Ten Recommendations for
Sustainable Fisheries on the B.C. Coast

SEAS OF CHANGE

by **Suzanne Tank** M.Sc.

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David
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Foundation

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Suzanne Tank is the Fisheries Analyst for the David Suzuki Foundation, where she uses her biological background to explore options for sustainable fisheries and fisheries management on the B.C. coast. Suzanne completed a Bachelor of Environmental Sciences at the University of Guelph, and a Master of Science at the University of Alberta which investigated how environmental stresses affect lake ecosystems. She has also worked as a biologist and researcher for governments and academics.

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David Suzuki Foundation
2211 West 4th Ave., Suite 219
Vancouver, B.C.
Canada V6K 4S2
Email: coast@davidsuzuki.org
Website: www.davidsuzuki.org
Tel (604) 732-4228
Fax (604) 732-0752

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Executive summary

British Columbia's fisheries are faced with a complex onslaught of habitat destruction, industrial pollution, and unsustainable fishing practices. Despite this, it is clear that fisheries and a healthy marine environment remain a fundamental part of British Columbia's culture and economy.

Today, the crisis faced by British Columbia's fisheries requires much more than simply catching less fish – although this is certainly critical in some cases. Instead, we need a new approach to fisheries management – one that will allow fisheries to continue well into the future, and allow those who fish to sustain themselves and their families.

The David Suzuki Foundation believes that such a new approach is both possible and critical, and has compiled ten recommendations for sustainable fisheries on the B.C. coast. These are:

- Manage the ecosystem, not individual stocks
- Adopt a precautionary approach to management
- Give those who care most about the fishery a say
- Decrease capacity and plan for stock fluctuations
- Protect diversity
- Protect habitat
- Create marine reserves to protect representative habitats
- Manage for and minimize bycatch and discards
- Make aquaculture sustainable
- Invest in monitoring, enforcement, and data acquisition

It is our hope that this document will inform and encourage dialog and actions that will create an economically and ecologically sustainable fishery for future generations.

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Table of contents

Introduction

What is the problem?

The Pacific coast of Canada is truly unique. Over 29,000 kilometres of coastline is bordered by an ocean with a vital suite of ecological properties. These properties – a lack of sea ice year-round, relatively constant water temperatures, and waters rich in nutrients – have given rise to a level of biodiversity[1] unparalleled in other Canadian waters. Over 400 species of fish live here (MSRM 2002), including more than 9,600 genetically distinct salmon stocks[2] (Slaney et al. 1996). At least 7,000 marine species inhabit these waters, which represent four percent of the world's marine biodiversity (CPAWS 2002). Such diversity has supported a rich fishing tradition along this coast for thousands of years.

Despite this rich species mix, the popular depiction of Canada's Pacific waters as pristine and with untapped resources is quickly becoming mythical. In just 100 years, Pacific salmon have disappeared from approximately 40 percent of their original range along the northwest coast of the United States (NRC 1996). In Canada it is also clear that the salmon fishery needs to change. Some stocks have declined to a level where they can no longer be fished, and overall catches have declined significantly. In the Fraser River, home to the most productive salmon fishery in the world (Northcote and Larkin 1989), the entire interior Fraser coho salmon population is officially considered endangered, as are Cultus Lake sockeye (COSEWIC 2003). Further up the coast, the Sakinaw sockeye population on the Sechelt peninsula is also officially listed as endangered (COSEWIC 2003). At least 140 stock extinctions have occurred, while many other stocks believed to be at risk (Slaney et al. 1996) have yet to even be assessed.

Salmon are one of British Columbia's greatest icons. Therefore, their decline has garnered much public attention. But salmon are not the only species in crisis in B.C. waters. Rockfish, which can live for more than 100 years, have been so overfished in some areas (Yamanka and Lacko 2001) that the fishery has declined to a point of near non-existence in many regions. Several other fisheries, like lingcod and abalone, have met with a similar, or worse fate (lingcod, DFO 2001a; abalone, COSEWIC 2003). And where dramatic collapses have not occurred, the numbers of fished species are almost universally down from historic levels. A scientific analysis of how the Strait of Georgia ecosystem has changed since 1880, for example, suggests that almost all commercially fished species have declined (Pauly et al. 1998a).

Paralleling these declines in stock numbers, changes to the structure of the fishing fleet have severely affected fishermen's ability to make a living. Programs to buy back salmon licenses in the early 1970s and again in the 1990s did nothing to solve the problem of over-capacity in the fishery. Instead, these programs resulted in a more industrialized and capital-intensive fishing fleet, whose boats are often high-tech and whose owners often live far from the resource (Edwards and Glavin 1999). Increasingly, fishing licenses are held by corporations which, in order to make a profit, may over-exploit local resources and then move on once the resources become depleted (M'Gonigle et al. 2000). Licenses are also often leased by an 'armchair' fisherman to one who actually catches the fish, causing him or her to pay an inflated price to be able to fish (Cruikshank 1995). Clearly, a new direction for British Columbia's marine fisheries is long overdue.

What is the purpose of this report?

Despite this disheartening state, there is still time for B.C. fisheries to recover. For the most part, we know where we are going wrong. The challenge is to find solutions. Along this coast and world-wide there are examples of fisheries that operate in balance with nature (see, for example, Pinkerton and Weinstein 1995). The purpose of this document is to outline solutions for our fisheries. Such solutions must allow fishing to occur in such a way that healthy ecosystems of fish exist for future generations, while at the same time allowing those who do fish now to sustain themselves and their families. In reality, making these types of changes is the only way that fishing can continue on Canada's Pacific coast.

How did we get here?

Before European settlement, fisheries on Canada's Pacific coast were managed by a complex framework of First Nations' regulations (Harris 2001). This framework resulted from thousands of years of adapting to, and depending upon, marine ecosystems (Lee and DeVore 1968). Despite rare incidents of over-exploitation, such as that of the Steller's sea cow, the rule in this fishery was for sustained harvests at levels the ocean could continually bear (Pauly et al. 2000). With European contact, colonial law was quickly imposed upon these fisheries. In many cases, traditional First Nations fishing methods became illegal[3] although First Nations fishermen were able, ostensibly, to fish alongside the new settlers if they purchased a fishing license (Harris 2001).

Even though licenses had to be purchased to partake, these early fisheries were largely open access. In other words, anyone who bought a license could fish and catch as much as they wished. Over time, the number of fishermen grew as did the ability to catch fish. This resulted in fisheries managers restricting access to fisheries and limiting the number of fish caught, often by imposing total allowable catches.[4]

The timing of the introduction of license limitations varied greatly between fisheries. In the Pacific salmon fishery, it began to occur in 1969 when Jack Davis, the Fisheries Minister at that time, announced a plan to limit the number of salmon fishermen. Conversely, other fisheries have just recently undergone license limitation. However, while it may seem counter-intuitive, this form of fishing control has seldom decreased the capacity to fish. Limiting the number of licenses actually creates a market for them, and the marginal fishermen who are catching just enough to get by, generally sell their licenses (Edwards and Glavin 1999). Not only does this result in corporate control of a fishery, it also can cause a situation where the ability of the fishing fleet to catch fish becomes increasingly greater than the ecologically defensible rate of harvest (Townsend 1990, Grafton and Nelson 1997). While other jurisdictions, like Alaska, have found methods to limit fishery participation to fishermen who own and operate their own fishing vessel (Pinkerton and Weinstein 1995), simple license limitation continues to be one of the primary means by which the fishery on the B.C. coast is managed.

Fisheries on this coast have also been characterized by management of single species, which maximizes the harvest of one species while ignoring the effects on all others in the ecosystem. It is now clear that such management methods have not always worked. In some cases, the data (Myers et al. 1997), or population growth assumptions (Hourston 1980) used to manage on a species-by-species basis have been poor, and stocks have collapsed. In others, fisheries have not been managed at all and stocks have collapsed before any regulatory regime has been established (Jamieson 2001). And sometimes, despite the best science, managers have allowed over-exploitation of a stock to meet immediate social pressures (Hutchings et al. 1997). However, single-species management has worked in some cases to maintain the population of one particular species at exploitable levels.

Because of this, the tools presented by single species management will continue to be useful for fisheries management in B.C. However, the problems outlined above make it clear that the fishing that these tools inform must be much more precautionary than it has been in the past.[5] And, we must undoubtedly do much more than just use single species management to manage our fisheries. Ultimately, managing this way has ignored important aspects of fisheries. First, many fisheries involve multiple species. Conserving biodiversity while harvesting using single-species models has failed worldwide. Second, this approach fails to address how one species fits into an ecosystem, how its removal affects other species, and how the ecosystem provides that species' needs, such as for habitat and food. When looked at from the perspective of the ecosystem, the rationale behind only using management measures that determine the surplus of a single species that can be harvested – in isolation of all other factors – becomes vague. In an ecosystem context, very little – if any – production is truly in surplus (Ecosystem Principles Advisory Panel 1999).

What has worked in the past?

Undoubtedly, there have been many sad stories in the history of Canada's Pacific fishery. The most common, perhaps, is that of salmon, whose harvest rates have often reached an alarming 85 percent of the available total (Glavin 1996), and for which increasing numbers of stocks are listed as endangered (COSEWIC 2003). In the late 1960s, herring went through a collapse brought about by tremendous overfishing (Departments of Environment and Fisheries and Oceans 1998). In the early 1960s, catches reached 250,000 tonnes per year (Departments of Environment and Fisheries and Oceans 1998). Then catch rates plummeted. In 1967, the herring fishery was closed coast-wide amidst fears it might never recover. The fishery has since reopened, focusing on a smaller harvest to generate greater value products. Despite these changes, however, the fishery is still periodically closed – particularly on Haida Gwaii (Queen Charlotte Islands) – because of low stock levels (Jones 2000, DFO 2002a and related documents).

There are, however, fisheries in British Columbia that can be held up as success stories to a greater or lesser degree. Some would call the herring recovery a success, despite the concerns outlined above. Many consider the halibut fishery to be a success. Halibut has supported a longline fishery in Canadian and U.S. waters for more than 100 years (Parma 2001), and has been important to First Nations for millennia. A commercial fishery was launched between 1910 and 1930, leading to a tripled fishing effort and a 70 to 90 percent decrease in catch (Clark and Hare 2002). This resulted in the creation of the International Pacific Halibut Commission, a joint Canada / U.S. body that has regulated the fishery since 1923 (Sullivan and McCaughran 1995). The stock was brought back from decline but again faced severe depletion in the 1970s, presumably because of heavy bycatch in an offshore trawl[6] fishery and a change in environmental conditions (McCaughran 1997). Since then, halibut in the north Pacific has again recovered with lower fishing mortality rates, and today seems stable (Sullivan and McCaughran 1995).

Although halibut stocks appear to be managed in a way that will continue to allow sustainable catches, the allocation system recently adopted in the fishery is more controversial. The fishery is based on a system of Individual Transferable Quotas (ITQs) that assure all licensed fishermen a set percentage of the total catch each year (McCaughran 1997).[7] Although the system has eliminated the ‘derby’ fishery that had come to characterize halibut fishing (Dewees 1998), it appears to have also eliminated many of the small boat fishermen, limiting participation and fishery control to fewer fishermen and more corporate interests that can invest in large, expensive boats. Because this is a lucrative fishery and halibut licenses can be bought and sold, increasingly only corporate interests may be able to participate. Further, issues surrounding the bycatch of vulnerable species like rockfish, and local stock depletions continue to exist (Wallace 2001, Glavin 2002).

Looking towards the future, an interesting partnership on the west coast of Vancouver Island may well be a success story waiting to happen. This is a co-management regime,[8] the West Coast Vancouver Island Aquatic Management Board (WCVIAMB), where governments, First Nations, fishermen and community members have been mandated by DFO to work together to make decisions about how the fishery should be managed. The board for this co-management group is comprised of First Nations, federal, provincial and regional district representatives, as well as non-governmental members such as sport and commercial fishermen (Pinkerton 2002). Through terms of reference approved by the federal Minister of Fisheries, this board is to develop and implement a strategy for the integrated management of aquatic ecosystems within the west coast of Vancouver Island management area (WCVIAMB 2001); hopefully putting behind it the clearly non-tenable methods of earlier fisheries management. It may be too early to know for certain the ecological benefits of this management partnership. One barrier will certainly be overcoming some serious concerns that Fisheries and Oceans Canada (DFO) is not truly committed to allowing the meaningful, shared decision-making necessary to make this process viable. At least, however, the Board is a model for bridging the distance between disparate groups that has been so common in Canada's Pacific fisheries.

Where are we now?

With the release of the *Oceans Act* in 1997, the Canadian government ostensibly embarked on a new direction for fisheries management. In its preamble, the *Act* commits Canada to marine management based on sustainable development, integrated management[9], and the ecosystem approach[10] and precautionary principle[11] – all of which are critical to sustainable oceans management.

However, despite its promising language, Canada's *Oceans Act* is simply 'enabling' legislation. This means that the *Act* does not compel anyone to change his or her actions or even to comply with what the *Act* says. Instead, the *Oceans Act* enables the government, through the Department of Fisheries and Oceans, to move towards more responsible practices. To date, any momentum for such movement has been lacking.

Although the government releases Integrated Fisheries Management Plans, these still do not truly assess the impact of removing a stock on the surrounding ecosystem. Nor has DFO yet put into place strategies to ensure the needs of species are met by the ecosystem. Further, there is little integration of social considerations into fisheries management. And, although this new direction is billed as an integrated, ecosystem-based approach, the vast majority of the research budget is still spent on only a few fisheries.

Alarmingly, B.C. fisheries continue to be substantially owned by corporate interests. Recent estimates put nearly 40 percent of the salmon seine fleet under the control of just one company (Edwards and Glavin 1999), and one-third of the trawl fishery under the control of just seven (Glavin 1996).

Where would we like to be?

Many things must change to ensure the viability of marine ecosystems and the future of fishing communities on British Columbia's coast. We must begin to catch fish at a rate that the ecosystem can bear, and respect the entire ecosystem – fished and unfished species, predator and prey – rather than just the exploited species in question. If we do not know what this rate is, we must err on the side of caution. Fisheries must be selective, so that stocks and species not intended to be caught are not killed as a by-product of fishing. Because our oceans and their bounty are a common property, their benefits, and how they are managed, must be shared equitably among a larger public than just those who catch fish. Although this last point carries with it important ethical weight, its value is more than that. Increasingly, evidence shows that involving the wider community in management – and not just those who benefit economically from fishing – is crucial for fisheries to be ecologically, as well as ethically, viable. Finally, we must better protect crucial fish habitat like the ocean bottom, nearshore areas, and rivers and streams – an endeavour that may take us outside the narrow boundaries of fisheries management.

NOTES TO INTRODUCTION

1 **Biodiversity**, or biological diversity, is the variety of life. It consists not only of all species of plants, animals and other organisms, but also the range of differences within each species, and the variety of ecosystems (IUCN, UNEP and WWF 1991).

2 We refer to "locally adapted spawning populations [that] originate from spatially well-defined locations" as a **stock** (Slaney et al. 1996). In many scientific texts and documents, this grouping would be referred to instead as a **deme**.

3 Traditional First Nations fishing methods include fish weirs and dip nets. They were replaced by less selective, open-water fishing methods that employed techniques such as seine and gill netting (Harris 2001). The need for more selective fishing methods is discussed in more detail in Recommendation 5.

4 **Total allowable catch**, also referred to as **TAC**, is the annual allowed catch of a particular species, in any given fishery.

5 In a few cases, this is occurring. Many new invertebrate fisheries in B.C. are managed by a precautionary framework laid out in Perry et al. (1999).

6 **Trawlers**, often also referred to as 'draggers', function by towing a funnel- or bag-shaped net through the water. Although trawl nets are often dragged along the sea bottom, they are also often towed above the ocean bottom at various depths.

7 The ITQ allocation system is discussed in more detail in Recommendation 4.

8 Here, we use **co-management** to mean a partnership between community members and government bodies to manage the community's fishing interests. Its usefulness and different forms of co-management are further discussed in Recommendations 3 and 4.

9 Ideally, a system of **integrated management** integrates management activities across industry sectors, political boundaries, ecological boundaries and applicable levels and departments of government (WWF 2002).

10 The **ecosystem-based management** approach to fisheries management is one that takes all ecosystem components and services into account in managing fisheries. If successful, management that focuses on ecosystem structure and function will also improve the sustainability of fisheries (NRC 1999). The topic of ecosystem-based management is explored in more detail in Recommendation 1, and throughout this report.

11 The **precautionary approach** to management begs caution until clear evidence is found to support fishing or an increase in fishing pressure. In many ways this is directly opposite to how fisheries have traditionally been managed, where scientific evidence of harm through fishing needed to be demonstrated before a change in policy occurred (Garcia 1994).

RECOMMENDATIONS

RECOMMENDATION 1

Manage the ecosystem, not individual stocks

Rationale

Almost ubiquitously, fishing affects ecosystems significantly. Within species, it generally acts as a selective agent by targeting older and larger fish, removing the organisms with the greatest reproductive capacity from the population, and causing selection towards smaller individuals (Conover & Munch 2002). Among populations, fishing practices target higher trophic levels[1] disproportionately, thus leading to a trend where we are "fishing down the food web" – causing drastic changes in marine food webs through the removal of choice species (Pauly et al. 1998b). Further, unintended catch, or 'bycatch' has enormous effects on the marine ecosystem, adding to fishing mortality by increasing fishing pressure on already heavily exploited stocks and removing important components of the marine ecosystem (NRC 1999). This bycatch is often discarded.

Fishing also affects ecosystems physically. One striking example of this occurs in the trawl fishery, which has been cited as the marine equivalent of forest clearcutting. As the trawl apparatus drags along the sea floor it upends and crushes crucial habitat structures and marine animals (Watling & Norse 1998). Ecosystem damage caused by other activities also drastically harms critical fish habitat. The effect of poor forest practices is just one example of this: improper logging can alter water flow regimes, increase water temperatures, and cause landslides and soil erosion in and into the freshwater streams that are essential habitat for salmon (Hicks 2002).

Clearly, human activities such as fishing have the power to change ecosystems drastically. At the same time, ecosystem change will certainly affect fish populations. Thus, in order to understand the level of harvest a population of fish can bear, we must also understand the ecosystem in which it exists. Removals of a species' predators, or its prey, or changes to its habitat will all drastically affect the level at which this species can be fished.

Understanding and taking these interactions into account is critical to fishing in an ecologically viable manner.

Further, as much as we must understand the ecosystem surrounding a species in order to assess the level at which it might be fished, we must also ensure ecosystem integrity in order to maintain healthy fisheries. Changes in habitat and food-web structure have led to drastic results in the past. One example of this is the extensive changes in ecosystem structure caused by the decline of the sea otter. Because of their valuable pelts, the sea otter population was hunted to near extinction in the early 1900s. This led to a vast increase in biomass[2] of one of their food sources, the sea urchin, which in turn decimated the once-abundant kelp forests of the West Coast. These kelp forests and their by-products were a crucial food source for many herbivores, including mussels and barnacles (Duggins 1980, Duggins et al. 1989, NRC 1999).

Most important, perhaps, is the need to sustain ecosystem integrity in and of itself. However, the integrity of ecological systems is also critical for social and economic well-being now and for future generations (Christensen et al. 1996, Drever 2000). All of the world's ecosystems provide goods and services, without which life on earth would cease to exist. In the marine environment, ecosystem goods and services range from the provision of food, to the regulation of the earth's climate system, to the assimilation of pollutants (Ehrlich & Ehrlich 1991). The totality of services that the world's ecosystems provide us is astounding: one study has estimated that the goods and services humans derive from the planet's marine ecosystems totals a staggering $21 trillion annually (Costanza et al. 1997).

Current practices

Several pieces of legislation lay the foundation for Canadian fisheries management. Of these, the *Fisheries Act* recognizes that habitat protection is a key component of effective fisheries regulation. Section 35(1) of the *Act* states:

> *"No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat."*

This addresses one important piece of the ecosystem-based management puzzle. Despite the strength of this legislation, however, the *Act* was never intended to fully recognize the need for management at the scale of the ecosystem. More recently, the *Oceans Act* was established in an attempt to fill this yawning gap. As part of its preamble, the *Oceans Act* states:

> *"… Canada holds that conservation, based on an ecosystem approach, is of fundamental importance to maintaining biological diversity and productivity in the marine environment."*

Distressingly, this need for management that recognizes the importance of ecosystem considerations is never actually addressed in the body of the *Oceans Act*. Further, the *Act* is largely 'enabling' legislation, meaning it can enable governments to move in the outlined direction rather than to mandate change. One of the few things the *Act* explicitly required was the creation of an *Oceans Strategy*, the action points of which have done nothing to address the need for management in the context of the ecosystem. DFO's most recent Sustainable Development Strategy, which expired at the end of 2003, also addresses ecosystem-based

management by stating, among other things, that DFO must "develop an operational framework for incorporating eco-system considerations into fisheries and oceans management", and "consider multi-species and ecosystem-type approaches". It is unclear how, or whether, this has occurred.

The *Canadian Environmental Assessment Act* (CEAA) does recognize the need to address the entire scope of ecological impacts from an activity. Unfortunately, this legislation has yet to be applied to fishery activities, and to date it has mainly been applied to industrial developments and similar undertakings. Even here DFO has tended to be very narrow in its consideration of the effects of a project.

Best practices

Despite the importance of healthy ecosystems for all aspects of human life, there are few working examples of ecosystem-based management. Those that do exist are new and therefore remain largely untested. Even so, several fisheries management systems appear to be moving in the right direction. Two of these are discussed below and on page 12.

Best practices: example 1

The Back to the Future approach to fisheries management

The Back to the Future approach to fisheries management is an innovative one, based on the premise that "rebuilding rather than sustaining" is the correct goal for fisheries management in almost all marine ecosystems (Pitcher & Pauly 1998). This method was developed by researchers at the University of British Columbia. Its proponents highlight our knowledge that marine food webs have degraded from what they once were, with most top-level species greatly removed or severely depleted (Pauly et al. 1998b). To overcome this, Back to the Future uses models to reconstruct the state of an ecosystem at several key time periods,[3] thus giving managers a concrete ecosystem status goal to work towards (Pitcher 2001).

Although this approach is in its infancy, and thus still saddled with several key shortcomings, its benefits are multi-fold. First, the modeling approach used is a relatively simple one, making the process much more inclusive, useful, and practicable than might be expected (Pitcher et al. 1999). Second, the process is a participatory one, relying on – among other things – traditional and local knowledge to build past ecosystems (Pitcher 2000). Third, this approach includes a process by which different ecosystem states can be economically valued. The ecosystem state that maximizes total benefit to society can then be set as a management benchmark (Pitcher et al. 1999), which is an important goal for viable fisheries (NRC 1999). Not surprisingly, the most valuable ecosystem state is likely to be one of the past when abundance of exploited species was greater (Pitcher & Pauly 1998). Finally, viable rates of harvest can be defined in such an ecosystem model as ones that do not alter the structure of the ecosystem (Pitcher et al. 1999).

Best Practices: example 2

Fisheries management under the *Convention on the Conservation of Antarctic Marine Living Resources* (CCAMLR)

Since exploitation of the Southern Ocean began, fishing in this region has been characterized by periods of heavy activity, which have often resulted in the severe depletion of harvested stocks (Kock 2000). The *Convention on the Conservation of Antarctic Marine Living Resources* (CCAMLR) came into force in 1982 in response to the recognition that the conservation of krill, a newly exploited species at that time, was fundamental to the maintenance of the Antarctic marine ecosystem (Kock 2000). CCAMLR is an international agreement that differs from many other fisheries conventions in that it mandates the conservation of ecosystems, in addition to regulating fishing effort (Kock 2000, WWF 2002). Article II of the *Convention* states:

There are few working examples of ecosystem-based management

> *Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:*
>
> *(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;*
>
> *(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and*
>
> *(c) prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades … with the aim of making possible the sustained conservation of Antarctic marine living resources.*

In order to attain an ecosystem approach to management, CCAMLR attempts to minimize the adverse effect of fisheries on "dependent and related species". Because CCAMLR recognizes its lack of knowledge to regulate such a large and complex ecosystem, its approach is to focus instead on key 'indicator' species of the food web. Although single species models form the foundation of the CCAMLR management approach, the crucial step of going beyond single species models and integrating ecosystem considerations into decisions has been made. As an example, in order to set acceptable fishing levels for krill, CCAMLR has taken both the krill population into account and the needs of key species dependent on it, such as seabirds and seals, which are also monitored (Kock 2000, WWF 2002).

Although the CCAMLR has largely pioneered an ecosystem approach to management (WWF 2002), its methods are not problem-free. They continue to struggle with problems related to illegal catch, while a recent report suggests that the current allocation for krill may in fact be negatively impacting the Antarctic fur seal population (Thomson et al. 2000). Positively, however, one element central to CCAMLR's management approach is to continually refine its management scheme as knowledge evolves (Kock 2000).

How do we get there?

Although single-species models will continue to be important for fisheries management, it is clear that we must also undertake a much more integrative form of management. In a report to the United States Congress, the Ecosystem Principles Advisory Panel (1999) suggests a series of steps for moving towards ecosystem-based management. Many of these are also applicable to the British Columbia situation. They include:

1. **Delineate the geographic extent of the ecosystem(s) that occur(s) within a management area.** Ecosystems supporting fisheries vary greatly, which will influence how the fisheries are managed. In addition to mapping ecosystems, the biological, chemical and physical dynamics within each ecosystem should be described. This information should then be used to zone the area for alternate uses, such as limiting certain fishing gear or establishing marine protected areas.
2. **Develop a conceptual model of the food web within each ecosystem.** In order to make informed decisions about harvest levels, managers must have an understanding of the food web under their care. All commercial species should have their predator and prey species described at each stage of their life cycle in their fisheries management plan.
3. **Describe the habitat needs for each of the life history stages of all plants and animals contained in the above food web**. In order to protect the organisms within ecosystems, it is essential to also protect the habitat that sustains them. Management plans should include provisions to protect the critical habitat of all life history stages of organisms.
4. **Calculate the total fishing mortality and show how it relates to standing biomass, production, natural mortality, and trophic structure.** Too often we are unaware of the total biomass being fished from the oceans. In order to prevent a situation where fishing results in a loss of ecosystem health, we must have a firm grasp on the total fish landed, caught and released, and caught or killed as bycatch. This must occur across all fishing sectors and gear types.
5. **Develop indices of ecosystem health as targets for management.** In order to ensure healthy ecosystems, we must have a firm grasp on what defines ecosystem health. One way to do this is to identify 'unhealthy' ecosystem states to avoid. Alternatively, targets might include the maintenance of all ecosystem components or of a certain percentage of biomass relative to the unfished state. This is similar to the approach used by CCAMLR. Another approach is to target management towards a previous, healthier ecosystem, such as in the Back to the Future approach, above.

(Adapted from Ecosystem Principles Advisory Panel 1999).

NOTES TO RECOMMENDATION 1

1 The **trophic level** of an organism is their position in the food chain, determined by the number of energy-transfer steps (i.e., a predator eating a prey item) to that level. For example, plants are assigned a trophic level of 1, and organisms that eat only plants a trophic level of 2.

2 **Biomass** refers to the weight of living material.

3 Because ecosystems vary in their exploitation history, the time periods chosen for reconstruction in Back to the Future will also vary (Pitcher 2001). For example, in their modeling of the Strait of Georgia, the Back to the Future team chose to model (a) the present day, (b) 100 years ago, before the onset of large salmon fisheries, and (c) 500 years ago, before European contact and settlement (Pauly et al. 1998a).

RECOMMENDATION 2

Adopt a precautionary approach to management

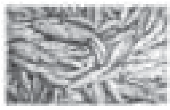
Rationale

Uncertainty is inherent in ecosystem management. In some cases, our uncertainty about ecosystem structure and function can be lessened through collecting better data or increasing our understanding of ecosystem processes (Hilborn 1987, Christensen et al. 1996). However, ecosystems are complex and transient and we must recognize that we will never completely understand them (Hilborn 1987). Thus, incorporating uncertainty into fisheries management decision-making processes is crucial.

One approach central to dealing with uncertainty focuses on reversing the burden of proof (NRC 1999). Traditionally, this burden has been placed on fisheries managers who have been forced to demonstrate that a fishery causes harm before it might be curtailed. In the face of uncertainty, the general rule has been to err on the side of socio-economic considerations, resulting in overfishing, rather than cut back to what the ecosystem can sustain and risk the possibility of damaging communities economically (Ecosystem Principles Advisory Panel 1999).

Reversing this burden to favour the ecosystem would mean caution until clear evidence is found to support increased fishing effort (Garcia 1994), or to ensure that increased habitat alteration will not result in unacceptable harm. This switch in the burden of proof is embodied by the precautionary principle, as laid out in the United Nations Food and Agriculture Organization's (FAO) *Code of Conduct for Responsible Fisheries*. In practice, such a switch will mean that when the effects of fishing on species or the surrounding ecosystem are unknown, fishing should not expand within species or to new 'under-utilized' species (Ecosystem Principles Advisory Panel 1999). The same is true for non-fishing activities that affect fish habitat.

The traditional emphasis on short-term rather than long-term goals, i.e. overfishing for economic gain rather than managing for ecosystem viability,



has had disastrous consequences. Worldwide, the global catch of fish is declining despite increasing fishing effort (Pauly et al. 2002). In fact, 70 percent of species currently fished have been assessed as fully- or over-exploited (Botsford et al. 1997). In Canada, examples of such overfishing have been dramatic, particularly on the East Coast with the collapse of cod stocks (Hutchings and Myers 1994), and in British Columbia with species like rockfish (Wallace 2002) and abalone (Jamieson 2001). Most troubling is research that suggests that once a population is exploited to the point of collapse, it may take decades, or longer, to recover (Hutchings 2000).

Current practices

The FAO *Code of Conduct for Responsible Fisheries*, of which Canada is a signatory, requires the adoption of the precautionary principle. Sections 12 and 13 of the *Code of Conduct* state:

> *The precautionary approach recognizes that fisheries systems are slowly reversible, poorly controllable, not well understood, and subject to changing human values.*
>
> *The precautionary approach involves the application of prudent foresight. Taking account of the uncertainties in fisheries systems and the need to take action with incomplete knowledge, it requires, among other things:*
>
> *(a) consideration of the needs of future generations and avoidance of changes that are not potentially reversible;*
>
> *(b) prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly;*
>
> *(c) implementation of necessary corrective measures without delay, to achieve their purpose promptly, on a time scale not exceeding two or three decades;*
>
> *(d) that where the likely impact of resource use is uncertain, priority be given to conserving the productive capacity of the resource;*
>
> *(e) harvesting and processing capacity commensurate with estimated sustainable levels of the resource, with increases in capacity further constrained when resource productivity is highly uncertain;*
>
> *(f) all fishing activities having prior management authorization and being subject to periodic review;*
>
> *(g) an established legal and institutional frame-work for fishery management, containing plans to implement the above points, and*
>
> *(h) appropriate placement of the burden of proof by adhering to these requirements.*
>
> (Adapted from FAO 1996 and Mace 1997).

Arguably, few of the above are heeded by Canada's current fisheries management strategy. The *Oceans Act* stipulates that Canada "lead and facilitate the development of a national strategy for the management of estuarine, coastal, and marine ecosystems … [which] will be based on the principles of … the precautionary approach, that is, erring on the side of caution". However, this newly released *Oceans Strategy* does nothing to explicitly incorporate precautionary decision rules into Canada's ocean policy (DFO 2002b), and it seems that lack of information or uncertainty will not be used to delay development. This is despite the fact that Canadian courts have determined that conservation must be the first priority in Canadian fisheries (R. v. Sparrow 1990).

Best practices

Despite its signature of the FAO *Code of Conduct for Responsible Fisheries*, there is no one over-riding direction for precautionary management in Canadian fisheries. Of the examples below, one highlights an approach that has been implemented in a few B.C. fisheries.

How do we get there?

To accompany the signing of its *Code of Conduct*, the FAO has released a compilation of detailed guidelines for attaining precaution in fisheries management (FAO 1996). Among other things, they suggest that jurisdictions adopting precautionary management for fisheries must:

1. Within all management plans, develop and describe precautionary actions that will be taken to avoid undesirable outcomes, such as

Best practices: example 1

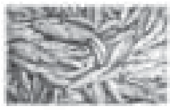
The *Convention on the Conservation of Antarctic Marine Living Resources* (CCAMLR)

Precaution is central to the CCAMLR approach to management and is embodied in one of the principles of Article II of the Convention, which states,

> "*… prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades …*".

Towards this end, CCAMLR has endeavoured to set precautionary catch limits and tie TACs of target species to TACs of bycatch species so that a fishery might be closed when the TAC for a bycatch species is reached, even if the target species has not been fished to its limit (Kock 2000). Under the Convention, new and emerging fisheries are managed with the knowledge that management should be precautionary from the start, with an aim to ensure that a new fishery is not allowed to expand faster than the information necessary to manage the fishery in an ecologically viable manner becomes available (Kock 2000). Among other things, CCAMLR may mandate limited catch or fishing effort, or make scientific observation of the fishery mandatory (Kock 2000).

Despite its advances, CCAMLR continues to be faced with the problem of Illegal, Unreported, and Unregulated (IUU) fishing (WWF 2002). IUU fishing continues to take substantial quantities of toothfish from the Southern Ocean area well above scientific estimates of the sustainable global limit of fishing for this species. CCAMLR has responded to this issue by developing a range of measures that should make IUU fishing more difficult and less profitable (WWF 2002).



overfishing, overcapacity and habitat damage.

2. Specify precautionary management targets and constraints. This is similar to recommendations discussed in Recommendation 1. Targets might include the level of desired abundance relative to the un-fished state, or target fishing mortality. Constraints should define the undesirable outcomes to be avoided.
3. Develop precautionary decision rules[1] to allow for quick, ecologically valid actions in

Best practices: example 2

Framework for New Invertebrate Fisheries Management, British Columbia

As fisheries around the world become increasingly exploited, the trend has been to turn to new, unexploited species for continued fishing revenue. The strategy used to manage many new invertebrate fisheries in British Columbia is based on precaution, and was developed with the recognition that by the time enough scientific information existed to properly manage new fisheries, the species was often already overexploited (Perry et al. 1999). The system is a simple one, consisting of three phases. The first is a compilation of existing information on the species and related fisheries from around the world – an obvious step often overlooked in fisheries management. The second consists of collecting new information, often in the form of small, experimental fisheries, and the evaluation of alternative management strategies. In the third phase the fishery moves to monitored fishing. This phase should be an adaptive one, using the information collected to continually assess the success of fisheries management (Perry et al. 1999).

This framework has been employed in several fisheries on B.C.'s coast. One successful example is that of the sea cucumber fishery, which, after a period of rapid expansion that saw declines in catch per effort, had its management regime changed to follow this approach. Today, this fishery is in the third phase of development (Perry et al. 1999), however, only 25 percent of B.C.'s coast is opened to sea cucumber fishing. A further 25 percent of the coastline has been designated for scientific research to better determine the sea cucumber stock size on the Pacific coast, while the final 50 percent of the coast is closed to sea cucumber fishing altogether (DFO 2003a). Continued learning about how this species responds to exploitation will be used to refine management (Perry et al. 1999). This framework, however, has not been applied universally, or with full rigour to all invertebrate fisheries on the B.C. coast. Further, although it has also been retroactively applied to more established fisheries, this has not always met with the full success described above (e.g., Orensanz et al. 2000).

By the time enough scientific information existed to properly manage new fisheries, the species was often already overexploited

the face of change. Decision rules should include those that respond to unexpected or unpredictable events.

4. Develop contingency plans to ensure the ability to meet targets in the face of major adverse, low-probability events, and include mechanisms for revising targets and constraints if necessary given such events.
5. Evaluate the management plan, and not accept the plan until it has been shown to perform effectively; re-assess the level of precaution in the plan periodically.
6. Monitor, in order to collect all information necessary, to ensure the plan is being executed properly and to detect ancillary impacts.

The committee members responsible for these guidelines further recognized that "although the precautionary approach to fisheries may require cessation of adverse fishing activities, it does not imply that no fishing can take place until all potential impacts have been found to be negligible" (Adopted from FAO 1996).

The need to apply a precautionary approach to issues such as habitat protection is discussed in Recommendation 6.

NOTE TO RECOMMENDATION 2

1 A **decision rule** is a pre-agreed description of what management actions will take place given future possible states of nature (FAO 1996).

RECOMMENDATION 3

Give those who care most about the fishery a say

Rationale

Worldwide, we are faced with the failure of centralized, government-based fisheries management (Lane and Stephenson 2000). While the failures in British Columbia's marine fisheries have not been quite as spectacular as on Canada's East Coast, the fact remains that several species and stocks on the West Coast have been managed so poorly that we do not know when, or if, they might return to fishable levels. A global examination of fishery management models reveals that in many cases those that are sustainable allow the community of interest[1] surrounding a fishery to actively participate in the decision-making governing its management. While at first this may seem like 'putting the fox in charge of the hen house', this type of management has both proposed and proven many benefits. In fact, modern-day models that allow fishermen control of their resource have persisted in many cultures and places for hundreds of years (see, for example, Pinkerton and Weinstein 1995).

One clear advantage of this type of management, often referred to as co-management,[2] is the enormous volume of knowledge brought to the table by First Nations, fishermen, and related stakeholders. Certainly, scientifically collected information remains crucial for making informed decisions about fisheries management (Felt et al. 1994), but recognizing the importance of and seeking out the vast body of traditional and local ecological knowledge possessed by those with a history of fishing can only lead to better information being available for decisions. In many cases, this knowledge may contribute the only information available for a given area, clearly increasing the likelihood of decisions that are appropriate to the eco-region or species in question (Costanza et al. 1998, Pinkerton 2002). Alternatively, aboriginal and local knowledge may provide managers with hypotheses based on many years of observation (Pinkerton 2002).

The usefulness of aboriginal and local

knowledge also goes far beyond the ecological. Because of their understanding of fishermen and fishing communities, the information provided by the community of interest allows rules to be developed that assign responsibility correctly and are workable within the bounds of the specific region, fishery, or both (Pinkerton 2002). Further, using aboriginal and local knowledge to arrive at locally appropriate solutions can help to ensure that the regulations surrounding a fishery are more likely to benefit local fishing communities (Costanza et al. 1998). In an age of increasing fisheries commercialization, it is important that at least long-established fisheries benefit those who have traditionally participated in them.

Perhaps most importantly, if the community of interest is able to (1) contribute information that is seen as valid, (2) have a role in deciding the rules and responsibilities surrounding the fishery, and (3) in turn derive benefit from their fishery, participation acts to legitimize the rules themselves (Felt et al. 1994, Brown 1998, Costanza et al. 1998). Thus, through participation the fishery stakeholders might increasingly accept and comply with the rules governing their fishery: a goal that has repeatedly eluded centrally-based fishery managers (Felt et al. 1994, Brown 1998). This legitimization may additionally lead fishermen to go beyond rule compliance and actually work to ensure that rules are enforced. Despite the fact that volunteerism by fishermen is often seen as a contentious issue that represents the abdication of federal responsibilities (J. Sutcliffe, Canadian Council of Professional Fish Harvesters, personal communication), several sociologists have shown that when fishermen have a meaningful role in the management of their fishery, they will work to ensure its survival (Pinkerton 2002).[3]

Current practices

Decisions regarding licensing, allocation, and regulation of fisheries falls to Fisheries and Oceans Canada, as legislated by the *Fisheries Act*. Generally, the existing consultative process has evolved in an ad hoc manner (DFO 2000), and is different for different fisheries. Commercial and recreational fishermen have long been incorporated into the consultation process, although there is no guideline that outlines how or whether their input must be considered. At the same time, fishermen have been disenfranchised by consultation processes because those who are asked to consult with DFO often do not represent the entire commercial sector (D. Lane, T. Buck Suzuki Environmental Foundation, personal communication). More recently, First Nations and conservation groups have been recognized as having full interest in consultation processes (DFO 2003b). Despite this, it is unclear whether these groups will have equal access to decision processes.

In B.C.'s non-salmon fisheries, consultation occurs to a greater or lesser extent. There appears to be more rigorous consultation for fisheries governed by individual quotas (such as sablefish and halibut), but consultation is only with the small group of directly concerned license holders, processors and scientists, rather than a broad community of interest representative of other fishermen, conservation groups and the general public (Felt et al. 1994). For example, halibut harvesting decisions in Canada and the United States are overseen by the International Pacific

Halibut Commission (IPHC), a joint Canada / U.S. body. Three Canadian and three American commissioners are appointed by their respective governments. Traditionally, each country has appointed one employee of their federal fisheries agency (in Canada, DFO), one fisherman, and one buyer or processor. Ultimately, the commissioners adopt regulatory measures after considering the advice of representatives from the commercial and sport fishing sectors, and the processing sector (IPHC 2002).

In Canada, consultation with First Nations differs from that with other interested parties. Recent federal court decisions have required the Department of Fisheries and Oceans to consult formally with individual First Nations and aboriginal organizations regarding the fishing they wish to conduct and the management measures to be implemented in these fisheries. Despite these obligations, there is significant debate about what consultation entails. Government has generally interpreted court decisions in a very restrictive way. However, recent legal rulings have ordered that consultation must be meaningful and that accommodation of aboriginal title – including compensation for infringements on title – must occur (Delgamuukw v. British Columbia 1997). Consultation has often occurred through the negotiation of fisheries agreements with individual First Nations. Of the First Nations on Canada's Pacific coast, only the Nisga'a are signatory to a modern-day treaty. Because of this, the Nisga'a have treaty rights to given allocations of finfish and shellfish species within their treaty area, and certain rights to decide how this allocation is managed (Nisga'a Final Agreement 2000).

One example of co-management in Canada's Pacific fisheries is that of the West Coast Vancouver Island Aquatic Management Board. Formally established in early 2002, the Board will "lead and facilitate the development and implementation of a strategy for the integrated management of aquatic ecosystems in the management area" (WCVIAMB 2001). The Board consists of federal, provincial, First Nations, and municipal government members, as well as non-governmental members. Its decisions are reached by consensus. The authority of the Management Board has been mandated to range from information-sharing for management purposes to full responsibility for management, depending largely on the degree to which the management action impacts the management area (WCVIAMB 2001). Despite these advances, however, concerns have recently been raised that DFO is disinclined to allow community members an effective role in this shared decision-making venture. If this continues to be the case, it could be fatal to the Board (G. Mirau, WCVIAMB member, personal communication).

Best practices

There are many means by which a community of interest might increase their contribution to the operation of their fishery. The co-management example discussed below is a very deep-rooted one where only local inhabitants can participate in fishing or managing local fisheries. Although this model has been highly successful, other options are discussed later in this chapter for including broader communities in fisheries decision-making, and for dealing with fisheries that are more complex.

Best practices: an example

Japanese coastal fisheries

Unlike most examples of co-management, Japan's co-managed coastal fisheries are not limited to one, small geographic pocket. As long as a fisherman belongs to a cooperative association he or she can fish in Japanese coastal waters (Felt et al. 1994, Lim et al. 1995). The current management system was established in 1949, but is based on a culture of fisheries management that goes back to Japan's feudal era (Ruddle 1992). In the current system, the fisheries rights to a given area are under the jurisdiction of a Fisheries Cooperative Association (FCA), and are the personal property of FCA members (the fishermen). Over 2,000 FCAs exist in coastal Japan (Felt et al. 1994). Although higher levels of management exist, the FCA tends to oversee the day-to-day operations of the fishery, including the creation of management plans, approval of regulations, and budgets and licenses (Pomeroy and Birkes 1997).

Because the rules are essentially made by the fishermen themselves their legitimacy is high and recorded incidences of rule breaking are low (Lim et al. 1995)

Boards of Directors, which are elected by individual fishermen (Lim et al. 1995), administer the FCAs, and these boards include representatives of the different types of fisheries in the FCA (Lim et al 1995). Further, through small group decision-making, individual fishermen retain control of many of their own affairs (Ruddle 1992). Membership in FCAs is restricted to residents actively engaged in fishing (Ruddle 1992), and members who do not abide by the rules risk expulsion from the local cooperative (Jentoft 1989). However, because the rules are essentially made by the fishermen themselves their legitimacy is high and recorded incidences of rule breaking are low (Lim et al. 1995). The success of Japan's inshore fishery is largely attributed to this system of management, which continues to deliver 26 percent of the country's fisheries production and 41 percent of its fisheries value (Ruddle 1992).

How do we get there?

We are becoming increasingly aware that all stakeholders must be involved in the formulation and implementation of decisions concerning natural resources (Costanza et al. 1998). When the process of stakeholder involvement is not carried out in a complete and transparent manner, the rules governing a fishery often are not considered credible and thus are not accepted and followed (Costanza et al. 1998). Despite the fact that managing fisheries is more about managing the actions of people than fish populations, management systems have been slow to include human activities in crucial fisheries management decisions (Pinkerton and Weinstein 1995).

In any specific fishery, different types and magnitudes of stakeholder involvement are warranted. Options available for increased involvement are numerous, ranging from public hearings to partnership management, to full

community-based management (NRC 1999). As laid out by Pinkerton and Weinstein (1995), fishing communities suitable for co- or community-based management possess several key characteristics. These include the community being:

(a) highly dependent on the fishery,
(b) highly vulnerable to non-sustainable use,
(c) highly identified with their fishing place,
(d) unwilling to transfer access rights away from the fishery,
(e) able to assert their management rights, including the right to ensure habitat stewardship, and
(f) willing to ensure equitable resource access and to invest resources in management (Modified from Pinkerton and Weinstein, 1995).

While co-management will occur most easily when all of these conditions are in place, with more effort effective partnerships can occur in their absence (Pinkerton and Weinstein 1995). This is particularly true where only a few of the above characteristics are lacking.

Under the co-management umbrella, many types of arrangements are possible. Decisions about the types of responsibility to be undertaken cooperatively must be made with the recognition that different rights exist within a fishery. These include the right to make and evaluate policy, to regulate access, to regulate harvest, to enforce rules, and to coordinate with other uses (Pinkerton and Weinstein 1995). Not all of these rights will be appropriately vested in all co-management partnerships; their selection and combination will affect the ability of the partnership arrangement to achieve efficiency and conservation (NRC 1999, Pinkerton 2002).

The type of community of interest to be included in the responsibility of management must also be evaluated. Because they are most connected to and dependent upon the local resource, a local community is much more likely to undertake ecologically conservative management. However, in most cases, geographically-based communities will not fully encompass the community of interest surrounding a particular fishery. External interests may include fishermen that partake in the fishery but do not live adjacent to the resource, interested scientists, and members of the conservation community. Some fisheries may not be geographically based at all. When the community of interest does not meet all of the above-listed requirements for co-management, formal checks and balances and constant monitoring are needed to ensure sustainable management of the resource. Such mechanisms might include formalized, outside reviews of management measures (Pinkerton and Weinstein 1995, Walters 1995). Alternatively, in situations where a group of community members (often non-local) is likely to lead the management regime off-track, their participation might be limited to certain, central management decisions (Pinkerton 2002). This is exactly what has occurred on the West Coast Vancouver Island Board where non-local fishermen do sit on certain committees but are not represented directly on the Board that makes overall policy (Pinkerton 2002).

No matter how carefully communities craft a co-management arrangement, however, they will likely face several barriers to initiating local authority. Pinkerton (1999) identified several such barriers and possible approaches to overcome them. These barriers included (1) the desire of government to control data, (2) the tendency of government to push traditional management approaches such as mass harvesting and processing, (3) the domination of policy by the needs of large harvesters, and (4) the privatization policies that are increasingly being supported by DFO.[4] Perhaps the greatest impediment to establishing working co-management regimes in British Columbia, however, is the fact that co-management is clearly dependent on government willingness to create the appropriate legal frameworks to support it (Felt et al. 1994). In order for co-management to succeed, therefore, the many current legal impediments to local authority must be removed (Walters 1995).

It is also important to recognize that Canadian fisheries are a public resource managed on behalf of all Canadians. Although the right to manage them is designated to a few individuals, they truly belong to all of society. Because of this, several overarching principles for community management should be decided upon by society at large. Questions of this nature might include the standard of risk that is acceptable when making fisheries decisions,[5] and the speed with which we should move towards implementing local authority management (Walters 1995). Rather than rapidly adopting this new approach to management, as has been done in the past with endeavours such as hatcheries and the move towards centralized management, it is prudent to scientifically test and improve upon management schemes before they are fully implemented (Walters 1995).

In fisheries and communities where co-management is not a viable option,[6] a movement towards an advisory process that is credible and transparent is clearly needed. In their recent review of the British Columbia salmon fishery, the Institute for Dispute Resolution (2001) suggests that the consultation practices of all British Columbia fisheries need to address several key issues. These include the need to (1) rebuild trust between all parties, (2) address the inconsistency of consultation protocols, (3) address the perceived success of corporate interests to lobby outside the process, (4) address the failure of DFO to act on advice received through consultation or provide a response to recommendations, and (5) ensure a clear understanding of representation (i.e., who represents whom), and that representatives are accountable to their constituents. No matter how consultation between fishermen and decision-makers occurs, a genuine process to include concerns of the general public and other stakeholders in fisheries decisions must be developed.

NOTES TO RECOMMENDATION 3

1 The **community of interest** surrounding a fishery will vary considerably depending on the fishery in question. While the participants in some fisheries may be confined to the geographic region that encompasses the fishery, others may live remotely from the resource. The community of interest may also include processors and interested environmental advocates and scientists. However, a community of interest with very strong local ties is much more likely to feel connected to the local resource, and thus conserve it. As discussed in "How do we get there", when non-local interests are part of the decision-making process, rules that ensure the management regime is not led off-track may be needed.

2 Specifically, we use **co-management** to refer to an agreed partnership between community members and government officials to manage a fishery. Co-management systems of decision-making arise

where the rights of the community have been formalized, and community members and government representatives carry balanced weight at the decision-making table. **Cooperative management** is a less formalized system, where community members might sit at the decision-making table, but do not necessarily have a formalized right to affect final decisions. When communities themselves work to create fisheries rules, the result is **community-based management**.

3 Such 'volunteerism' might include the enforcement of rules, and work to improve habitat.

4 Included in the possible approaches to overcome these barriers are (1) the use of credible third parties, such as universities, to oversee data sharing, analysis, and transparency, (2) the building of alliances between communities undertaking co-management to counterbalance the political pressure exerted by large harvesters, and (3) through partnerships and the investment of social capital ensuring that alternate solutions to the problems that privatization addresses are easily visible and available.

5 Whether management is undertaken by communities of fishers or centralized decision-makers, an assessment of acceptable risk for fisheries decisions is crucial. The need for this is outlined in Recommendation 2, which discusses the need for decision rules for precautionary management.

6 As discussed earlier in this chapter, not all fisheries are ideally suited to co-management arrangements. Charles (2002) suggests that recently developed, highly industrialized fisheries are amongst those least suited to co-management. In addition, fisheries where participants are equally able to make a suitable living by other means, or unable to effectively police the fishery resource will also be poor candidates for co-management (Pinkerton and Weinstein 1995).

Providing incentives for sustainable fisheries

The need for transformation in Canada's Pacific fisheries is clear. Changes like more precautionary management, decreased capacity, less bycatch, and better habitat protection, for example, are all crucial to ensuring sustainable fisheries. However, it is not always clear whether fishermen will be rewarded for these changes, at least in the short term. Certainly co-management, as discussed in Recommendations 3 and 4, is one way to ensure sustainable fisheries and fishing communities. However, not all communities are suitable for co-management, and society's values for the marine environment may not always mirror those of community managers. Because of this, incentives that ensure fishermen benefit from ecologically rigorous decisions may be useful to achieve continued health of the marine environment.

One example of such an incentive is the eco-certification of sustainable fisheries (Peterman 2002). Ideally, eco-certification evaluates fisheries using widely accepted ecological principles, and rigorous scientific criteria to evaluate whether these principles are being met. The process for undertaking this evaluation must be a credible one. However, simple certification does not ensure effective incentives. If consumers are unaware of the value of consuming certified products, there will be no increased demand for them, and no benefit to fishermen. And, if the certification standards are not rigorous, consumers might in some cases believe they are buying products from well-managed fisheries when in fact they are not.

One organization currently undertaking the eco-certification of fisheries around the globe is the Marine Stewardship Council (MSC). This organization is a new one that has had early criticism about weak standards of certification, and a lack of independence (Peterman 2002). It remains to be seen whether these criticisms will lead to sounder certifications as the organization matures. Incentives may also be crucial to ensure that non-fishing industries do not negatively impact fisheries and the marine ecosystem. One example of this is the Forest Stewardship Council (FSC), which certifies wood products from across Canada with standards that ensure, among other things, better protection of freshwater habitat during timber harvesting.

RECOMMENDATION 4

Decrease capacity and plan for stock fluctuations

Rationale

Overcapitalization has been argued by several experts to be the greatest problem facing world fisheries (Mace 1997, Pauly et al. 2002). Simply put, the collective power of the planet's fishing vessels to catch fish is far greater than the number of fish in the oceans. Recent estimates suggest that the total capacity of the global fishing fleet sits at least 25 percent above the number of fish that can be extracted on a sustainable basis (Garcia and Newton 1997).

Several explanations have been put forward to explain the development of overcapacity. Generally, these are 'ratchet-like' processes that move easily in one direction (towards capacity increases) and poorly in the other (Ludwig et al. 1993, Pitcher 2001). The first of these, often termed Ludwig's ratchet, occurs as a result of natural fluctuations in biomass that are expected to occur in all populations. In this process, years of high biomass and good fishing lead to additional investments in fishing gear and technology, which translates to overcapacity when biomass levels return to a more median level (Ludwig et al. 1993, Pitcher 2001). In another ratchet-like process, fishermen feel pressured to continually improve the efficiency of their vessels so they might continue to compete with the other fishermen with whom they vie for a limited pool of resources, or to maintain their catch as supply dwindles (Munro et al. 1998).

Simply put, the collective power of the planet's fishing vessels to catch fish is far greater than the number of fish in the oceans.

In both cases, this increase in vessel efficiency is often encouraged by government subsidies (see, for example Pitcher 2001) thus creating perverse incentives for increases in vessel efficiency. When overcapacity is recognized, government efforts to decrease fleet capacity often take the form of license buyback schemes. Because these tend to be most attractive to marginal, less-efficient fishermen, these schemes tend to further industrialize the fishery rather than to decrease its capacity (Townsend 1990). In fact, capacity may increase as those remaining in the fishery begin for a short time to realize greater profits, thus leading to reinvestment in the fishery. Though some may argue this creates a more efficient fleet, experience shows that it does nothing to decrease pressure on the fish.

Programs that both limit license numbers and limit fisheries participation to owner-operators are one possible way to address capacity in B.C.'s fishing fleets (Cruickshank 1995)

The story in British Columbia closely mirrors the pattern observed worldwide. Here, some fisheries that used to last for months are now limited to just a few days (Walters 1995). Worst of all, overcapacity means that fishermen need to fish more to pay off their debts and break even on the high investments they have made, which in turn imparts pressure on governments to increase catch rates, rather than risk losses of jobs and profits (Rosenberg et al. 1993). As laid out in Recommendation 1, the risks of such short-term, non-precautionary decisions are enormous.

Current practices

Overcapacity has been recognized internationally as a major impediment to the long-term viability of fisheries. As a signatory to key international agreements, Canada has acknowledged the importance of this issue and pledged action towards it. In particular, the FAO *Code of Conduct for Responsible Fisheries* clearly states the need for signatory states to address capacity issues in their fishing fleets. This is clearly stated in the General Principles of the *Code*, which declares:

> *States should prevent overfishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization.*

Currently, ITQs are one of the major mechanisms used by DFO to address capacity issues in the fishing fleet. Although ITQs do appear to have ended the race for fish in fisheries where this system has been instituted, concerns remain. There are questions of sustainability in some ITQ fisheries (e.g. the groundfish trawl, Morgan and Chuenpagdee 2003), as well as other concerns related to this system of management, discussed below in *How do we get there?*.

Other specific policies to encourage decapitalization in Canada's West Coast fisheries have been few. Any effort that has occurred has been patchy, and in several cases, ineffective. Decreased capacity in the salmon fishery has only been attempted through license buyback schemes, which, as discussed above, have been a dismal failure. In these schemes, short-term gains were usually offset by further overcapitalization and increased catch by those who were not bought out.

Best practices

Many programs instituted to combat excess capacity in fishing fleets simply do not work. As previously discussed, merely limiting or decreasing the number of licenses in a fishery often leads to increased corporate control of the fleet, and no real

reduction in capacity. Programs that both limit license numbers and limit fisheries participation to owner-operators are one possible way to address capacity in B.C.'s fishing fleets (Cruickshank 1995). These issues might also be addressed through co-management. Although community-based and co-managed fishery regimes usually come about for reasons other than overcapacity issues, an analysis of these fisheries shows that many have existed for centuries. Co-management – if implemented effectively – has not been undermined by the problems of overcapacity (see, for example,

Best practices: example 1

The Point No Point Treaty Council, Washington State

The Point No Point Treaty Council (PNPTC) is a fairly new fisheries management regime, established in 1976 in response to the Boldt Decision, which mandated that First Nations in Washington State and non-aboriginals share the salmon catch equally (a 50/50 distribution; U.S. v. Washington 1974). It is a regional fisheries management co-operative between four Point No Point tribes and the Washington Department of Fisheries (WDF), which manages the salmon fisheries in the tribes' traditional territories. Management of fisheries under the PNPTC generally occurs on two levels: each tribe sets its own regulations for fishing in its "exclusive area" – often freshwater areas in the tribe's traditional territory – subject to arrangements with the WDF, and conservation concerns. Marine fisheries within the PNPTC area are generally considered "common areas", and are managed by the Council itself, which has representatives from each tribe. For the most part, fishermen feel well represented on the Council Board, and by the tribes' decisions.

Ensuring that fishery overcapacity does not occur has been a central focus for the PNPTC tribes. Both traditional values that have been incorporated into the management system and specific management mechanisms discourage capacity build-up. Values incorporated into the management system include the right of all tribal members to benefit in some way from the fishery, whether or not they fish. Similarly, management mechanisms include specific allocations to less capital-intensive gear (such as in-river gear). Seine gear is prohibited, largely because of the voluminous catch needed to support the large investment of a seine boat. The tribes have decided that it is better to have more members participate, even if at a reduced income, than to have a few members catching large volumes of fish. Boat purchase loans are examined by the fisherman's tribe, decreasing the likelihood of gear investments greater than necessary and preventing joint ventures with large actors not partner to the treaty. Fishing territories are small enough that large boats are not needed to cover them, and finally, fishing seasons are purposefully made to be geographically and temporally dispersed to discourage the 'race for fish' that leads to capital build-up. Overall, these measures appear to have been effective for restraining over-investment (from Pinkerton and Keitlah 1990).

Pinkerton and Weinstein 1995). Additionally, many researchers are increasingly recognizing that co-management should be considered an effective tool for the control of excess capacity (see, for example Gréboval and Munro 1999, Cunningham and Gréboval 2001). Although both of the examples below are co-managed fisheries, their success depends in large part to the owner operator provisions at their core.

How do we get there?

Often, the push towards overcapitalization occurs when fishermen are unsure about the share of the resource to which they will have access in coming years. One alternative to this problem is to assign use rights. If the guarantee of a right to fish allows fishermen to make a “predictable and reasonable living”, the incentive to increase capacity can disappear (Pinkerton and Weinstein 1995). In

Best practices: example 2

The Japanese inshore fishery

Much has been written about the Japanese inshore fishery, perhaps because it is one of the longest-standing and most pervasive examples of co-management on the planet, so much so that if a fisherman is not a member of a fishing cooperative it is culturally and economically impossible to make a living from coastal fishing (Lim et al. 1995).

Japanese fisheries were historically managed by local fiefdoms, which gave villages control over their adjacent waters. Not all village inhabitants, however, gained equal access to the fishing grounds, which were often monopolized by the local affluent (Ruddle 1992). These fiefs collapsed in 1876, and ownership reverted to the central government, resulting in great increases in new entrants, large-scale fishing pressure, and large, capital-intensive operators (Ruddle 1992, Pinkerton and Weinstein 1995). To counteract declining catches and this increasing capitalization (Lim et al. 1995), the *Fisheries Law* was passed in 1901, creating local Fisheries Associations which were charged with managing local fisheries. However, problems with excess capacity (Pinkerton and Weinstein 1995) and the domination of large-scale interests (Ruddle 1992) prevailed. The law was therefore reformed in 1949 to include assurances that only those who fished would gain licenses and that these licenses could not be leased or sold, thus ending the previous concentration problems (Ruddle 1992).

Today, the Japanese inshore fishery is heralded as one of the most successful examples of co-management (Jentoft 1989). Although these fisheries account for only 26 percent of Japan’s fisheries production, they provide fully 41 percent of its value (Ruddle 1992). However, new modern-day problems are emerging. Conflicts with industrial and residential developments in coastal waters are increasing (Pinkerton and Weinstein 1995), while membership in fishing organizations is declining. Restrictions in access to inshore fisheries are strong as fishing rights can only be inherited by kin resident in the fishing area (Ruddle 1992). Because the younger generation is often not interested in pursuing a career in fishing, recruitment has become a problem (Ruddle 1992). This could, however, lead to opportunities for those who wish to join the fishery from outside (Pinkerton and Weinstein 1995).

addition, use rights that extend far into the future give fishermen a strong incentive to plan for the future and conserve with respect to stewardship of the resource (NRC 1999, Charles 2002).

Many forms of rights-based management exist. Two of the more common, arising from opposite ends of the ownership spectrum, are community-based and individual rights. Of these, community-based rights work by imparting, at the very least, exclusive rights of use or access to fishing communities.[1] These rights may also extend to management rights and rights to information. Research has shown that such rights can be effective in controlling capitalization if they allow fishermen to secure their ability to make a living into the foreseeable future (Pinkerton and Weinstein 1995), and prevent fishermen from having to compete for a share of the resource. Community-based rights, however, may not be suitable for all fisheries. As discussed in Recommendation 3, in order for such a management system to be successful, communities should ideally be highly dependent on the fishery, vulnerable to non-sustainable use, and identified with their fishing place (Pinkerton and Weinstein 1995). Charles (2002) suggests that such management regimes work best when the fishery is a deep-rooted one.

Conversely individual rights generally take the form of individual quotas, where each participating fisherman is allocated a share of the fishery. Such shares usually consist of a right to fish a certain proportion of the fishery's total allowable catch (TAC), and may be transferable (able to be bought, rented, or sold), or non-transferable to a greater or lesser degree. Although individual rights have been proposed as a useful mechanism for decreasing capitalization, several problems have been identified with them.

Despite their ability to alleviate the race for fish, several aspects of individual quotas have been identified as cause for concern. Individual quotas may provide incentive for fishermen to dump or 'high-grade' their catch, in order to fill their quota with the most valuable product (Fujita et al. 1998, Charles 2002, WWF 2002). Similarly, quotas may lead fishermen to under-report their catch in order to allow direct increases in their total catch (Charles 2002). This contrasts with co-management schemes, where participation tends to lead to increased rule acceptance, and enforcement of these rules by community members (Felt et al. 1994, Charles 2002). The heavy monitoring needed to counteract these issues may then decrease any price or efficiency gains for the fishermen that the individual quota system provides (WWF 2002). Critics of this system also point out that it continues to rely on traditional fisheries science: a method of setting catches that has been well-discussed as leading to overfishing (Walters and Pearse 1996, Charles 2002, WWF 2002). Thus, unless measures are taken to address the catch quota issue, the individual quota system – or other forms of rights-based management – will not lead to viable fisheries. Several social equity concerns have also been raised with respect to individual quotas. Foremost among these is the fact that if transferable, individual quota systems can lead to severe consolidation of the fishery into the hands of a few fishermen or corporations (Fujita et al. 1998, WWF 2002). Finally, transferable quotas often do not decrease capacity in the fishery. While they may decrease incentives to invest in boats and gear, transferable quotas on the market often become extremely expensive. To pay off quota costs, fishermen may be forced to catch more fish (Buck 1995). ITQ fisheries are also often very profitable ones, leading fishermen to re-invest in other fisheries and spill over pressure into other fisheries resources (J. Sutcliffe, Canadian Council of Professional Fish Harvesters, personal communication).

In his advocacy of rights-based management, Charles (2002) suggests that the applicability of use rights will depend on the fishery in question. Because different use right structures have inherent advantages and disadvantages, the 'best' choice will depend upon the fishery. Factors that might tie into the decision of which use rights are most applicable will include society's objectives for the fishery, the relevant social, cultural and economic environment surrounding the fishery, and the history and traditions of the fishery. Decisions to be made may include whether or not to allow market forces to govern the fishery, whether rights should be individual or community-based, the duration of the tenure of rights, and whether or not rights should be transferable. Simply ensuring that participants in fisheries are themselves owner-operators, and do not lease their licenses to non-license fishermen, could also go a long way to reducing capacity in our fisheries (D. Lane, T. Buck Suzuki Environmental Foundation, personal communication). Programs that limit fishery participation to owner operators do, in fact, occur elsewhere. In Alaska, for example, owner-operator provisions have successfully prohibited corporate control of the salmon fleet, and have limited capacity more than would have otherwise occurred, although an external influx of cash during the 1980s led to larger boats that have not been able to fish during years of lower fish prices (Pinkerton and Weinstein 1995).

NOTE TO RECOMMENDATION 4

1 The many different forms that such communities could take, and implications of these various forms, are laid out in Recommendation 3.

RECOMMENDATION 5

Protect **diversity**

Rationale

Species diversity

Life in the Pacific Ocean is complex, and scientists know we are not even close to understanding the number of links between the plants and animals of this ecosystem, or their importance. Although human interest generally focuses on the few species that we exploit, full ecosystem function requires a diverse mix of many species. This rich mix allows for the continued provision of essential ecosystem services such as photosynthesis and climate regulation (Christensen et al. 1996, Patrick 1997). Such species diversity also allows for a great deal of ecosystem resiliency: the presence of numerous organisms performing similar functions provides both stability to and recovery from ecosystem disturbances, by buffering against the loss of individual species (Christensen et al. 1996, NRC 1999). This overlap in the performance of ecosystem function also allows ecosystems to adapt effectively to long-term change and to provide their services through space and time (Christensen et al. 1996).

Genetic diversity

In addition to species diversity, genetic diversity within species is also crucial to ecosystem function (Christensen et al. 1996). This is perhaps most evident for salmon, where local populations are reproductively isolated from one another and genetically adapted to survive and reproduce in their birth environment (NRC 1996, Policansky and Magnuson 1998). Many other species of fish, however, including herring and rockfish (Buonaccorsi et al. 2002), also consist of smaller, genetically distinct populations. Similar to species diversity, the variety provided by genetic diversity allows populations to survive under times of stress, such as low food availability or adverse water conditions (NRC 1996). Unfortunately, fisheries management has rarely focused on maintaining these individual, genetically distinct populations.

Instead, fisheries have often been managed by grouping several of these populations into larger, aggregate units.

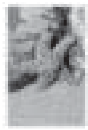
When fisheries are managed using these genetic aggregates, mixed-stock fisheries – those that target more than one genetically isolated unit – are bound to occur. Because fish are often found in such mixed groups when they are not in their natal environment, mixed stocks in the open ocean are the rule rather than exception. Unfortunately, not all of the populations in this mix are as productive, or numerous, as others. It is thus very easy for certain populations to be overfished in a mixed-stock fishery. Scientists have cautioned that managing in this way – ignoring the reproductive units that make up larger, managed stock groups – will lead to the disappearance of local breeding populations and eventual collapse of overall production (Hillborn et al. 2003). In the U.S. Pacific Northwest, scientists suggest that over 40 percent of local salmon reproductive units have already been lost (NRC 1996).

More specific to salmon, the use of hatcheries[1] has also raised great concern for the maintenance of genetic diversity (NRC 1996, Beamish et al. 1997, Gardner et al. 2004). This has occurred for several reasons. First, scientific evidence suggests that the tremendous production of hatchery salmon is overwhelming the ability of British Columbia's rivers and the Pacific Ocean to sustain them. This overcapacity forces fish to compete for limited resources; a competition that scientists fear is being lost more often by the wild fish (Cooney and Brodeur 1998). Thus, by overwhelming these waters with hatchery fish we are directly reducing the survivorship of wild fish and doing little to increase the ocean's yield (Hilborn and Eggers 2000). A second concern with hatcheries is that they can further exacerbate the troubles described above for mixed-stock fisheries. When hatchery fish return with their wild counterparts, the tendency is to fish the run strongly: hatchery returns are often comparatively large, and unlike wild runs, do not require large numbers of fish to be set aside as spawners. This in turn severely depletes the co-running wild stock (Hilborn and Eggers 2000). Finally, because they inevitably differ genetically from wild fish, hatchery fish can cause genetic changes in wild stocks adjacent to the hatchery area. Thus, hatcheries can cause a loss of the adaptation so crucial for these wild stocks to survive in their natural environment (NRC 1996, Gardner et al. 2004). The consequence of hatchery use is evident in the Strait of Georgia where drastic increases in hatchery fish have been accompanied by stagnant, or even reduced, salmon numbers (Sweeting et al. 2003).

Current practices

The maintenance of biodiversity is not specifically legislated for in Canadian waters. However, Canada is signatory to, and has ratified the 1993 United Nations *Convention on Biological Diversity*. It states, among other things:

> *Each Contracting Party shall:*
>
> - *Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity;*
>
> - *Integrate, as far as possible and as appropriate, the conservation and sustainable use*



of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies;

- *Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;*
- *Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations;*
- *Integrate consideration of the conservation and sustainable use of biological resources into national decision-making.*

(Adopted from United Nations *Convention on Biological Diversity*).

In response to this Convention, Canada developed the *Canadian Biodiversity Strategy*, which was released in 1995. However, the *Strategy* is not a legal document and there is no requirement that its suggestions be followed. To date, Canadian action to uphold diversity has been weak. For example, in the marine environment, it is still the case that only exploited species are actively considered for management. Even their management plans, as discussed elsewhere, are often grossly inadequate (see, for example, Recommendations 1 and 10).

Two strategies set forth by Fisheries and Oceans Canada specifically deal with issues related to salmon biodiversity. The *Selective Fishing Policy* sets out to "harvest target species or stocks while avoiding, or releasing unharmed, less productive species or stocks, including marine mammals and sea birds (bycatch)". Although this strategy has led to laudable change in the way that B.C.'s fishery operates, and has somewhat successfully reduced the bycatch of non-target species in certain fisheries,[2] it has not led to the ability to truly fish selectively at the population level. The 2000 draft DFO *Wild Salmon Policy* acknowledges the fundamental need to "conserve wild salmon by maintaining diversity of local populations and their habitats". This policy has been stalled repeatedly; it is unclear when, or if, it will be finalized.

The federal government has established the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to give Canadians a means by which to identify species that are endangered or threatened. COSEWIC was initiated in 1977 and is composed of panels of respected scientists who evaluate the status of species of concern that lie within the panel's area of expertise. In the marine environment, fish, mammals, reptiles and molluscs are currently evaluated by COSEWIC. The consideration process, however, has been slow; for example, only three salmon stocks of the many considered at risk have been listed by COSEWIC.

Legislation to mandate action on COSEWIC listed species, Canada's *Species at Risk Act* (SARA), received royal assent in December 2002. In theory, SARA prohibits the killing, harming, harassing, capturing or taking of species officially listed as threatened, endangered or extirpated. Unfortunately, the listing of species as endangered and threatened is ultimately at the discretion of the responsible Minister, rather than the panel of COSEWIC scientists. It is also alarming that permits to kill listed species (including those caught as bycatch in fisheries; Environment Canada 2003) may be issued. It is yet to be seen whether the SARA legislation will translate into an effective management regime.

Best practices, and how do we get there?

Worldwide, the realization that fisheries must be more selective and any operating hatcheries must be managed with genetic diversity in mind is a recent one. Thus, working examples of best practices are scarce, and the above two sections have been combined.

Maintenance of species diversity

One concept central to the effective maintenance of species diversity is that of functional extinction. Although true extinction events in the marine environment have been rare, examples abound of species that have been fished to extremely low levels (e.g., abalone, COSEWIC 2003; rockfish, Yamanka and Lacko 2001). Often, this has been seen as 'economic extinction'; in other words, from the perspective that these species can no longer viably support commercial exploitation. However, when viewed from an ecological perspective, the ability of a species to continue to contribute to its surrounding ecosystem is crucial. When a species' numbers drop dramatically, this is no longer possible. Because of this, it is imperative that management for biodiversity goes far beyond its traditional focus on endangered species to focus on the maintenance of functional integrity of the earth's systems (Woodwell 2002).

The conservation of species diversity depends, at its core, upon us changing the way we fish. The conservation of marine biodiversity requires that we consider both target and non-target species as we manage fisheries, and ensure that ecosystem needs are met when we decide how much we will fish. Many of the approaches necessary toward this end have been examined in Recommendation 1 of this report, which discusses management at the ecosystem level.

In addition to recognizing ecosystem considerations in fisheries management, it is crucial that habitat be protected to ensure biodiversity conservation. Worldwide, habitat loss has been implicated as the single largest threat to biodiversity (Vitousek et al. 1997). Protecting habitat includes measures such as the implementation of marine protected areas, and the protection of spawning, nursery and rearing grounds from habitat destruction. These issues are discussed in detail in Recommendations 6 and 7.

Maintenance of genetic diversity and hatcheries

Recent clear direction from scientists distinctly outlines the need to reassess hatchery programs. One group of leading academics, formed to address and evaluate options for improving the prospects for long-term sustainability of salmon in the U.S. Pacific Northwest, gave the following recommendations with respect to genetic diversity and hatcheries:

1. The intent of hatchery operations should be changed from that of making up for losses of juvenile fish production and increasing catches of adults. They should be used only when they will not cause harm to natural populations, and only to assist recovery and genetic expression of wild populations.
2. Hatcheries should be dismantled, revised, or reprogrammed if they interfere with a comprehensive rehabilitation strategy designed to rebuild natural populations of

salmon. For example, if habitat restoration rather than hatcheries will best restore salmon populations, then hatcheries should not be utilized.

3. All hatcheries should adopt a genetic conservation goal of maintaining genetic diversity among and within both hatchery and naturally spawning populations.
4. Salmon management should be based on the premise that local reproductive populations are genetically different from each other and valuable to the long-term production of salmon.
5. Fishery management should explicitly recognize the need to conserve and expand genetic diversity via natural increases in population size.

(modified from NRC 1996).

Closer to home, a group of academics has gone even further by calling into question the usefulness of hatcheries even to assist stocks that are near extinction. At best, they say, such programs lack clear guidance and policy for when they should be used. At worst, some of the group argue, there is evidence that such interventions could cause harm (Continuing Studies in Science, Simon Fraser University 2002). What is clear, however, is the need for a rigorous evaluation of how B.C.'s hatcheries affect wild salmon populations (Gardner et al. 2004).

Maintenance of genetic diversity and selective fishing

It is clear that in order to preserve the genetic diversity of fish stocks we must begin to fish more selectively. This may entail large changes in the way B.C.'s fisheries operate, although some of these changes have already been accomplished through the selective fishing program. Recommendations 4 and 5 above are crucial to understanding how these changes must occur. In addition to these, the above-cited academics (NRC 1996) state:

> *Management of salmon should be based on the genetic structure of their populations and should allow for separate management regimes for strong and depleted demes and metapopulations whenever possible. … To achieve this, fishing should only take place where the demic identity of the salmon is known and where catching technology can reduce mortality rates in depleted demes. In many cases, that would require fishing to take place in the home-stream estuary or in the river upstream.*[3]

NOTES TO RECOMMENDATION 5

1 The use of hatcheries can also manifest itself as the practice of **ocean ranching**. In ocean ranching, the fish produced and released by the hatchery are 'owned' by a given body or group of individuals. When the hatchery fish return to spawn, the right to fish them falls at least partially to these owners.

2 For example, B.C.'s salmon fisheries are now much more selective with respect to species (as opposed to stock selectivity). Methods such as brailing and recovery boxes have greatly improved the ability of bycatch species to survive capture in these fisheries.

3 Here, **deme** is used to mean locally adapted spawning populations that originate from spatially well-defined locations. Elsewhere in this document, this grouping is referred to as a **stock**.

RECOMMENDATION 6

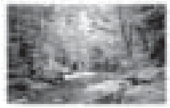
Protect habitat

Rationale

To maintain diverse, healthy marine populations, it is imperative to preserve the habitat that sustains them (Vitousek et al. 1997). Not only does this mean protection of the open ocean; we must also address the issues affecting freshwater, estuarine and nearshore habitats. In many cases, it is the latter three that have faced the greatest onslaught.

Species such as salmon that depend upon many habitats – the open ocean, shorelines, estuaries[1] and freshwaters – are especially vulnerable to habitat impairment and loss. This loss is most pronounced in the freshwater and estuarine environments. In B.C.'s freshwaters, logging is one of the major threats to habitat integrity. For example, upland vegetation removal and road construction lead to increased sediment loads in nearby streams. This increased sedimentation critically affects salmon spawning habitat by clogging the gravel that salmon rely on to build their redds (nests). The clogging of the interstitial spaces in the gravel reduces sub-gravel water flow and decreases oxygen flow to incubating eggs (Scrivener and Brownlee 1989). Further, poor installation or maintenance of culverts[2] can obstruct the upstream spawning migration of adults (Warren and Pardew 1998, Harper and Quigley 2000) while the amount of in-stream large woody debris, critical for creating and maintaining salmon habitat, decreases substantially with the removal of old-growth forest (Hicks 2002). Other threats, such as increasing urbanization, dams, and decreasing water quality are also critically affecting freshwater habitat (Langer et al. 2000).

The well being of British Columbia's estuaries is also crucial for dozens of species. For example, estuaries are considered crucial salmon habitat: certain stocks of chinook and coho use estuaries as nursery grounds while all species of salmon migrate twice through this habitat (Levings 2000). The estuary is probably the most productive natural habitat in the world (Odum 1971), and perhaps because of this, it has also been a hub for



human settlement. Estuaries have been attacked on many fronts in recent years. Among these, pollution from upriver sources, dredging and diking, and urban development have perhaps been the most prevalent (Williams and Langer 2002). In British Columbia's Fraser estuary, for example, between 70 and 90 percent of wetland habitat has been lost since European settlement (Levings 2000).

As society increases in size there is greater pressure for access to the coastline for transportation, residential use and aquaculture. Near the shoreline, the ocean environment faces many of the same challenges facing estuaries. Because of their accessibility to humans, nearshore areas are prone to disruption from development and pollution, among other stresses (Thompson et al. 2002). Foreshore property development puts tremendous pressure on shore habitats, although solutions are being proposed (Stewardship Technical Committee 2004), while dredging, docks, flood protection, and intertidal[3] and nearshore shellfish and finfish farming are all having significant incremental effects on key fish habitat areas. Pulp mills have also had a significant impact on shoreline fish habitats.

Further from shore, pressure on habitats has grown more recently. Here, increased fishing pressure and the habitat damage that fishing can cause interacts with other forms of habitat degradation, such as ocean dumping, mining activities, increased ultraviolet radiation, and changes in climate, to destabilize marine ecosystems (Lauck et al. 1998).

Current practices

Despite the strong legislative and policy direction of Canada's *Fisheries Act*, recent enforcement of habitat violations has been weak in British Columbia. In freshwater, this has been especially true with respect to violations caused by improper logging practices, perhaps one of the largest impacts on the habitat quality of British Columbia's streams (Werring and Chapman 2002).

It is clear that DFO often lacks the will to enforce its stringent legislation and policy (Hutchings et al. 1997). However, part of the reason for this lack of habitat protection may lie with the fact that fish habitat is affected by activities that do not fall directly under the control of the federal government, while the Department of Fisheries and Oceans has to prove a negative impact for successful enforcement action. For example, forestry and water resources both fall under provincial jurisdiction. Unless damage to stream habitat occurs beyond a reasonable doubt, DFO has little control over the activities that fall under provincial jurisdiction. Many of these activities (such as logging and urban development) occur far from the stream and riparian zone that most courts accept as fish habitat.

Another issue impeding habitat protection is the lack of baseline or follow-up monitoring to ensure that no net loss of habitat actually occurs (A. Wood, Allen Wood Consulting Inc., personal communication). In freshwaters, estuaries, and the ocean, the continued degradation of habitat has been well documented despite the No Net Loss mandate (Kistritz 1995, Harper and Quigley 2000).

Regulations protecting fish habitat in the logging industry are currently in transition, from B.C.'s *Forest Practices Code*, to a results-based code legislated by the *Forest and Range Practices Act* (FRPA). Prior to November 2002, protection of fish habitat was regulated solely by the *Forest Practices*

Code and related regulations, some of which provided managers broad discretionary powers to set the conditions for operation around streams, lakes, and wetlands. For example, the Operational Planning Regulation specifies the minimum riparian buffer width to be left along various classes of streams, while at the same time allowing managers to vary these widths (Operational Planning Regulation Section 73; Werring and Chapman 2002). Between 2003 and 2005 the *Forest Practices Code* is being phased out, and the new results-based code (FRPA) is being phased in. During this time, forest companies can choose to follow either set of regulations.

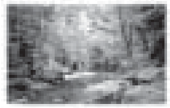
Clearly, strong legislation alone will not protect aquatic habitat. The political will to do so must also exist.

The new, results-based code has been strongly criticized for its inability to ensure ecologically-sound management, including the protection of fish habitat. Critics argue that the identification and prevention of unacceptable results, such as loss of fish habitat, will be much harder under the results-based code because there is no requirement for operational plans[4] to be prepared and approved (FPB 2002). Further, the results on which the code will be based also appear to be weak, non-specific and difficult to measure, while there is no requirement for the collection of baseline information from which to gauge the results (FPB 2002). To this day, farming, dams, logging, road building, urban development, and dredging and filling all continue to affect freshwater fish habitat significantly.

This lack of protection for fish habitat also occurs in the open ocean. For example, trawling over structured bottom habitat still occurs despite the damage it inflicts on these marine communities (e.g., Watling and Norse 1998). In the Strait of Georgia and elsewhere, ocean pollution continues to increase. Despite the fact that pollution-related problems continue to intensify – for example shellfish beds continue to be closed – inadequate movement has been made to protect ocean habitats.

Current practices: an example

One well-known example of the failure of the *Fisheries Act* to halt the destruction of freshwater habitat occurred on the Nechako River, which historically has supported several salmonid species. An Alcan smelter and associated dam has been in place on this river since the early 1950s. Until the late 1970s, the dam reduced water flows on the Nechako by 40 to 50 percent. However, as Alcan's electricity needs grew, withdrawals of water from the system increased. To obtain greater flows and to achieve a permanent resolution on allowable flow rates, DFO took the matter to court. Despite these actions, senior DFO bureaucrats reached an out-of-court settlement with Alcan to allow a discharge rate at marginally above 10 percent of natural flows – a flow rate less than one-third of what their own scientists strongly advised was needed to protect the river's salmon stocks (Hutchings et al. 1997). Clearly, strong legislation alone will not protect aquatic habitat. The political will to do so must also exist.



Best practices

Worldwide, one of the strongest pieces of habitat protection legislation is Canada's *Fisheries Act*. It is outlined below.

How do we get there?

Given its strength, perhaps the best thing we can do in Canada to protect fish habitat is to ensure consistent and diligent enforcement of the *Fisheries Act*. As illustrated by the Nechako example discussed above, and many other documented cases of the failure to achieve no net loss (Kistritz 1995, Harper and Quigley 2000, Levings 2000, Chestnut 2002), political will by DFO to fulfil its mandate is fundamental to the *Act*'s enforcement. So too is the provision of the resources necessary for enforcement.[6] Stringent regulations in areas under provincial control, such as water flow and

Best practices: an example

The Canadian *Fisheries Act*, and No Net Loss

Under the Canadian Constitution, responsibility for the stewardship of marine fisheries, fish and their habitat falls to the federal government. The legislation most widely applicable to fisheries habitat is the *Fisheries Act*, which was amended in 1976 to include a key section allowing for the comprehensive protection of fish habitats. It states:

> *35(1) No person shall carry on any work or undertaking that results in the harmful alteration, disruption, or destruction of fish habitat.*

The *Act* has long included a section that protects fish from pollution. Currently, it states:

> *36(3) … no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place … where the deleterious substance … may enter any such water.*

In response to the rigid requirements of section 35(1), the Department of Fisheries and Oceans has developed clear policies that state a "net gain of habitat for Canada's fisheries resources" as an explicit objective (DFO 2001b). This net gain applies not only to freshwater habitat, but also to physical habitats in marine and estuarine environments. Damage that might occur to fish habitat because of degraded water quality does not fall under the mandate of the No Net Loss policy, but is an indictable offence under Section 36 of the *Act*.[5]

The Department of Fisheries and Oceans has developed clear policies that state a "net gain of habitat for Canada's fisheries resources" as an explicit objective

Despite the strength of this legislation, Canadian courts have ruled that it only applies to waters that directly, or indirectly, support a fishery (R. v. MacMillan Bloedel 1979). Further, although legislation has been in effect for over 25 years, its compliance and enforcement record is patchy. As discussed above, this powerful legislation has not been fully translated into adequate habitat protection.

pollution, are also critical. In addition, however, we must ensure that habitat already degraded is restored to its natural state.

As a fundamental starting point, we must follow the precautionary principle when we make decisions about exploiting fish habitat and the impact that this exploitation will have. In freshwater systems, watershed analysis has emerged as a useful tool to guide decisions about how best to move towards the restoration of complete ecosystems and to plan for future developments (NRC 1996, Armantrout 2000). This process makes use of detailed maps of the pristine vegetation, hydrology, geomorphology and current human use, among other things, of the watershed (Armantrout 2000, BCMELP and DFO 2001). These are then used to set priorities for restoration, or, in an undeveloped watershed, protection. The following are priorities for conservation:

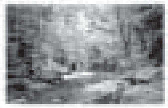
Given its strength, perhaps the best thing we can do in Canada to protect fish habitat is to ensure consistent and diligent enforcement of the *Fisheries Act*.

1. The retention of full riparian zones in forests and agricultural settings.
2. The reduction of sediment to a magnitude appropriate to the geological setting of the river basin. There should be no net increase in sediment through human intervention, either caused by changes in surface erosion, or more catastrophic mass-wasting.
3. Matching patterns of runoff, to the greatest extent possible, to natural patterns.
4. The treatment of toxic wastes before they enter the water to ensure compliance with relevant guidelines.
5. An emphasis on the rehabilitation of ecological processes during habitat reclamation or enhancement, rather than the creation of artificial habitat. Placement of permanent or semi-permanent structures in streams should be discouraged unless it can be demonstrated that no other alternative exists.
6. The preservation of the beneficial long-term effects of natural disturbances, such as flooding, wherever possible.

(Adapted from NRC 1996, BCMELP and DFO 2001).

Although habitat protection must clearly be paramount during watershed analysis, the degree of freshwater habitat alteration varies widely along B.C.'s coast. Where habitat has been altered, natural restoration or artificial rehabilitation of habitat may be necessary to ensure the continued survival of fish species across their habitat range (NRC 1996). DFO's *Policy for the Management of Fish Habitat* clearly states that when confronted with development, protection of habitat is always preferable to habitat rehabilitation or other mitigating measures. However, habitat degradation continues to occur.

In the marine environment, an integrated planning system should similarly be used to map marine habitats and gain an understanding of which need protection or rehabilitation, and which can support development. As discussed in Recommendation 1, this approach is key to managing fisheries from an ecosystem perspective. One key aspect of marine planning – the implementation of marine reserves – is discussed in Recommendation 7.



NOTES TO RECOMMENDATION 6

1 An **estuary** is the region through which a river discharges to the ocean. It is an area of mixed fresh and salt water, and is generally bounded by land. Because the soils underlying estuarine waters are generally extremely fertile, dykes and ditches are often used to drain estuaries for use as agricultural land, thus destroying the land as habitat for resident species. The salt marshes found in estuaries also provide important habitat and refugia for many species (Barnes 1984).

2 **Culverts** are commonly used in the construction of logging roads, to allow streams to flow under road crossings.

3 The **intertidal** zone is the area of the shoreline between the high- and low-water marks.

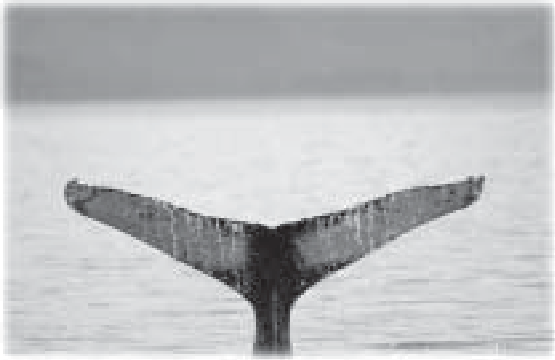
4 Requirements for operational planning under the *Forest Practices Code* included the development of forest development plans, silvicultural prescriptions, and road layout and design, as well as assessments to identify and prevent negative impacts.

5 The Federal government's No Net Loss policy specifically states that when fish habitat has been degraded, this habitat must be compensated for – the equivalent amount of habitat must be restored or created in another area. Water quality, on the other hand, is not something that can be compensated for. Because of its importance, in principle the degradation of water quality is simply not allowed.

6 The need to commit substantial resources to research, monitoring and enforcement is discussed in Recommendation 10.

RECOMMENDATION 7

Create marine reserves to protect representative habitats



Rationale

One of the failings of traditional, single-species management has been that it does not recognize the impact that fishing has on the entire ecosystem. Marine reserves are one key tool that can help to protect the ecosystem from the effects of fishing. Among other things, reserves can protect exploited species during critical stages of their life, reduce the secondary impacts of fishing (such as habitat degradation brought about by trawl fisheries), and function as 'insurance' against the failures of traditional management (NRC 2001). By their simplest definition, marine reserves are areas of the ocean that are free from all exploitation.[1]

Although their usefulness is perhaps most evident for sedentary species like shellfish, reef, and rock-fish, marine reserves can also help protect migratory species like salmon and cod, most notably through the protection of key spawning and rearing grounds, and migration bottlenecks (Guénette et al. 1998, Roberts 2000). From a conservation perspective, reserves have been shown to increase the density of organisms within their boundaries, increase the average size (and therefore age) of organisms, and increase the numbers of many exploited species (Halpern and Warner 2002). Not all species should be expected to increase in number in marine reserves, however. One of the benefits of reserves is to return the protected ecosystem to its pre-exploited state: thus, the numbers of some organisms should be expected to decrease (for example, those which undergo increased predation as top predators return to the ecosystem; NRC 2001). Although the return of higher trophic level organisms to ecosystems will result in a net benefit for fisheries, contingency plans may be necessary to address the overall effects of these changes on fishing industries.

Perhaps one of the greatest attractions of marine reserves from a fisheries perspective is the evidence of their ability to enhance fish populations outside of the reserve. Spillover into areas adjacent to reserves can be expected to occur if the density and size of organisms increases within established reserves. Such spillover of adult fish has been documented adjacent to marine reserves (e.g., Roberts et al. 2001a). Larvae, which presumably increase in numbers both because of an increase in parent organisms and because older organisms are more fertile than their younger counterparts, can also be expected to spill over reserve boundaries (Palumbi 2002).

By providing information about the structure of unexploited ecosystems and how they compare to their exploited analogues, reserves can also be important scientific tools. Marine reserves are not, however, a panacea for damaged marine ecosystems. The protection of habitat outside of reserves and reformation of fishing practices are essential complements to the establishment of reserves (Allison et al. 1998).

Current practices

The establishment of marine protected areas in Canadian waters is regulated by two pieces of legislation: The *Canada National Marine Conservation Areas Act*, and the *Oceans Act*. The *Canada National Marine Conservation Areas Act* allows Parks Canada to establish marine conservation areas in order to provide a representative sampling of the various marine environments found in Canada's oceans and the Great Lakes. Despite the fact that such marine conservation areas are to be managed by Parks Canada, they will differ from terrestrial National Parks in that they will be managed for sustainable use. The *Act* states:

> *(4) Each marine conservation area shall be divided into zones, which must include one zone that fosters and encourages ecologically sustainable use of marine resources and at least one zone that fully protects special features or sensitive elements of the ecosystem, and may include other types of zones.*

The Department of Fisheries and Oceans also has the ability to establish MPAs under the *Oceans Act*, which states:

> *35(2) …the Minister will lead and coordinate the development and implementation of a national system of marine protected areas on behalf of the Government of Canada.*

Generally, it is understood that the intention of the Parks Canada program is to provide a representative sampling of the various marine environments found along Canada's coasts, which is a strategy more likely to create patchily-distributed marine museums than to preserve connected, healthy marine habitats. In contrast, the *Oceans Act* focuses its intentions on addressing resource management problems, an approach better suited to the creation of ecologically-based reserves (Dunsmuir 2001). Despite this, reserve creation to date under the *Oceans Act* has been negligible.

The protection of habitat outside of reserves and reformation of fishing practices are essential complements to the establishment of reserves
(Allison et al. 1998)

Best practices

No country has moved fully towards the practices we discuss below for the establishment of marine reserves. Despite the increasing evidence of the success of this management technique, less than one ten-thousandth of the world's oceans are fully protected in reserves (Roberts 2001b). Some countries, however, have come further than most. For example, the New Zealand parliament has announced its intent to protect 10 percent of its coastline in reserves before 2010 (Ballantine 1999), while Australia has announced its plan to create the world's largest marine reserve (Environment Australia 2002). As discussed below, Canada's slow start on the creation of marine reserves is partly due to its top-down approach in determining protection locations.

How do we get there?

The concept of marine reserves is a relatively new one. Therefore, debate continues about how best to implement them. Leading researchers suggest that the following components are crucial for a well-functioning system of marine reserves.

1. **Establish broad networks of reserves.** Scientific research is beginning to suggest that networks, rather than single large reserves, will best meet conservation and fisheries goals. Large reserves will continue to have benefit within networks to ensure the protection of organisms needing larger areas of habitat. However, networks themselves have several benefits. Because they can be made up of a number of protected areas, they will likely have higher spillover to adjacent fishing areas. Networks will also seed each other – effectively creating a web of protected areas, rather than one isolated unit. Creating more individual reserves will also decrease the risk of catastrophic habitat loss, while at the same time allowing more pieces of crucial habitat for more mobile species (such as spawning and rearing grounds) to be protected (Palumbi 2002). When establishing reserve networks, several factors should be taken into consideration:

(a) **The decision-making process for establishing reserve networks.** There are many reasons to create marine reserves. Among these are protection of biodiversity, improvement of fisheries management, protection of marine habitat, and supplementation of other management efforts (NRC 2001). These goals will be central to decisions about how and where to establish reserves and networks. Several stages have been identified as necessary to successfully design reserves in a given region. These are: (1) identify needs, (2) set goals, (3) divide the region into units, (4) collect and assemble information on the region, and (5) score each of the units based on their suitability for protection. This scoring process will result in a variety of options for siting reserve areas that meet the agreed-upon goals (NRC 2001, Roberts et al. 2003a).

Roberts et al. (2003b) have suggested several major criteria to be used when scoring areas for their potential as marine reserves:

- *Biogeographic representation:* All biogeographic regions should be represented and reserves should be replicated in each region.
- *Habitat representation and heterogeneity:* All habitats should be represented in replicate within biogeographic regions.
- *Human threats:* High levels of human threat

should exclude a site from consideration, while threats that can be mitigated should increase priority for protection.

- *Natural catastrophes:* Sites that commonly experience extreme natural disturbances should be excluded.
- *Size:* Sites should be large enough to support viable habitats.
- *Connectivity:* Sites should interconnect with others through dispersal and migration.
- *Presence of vulnerable habitats and life-history stages:* Vulnerable habitats and life-history stages have higher priority for protection.
- *Exploitable species:* Sites must be capable of supporting exploited species
- *Presence of species or populations of special interest:* Endemic, relict, or globally rare species, and populations that are genetically disctint, increase the value of a site.
- *Ecosystem functioning and linkages:* Areas that link with and support other systems have a greater value than those that do not, while sites that depend on links with other systems are vulnerable unless these places are also protected.
- *Ecological services for humans:* Services such as coastal protection or water purification add value to a site.

(b) **Specific requirements of reserves and reserve networks.** In addition to the above evaluation criteria there are several requirements to ensure reserves and reserve networks meet the goals set for them. These include:

- *A significant amount of marine habitat should be protected*. There has been considerable debate about what specific percentage of the marine environment should be protected in reserves. It seems likely that the level of protection needed depends on the type and effectiveness of marine and fisheries management occurring outside reserve areas (NRC 2001).
- *Reserves should be fully protected from all human influence*, although buffer zones might be included where the level of protection is less stringent (NRC 2001, Roberts et al. 2001b). Use in buffer zone areas may include restricted harvests by local communities, which could serve to strengthen monitoring efforts, and increase surveillance and compliance (Russ and Alcala 1999).
- *The reserves within a network should be of variable size* (Roberts et al 2003b). Larger reserves will provide security for more mobile species, while smaller reserves will allow spillover of reserve residents into nearby fishing grounds (Roberts et al. 2001b). Collections of reserves of different sizes and shapes will best capture the diversity and variability of marine ecosystems (Palumbi 2002).
- *Variable distances should separate reserves*. These distances will accommodate the dispersal range of a large variety of species (Roberts et al. 2001b).

2. **Include stakeholders throughout the planning and implementation process.** Often, the development of reserves has focused solely on scientific criteria and largely ignored socio-economic factors (NRC 2001). While reserves

must clearly meet rigorous scientific standards, overwhelmingly, we are realizing ignoring stakeholders will lead to the failure of reserves (NRC 2001). Unfortunately, Canada's approach to establishing reserves has been a top-down one, in which ecological factors alone have been used to develop priority areas for protection. In contrast to other countries where socio-economic factors were taken into account throughout the reserve planning process, Canada's program has met with little success (NRC 2001). In order to achieve meaningful stakeholder involvement, all affected parties must be identified, have their needs assessed, and be involved in reserve planning, design and implementation (NRC 2001).

3. **Move incrementally and adaptively to establish reserves within a network.** The incremental adoption of reserves within a network will meet several goals. It allows for early incorporation of areas most needing protection into the reserve network (NRC 2001), and allows for continued improvement in the way in which protected areas are designed and implemented (Palumbi 2002, NRC 2001). Thus, the monitoring and research of earlier efforts can be used to inform the latter (Palumbi 2002).
4. **Research.** Research and monitoring are essential to determine if goals are being met, and to provide information to refine later reserves (NRC 2001). Such research should examine ecological, as well as sociological questions (Palumbi 2002). Monitoring will also contribute to our understanding of marine ecosystems and could allow for important experiments in marine ecology (NRC 2001).
5. **Ensure that reserves are not undertaken in isolation.** Marine reserves are not a substitute for other forms of fisheries and aquatic management. If reserves are undertaken in isolation of other, ecosystem-based improvements in management their coverage will have to be extremely broad to be effective (NRC 2001). The goal of reserves must be to maintain ecosystem health beyond the boundaries of reserves. As such, their implementation will have to be complemented by other measures such as fisheries management approaches (NRC 2001). In fact, several of the problems facing our oceans will not be solved at all by the use of marine reserves (e.g., the introduction of exotic species, climate change, effects of industries such as oil and gas, or pollution; Palumbi 2002).

NOTE TO RECOMMENDATION 7

1 In this document, we differentiate between **marine reserves** and **marine protected areas**. In contrast to marine reserves, marine protected areas may allow certain types of exploitation (for example specified fishing activities, resource extraction) within their borders. Marine protected areas often include smaller reserve areas within them.

RECOMMENDATION 8

Manage for and minimize bycatch and discards

Rationale

To a greater or lesser degree, all marine fisheries incur bycatch – the catch of non-target individuals or species.[1] Although some bycatch is retained, too often it is discarded back to sea. Because discarded fish often perish during this process, this can result in vast under-reporting of the true rate of fish killed during fishing. Although in some cases the mortality of discarded fish can be minor, generally where catch conditions are good and the species is hardy (Trumble et al. 2000, Davis 2002), in other instances discard mortality can be as high as 100 percent (Kaiser and Spencer 1995, Chen and Gordon 1997, Pascoe 1997). For example, the mortality of bycaught rockfish is presumed to be extremely high because the swim bladder of these deep-dwelling fish fatally distends as they are brought to the surface (DFO 2002c). Unfortunately, when a catch rate is set for a species, bycatch is often not taken into account. Thus, this under-reporting of catch often causes sustainable harvest rates to be vastly exceeded. Even the most ecologically sound rate of catch can lead to dismal results if bycatch is not accounted for. In the Atlantic cod fishery, this lack of acknowledgement has been implicated as one of the key factors leading to that stock's collapse (Myers et al. 1997).[2]

Even more troublesome is the fact that certain fishing methods can lead to 'invisible bycatch', where animals that never reach the ocean surface die after encountering fishing gear (Crowder and Murawski 1998). An example of this occurs in some trawl fisheries where it is common for nets to be regulated by a minimum mesh size or specific mesh configuration, ostensibly allowing the youngest and smallest fish to escape through the trawl apparatus. Unfortunately, this escape process is an exhausting and destructive one that can lead to extensive mortality in escaped fish, either directly or because the exhausted fish are more easily preyed upon (Ryer 2002).

Not surprisingly, certain fisheries are much worse than others when it comes to bycatch and the related discards. By its very nature as largely a specific mixed-stock fishery, the trawl fishery often incurs substantial bycatch. In the British Columbia trawl fishery, over 75 species can be legally landed, despite the fact that only 27 of these species have total allowable catches set for them (DFO 2002d). One study suggests that between 50 and 65 percent of the 1996-97 landed value of the B.C. trawl fishery, excluding Pacific hake, is from species or stocks for which we do not have reasonable population estimates (Walters and Bonfil 1999). Worldwide, shrimp trawl fisheries are perhaps the worst bycatch offenders. One survey conducted between 1988 and 1990 found that although shrimp trawls produce only about two percent of the world fish catch by weight, they produce over one-third of the global bycatch (Alverson et al. 1994).

To the extent practical, fish harvesters will minimize unintended bycatch and reduce waste and adverse impacts on the freshwater and marine ecosystems and habitats to ensure healthy fish stocks.

In order for fisheries to be truly ecosystem-based, fisheries managers and fishermen must stop treating bycatch and discards as simply by-products of fishing (NRC 1999). Whether bycaught species are commercial or not, it is crucial that we understand and plan for the full catch of all species. Without this, we will continue to remove both target and non-target species from ocean ecosystems at a rate that these ecosystems cannot bear.

Current practices

Although there is no specific federal or provincial legislation addressing bycatch and discards, Canada is signatory to the FAO *Code of Conduct*, which does address bycatch issues by stating, among other things:

> *7.6.9 States should take appropriate measures to minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and negative impacts on associated or dependent species, in particular endangered species. … States and subregional or regional fisheries management organizations and arrangements should promote, to the extent practicable, the development and use of selective, environmentally safe and cost effective gear and techniques.*

One of the few Canadian documents that does address the bycatch issue is the *Canadian Code of Conduct for Responsible Fisheries*. The *Canadian Code* was developed by fishermen to allow better self-regulation of their industry. This is not a legally binding document. However, it does state:

> ***Principle 6.*** *To the extent practical, fish harvesters will minimize unintended bycatch and reduce waste and adverse impacts on the freshwater and marine ecosystems and habitats to ensure healthy fish stocks.*

Finally, Canada's *Selective Fishing Policy* was created specifically to address bycatch issues. Unfortunately, this policy has dealt with few issues other than those directly related to the salmon fishery, and has not received the resources necessary to make it a success.

Best practices

Where the catch of certain species tends to be accompanied by large volumes of bycatch, a change in fishing gear can sometimes offer solutions. One such solution is discussed below.

How do we get there?

It is clear that in order to address the problems associated with bycatch, this issue must be explicitly dealt with in fisheries management plans.[3] Although several approaches to overcoming the environmental degradation associated with bycatch have been put forward, any such approach must ensure that (1) all bycatch is measured, and (2) the rate of fishing is sustainable for the most affected or vulnerable species caught.

Key to reduction of bycatch is reduction of the speed of fishing (Alverson et al. 1994). As discussed in Recommendation 4, the majority of the world's fisheries are vastly overcapitalized. One consequence of the 'race for fish' that results from overcapitalization is that fishermen do not have time to select the cleanest (i.e., lowest bycatch) fishing grounds, ensure that discarded fish are handled in a way that decreases mortality, spend time researching and investing in low-bycatch fishing gear, or otherwise ensure as little bycatch as possible (Alverson et al. 1994). Because of this, arrangements that decrease capacity – such as those discussed in Recommendation 4 – should be explored to overcome the bycatch problem.

Several methods specific to the reduction of bycatch have also been proposed. Bycatch quotas specify how much of a bycaught species each vessel in a fishery can catch. When the vessel exceeds this value, its fishing season is curtailed. Although these methods can be successful (Alverson et al 1994, NRC 1999), they will not be suitable in all cases. For example, there will be some species for which no limit of bycatch is acceptable – most notably those that are endangered or are otherwise particularly vulnerable to exploitation (NRC 1999). When quotas are set, they can also lead to a situation where the full bycatch quota is always taken, or, where quota is decreased in a targeted fishery to allow for bycatch in another.

Changes in gear may also be particularly effective at controlling bycatch. While some gear

Best practices: an example

Shrimp and prawn trap fisheries

Although not all shrimp and prawn species can be easily targeted with trap gear, for those that can, traps represent a low bycatch alternative to the shrimp trawl fishery. Traps catch less bycatch (DFO 2001c), and the bycatch that is caught tends to be less damaged, thus allowing discarded organisms to better survive the fishing process. For example, Troffe et al. (2003) showed that shrimp caught in traps experienced significantly less body damage than those caught in trawl. In British Columbia, spot prawn, and some humpback and coonstripe shrimp are caught in trap fisheries.

types, such as the trawl, are well known to incur large volumes of bycatch, others are much cleaner. In many cases, these low bycatch alternatives seem obvious substitutes for high bycatch technologies: for example, traps as a substitute for trawl, or in-river or other stock-selective fishing methods as a substitute for open-water mixed stock fishing methods (NRC 1996). Incentives to encourage the development of new gear should also be explored.

In concert with the above methods, changes in fishing patterns to ensure avoidance of sensitive times and areas may also be crucial to the reduction of bycatch (Alverson et al. 1994, NRC 1999). While this is a strategy that could be undertaken as needed for a single species, its benefits could be greatly increased by incorporating it into an integrated approach to the design of marine protected areas. When all else fails, fisheries that continue to incur substantial bycatch must be more stringently regulated, or discontinued.

NOTES TO RECOMMENDATION 8

1 **Bycatch** can involve both non-target species and non-target individuals within species. Small and juvenile fish are also often caught unintentionally as bycatch.

2 Myers et al. show that the bycatch, discard, and mortality of juvenile fish in the Atlantic cod fishery was not properly accounted for when the stock size was assessed. This contributed to this stock's collapse.

3 The *How do we get there?* section in Recommendation 1 further examines how measurements of bycatch should be integrated into management plans.

RECOMMENDATION 9

Make aquaculture **sustainable**

Rationale

Finfish aquaculture

Worldwide, the production of finfish and shellfish using aquaculture has increased exponentially over the last 30 years (FAO 2002). Although in some areas aquaculture is still practiced as it has been for centuries (Costa-Pierce 2002), the past few decades have seen the rise of a new, industrialized form of farming the oceans. Billed as a 'blue-revolution' in its infancy, the results from countries that practice industrialized aquaculture tell a different story.

On British Columbia's shores, the vast majority of fish farming is for salmon (British Columbia 2001). The open netcages used for salmon aquaculture have been repeatedly shown to be environmental disasters. Because of the high density of fish in each cage, the potential for disease and parasites to spread among the farmed fish, and from them to their wild counterparts, is enormous. One parasite, the sea louse (*Lepeophtheirus salmonis*), has devastated wild and farmed salmon in areas around the world where salmon is farmed. Patterns of sea lice infestation followed by wild salmon declines have been seen in Scotland, Ireland, and Norway (Gargan 2000, Watershed Watch 2001), while this same louse was implicated in a recent pink salmon collapse in British Columbia's Broughton Archipelago (PFRCC 2002, Morton et al. 2004). Other infestations are also common in salmon farms. The Infectious Hematopoietic Necrosis (IHN) virus occurs naturally in wild salmon populations, but has caused massive mortalities on B.C. salmon farms (Gardner and Peterson 2003).

Intensive aquaculture operations, such as those on the B.C. coast, rely upon huge subsidies from nature for their existence. For instance, waste released from open netcage systems is immense. Surplus food often contains antibiotics and pesticides intended to combat the diseases that result from the densely packed conditions (Naylor et al. 1998). These, in combination with the large volume of feces produced by the crowded fish, pollute the aquatic environment surrounding farms. Although estimates vary regarding the amount of waste produced by an average farm, one study suggests that 100 to 200 times the area of a caged fish farm is needed to assimilate finfish waste (Folke et al. 1998).

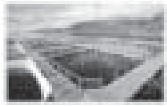
Intensive salmon farms also rely on the marine ecosystem to provide vast quantities of fish for feed. Salmon are carnivorous and feed largely on other, smaller animals in the wild and on fish meal when they are penned. Thus, salmon farming causes a 'net loss' of protein from the ocean. Worldwide, the mean trophic level of non-Asian aquaculture has increased steadily since the 1970s because of the increasing production of carnivorous organisms. We are "farming up the food web", allowing captured fish to be used to feed luxury products like salmon, rather than simply consuming those fish (Pauly et al. 2002). B.C. fish farms are contributing to this net loss. It has been estimated that salmon netcage farms like those on this coast depend on an area 40,000-50,000 times that of the cage to obtain the necessary feed fish (Folke et al. 1998). Often, the fish converted to feed is itself perfectly edible. As we continue to allow coastal and marine ecosystems to deteriorate for the pursuit of intensive aquaculture, it is clear that the market price of intensively farmed fish does not include the environmental cost of using nature's services (Folke et al. 1998).

Of the salmon farmed on B.C.'s coast, four-fifths are exotic Atlantics (British Columbia 2001). In the current open netcage system, the potential for escape is enormous. In jurisdictions that have a longer history of commercial aquaculture than B.C., farmed fish often dominate the commercial catch. In some areas of Norway, for example, over 80 percent of the fish caught by commercial fishermen have escaped from a farm (Volpe 2001). On the B.C. coast, we know that escaped Atlantic salmon are spawning naturally outside of fish farms (Volpe et al. 2000), and that they can compete for habitat with wild fish (Volpe et al. 2001). It seems that we have inadvertently added another species to the British Columbia landscape.[1]

This concern about escaped species is not limited to Atlantics. Pacific chinook and coho salmon are also farmed in B.C. (British Columbia 2001), and their escape causes additional risks. Because farmed fish are selected for characteristics such as rapid growth and high feed conversion, they differ a great deal from their wild counterparts (Gross 2002). The genetic concern for escaped Pacific salmon is thus high because of their potential to breed with wild fish and reduce the wild adaptations of salmon populations (Gross 2002). No matter what species of fish we farm, it is crucial to eliminate their escape (Volpe 2001).

Shellfish aquaculture

Although small compared to the salmon farming industry on the coast, shellfish farming is a visible and growing component of B.C.'s aquaculture industry (British Columbia 2001). The farming of shellfish, such as oysters and clams, does not incur several of the environmental concerns that finfish farming does, largely because shellfish are filter feeders and therefore do not require commercial feeds. Because of this, pollutants such as excess feed are not being deposited into the marine



environment, and shellfish aquaculture is not 'farming up the food web' – the protein produced by this form of aquaculture does not require the appropriation of wild seafood.

However, there are concerns about the farming of shellfish. As is the case with salmon farming, the farming of exotic shellfish is the rule rather than the exception in B.C. Unlike salmon, however, the exotic shellfish farmed were generally introduced long before recent aquaculture began. The relevant question for the farming of exotic shellfish is whether the large-scale addition of invasive species already present in the environment will degrade beach processes, or negatively impact native species.

Further, it is common practice to farm clams and certain oysters in the intertidal zone of oceans – a habitat area of high productivity and biodiversity extremely sensitive to disturbance. Because of this, it is essential to ensure that shellfish farming is carried out in an ecologically viable manner. For example, the fencing and anti-predator netting often used on shellfish culture beaches may interfere with fish migration and degrade the habitat of organisms native to the intertidal zone (Bendell-Young 2001). If shellfish are farmed intensively at high concentrations, which is the case in several of B.C.'s larger operations, additional concerns arise. Scientists are still unsure of the extent to which such intensity would affect competing organisms, both through direct competition for food and other resources, and because the waste produced by these organisms should be expected to modify the surrounding environment (Grant et al. 1995). Although the farming of shellfish could be a development opportunity for coastal communities, it clearly must be carried out in a manner that does not significantly impact marine ecosystems.

Current practices

Authority over aquaculture practices in British Columbia falls to both the federal and provincial governments. Under a memorandum of understanding signed in 1988 (in British Columbia 1997), the provincial government holds the responsibility for site approvals and overseeing day-to-day operations, while the federal government oversees areas such as research and development, the protection of wild fish, and regulating the transfer of interprovincial and international fish products. The lead agencies are the B.C. Ministry of Agriculture, Food and Fisheries (MAFF), and Canadian Department of Fisheries and Oceans (DFO).

Despite its mandate to protect wild fish stocks, DFO appointed a Commissioner of Aquaculture Development in early 1999; a position designed to advise the Minister on the creation of policy and legal frameworks supportive of aquaculture. In 2000 the federal Auditor General released a report condemning DFO for not meeting its legal obligations to protect wild salmon stocks and habitat in the Pacific (Minister of Public Works and Government Services Canada 2000). Despite this, aquaculture development continues to be supported within the Department as a high priority – recent direction from the Minister was to "ensure aquaculture is more of a priority", and "create and enabling regulatory environment" for aquaculture (DFO 2004).

In September of 2002, the provincial government lifted a long-standing moratorium on applications for new fish farm tenures in provincial waters. Applicants for these now-available tenures must submit a Commercial Finfish Aquaculture Management Plan to MAFF, and the Minister will decide on the validity of the application. New waste standards were also set at the time the moratorium was lifted, based on the free sulphide concentration on the ocean bottom below the site[2]. Farm operators will self-monitor their site, and submit results to the province (British Columbia Waste Management Act).

The experience in British Columbia and elsewhere has shown overwhelmingly that the intensive farming of carnivorous fish cannot be the substitute for marine capture fisheries that it was once promised to be.

A similar regulatory arrangement exists for shellfish aquaculture. The federal Commissioner of Aquaculture Development also works in support of shellfish aquaculture, while it is the province that issues the licenses necessary to farm shellfish. The provincial Ministry of Agriculture, Food and Fisheries has recently issued an enforceable Code of Practice (MAFF 2002) which addresses issue such as siting, waste management, vehicle use, and noise, light, and odour. This results-based Code, however, generally aims to minimize impacts rather than eliminate them altogether, while knowledge of what threshold of impacts the environment can bear from shellfish farming is almost entirely lacking. It is also unclear how enforcement of this Code will occur.

Best practices

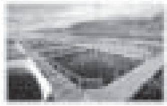
The experience in British Columbia and elsewhere has shown overwhelmingly that the intensive farming of carnivorous fish cannot be the substitute for marine capture fisheries that it was once promised to be. These systems of aquaculture rely heavily on subsidies of feeds from the world's oceans, and on ocean space for waste disposal (Folke et al. 1998). It has become clear that aquaculture practices in B.C. must change by farming lower trophic level organisms, reducing fishmeal and oil in feeds, and promoting environmentally sound practices (Naylor et al. 2000).[3] One such example is illustrated on page 57.

How do we get there?

Salmon aquaculture

Although aquaculture could be made to be an important component of viable coastal communities, it is clear that we must radically change industry practices. The British Columbia-based Coastal Alliance for Aquaculture Reform has, in conjunction with several scientists, developed the following requirements for change in B.C.'s salmon farming industry:

1. **Develop technology that eliminates the risk of disease transfer to wild fish and escapes of salmon into the wild.** When salmon are farmed at great densities, their potential to incubate disease is enormous. Experience from British Columbia and elsewhere provides compelling evidence that, when open netcages are used, these diseases then spread to wild salmon populations (reviewed in Gardner and Peterson 2003). In open netcages, escapes also occur (Volpe et al. 2000). Competition (by farmed Atlantic salmon) and interbreeding (by farmed Pacific salmon) with wild salmon could have significant deleterious effects on wild salmon



populations (Volpe et al. 2001, Gross 2002). Technology that ensures that disease and parasites from farms cannot be spread to the wild, and escapes cannot occur, is crucial.

2. **Guarantee fish farm waste is not released into the ocean.** Studies have shown that an area up to 100-200 times the size of a typical, industrialized fish farm is necessary to assimilate the waste it produces (Folke et al. 1998). This waste can contain chemicals such as pesticides and drugs, and will inevitably change the community composition below and surrounding the farm. The current waste control regulations use sulphide concentrations to judge the amount of damage being done to the ocean bottom community. The sulphide concentrations allowed in ocean bottom sediments has been measured, on average, to result in a 75 percent decline in the number of species in these communities

Best practices: an example

The contained farming of herbivores

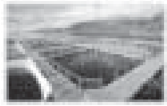
Around the world, the practice of extensively farming herbivorous fish has persisted for millennia, and has provided sustenance for many of the world's people. Today, many herbivorous species are farmed for profit; often, this occurs in quite innovative ways. One example of this is the farming of tilapia, which occurs throughout the world and in North America (Watanabe et al. 2002).

Rather than farming this freshwater species within natural ecosystems, the common practice is to farm it in small, artificial ponds, or, where climate is cooler, in tanks or recirculating systems (Watanabe et al. 2002). Innovative approaches to farming this species include integrating its culture with agricultural activities through using the waste for irrigation, or using crop residues as feed (Rakocy 2002, Watanabe et al. 2002). Another innovative process uses suspended micro-organisms within the growing tanks to convert waste directly back into feed, thus decreasing the need for added food, and the need to exchange water (Watanabe et al. 2002). In B.C., a tilapia farm that uses vegetarian feed and obtains some of its energy from solar sources has recently started up (McDonald 2003). Farming herbivorous species in closed containment systems can overcome many of the challenges presented by aquaculture on the B.C. coast.

As discussed in the above section on shellfish farming, however, the farming of herbivorous organisms is not necessarily ecologically benign. For example, when farming herbivorous fish, it has become commonplace to include fishmeal in feed to increase growth rates (Naylor et al. 2000), a practice which would contribute to a net loss of protein. Further, while the use of on-land tanks greatly reduces the risk of contamination of wild fish species, it does present the challenges of increased energy use to aerate and heat the water if alternative energy sources are not sought out (Watanabe et al. 2002). Finally, organisms like tilapia are often pest species that are not endemic to the area in which they are being farmed, and farmed organisms are as a rule bred selectively to make them more suitable for captive rearing. Although the potential for escape from on-land systems is remote, its occurrence could be disastrous.

(Brooks 2001, British Columbia Waste Management Act).

3. **Use fish food that does not result in a global loss of seafood for human consumption, or ecosystem functioning.** The average salmon farm requires an area between 40,000 and 50,000 times that of the cage to provide the necessary feed fish (Folke et al. 1998), while the average trophic level of farmed fish produced in industrialized countries continues to rise (Pauly et al. 2002). In other words, we are farming more carnivores, and depleting the oceans to do so. Industrialized aquaculture, as currently practiced, is not a substitute for fisheries (Folke et al. 1998).
4. **Ensure that wildlife is not harmed as a result of fish farming.** Marine wildlife is known to interact with aquaculture operations. DFO allows large marine mammals that cannot be deterred by non-lethal methods to be killed: one study estimates that over 3800 harbor seals, California sea lions, and Steller sea lions were killed between 1989 and 1996 for this purpose (Nash et al. 2000). Non-lethal methods can also be detrimental to wildlife health. A recent study investigating the effect of acoustic predator control devices on killer whales has shown that the noise pollution they emit displaces these whales (Morton and Symonds 2002).
5. **Prohibit the use of genetically modified fish.** Genetically modified fish are organisms into which foreign genes have been inserted, presumably to arrive at organisms that are more suited to aquacultural practices. Both the human health impacts of genetically modified fish and the ability of escapes to interact with their wild counterparts is of concern. The impact of genetically modified fish on aquatic ecosystems has been largely unstudied (reviewed in EVS Environmental Consultants 2000). Currently, genetically modified fish are not used on B.C. fish farms.
6. **Eliminate the use of antibiotics in fish farming.** Antibiotics and pesticides are used in fish farming to ward off the disease and parasites that become commonplace when fish are packed in such close density. The use of these chemicals, however, is not without cost: several authors have raised concerns about (1) bacteria surrounding fish farms becoming antibiotic resistant, (2) the appearance of antibiotic residues in non-target marine mammals, and (3) the deleterious effects of pesticides on other organisms in the marine environment (reviewed in EVS Environmental Consultants 2000).
7. **Respect the views of coastal residents and do not locate farms where First Nations or other communities object.** Recent Supreme Court of Canada decisions have made clear that consultation with, and accommodation of First Nations must occur for practices that will impact their traditional territories. Unfortunately, community members are not always consulted when farm or hatchery siting decisions are made.
8. **Label all farmed fish so consumers can make informed choices.** In addition to the many environmental effects brought about by aquaculture, there are also human health concerns. For example, studies indicate that farmed fish may contain higher levels of certain chemicals, such as PCBs, than their



wild counterparts (Easton 2002, Hites et al. 2004). Farmed salmon are also fed colorants to allow their flesh to become the same pink colour as that of wild salmon. Clearly, the consumer has the right to know the origin and composition of their food.

Shellfish Aquaculture

Although it has the potential to be much more benign than salmon aquaculture, farming shellfish can also present environmental concerns if not undertaken correctly. Suggestions for caution in this industry, developed in concert with First Nations, academics, and industry participants include:

1. **Chose sites carefully.** An initial, rigorous site selection must occur to ensure that sensitive areas such as estuaries and sea grass beds are not used for shellfish aquaculture.
2. **Gather baseline information of the area to be farmed.** The collection of baseline data before farming begins is crucial to understanding how the farming operation changes the surrounding environment. Without baseline pre-farming ecological information, the effects of farming on the surrounding environment will be extremely difficult to measure and if necessary, to correct.
3. **Eliminate or minimize beach and substrate disruption.** The integrity of the intertidal substrate is critical for the many species that live on and within it. To minimize its disruption: (1) Harvesting should be done by hand digging, other beach life should be left in place during harvesting, and harvest timings should be staggered to allow for full recovery. (2) Foot traffic on the beach should be minimized at all times. Vehicle traffic should be eliminated. Driving on beaches can introduce oil and gas into the environment, and compact substrates. If absolutely necessary, steps must be taken to minimize impact, such as using small vehicles with choosing large, low pressure tires, and not driving on the substrates most susceptible to damage. (3) Other organisms should be left in place when shellfish seeds are added to beaches. The maintenance of biodiversity on farmed plots is essential. Allowing the intertidal community to co-exist with the farmed species is the only way to do this.
4. **Minimize use of anti-predator netting.** Anti-predator netting is stretched along the beach surface to prevent birds and other predators from eating young shellfish, potentially preventing these natural predators access to their feeding areas. This netting should only be used if sample plots have shown it to be absolutely necessary. When it is employed, its use should be minimal, should include large gaps between panels, and should be lifted prior to bird migration periods.
5. **Minimize the use of, or do not use, fencing.** Fencing is used in the beach culture of oysters to prevent the farmed organisms from moving off the beach. As a rule, fencing should not be used. Where fences must be used, they should allow full passage of fish and other marine life throughout the water column, and should follow the natural contours of the beach.
6. **Farm oysters at lower, rather than higher, densities.** Oysters are often farmed attached to long ropes, which are attached to rafts. High density cultivation could lead to

decreased nutrients in the water column, and deposition of pseudofeces[4] on the sediment below. Both of these could potentially harm aquatic life and change the surrounding community composition. High raft densities are of particular concern in confined bays or inlets with limited flows.

7. **Include measures for waste disposal in the management plan.** Waste produced from farm applications (such as rope and other materials) should always be disposed of in the proper manner, away from the farm site.

NOTES TO RECOMMENDATION 9

1 Exotic species have been calculated to be second only to habitat destruction in the worldwide decrease of biodiversity. In the marine environment, exotic species are particularly troublesome. International shipping and the connectivity of the marine environment have made the spread and introduction of these organisms relatively easy. Unfortunately, documented cases of invasive species dramatically altering ecosystem structure and function are numerous (Carlton 2001).

2 Several studies suggest that phosphorus may be a much better indicator of contamination around fish farms (MacLeod et al. 2002). Other studies have shown that the levels of sulphide currently allowed in the benthos below salmon netcages results, on average, in a 75 percent decrease in the number of different benthic species (Brooks 2001, British Columbia Waste Management Act).

3 More specifics on changes necessary for sustainable aquaculture are given in *How do we get there?*.

4 **Pseudofeces** are composed of material rejected by animals like oysters before it enters the gut for digestion.

RECOMMENDATION 10

Invest in monitoring and data acquisition

Rationale

In order to make rational, ecologically sound decisions for fisheries management on the Pacific coast, it is imperative that we have reliable information to base these decisions on. Basic data collection has long been the staple of fisheries management: collection of reliable data over long time periods, on the proper parameters and from the correct locations is crucial (NRC 1999). Unfortunately, as resources are cut from the regulatory bodies that manage B.C. fisheries, their ability to collect the necessary data continues to decline precipitously. As just one example, there was a 47 percent decrease in the enumeration of salmon spawners in B.C. streams between 1985 and 1999 (Thompson and MacDuffee 2002), and this decline continues. These cuts in government resources are occurring as scientists realize that more extensive information may in fact be needed to understand what ecologically viable harvest rates are. The ecosystem approach to management advocated in this report requires that information on the food web that surrounds exploited species be collected, in addition to data on the species itself (see Recommendation 1 for more detail on these needs).

District field staff, necessary to monitor widely dispersed fish populations, have been cut back severely over the last few years (Walters 1995). Although these staff are critical for local data collection, on-the-ground personnel are also needed to ensure compliance with existing legislation, including enforcement. As detailed in Recommendation 6, the need for resources to ensure compliance with habitat regulations is acute. In addition, we must also provide the resources to monitor fishing effort, and understand levels of catch and bycatch.

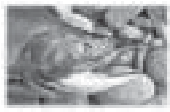
The analysis of collected information must occur in a non-biased way. The bias of some government scientists, and particularly the ability of government policy makers to misconstrue scientific findings to support their policy decisions has been documented in Canada, and suggested to be a contributing factor to at least one fishery collapse (the northern cod; Hutchings et al. 1997). This lack of bias must also be carried forward to the information available for public use. Several studies have documented that without readily available, unbiased and transparent data stakeholders of the fisheries management process will necessarily be distrustful. Without unbiased, transparent data, stakeholders can not fully participate in management decisions or evaluate the decisions made; often when this occurs the rules governing the fishery are not perceived as credible, and the well-known split between scientists, managers and fishermen can occur (e.g. Costanza et al. 1998).

Finally, it is crucial to recognize that while the collection of necessary data must be made a priority for fisheries management, such management will always be made in the face of uncertainty (Christensen et al. 1996). Biological systems are complex, and as such will never be completely understood. Given the inherent complexity of biological systems, we must also acknowledge that we cannot know for certain the consequences of the actions proposed in this report. Thus, we must monitor the results of these new actions. Using the precautionary principle to guide management decisions, as discussed in Recommendation 2, is one crucial way to deal with this uncertainty. Adaptive management is another important tool for managing in the face of uncertainty. This technique uses management alternatives as experimental units (i.e., with the proper use of replicates and controls) to allow a greater degree of learning about the system under study (Walters and Holling 1990). These management regimes are designed to facilitate data collection and hypothesis testing, allowing management plans to evolve as hypotheses are either supported or rejected (NRC 1999).

Current practices

Under the Canadian Constitution, responsibility for the management, conservation and protection of marine and inland fisheries, fish, and their habitat falls to the federal government. This responsibility includes the collection of information needed for management, and necessary monitoring and enforcement. Under an agreement signed with the British Columbia government, however, jurisdiction for the management of steelhead salmon and freshwater species falls to the province. Over the past 10 years, DFO and the provincial government have funded and encouraged public groups such as streamkeepers and watershed councils to collect large quantities of habitat and fisheries data. This funding has been cut, and how this data will be subject to quality control and brought into an overall database remains to be seen, especially given the current lack of resources to support this undertaking.

The loss of resources for monitoring, enforcement and stewardship in recent years has been drastic. Collectively, the two levels of government have cut tens of million from salmon restoration programs (e.g., Kariya 2002), and a documented loss of monitoring effort has also occurred (Thompson and MacDuffee 2002). Decreases in effort in other, non-salmon fisheries have not been as well documented. Some fisheries and



communities have become involved in the collection of their own fishery-specific or area-specific information. For example, research in the halibut and sablefish fisheries is undertaken or funded by the group prosecuting these ITQ-system fisheries (DFO 2002e, 2002f). In other places, communities and stewardship societies have taken on the burden for local stewardship and monitoring initiatives (e.g. Pinkerton and Weinstein 1995).

Scientific information is available to the public through the work of the Pacific Scientific Advice Review Committee (PSARC). PSARC produces stock status reports, habitat status reports, and more detailed research documents related to the fisheries managed by the federal government. The Pacific Fisheries Resource Conservation Council (PFRCC) was founded in 1997 in response to a recommendation in the 1994 Fraser River Sockeye Public Review board to provide inde-pendent public reporting on salmon-specific conservation issues. The PFRCC reviews available information to provide the public and the Minister with advice on stock conservation and habitat restoration and protection, the review of current government initiatives such as research programs and enhancement initiatives, and provide governments and the public information on the status of Pacific salmon stocks and their habitat.

Best practices, and how do we get there?

In order to move more completely towards ecosystem-based management, the collection and analysis of fisheries information must be much more overarching than it has been in the past. Although these traditional monitoring needs remain, additional elements with new foci must also be added. Because there are few working examples that incorporate the data collection needs of ecosystem-based management, the above two sections have been combined. A review of the few existing documents on the subject, and an analysis of current government direction suggests the following priorities for action on monitoring and data acquisition:

1. **Commit more resources to information gathering, monitoring, and enforcement.** Research in the public interest is a key government obligation. The recent withdrawal of funding resources from much-needed monitoring and enforcement work has been heavily felt. As discussed above, 47 percent less salmon streams have good data collected about them than was the case 15 years ago (Thompson and MacDuffee 2002). The need for such data in making good management decisions is crucial. As well as allocating resources to recover to past levels of monitoring and data collection, we must recognize that additional forms of data are required. First, if we are to manage for genetic diversity in species like salmon, it is clear that we must begin to collect data on more genetically distinct stocks, at least for the short term until suitable conservation units for management can be identified (Thompson and MacDuffee 2002).[1] Second, to undertake an ecosystem approach to management, further additions to our data collection and changes to the way that we use this data will likely be needed (as outlined in Recommendation 1). Ecosystem models

might help to inform these data needs, by indicating new observations that should be collected, or new research approaches (NRC 1999). Resources for data gathered for monitoring and enforcement must be great enough to ensure information suitably rigorous for legal proceedings is collected.

2. **Ensure that the gathering of information and its analysis occurs in an unbiased, transparent manner.** Access to unbiased information is critical if stakeholders are to have confidence in the management regime, and management decisions are to be made in an open manner. The system in place has improved in recent years: the information used by government to base its management recommendations on is largely available through PSARC, and the PFRCC has allowed open critiques of the needs of British Columbia's salmon fisheries to be expressed. However, science within the department does not always proceed in an unbiased way (e.g., Hutchings et al. 1997), and public data is often not publicly shared. Because of this, we suggest that:
   a) direction from senior levels of the Department, including the Minister, must be to conduct unbiased scientific research, to limit the interference of policy makers into this research, and to ensure that data gathered in the public interest is accessible to all, and
   b) the creation of an ombudsman, through whom complaints from both the general public and within DFO could be heard, should occur. For such an ombudsman to be effective there must be a requirement for DFO to accommodate its requests and suggestions.
3. **Acknowledge uncertainty through managing adaptively and monitoring to ensure that management actions are having the required consequences.** At the very least, past mistakes should be allowed to inform future management direction (Walters and Holling 1990). Managing adaptively – treating management efforts as experiments through which we might inform future management action – is one way to reduce the uncertainty that surrounds fisheries management. Clearly, it is crucial to monitor the results of any management change, including those proposed in this document. The uncertainty central to all ecological systems obliges us to ensure that the results of these changes are beneficial ones.

NOTE TO RECOMMENDATION 10

1 Such conservation units could be based on factors such as differences within and between species, productivity, run sizes, times, and environmental considerations (Thompson and MacDuffee 2002).

Conclusion

The solutions outlined in this document are crucial to ensuring diverse, resilient marine ecosystems for future generations. Additionally, however, they can also facilitate healthy coastal communities, allowing those who fish now to sustain themselves and their families. These solutions revolve around three clear, central themes. First and foremost is the need for the protection of marine ecosystems. Fisheries must occur under the umbrella of ecosystem-based management, which includes measures such as the creation of marine reserves, the ecological principles of proper catch setting, and habitat and diversity protection. Participation in fisheries management – allowing those closest to the fisheries to have a say in how they are managed – is also clearly necessary for sustainable fisheries management. Anything else will only perpetuate the adversarial problems currently faced in B.C.'s fisheries. And finally, this document underlines precaution as a fundamental foundation of all fisheries management. Only if we err on the side of caution, can we be sure that well-managed fisheries will continue to exist well into the future.

Our marine environments are managed by the government on behalf of all Canadians. Canadians must demand a commitment from their government to manage in an ecosystem-based, precautionary way. Anything less will threaten this vast, precious resource, and the many people who depend on it.

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The Pacific marine environment, and the rich fishing tradition that it supports, are a fundamental part of British Columbia's culture. This is for good reason – the unique properties of the Pacific Ocean produce a level of biodiversity unparalleled in other Canadian waters. This biodiversity has supported vibrant fishing communities for millennia.

Despite this powerful history, the ecological integrity of Canada's Pacific Ocean continues to decline. Important fish species continue to be listed as threatened or endangered, under severe pressure from a complex mix of habitat destruction, industrial pollution and unsustainable fisheries practices. Clearly, a new direction for Canada's Pacific fishery is long overdue.

A better approach is very possible, and highly critical. Responsible ecosystem-based management must understand and integrate the ecology, economics and social issues of the fishery in order to be successful. ***Seas of Change: Ten Recommendations for Sustainable Fisheries on the B.C. Coast*** puts forward ten essential requirements for workable, sustainable solutions that will manage our fisheries for the future.

David Suzuki Foundation

SOLUTIONS ARE IN OUR NATURE

Working through science and education to protect the diversity of nature and our quality of life, now and for future generations.

David Suzuki Foundation
2211 West 4th Ave., Suite 219
Vancouver, BC
Canada V6K 4S2
www.davidsuzuki.org
Tel (604) 732-4228
Fax (604) 732-0752

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