently used would lead to better or worse economic and environmental outcomes for the management of yelloweye bycatch.

For the **San Francisco** workshop we chose the potential impacts of fishing on essential fish habitat as the case study. The potential impact of commercial fishing on marine habitats is becoming a major issue for fishery managers and the fishing industry. The Magnuson-Stevens Fishery Conservation and Management Act requires the Pacific Fisheries Management Council (PFMC) to describe “essential fish habitat” (EFH), which is “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity”. The Council is also required to minimize impacts on this essential habitat from fishing activities.

Many different gear types are used to target the more than 90 different species of groundfish managed by the Pacific Fisheries Management Council. Although the trawl fishery harvests most groundfish, they can also be caught with troll, longline, hook and line, pots, gillnets, and other gears. Although there are numerous theories and a great deal of speculation about the effects of these various fishing gears on EFH, there is little information on the effects of fishing gears on the habitat of Pacific coast groundfish.

The PFMC identified groundfish EFH as all waters form the high tide line to 3,500 meters in depth. The Council is also required to minimize impacts on this essential habitat from fishing activities. As a result the Council adopted mitigation measures directed at the adverse impacts of fishing on groundfish EFH, including closed areas to protect sensitive areas known as Habitat Areas of Particular Concern. There are 34 bottom trawl areas that are closed to all types of bottom trawl fishing gear (covering 11,787 square miles), a bottom trawl footprint closure area in the EEZ between 1,280 meters and 3,500 meters (covering 246,062 square miles) and 17 bottom contact areas that are closed to all types of bottom contact including fixed gear, such as longline and pots (covering 1,668. square miles). In total, these gear restrictions protect some 259,517.6 square miles of area along the West Coast.
For the groundfish essential fish habitat case we asked whether or not participants believe that the use of alternative management approaches relative to those currently used would lead to better or worse economic and environmental outcomes for the essential fish habitat and habitat areas of particular concern.

**Fisheries Management Participants**

All three workshops were composed of 26 people involved in the fishery management process representing fishing industry (fishermen, processors, etc.), federal and state agencies, environmental groups, and academia. The breakdown in the number of workshop participants by sector can be seen below:

![Number of workshop participants by sector](image)

**Process and Results**

The uncertainty inherent with making fisheries management decisions and the lack of relevant policy models for the environmental impacts of fishing make the potential use of multi-criteria analysis as a helpful decision support tool in guiding fishery management decisions. The following seven steps summarize the decision process through the three one-day workshops on managing bycatch of yelloweye rockfish and essential fish habitat.

1. **Define the Issue** – The first major task was to develop an issue statement that workshop participants believe best represented the management challenge being explored. The policy problem had to be specific because imprecise or partial specification would mean that subsequent steps in the analysis may multiply the initial error several fold through flow-on effects. The decision support software provided a free-text window in the application to capture the issue. As simple as that may seem, getting the group to agree on the issue in writing and how to word them, proved to be a valuable exercise in the process.
   - For the Portland workshop, the issue was: How to best manage rebuilding of yelloweye rockfish?
   - For the San Francisco workshop, the issue was: How to best manage essential fish habitat?
   - For the Newport workshop, the issue was: What management strategy has the best potential to allow us to continue fishing while rebuilding yelloweye rockfish?

2. **Define and characterize the decision criteria** – The management alternatives for each of the issues were assessed against some performance criteria. The criteria against which to assess the alternatives must have these characteristics:
   - Complete and comprehensive - if two alternatives have the same score for each criterion then it must be agreed that the two alternatives are equivalent. In other words there should be no other basis for distinguishing between the criteria. The criteria should encompass the whole range of relevant outcomes, both those sought from the policy or action, and those arising as a consequence.
   - Directional – scoring or ranking of criteria should be able to reflect the direction of an outcome, to distinguish between a negative outcome and a positive one. On a simple ranking, a negative outcome will typically be ranked lower than a positive one, but it is important that the nature of the outcome is reflected whenever possible.
   - Operational – the set of criteria must be able to be used in a meaningful way in subsequent analysis.
   - Understandable – each criterion should be interpreted in the same way by a range of people with different backgrounds.
Decomposable – each criterion should be independent. For example, if criteria include job creation and labor costs and an increase in jobs is considered desirable when it results in unemployed people being employed but undesirable because it pushes up the cost of labor for people already employed. The two criteria are not decomposable because job creation cannot be evaluated independently of labor costs. In practice, it is important to recognize that many criteria are functionally related, and that the decomposable test may not be met. Nevertheless, it may be preferable to the non-decomposable criteria, since acknowledgement of both criteria is more important than eliminating the co-dependence of the criteria. For this, it is especially important to understand the processes through which policies or actions will have effect, and the nature of the relationships among criteria.

Non-redundant – no aspect of the problem should be accounted for more than once.

Minimal – there should be no smaller set of criteria satisfying the preceding conditions.

Simple – criteria containing a number of different aspects should be avoided if the combination of elements complicates interpretation and application of the criteria.

Below are the example criteria that participants were given before the workshop to give ideas and spark discussion.

<table>
<thead>
<tr>
<th>Criteria Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High profitability</td>
</tr>
<tr>
<td>Low impact of fishing communities</td>
</tr>
<tr>
<td>Low administration cost</td>
</tr>
<tr>
<td>High conservation effectiveness</td>
</tr>
<tr>
<td>High environmental information availability</td>
</tr>
<tr>
<td>High consistency with state and federal fisheries legislation</td>
</tr>
<tr>
<td>High flexibility</td>
</tr>
<tr>
<td>High innovation</td>
</tr>
<tr>
<td>High enforceability</td>
</tr>
<tr>
<td>High stakeholder acceptability</td>
</tr>
</tbody>
</table>

Although both quantitative and qualitative criteria could have been used, only qualitative criteria were used in all three workshops due to ease of use and time constraints. For the Portland workshop there were up to 17 decision criteria in the first go around. By the second round the 11 most critical and discriminate criteria had been identified and were ultimately used. In the San Francisco workshop participants came up with 20 decision criteria in the first brainstorming exercise. Eventually 11 of the most decisive and distinguished criteria had been recognized and were eventually used. And for the workshop in Newport, 21 decision criteria were thought of in the initial discussion. Participants were able to identify and use 12 of the most important and discrete criteria. The table below gives the final criteria developed for each of the workshops:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Newport</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High profitability</td>
<td>1. Low additional cost to fisheries enterprise</td>
<td>1. Generates broad ecosystem benefits</td>
<td></td>
</tr>
</tbody>
</table>

200
3. Identify the alternatives – Although most approaches to managing the possible adverse effects of fishing on the marine environment will be a mixture of tools, in these workshops we were concerned with the dominant philosophy behind the overall approach. Participants were given four general classes of policy approaches, with respect to the specific fisheries management scenarios, before the workshop to introduce general concepts and begin dialogue. They were:

1) Command and Control – the government dictates how, when, where and how much fishermen can fish for controlling environmental impacts. This approach generally relies on detailed prescriptive regulations followed up by a compliance regime based on at sea observers, port inspections and catch reporting. Types of command and control regulations include:
   - Technology based standards that specify the method, and sometimes the actual equipment, that fishermen must use to comply with a particular regulation. Examples include gear restrictions such as mesh size restrictions, trawl gear modifications, hook size restrictions, and vessel power restrictions.
   - Temporal or spatial regulations that restrict when and where fishing can take place.

2) Performance Based Standards – the central government sets a specific target for the environmental impact being managed. This usually allows some flexibility in how this target is met by fishermen. Common examples, in fisheries management are total allowable catches for target stocks, bycatch allowances and maximum allowable limits for sea bird and marine mammal fishing-related mortality.

3) Economic Approaches – government sanctioned financial tools to encourage efficient and cost effective environmental protection in managing the possible impacts of fishing on the marine environment. These policy instruments are often described as "harnessing market forces" because if they are well designed and implemented, they encourage individuals and companies to undertake efforts that are in their interest and that collectively meet policy goals. The various types of incentive-based economic policy instruments include:
   - Fees and Charges: A schedule of fees and charges is set based on the potential impacts of different gear types of the marine environment. Fishermen would have an economic incentive to use gear types that have potentially less impact to the marine environment.
• Subsidies: The opposite of fees and charges — subsidies are special pricing, discounts, or payments for adopting specific fishing behaviors, actions, or activities that have a potentially reduced impact on the marine ecosystem.

• Tradable permits or “quotas”: Permits or quotas are awarded as a right to use or take an amount of a resource or to impact the marine environment. The number of permits/quotas depends on the total amount of a resource available for use or the acceptable level of the environmental impact. Permits/quotas may be traded among individuals. An example would be a by-catch quota trade program that allows fishermen to sell unused by-catch quota to a fisherman who needs it.

4) Voluntary Approaches – Community or fishing industry designed, adopted and enforced measures and codes of conduct for managing the potential impacts of fishing on the marine environment. These voluntary approaches are not enforced through state or federal regulations. Voluntary agreements can be enforced through civil contract and associated penalty. Examples of voluntary approaches include industry agreements on time and space closures and the adoption of by-catch mitigation technologies such as gear modifications.

For the Portland workshop, in the first round of discussion, participants identified 10 different management alternatives. Those were then refined to 6 distinct alternatives. In the San Francisco workshop, for the first brainstorming session participants identified 8 different management alternatives, which were then developed into 6 separate alternatives. In Newport, participants identified 8 different management alternatives in the initial dialogue and then were distinguished to 4 alternatives. The table below includes the final alternatives developed for each workshop:

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Portland</th>
<th>San Francisco</th>
<th>Newport</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Individual transferable bycatch</td>
<td>2. Tradable EFH impact credits</td>
<td>2. Area specific total allowable catch</td>
<td></td>
</tr>
<tr>
<td>quota</td>
<td>3. Sector and area total allowable catch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>catch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Volunteer closed areas</td>
<td>4. Subsidies not to impact EFH</td>
<td>4. Full retention with consequences</td>
<td></td>
</tr>
<tr>
<td>5. Higher fees</td>
<td>5. Gear specific EFH area permit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Status quo: command and control (Portland) – the current approach used to manage bycatch of yelloweye rockfish, which is primarily with area closures set by the government.

• Individual transferable bycatch quota – a total allowable bycatch of yelloweye rockfish would be set by the government and a share of it would be allocated to individuals in the fishery as quotas. Quotas may be traded among individuals at market prices.

• Sector and area total allowable catch – the government would set total allowable catch of yelloweye rockfish would and it would be allocated by sector (gear type and/or fishery) and, in addition, by regional area.

• Volunteer closed areas – the community or fishing industry would voluntarily agree to close off areas to fishing for yelloweye rockfish (as opposed to having the government tell them what areas are to be closed off).
• Higher fees – the government would impose high penalties if fishermen are to catch yelloweye rockfish. Fishermen would have economic incentive to avoid them (i.e. using different gear or avoiding areas of high yelloweye abundance).

• Volunteer processor incentive – processors would voluntarily agree to pay higher prices to fishermen that have reduced bycatch of yelloweye, giving fishermen economic incentive to avoid catching them.

• Status quo: command and control (San Francisco) – the current approaches used to manage fishing on essential fish habitat, which includes area closures and gear restrictions set by the government.

• Tradable EFH impact credits – the government would allocate a cap of impact credits to fishermen for fishing on essential fish habitat based on gear type and habitat type (different gear types and different habitat types would have different impact credit values). These impact credits could be tradable.

• Regional management co-op – the fishery would be managed spatially at the regional level in the form of a cooperative among the community or fishermen (enforced through civil contract and associated penalties rather than through a state or federal agency).

• Subsidies to not impact EFH – the government would reward those fishermen not fishing on essential fish habitat through special pricing, discounts or payments.

• Gear specific EFH area permit – the government would allocate permits to fish on essential fish habitat by gear type and by regional area.

• Ban bottom trawl on EFH – bottom trawling on essential fish habitat would not be allowed.

• Full retention with consequences – fishermen would retain all of their catch (discarding would not be allowed) and would be penalized (e.g. through high fees) for catching yelloweye rockfish, giving them an economic incentive to avoid them (i.e. using different gear or avoiding areas of high yelloweye abundance).

4. **Weighting the criteria** – Having decided which criteria to use to evaluate the management alternatives, the next step was to determine the relative importance of the criteria relative to each other, by ranking them from most important to least important. Assigning weights to the criteria is a valuable aspect of the decision support computer tool. It allows different views to be incorporated into the evaluation process and their impacts on ranking of alternatives to be expressed explicitly. There are many methods for weighing criteria importance such as independent, fixed sum, ranking, and pairwise comparison. For this project, weights were assigned using a ranking method, where participants ranked the criteria and then weights were automatically set according to their ranking. Pair-wise comparison, used in the Analytical Hiearch Process, compares multiple alternatives relative to each other, one criterion at a time. It is widely used but was not applied in this project due to its time consuming and laborious nature (and there is no proof that the added work improves the results). General trends of the weighting of the criteria are discussed further in the analysis and discussion section.

5. **Individuals evaluate alternatives** – Stakeholders independently rated their knowledge and estimate of each management alternative to meet each criterion. Independent evaluation allowed participants to maintain individual values, helped avoid groupthink, and potential personality conflicts. This evaluation was accomplished graphically by placing a point on a simple decision matrix (also known as a belief map). Each participant had to decide two things:

- How well does the management alternative do compared to the evaluation criteria?
- How certain are they that if implemented, the management alternative would do as well as they have indicated?

The vertical axis on the belief map measured how well the criterion satisfied the management alternative and the horizontal axis measured the evaluator’s knowledge.

6. **Results** – The facilitator merged all the data from the participants (the criteria weightings plus the criteria scored against the alternatives) and the computer support tool produced an overall scoring of the management
alternatives. The alternative with the highest score is the most satisfactory alternative. An alternative with a satisfaction value of 100% means that the team is fully satisfied with it. Satisfaction can be interpreted both relatively and absolutely. Relatively, the highest score is the best, but this should be checked from many viewpoints to insure team consensus. Absolutely, there is a minimum level of satisfaction that should be obtained to warrant commitment to a specific alternative. There is no set value for this minimum, but a value below 65% for an alternative implies that the team is not very confident in its success. The results of the team, the evaluation for all viewpoints were calculated and only the highest and lowest values from the individuals are displayed numerically. The range of satisfaction scores for each alternative from the three workshops were as follows:

### Portland

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Satisfaction Range (0.0 - 1.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status quo: command &amp; control</td>
<td>Low</td>
</tr>
<tr>
<td>Individual transferable bycatch quota</td>
<td>0.67</td>
</tr>
<tr>
<td>Sector and area total allowable catch</td>
<td>0.71</td>
</tr>
<tr>
<td>Volunteer closed areas</td>
<td>0.30</td>
</tr>
<tr>
<td>Higher fees</td>
<td>0.49</td>
</tr>
<tr>
<td>Volunteer processor incentive</td>
<td>0.18</td>
</tr>
</tbody>
</table>

For the yelloweye rockfish example in Portland, the alternative with the highest satisfaction score was sector and area total allowable catch. The second highest satisfaction score was the individual transferable bycatch quota alternative. The third highest was status quo: command and control, with the higher fees alternative close behind. Finally it was the two volunteer alternatives that had the lowest satisfaction scores.
San Francisco

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Satisfaction Range (0.0 - 1.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status quo: command &amp; control</td>
<td>0.93</td>
</tr>
<tr>
<td>Tradable EFH impact credits</td>
<td>0.41</td>
</tr>
<tr>
<td>Regional management co-op</td>
<td>0.69</td>
</tr>
<tr>
<td>Subsidies not to impact EFH</td>
<td>0.50</td>
</tr>
<tr>
<td>Gear specific EFH area permit</td>
<td>0.25</td>
</tr>
<tr>
<td>Ban bottom trawl on EFH</td>
<td>0.11</td>
</tr>
</tbody>
</table>

For the essential fish habitat example in San Francisco, the management alternative with the highest satisfaction score was the status quo: command and control. That was followed by the regional management co-operative alternative. The third highest satisfaction score was the subsidies to not impact EFH areas alternative. Tradable EFH impact credits was the management alternative with fourth highest satisfaction score. It was followed by the gear specific EFH area permits policy alternative. And the least overall satisfaction score was the ban bottom trawling on EFH alternative.

Newport

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Satisfaction Range (0.0 - 1.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tradable bycatch quota</td>
<td>0.58</td>
</tr>
<tr>
<td>Area specific total allowable catch</td>
<td>0.76</td>
</tr>
<tr>
<td>Volunteer processor incentive</td>
<td>0.23</td>
</tr>
<tr>
<td>Full retention with consequences</td>
<td>0.44</td>
</tr>
</tbody>
</table>

For the Yelloweye Rockfish example in Newport, the alternative with the highest satisfaction score was area specific total allowable catch. The second highest satisfaction score was the full retention with consequences alternative, followed closely behind by the individual transferable bycatch quota alternative. And finally the management alternative with the least satisfaction score was volunteer processor incentive.

7. Evaluate and Discuss – The final step in the process was to conduct a sensitivity analysis. In the sensitivity analysis, various weights or aspects of the multi-criteria problem (scores, weights, evaluation method, etc.) were varied systematically to determine their effect on the satisfaction of the management alternatives. For example, it is possible to determine to what degree a particular weight or criteria score must change before the satisfaction of the alternatives changes. Participants could decide to re-weight criteria or change their scoring of alternatives against criteria. This reevaluation stage was guided by an assessment of what-to-do-next analysis. This is a decision technique that explicitly evaluates the benefit of collecting additional information to reduce or eliminate uncertainty. Combined with the level of team consensus, level of knowledge and weighting of criteria, it generates statements that guide the team to the most effective next set of actions. The what to do next suggestion are:

- **Build Consensus** – Evaluations that are important and where the team evaluations are not consistent are listed first in the what-to-do-next report. These require the least expense to resolve if they are resolvable with the information that is available. Consensus values range from 0% to 100% to the show the level of agreement among the members in their evaluation of the selected alternative featured.
- **Increase team knowledge** – Increasing team knowledge usually means performing more research, analysis, simulations or including more expertise on the team.
- **Refine criterion** – Qualitative criterion are flagged to be refined if they are critical to the decision.

The sensitivity analyses for the three workshops were:
Portland

• **Build Consensus** – Consensus in the following sensitive alternative/criterion evaluations is low. Discussion about them is advised.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Criterion</th>
<th>Team Consensus (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector and area total allowable catch</td>
<td>High ecosystem conservation effectiveness</td>
<td>46</td>
</tr>
<tr>
<td>Sector and area total allowable catch</td>
<td>High enforceability</td>
<td>67</td>
</tr>
</tbody>
</table>

• **Refine Criteria** – The following criteria are weak and refining them could change the results:
  
  i. High Profitability
  
  ii. High ecosystem conservation effectiveness
  
  iii. High enforceability
  
  iv. Low bycatch rate

• **Develop Alternatives** – The team is having difficulty differentiating between alternatives, either generate new criteria that better measure features or generate new alternatives.

San Francisco

• **Status Quo** has high satisfaction and probability of being the first choice is high from all view points.

Newport

• **Area specific total allowable catch** has high satisfaction and probability of being the first choice is high from all view points.
**Analysis**

Although each workshop came up with their own unique and different number of criteria to use for their issue, each workshop developed criteria that could be generally classified into four categories:

- Economic – (profitability, administrative costs, socio economic impacts on fishing communities/sectors, etc.)
- Environmental – (conservation effectiveness/benefits, stock knowledge, etc.)
- Management – (flexibility, enforceability, adaptability, feasibility, measurability, etc.)
- Social – (equity, acceptability, community heritage, etc.)

In general it was assessed from the three workshops that industry representatives weighed profitability and economic criteria high. Meanwhile representatives from environmental groups ranked conservation and ecosystem benefit criteria relatively higher than the other the criteria. And both agency and academic representatives had mixtures of conservation, management and stock knowledge criteria ranked relatively high.

For the management alternatives, each workshop came up with their own distinctive and number of policy approaches to use for their issue but for simplicity and comparison purposes we can group them into five a different types:

- Command and Control (Gear restrictions, vessel restrictions, area closures, time closures, etc.)
- Performance Standard (Total Allowable Catch (TAC), bycatch allowances, quotas, etc.)
- Economic Incentives (Fees, penalties, subsidies, etc.)
- Tradable Permit Scheme (Individual tradable bycatch quotas, Tradable EFH impact credits, etc.)
- Voluntary Approaches (Co-ops, co-management, etc.)

Note that for two of the workshops (Portland and San Francisco) there were six alternatives and listed above are only five categories of policy alternatives. For this analysis the lowest scoring alternative was not used (in the case of Portland it was the voluntary processor incentive alternative and in the case of San Francisco it was ban bottom trawling alternative) so there would be only one alternative for each category. For the Portland workshop the volunteer closed area policy approach under the voluntary co-op category was used for the analysis. And for the San Francisco workshop, the status quo policy approach for the command and control category was used for the analysis.

The two different issues compared for the three workshops had different trends in satisfaction scores of policy alternatives. In both the yelloweye rockfish case studies the stakeholders collectively rated the performance standard (area total allowable catch) policy approach as having the highest total satisfaction. Second in order of satisfaction was the individual transferable bycatch quota. The third highest policy alternative satisfaction score was economic incentives. Command and control, which was only used in one of the yelloweye rockfish workshops, scored as the fourth highest policy approach. And finally Voluntary co-ops was the policy alternative with the least high score. This trend is illustrated in the graph below.
Despite minor individual variance among sectors, the average ranking satisfaction scores of the different policy approaches were fairly consistent across all the sectors compared with the overall scores. Like the average total satisfaction score, performance standard and tradable permit were scored as the top two policy alternatives to satisfy the criteria by every sector. Economic incentive was the third highest policy approach for the industry sector. For the environmental, and academia sectors economic incentives and command and control tied for the third highest management alternative. As for the academia sector, command and control scored just slightly higher than the economic incentive approach. The lowest alternative score to satisfy the criteria for all the sectors was the voluntary co-operative policy approach. The graph below documents this.

For the management of essential fish habitat case study the trends were different. The stakeholders collectively rated the status quo (command and control regulations) policy approach as having the highest satisfaction. The second highest satisfaction score was the voluntary co-operative policy approach. This was followed by economic incentive, tradable permit, and finally, performance standard. Below is a graph that confirms the above description.

All three sectors in the Essential Fish Habitat Case Study scored the status quo command and control regulation as the highest policy alternative to satisfy the 11 criteria. In addition all three sectors scored the voluntary co-op as the second highest alternative. It was the final three alternatives in which there were differences. The industry sector
had the economic incentive policy alternative ranked as their third. The ENGO sector tied economic incentive and tradable permit as their third highest. The agency sector had tradable permit as their third highest management alternative. All three sectors had performance standard as their least highest satisfaction score. This can be seen in the graph below.

In all three workshops, the policy approaches that have not been used much in west coast fisheries management, especially voluntary approaches (and to some extent economic incentives), consistently rated with higher uncertainty when scoring the criteria to the alternative as compared to the other, more widely used policy alternatives (i.e. status quo/command and control).

Workshop Evaluation

Upon completion of the workshop, participants were given an evaluation survey on the workshop itself and the decision support tool. The survey was thirteen questions, 4 questions evaluating the workshop itself and 9 questions evaluating the decision support software tool. Participants were asked to evaluate the questions on a five point satisfaction Likert Scale with “1” meaning “Not At All” and “5” meaning “Extremely”.

Overall participants were satisfied with the workshop (mean score of 3.69). As one participant expressed “This was an excellent workshop and an excellent tool for decision making. In fisheries the problem is everyone is dug in with their opinion. This tool moves you off your position by just the exercise of identifying options and criteria. I could use this tool in my work.” Another person noted the importance of having all the various stakeholders represented and having them knowledgeable in the subject in order for the workshop to be effective: “Interesting process if focus groups are a good representative, cross section of all stakeholders and interested parties the process has potential. It remains very important to include informed and knowledgeable focus group.”

The background information about the workshop and issues were perceived as useful (mean score 3.48). Although not entirely convincing, results of the survey indicated that the workshop did give greater understanding of the range of approaches that could be used to manage fishing’s possible adverse impacts on the marine environment (mean score 3.32).

The usefulness of the case study to help evaluate the different approaches to managing the possible effects of fishing on the marine environment was met with mixed results (mean score 3.24). Both management of essential fish habitat and bycatch of yelloweye rockfish are extremely complicated issues. As one participant said “Interesting case study but it almost too complex to deal with in a short workshop”. There are many variables involved in the decision making process of those two issues and it takes a while to discuss, explain and evaluate the various alternatives and criteria associated with them. Participants would tend to get bogged down in the details due to their difficult nature. One participant expressed “There is too much history; there are too many hidebound opinions, to
make using a real example - especially one as contentious as yelloweye - provide much in the way of constructive results. Workshop participants spent too much time arguing over contemporary (or historical issues), which in turn influenced selection of both criteria and alternatives.” Another participant wrote “For so short a meeting, the problem was overly complex. We had some misunderstanding of what the criteria and alternatives were. Maybe introducing the approach with a simpler problem would have been more appropriate.” This sentiment was carried by another participant “… (We) needed a lot more time to look closely at alternatives and criteria.” As a result, a common complaint was that the participants needed more time in order to deal with such a complex issue (mean score 3.12).

Software Evaluation

Not only did the participants find that the decision support approach allowed for uncertainty (mean score 3.69) but it also allowed for socio, economic and cultural information about the impacts of fishing on the marine environment to be incorporated in the evaluation process (mean score 3.81). On the flip side participants didn’t think that the decision support approach allowed scientific information about the impacts of fishing on the marine environment to be incorporated into the evaluation process very well (mean score 2.96). As expressed earlier, the decision support software and methodology can support quantitative data but for these workshops it was not used due to time constraints and to facilitate ease of use. A participant recognized this, stating “(I) understand the application can handle quantitative data but we didn't use that function. A better understanding of this function could make me rate this higher.”

Participants especially felt that the decision support approach contributed to constructive discussion of the management alternatives by workshop participants (mean score 4.08). Participants also felt that the decision support tool was easy to use in the workshop (mean score 3.80). According to the survey results, the decision support tool helped to create common ground among participants on the management of possible adverse effects of fishing on the marine environment (mean score 3.32). A majority of respondents were satisfied with the results of the evaluation process (mean score 3.62). In addition, participants indicated that there is a potential of the decision support tool in stakeholder discussions about other contentious fisheries management issues (mean score 3.54). As one participant said “(The) support tool appears to have a significant potential for collaborative resolution of fishery management problems.”

Contact Us

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