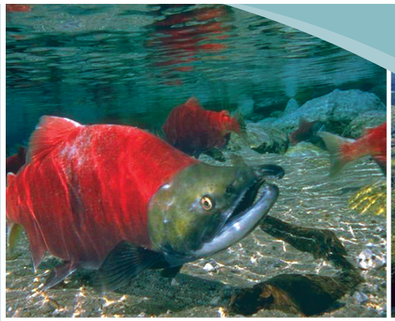

Patricia Gallaugher and Laurie Wood

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Patricia Gallaugher and Laurie Wood

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Speaking for the Salmon

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Preface

The World Summit on Salmon evolved in response to growing concerns of scientists and others about the future of the salmon stocks of the world, in light of the recent collapses of a number of the fish stocks globally, including Canada's North Atlantic Cod. Participants in the three-day workshop examined the factors associated with the collapse and subsequent efforts at restoration of fish stocks with the hope of applying the lessons learned to improve the outlook for the future of wild salmon in the Atlantic and Pacific. The summit was held at the Morris J. Wosk Centre for Dialogue at Simon Fraser University, a venue particularly well-suited for face-to-face dialogue given its UN-style format.

This volume is a collection of most of the papers presented at the Summit and incorporates the dialogue among all summit participants. A detailed agenda for the program can be found at: www.sfu.ca/cstudies/science/summit.htm.

Comments from some of the participants about the workshop

"I can say it [The World Summit on Salmon] is the most important conference in which I have participated, in that the most important environmental problems of our time have been brought to national and international attention, and the urgent and necessary solutions that must be applied to sustain our salmon and marine resources." Dr. R. John Gibson, Research Scientist, "Coasts Under Stress" Research Project, Memorial University of Newfoundland, July 7, 2003.

"While some may say that calling the gathering a 'World Salmon Summit' is presumptuous, I think it was aptly named, given the breadth of participation and the breadth and depth of presentations." Jan Konigsberg, Trout Unlimited, Anchorage Alaska.

"…this was a fabulous conference – one of the very best that I've ever attended." Robert Mazurek, Fisheries Research Biologist, Seafood Watch, Monterey Bay Aquarium, California

"I thought it was a most successful meeting, one of the best I have ever attended on salmon, with a very wide reach. I appreciated the invitation to participate, and found it most stimulating." Malcolm Windsor, North Atlantic Salmon Conservation Organization, Scotland

"…it [the World Summit on Salmon] was the best I've ever been to." Marc Porter, Habitat Inventory Biologist, Fisheries and Oceans Canada

The World Summit on Salmon is the 14th project in The Speaking for the Salmon series. This series, launched by Continuing Studies in Science at Simon Fraser University in January 1998, examines issues impacting the survival of wild salmon in British Columbia. Projects in the series include workshops, think tanks, proceedings and reports and to date include information pertaining to sea lice, nutrients and salmon production, hatcheries, aquaculture, wild salmon policy and more. Information about the series (including proceedings) is available on our web site: http://www.sfu.ca/cstudies/science/salmon.htm.

CHAPTER 1

Introduction

John Fraser, Chair,
Pacific Fisheries Resource Conservation Council (PFRCC),
Vancouver, BC, Canada

Introduction
The PFRCC described this summit in a press release as follows:

> *The current global collapse of fisheries underscores the critical objective of this summit. People with world-class skills are coming together to look at conservation challenges and search for new solutions. Finding new answers is essential because conventional approaches are failing. There are many serious pressures on the world salmon resource. It is incumbent on us to take stock of what we know, what we do not know and what we should know to ensure that the salmon is saved and this is why this summit is so important.*

The myth of super-abundance
On the cover of the June 2, 2003 edition of MacLean's magazine is the title, "How to Heal Nature". The article refers to the World Wildlife Fund and other groups who are trying to establish a means to make an environmental audit so that the public can understand what is happening to 'Nature', including the human population, and the economic implications of viewing the natural resources of our magnificent country as being 'free'. This article illustrates the degree to which we are challenged by the whole question of biological diversity.

> *Not long ago it was hard to imagine that we would ever face shortages of fish, wood, fertile soil, precious metals and fresh water but rapacious, near-sighted industrial-scale agriculture, aquaculture, fisheries, forestry, mining and oil and gas development, have changed that scenario. Despite repeated government promises to turn things around, the natural environment is under siege all across inhabited Canada.*

The comment "Not long ago it was hard to imagine that we would ever face shortages" reminds me of the book, *The Quiet Crisis*, published in 1963 where Stewart Udall, Secretary of the Interior for the government of the United States, stated,

> *It was the intoxicating profusion of the American continent which induced a state of mind that made waste and plunder inevitable. A temperate continent rich in soils and minerals and forests and wildlife, enticed man to think in terms of infinity rather than facts and produced an overiding fallacy that was nearly our undoing – the myth of super-abundance. According to the myth, our resources were inexhaustible and it was an assumption that made wise management of the land and provident husbandry superfluous.*

With reference to the resources of the ocean, he said: "*Geography has always been a global science and conservation must now become a truly global concept if the optimum use of resources is to be achieved. Nature's rules still attain, in all parts of the natural world from minerals and marine life to the gulf streams of the ocean and jet streams of the upper atmosphere, to obey a single set of laws. It is the seven seas themselves, the one remaining largely unspoiled, untapped resource, which now represent the largest remaining frontier of conservation on this earth.*" Most of us would not agree that today the seven seas are the one remaining largely unspoiled, untapped resource although there is no question that they are still a remaining frontier of conservation on this earth.

Decline of the world's fishing resources

Reference to the state of the fishery resources of the globe's oceans was recently published in *Nature* (Myers and Worm, 2003) where the authors, Ransom Myers and Boris Worm, described the findings of their study and from which I quote,

> *By using a meta-analytic approach, we estimate that large predatory fish bio-mass today is only about 10% of pre-industrial levels. We conclude the declines of large predators in coastal regions have extended throughout the global ocean with potentially serious consequences for eco-systems.*

There is no question that the concerns they put forward are potentially applicable to the salmon resources of the world. With respect to Atlantic salmon, there has already been a very serious effect and Pacific salmon are no more likely to avoid some of the ravages, mistakes, and over-consumption that has plagued other species and other predatory fish around the world.

The astonishing thing is that this is not really new. I have cited Stewart Udall because the general theme of his book, written in 1963, was as applicable then as it is today. There are endless arguments among people who are in positions to issue concern or, from the government side, as to how to approach all of this. Fundamental to this is that denial is not going to get us anywhere.

Getting the information out

It is sometimes very difficult to recognize the significance of a specific problem in a particular place because it may not seem to be important overall. Yet when we take that

problem and find the others and then put them together we recognize that we have an enormous challenge in front of us.

The other side to this is if we just get up in front of an audience and give a litany of all the woes that the world faces, and all the environmental and conservation issues, and then do not offer any solutions or hope, we will send an audience home who will go to bed and not want to get up in the morning.

The World Summit on Salmon aims to be very disciplined in discussing what we know and what we do not know and to find some answers. For example, those who we elect to government are not necessarily against environment, wildlife, and wild salmon protection, nor are they against conservation, but they do need answers from the scientific community, and also from the representatives of the communities that are most in touch with wildlife and wild fish, and rivers, streams and wetlands. We have to be able to provide these people with sensible and accurate descriptions of what can be done. Remember this - everybody that we elect has to face a whole series of issues and, with respect to those around a Cabinet table, there are competing issues, not necessarily against conservation, such as highways, schools, health, defence, and foreign affairs, to name a few. As a consequence, if we cannot give to our elected representatives succinct, accurate and compelling arguments to do something and describe where it ought to be done, then we are not doing our job. There has been, for many years, a feeling of frustration among elected representatives, at the municipal, provincial and federal levels, that the science community has failed to articulate the dangers and the solutions, in a cohesive way and in a way that is clearly understandable to the rest of the world and the media. Some of the solutions are not going to be easy, especially when they involve conflicting interests, but the issues have to become a part of the public debate.

The example of salmon aquaculture

As an example, I want to refer to the issue of salmon aquaculture. Mr. Yves Bastien is the Commissioner for the Office of Aquaculture Development (OCAD) in the federal Department of Fisheries and Oceans. His job is to try to follow the policy of the federal government with respect to the promotion of aquaculture; no doubt, he thinks that this promotion should be carried out subject to common sense and good conservation. In a recent article in the National Post newspaper he was quoted as saying, "Wild salmon stocks have been similarly devastated but while environmentalists blame farmed salmon, forestry, urbanization, industrial impact on rivers, the destruction of habitat in rivers, and climate change, all have had a huge impact. They have decimated wild stocks and yet people look at aquaculture, which has a much lower impact on wild salmon, and if they can even show a tiny impact on the wild stocks that it is good enough reason to try to stamp out salmon farming."

To be fair, Mr. Bastien has been under considerable pressure; however, there is something that he does not understand; that is, nobody is saying that those things he has enumerated have nothing to do with the dangers to the wild salmon stocks, they have had, and still have, everything to do with the danger to wild salmon stocks. But these are not the only dangers, and if we have another issue that comes forward then it has to be dealt with in a rational, objective way. We cannot slide away from it by taking the approach that, compared to all of the other things, this is not a problem. At the moment we may have issues to resolve with respect to the relationship between farmed fish and wild fish

but we cannot take the view that this is the only issue that is going to affect the survival of wild salmon. Indeed, we need to have a broad-based and even understanding of what it is that we are facing. That does not mean that we do not take some hard decisions and do not put a sharp edge on what we have to say. However, it is to say that we, especially those in government whether in the public service or political life, do not quickly take simplistic ways to avoid facing one problem by pointing to a number of other problems.

Conclusion

In conclusion, I want to bring to your attention an article published in the June 9, 2003 edition of US News and World Report "Empty oceans, why the world's seafood supply is disappearing". Under the lead page, it says, "Science and technology fished out", and it then goes on to offer hope: "It is not too late to rescue the oceans and keep seafood on our plates." The author goes to some length to set out reasons, methods and approaches that can be used to accomplish this.

As mentioned above, it is very easy to give a litany of all our woes - but if that is all we give to the public (and the media) and those we elect we are not going to resolve the problem. That is the context and challenge that we face today. As Chair of the Pacific Fisheries Resource Conservation Council, which has joined with others in organizing this event, I want to say how much we appreciate being here and how much we appreciate the efforts of many people in this room, over a number of years and sometimes against considerable difficulties, to advance the knowledge and also the instinct for the conservation of our wild salmon stocks. In closing, I want to add this - it is a reality and a truth that our First Nations, our native people, have viewed the salmon and their return, as part and parcel of, not just their physical life, but also their spiritual life. We now have generations of people who are not First Nations, but are now part and parcel of this, and other communities who have very much the same respect and awe and even spiritual recognition of the salmon. Let us keep all of these things in mind and diligently apply our minds and our energy to finding answers.

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SECTION I

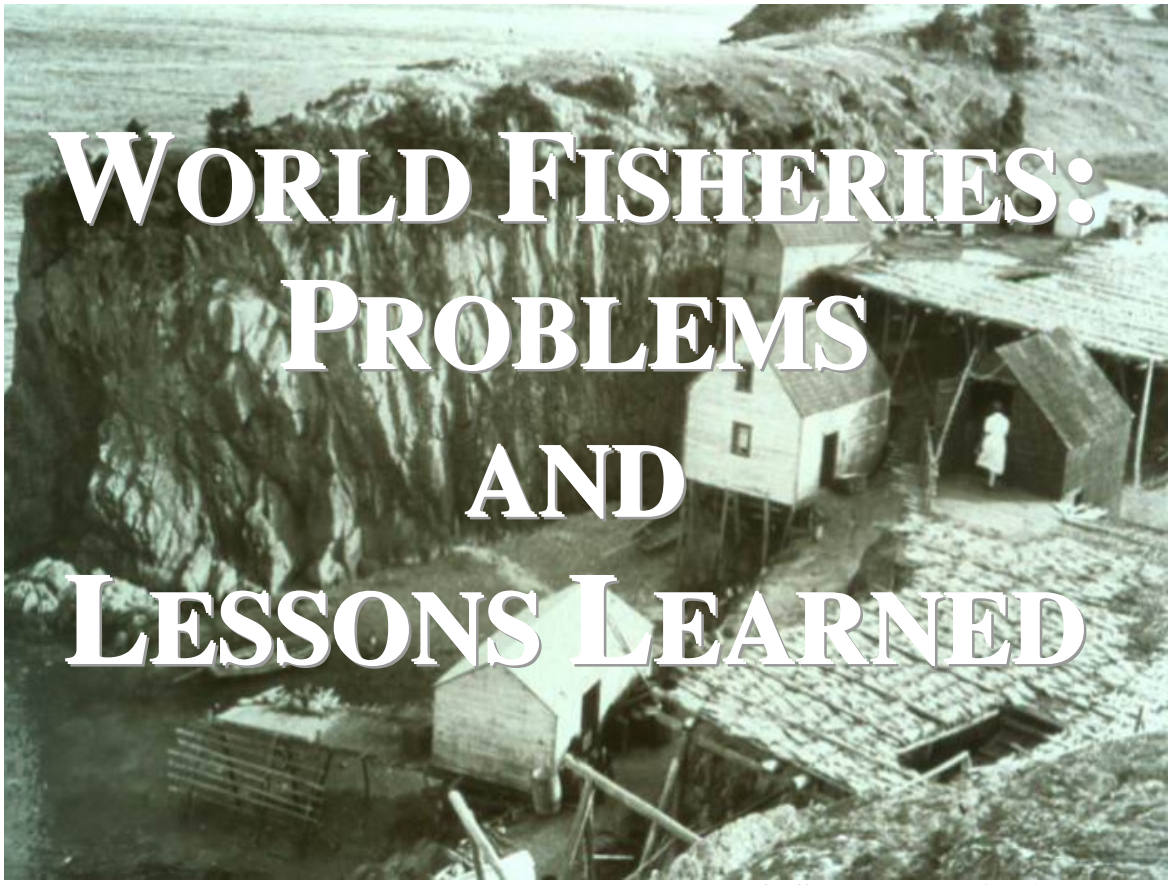

Photo courtesy of Jeffrey Hutchings, Dalhousie University

CHAPTER 2
State of the world's fisheries

Reg Watson, Senior Research Fellow, Fisheries Centre,
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Abstract
Only in the last few years have new tools given us the ability to see the big picture with regard to global fisheries and their impacts on the marine environment. Now we can put into focus the changes that our 'ever more desperate' fishing practices have created over the last century. Examination of large-scale data reveals patterns of decline that standout clearly against a blur of climate change and human development. Instead of an increasing number of collapses of apparently unrelated fisheries across much of the world, blamed loosely on climate change or vague coincidental inexplicables, we now see a systematic erosion in the marine systems supporting these fisheries, manifesting itself in species change, huge reductions in biomass, general trophic level decline and more frequent blooms of toxic species. While some people scheme to eutrophy the oceans and cheat fate, most accept that productivity, even on the high seas, is ultimately finite and must be carefully managed. Transporting pelagic production to coastal aquaculture sites in the form of fishmeal from reduction fisheries does not change the end sum. In the famous five stages of grief, most of us now are prepared to leave 'denial' behind. Many, however, still hover between anger, bargaining and depression. Some of us feel that it is time for acceptance, and with it action. Resistance is futile, the solutions must include substantial fishing effort reductions coupled with generous use of protected areas and closed seasons. Developed nations must resist the temptation to erode the marine resources of developing nations by exporting excess fishing capacity as a prerequisite for aid. Perverse subsidies that maintain impossible expectations must cease. Approaching a future challenged with topsoil loss and critical shortages of freshwater, we must maintain viable marine systems, if only for the food security they offer us.

Fisheries resources are limited
Like all resources on earth there are limits to the biological production from the world's oceans that can be extracted through fishing. Even before we concern ourselves about how the flow of the sun's energy was channeled through marine systems before man, we must first acknowledge that the energy that enters biological systems through solar radiation is forever finite. This is easy to overlook given the enormity of the world's oceans, particularly their volume. Unfortunately, significant solar radiation does not penetrate below about 200 meters (m), which eliminates much of the volume of the earth's oceans from the production process. Ice permanently covers part of the ocean's shallow seas, curtailing production and our access. Without input from the land

through run-off and erosion, the seas are usually limited by essential nutrients required for plant growth. Thus, only the very thin coastal strip, hardly visible on a world map, produces most of the marine life that we harvest. Offshore, most of the fish that we capture still largely inhabit the lighted waters above 200 m, and often range over considerable distances to obtain enough food. When we harvest marine resources we must ultimately accept that, like the solar energy that starts the process, the production of these marine systems is limited even if our demands are not.

Archaeological evidence shows that we have had a long history of exploiting shallow water stocks of marine animals and plants. Even before using boats we used nets, hooks, traps and other devices. Over time we made use of vessels to extend our range and effectiveness – we had to, our populations were growing and so were our needs. We found ways of using wind power to increase our fishing power. This gave way to the use of chemical energy released through burning wood, and finally fossilized (non-renewable) sources of energy such as coal and oil. Using these intensive energy sources, we were able to develop wonderful machines. These inventions could propel bigger vessels further and faster, freeze fish instantly and shred tonnes of low-grade fish into blocks of protein. They could also power fishing gears able to fish in the deepest depths (Roberts, 2002) or to quickly corral the fastest tunas. With these devices, and using these energy sources, we extended our fishing globally, exploiting entire oceans, eventually using even the less productive stocks which must live for decades in the cold deep waters to reach the required mass to reproduce. With that final access our 'mining' of comparatively non-renewal fish stocks had begun.

Our demands have had a variety of effects on marine life. Unlike harvests on land, marine life harvest is measured in tonnes, not usually in the number of individuals taken. Even the units used reveals how indiscriminate some forms of harvest are. The variety of life taken simultaneously by some fishing gears such as bottom trawls is equivalent to an attempt to harvest deer by removing whole forests; but also killing most of the birds, rodents and bears in the process. The animals killed through 'collateral' damage are unceremoniously tipped over the side of the vessel so that the sea can 'recycle' them. Should you think this terrestrial analogy too extreme, consider that some sharks and other fish currently discarded as 'bycatch' may require at least the same time to reach maturity as do the larger mammals in my example.

Like all organisms, the key to our existence is energy. We must appropriate more than we require because we are not completely efficient. The energy that we intercept as it moves through food webs, whether in terrestrial or marine systems, had users - species fully dependent on it, long before man arrived. Nothing was 'wasted', so strictly speaking there was no 'extra' for us to take. We cannot blame ourselves for requiring energy to exist, but we must abandon the thinking that anything that we do not harvest is 'wasted'. It is obvious that life has evolved some very complex interrelationships and it is sometimes very difficult to understand, much less predict, what will happen when we harvest 80-90% of the original biomass of some marine species (as many management plans currently allow). How does this impact other parts of the marine system? For the most part fisheries science has deliberately not considered this. Though folklore and traditional practices often have rules about how elements of the natural world are interrelated, and how this restricts possible harvest, modern fisheries science has been preoccupied for decades with the mathematics of only the population being harvested, as if it was magically isolated from the rest of the marine environment, or even grown in a laboratory strictly for our consumption.

Today most scientists realize that we ignore the rest of the marine environment at our peril. By harvesting a species of predatory fish we will reduce its consumption on its prey. Liberated from this pressure the prey species may live longer and increase in abundance. As a result its prey will not fare as well. By altering which species are abundant in the sea we force animals to change

their diets, and redirect the flow of energy through food webs. We select those individuals that can reproduce at a younger age and at smaller size, we even give a competitive advance to those species that can turn energy around quickly and make use of our 'discards'.

As we did on land, our energy needs have driven us to eliminate the competition, whether they are seals, sea lions, whales or sharks. In many cases we have already eaten the competition. In a process described by Daniel Pauly and others as 'fishing down marine food webs' we have progressively harvested to local extinction the largest predators in the sea. As large collections of sustaining energy, these animals were some of our earliest targets (once we had the technology to accomplish it). Having reduced their populations we inadvertently boosted the survival of their prey species. Man, always adaptable, then targeted the largest of these prey species. These became the new targets of our fisheries. Without their prey, and still under considerable fishing pressure, it is unlikely that the top predators will ever return to their former numbers. Current North Atlantic fisheries managers apparently see no problems with vastly increasing harvests on record abundances of shrimp while hoping cod and other overfished species will return to former numbers without their prey. Without good records, reports of the former abundance of predatory species are treated with skepticism by younger scientists and the public in general.

Even if the former ecosystem state is recognized there are many who do not want to revert to sharing with 'other' predators, much as ranchers resist sharing grazing land with wolves or lions. Under such circumstances expensive recovery plans are not widely supported. On land, a non-governmental organization (NGO) might buy land to conserve or even to re-establish an ecosystem, but this approach is difficult at sea. Offshore areas are usually common property controlled by states, and as such fishers exercise as much property rights or more than the public at large.

Adapting to change, marketing experts, never slow on the uptake, were quick to convince us that eating animals lower down the food web was actually preferable (not just necessary). Eating lobster no longer exemplifies the relative poverty of Atlantic fisher families but has been parlayed into the dish of choice for the wealthy. It is a subtle but necessary requirement that we forget about eating the larger species of inshore fishes that are now too rare to fish. A species of giant croaker that was used in ceremonies such as weddings in Hong Kong became unobtainable at any price so the feast was shifted to focus on other seafoods such as crabs or shrimp, or perhaps the offshore giants, the tunas, now that our newest fishing gear has allowed us to pursue them.

Over the last several decades we have developed the capacity to harvest all stocks, regardless of their distance offshore, or their depth. This has brought us into the realm of the slower growing species that eek out a living in the cooler, deeper waters. Our technologies for finding fish and for sharing information about their locations have also increased many times. It is now possible for ships at sea to consult current satellite maps and precisely locate 'in real time' where sea currents and temperatures concentrate fish. It is easier than ever for many vessels to work together to find even the smallest concentrations of fish, which can be quickly mopped up. Helicopters and 'spotter' aircraft are commonly used with tuna and some shrimp fisheries to locate the best fishing areas. All creatures in the water column are scanned with sonar and the sea bottom is routinely classified according to complex computer models indicating the best places to fish. The navigation of commercial vessels is highly automated, and productive sites can be returned to with great precision even years later. Advanced fishing gears and navigational aids allow fishing along side ragged rocks or between coral reefs, places that defeated fishers for centuries, but whose isolation guaranteed a refuge to stocks that were otherwise imperiled by fishing intensities that removed animals much faster than they could be replaced.

Knowledge about global fisheries is also limited

Given that our marine resources are limited and have great potential to be over-used, it is amazing that vital information about our use of marine resources is often missing or at best vague. It is also surprising how little support the few organizations charged with presenting an overview of marine resources receive. Information is provided to the Food and Agriculture Organization (FAO) of the United Nations (based in Rome) on a voluntary basis by the fishing nations of the world so that they can present an overview based on this global dataset (the only one presently possible) of the state of the world's fisheries. Their primary data sources started in 1950 when several major fisheries such as the North Sea and the Grand Banks were already well established. Some countries provide very little information, partially because their own resources are limited and their national priority for doing so is low. Others provide few details, and fail to detail where the landings were taken, or indeed what they were comprised of. Some major nations such as China report significant quantities of their landings simply as 'Miscellaneous Fishes'. In addition, investigations by Watson and Pauly (2001) and others have indicated that some of the landing statistics reported to FAO by China and other countries may indeed be quite misleading.

At best, most landing data do not include all catch; many tonnes are routinely discarded at sea, and in tropical trawl fisheries this may be more than eight times the quantity actually retained and reported. Other catches are not reported for a variety of reasons not the least of which is that they are illegal. FAO has to content itself with the 'official' national reports of landings which by definition and design do not include discarded or illegal catches.

When the location of landings is provided to FAO it is usually described by one of that agency's major reporting areas (Figure 2.1). Some of these areas such as the mid-eastern Pacific are enormous (48 million km^2) and do not really allow analysis on a scale relevant to many types of enquiries. In addition, several 'flags of convenience' are used to register fishing vessels from some countries. In these cases the true nationality of the fishing vessel is not tracked in the reporting process.

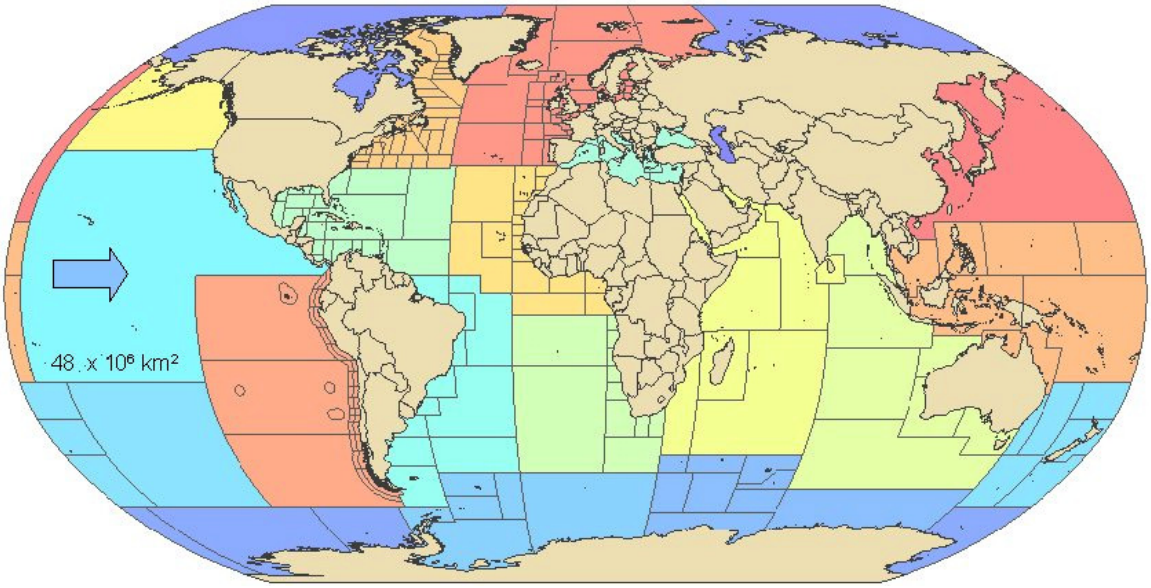

Figure 2.1. Major statistical reporting areas used by FAO for fisheries landings data since 1950 (arrow indicates an area measuring 48 million km^2).

The 'Sea Around Us' (SAU) project, based at the University of British Columbia in Vancouver, B.C. and funded by the Pew Charitable Trusts of Philadelphia, has a mandate to investigate the

impact of fishing on global marine ecosystems. Fisheries data as available from FAO cannot be used for this purpose without major reprocessing. Our refinements ensure that most landings are reported to at least the Family level of taxonomy, disaggregating such groups as 'Miscellaneous Fishes'. More significantly, it allows landings to be mapped into a system of 30-minute spatial cells that are far more useable for many analyses than the original large statistical areas. This is accomplished by a rule-based approach using specially constructed databases describing the global distribution of all commercial taxa and the known fishing patterns/access arrangements of fishing countries since 1950. The taxa distributions, the fishing access arrangements, and the resulting maps of landings, whether by national exclusive economic zones or by large marine ecosystems, are all available on the internet via http://saup.fisheries.ubc.ca.

Symptoms that all is not well

There are many types of information that can be used to assess the state of the world's fisheries. These include: the possible area of future expansion, the trajectories of catch rates, biomass estimates, average fish size and trophic level, and the fuel required to maintain landings.

The easiest trend to examine is that of total reported global landings. Figure 2.2 shows that since 1950 landings have increased more than three-fold. It also reveals that at the very least, landings have been relatively static since the mid-1980s, despite greatly increasing fishing effort and efficiencies. Indeed it is clear that invertebrates play an increasing part in maintaining the levels of global landings. Watson and Pauly (2001) showed that landings reported by China since the mid-1980s have been increasingly exaggerated in order that government workers could, on paper at least, fulfill government expectations of productivity gains. China reports a significant (and increasing) part of global landings. With the corrections of Watson and Pauly (2001), it becomes clear that global landings have fallen steadily since about 1987.

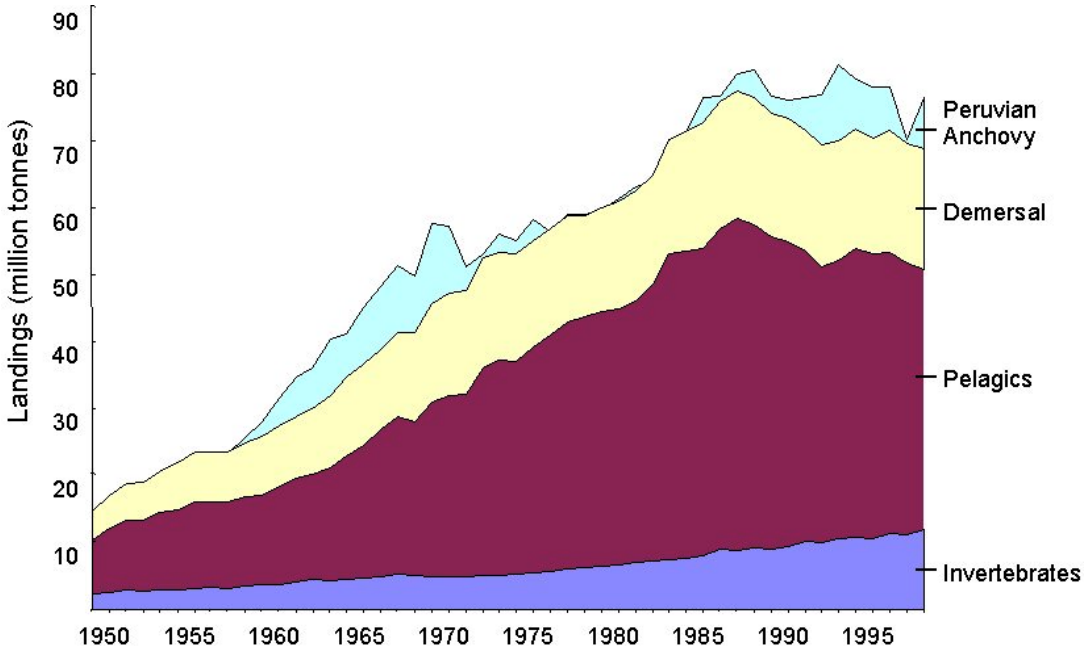

Figure 2.2. Global fisheries landings reported by FAO.

A chronology of the expansion for global fisheries shows that during the 1940s the North Sea became fully fished, with most fisheries exploiting traditional bottom fishes and whale stocks. By the 1950s fisheries fully used the North Atlantic and Pacific Oceans. In the 1960s the Indian Ocean was fully fished as well, and globally small pelagics (often used for reduction to fishmeal)

and temperate tunas were being exploited in addition to earlier targets. The next decade saw the full use of the South-West Atlantic Ocean and an expansion of fisheries to include tropical tunas and shrimp. By the 1980s all major areas of the world's oceans were being fished, and the target of these activities now included krill and oceanic squids. Since then we have added other deepwater near-polar species including orange roughy and Patagonian toothfish (Chilean seabass) to our fisheries. Fisheries now range from the Arctic to the Antarctic, with fishing fleets performing like highly mobile factories. Species such as the Chilean seabass mature slowly and are easily overfished from seamounts in unregulated high sea areas. Even though attempts are being made to regulate these fisheries (even enumerating individual fish and enacting various strict embargoes) you will still find fillets of these species at most local fish shops - at least while supplies last.

Indeed, when Grainger and Garcia (1996) presented a breakdown of the major marine 'resources' by development phase it became apparent what the trend was. In the early 1950s nearly half the resources were described as 'undeveloped' and the others as 'developing'. By 1970 there were no longer any 'undeveloped' fisheries but there was an increasing part they labeled as 'mature'. By the mid-1970s the pace of 'development' had accelerated and an increasing portion of the resources were classified as 'senescent' – likely through overexploitation. By 1995 this worrying 'senescent' development state had expanded to include nearly one-third of all marine resources. All indications are that this trend has continued.

Alverson et al. (1994) also examined FAO's data to assess the state of global fisheries. They determined that since 1980 the number of underexploited major fish resources fell from 25% to about 5% by 1990. More worrying, they found that over the same period overexploited resources increased from 20% to 50%. They also reported that the estimated number of species fished increased over the time period from 1980 to 1989, but then decreased.

Garcia and Newton (1997) showed a linear increase in global fleet capacity from 1970 to 1989 from 14 million tonnes (gross registered tonnage) to about 25 million tonnes. When they adjusted fleet capacity for efficiency improvements the growth trend was exponential over this period, with a similarly rapid decline in the total landing rate (catch per tonne of vessel).

Christensen et al. (2003) showed dramatic decreases in the biomass of predatory fishes in the North Atlantic in the century following 1900. Their approach integrated many existing ecological models and included the 30-minute landings data produced by the SAU project. Not surprisingly they also found that fishing intensity over this period also demonstrated a huge increase.

Using the methods developed by the SAU project to map global landings it was possible to complete other analyses of the statistics that FAO collects. Watson et al. (2003) mapped which decades have produced the highest landings for each of the 30-minute global spatial cells. This revealed that the major temperate fishing areas, for which classical fisheries stock assessment techniques were developed, and which are administered by some of the world's most prestigious fisheries research and management bodies, actually enjoyed their peak fisheries in the 1950s and 1960s after which landings were never as good. Though some of this decline followed from the introduction of quotas and other restrictions it is well known that these measures are never introduced without significant need, and only after considerable bitter debate.

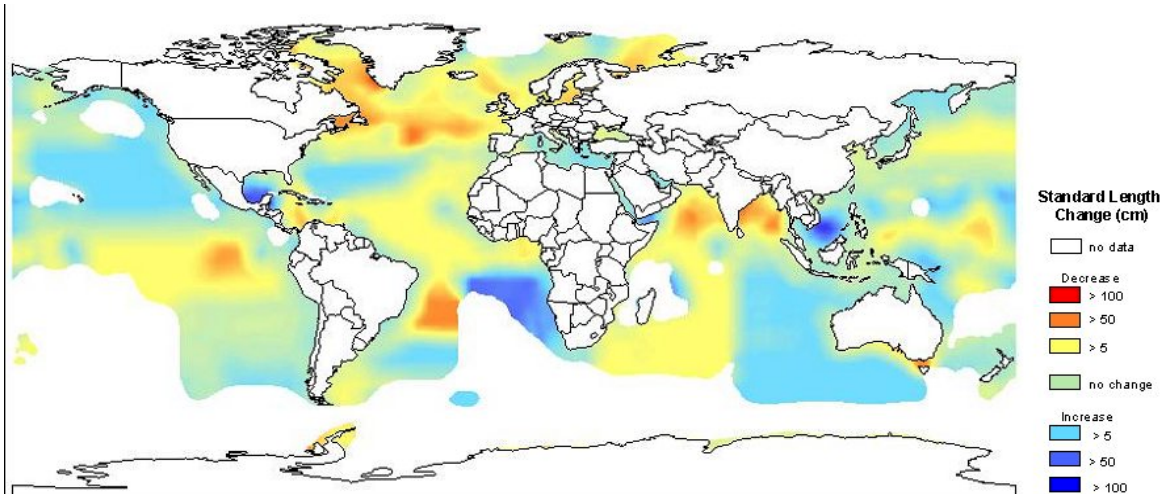

Figure 2.3. Map showing the change in length of animals taken commercial landings since the 1950s.

Similarly, it is possible to map the change in the mean length of fishes and invertebrates landed since 1950 (Figure 2.3). This reveals that many areas of the world have suffered a reduction in the length of fish harvested, but that this is most acute in the older temperate fisheries where reductions of 50 cm in average total length have occurred. Some offshore areas now harvest larger species due to the development of tuna fisheries where several decades ago there were only local reef fisheries; however, these are not the larger fisheries of the world. This can be illustrated by a line graph (Figure 2.4). Here there are two lines, one showing the decline in the length of the species in all landings in the North Atlantic and the other globally for all coastal areas. It should be noted that this analysis is very conservative as it uses a fixed size for every organism over the entire 50-year period. It has, however, been well documented that fisheries begin with the largest individuals and harvest progressively smaller animals within a species, and in fact exert strong selective pressures toward individuals whose genes allow them to mature at smaller sizes. This means that the overall size reduction of landed fishes is likely more dramatic if size reductions within a species have also been included.

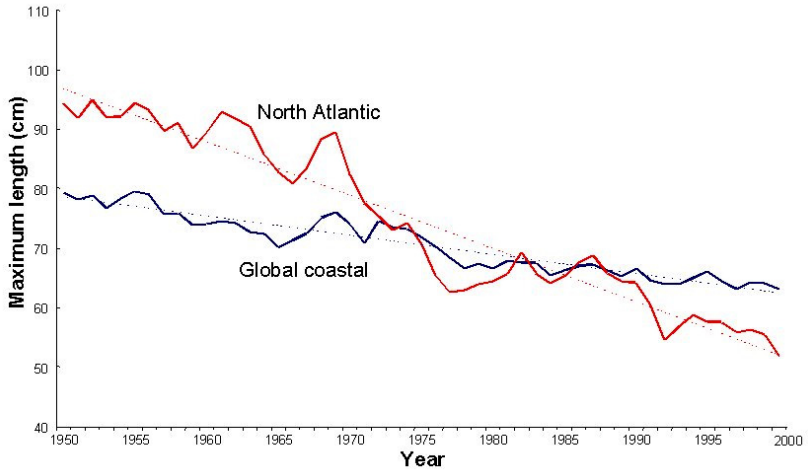

Figure 2.4. Graph showing the change in length of animals in commercial landings in the North Atlantic and in global coastal areas.

Fisheries target initially large, predatory animals when they can. On land the largest animals are herbivores but in the sea these are the top carnivores - the sharks, tunas, marlins etc. The result is that our fisheries concentrate hardest on the top of the food web and on animals that typically

mature only slowly to reproductive size. When these groups are reduced in biomass we move to the next largest animals in the system, and so on, moving down the food web toward the plant eaters. In this way we cause profound changes to marine systems by changing the balance between groups and by altering what food is available to predators. Pauly and Watson (2003) mapped the average change in the trophic level (position in the food web) of the fishes that are landed and showed that many long established fisheries have had significant reductions. There are areas in the Grand Banks where cod and other species have been pursued for more than one hundred years that showed a reduction of one whole trophic level. As with the analysis of size change, this estimate is conservative because it used a fixed single trophic level value for each species fished. In reality, animals increase their trophic level as they mature and grow larger. They can eat larger prey when they are larger and faster themselves. Thus, fishing individuals within a species at increasingly smaller sizes, as shown above, will actually depress the average trophic level of that species. A line graph (Figure 2.5) shows the reduction in trophic level for the North Atlantic and for all coastal areas. Trophic level changes are profound as they integrate a wide range of changes occurring broadly in marine ecosystems.

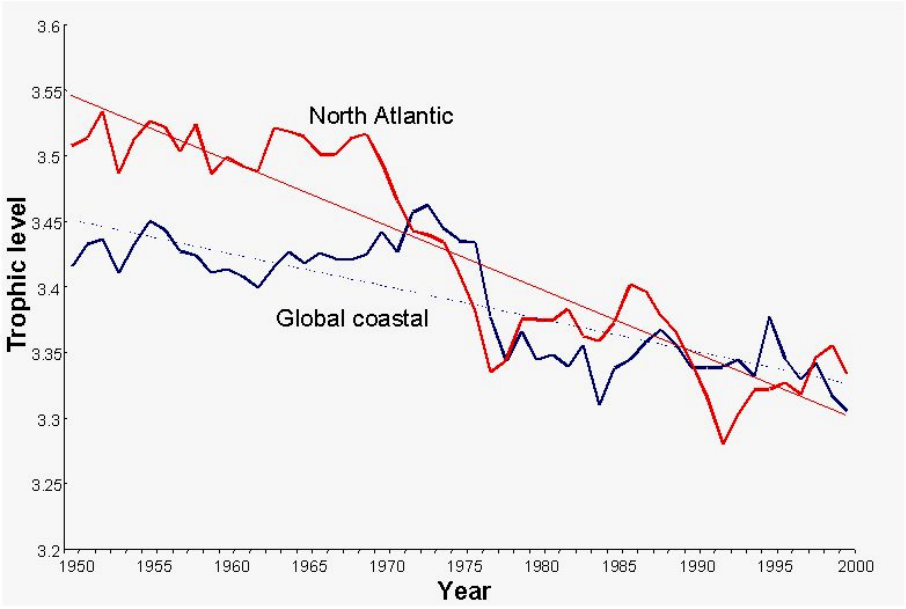

Figure 2.5. Graph showing the reduction in trophic level of commercial landings in the North Atlantic and in the global coastal areas.

Another symptom that fisheries are struggling with is the staggering amount of energy that is being consumed by fishing vessels to continue to land today's catches (Tyedmers, 2002). This varies widely from fishery to fishery, but globally for 2000 it was approximately 47 million tonnes of fuel (mostly diesel), which is amazing given that only 85 million tonnes of fish landings were reported that year.

The waters of developing nations supply more and more of the developed nations' fish diet. The large fleets of the European Union, for which there are no longer catches in the North Sea, patrol along the African coast. A range of aid arrangements to these and other developing countries are tied to commercial fishing access (Kaczynski and Fluharty, 2002). The same fishing pressures that destroyed stocks in Europe are now deployed in Northwest Africa. Developing nations have a dilemma; they need marine resources to develop but they also need the financial aid. Often their marine resources are sold much too cheaply considering their importance to their future.

Those agencies experimenting with fertilization of the world's oceans by the addition of iron with a view to removing excess greenhouse gases have sometimes suggested that this process will contribute to higher marine productivity. The consequences of this approach are potentially disastrous. Marine systems often evolved to be low in productivity, and enriching the waters means the replacing of one ecosystem with another. It means changing coral reefs to algal beds, and replacing all the dependent animals in the process. The mere suggestion of this as a future alternative to meet our needs demonstrates the depth of desperation that is developing, and underscores the need for significant changes now to maintain our resources.

Aquaculture and global fisheries – the reduction game

There are a wide and increasing variety of species that are grown in fresh and marine systems globally. Some of these, such as shellfish, are filter feeders; others, such as catfish, can eat a wide variety of feeds, but increasingly the interest of consumers is drawn to the carnivores. Species like tuna and dolphin fish are ranched, but many species like salmon are grown throughout their lives in aquaculture facilities and require a constant diet of prepared feeds. These feeds must contain protein and fatty oil sources. For the most part this requires fishmeals and oils taken from reduction of a range of wild fish species (mainly anchovy and herring). At present about 38% of total global landings are used for reduction. Though the products of this process are now important to most terrestrial farming systems (livestock feeds, fertilizers etc) they are vital to marine aquaculture.

The status of the stocks of fishes that are used for reduction is just as uncertain as that of any other highly fished resource. Indeed, the targets of reduction fisheries were included in all the worrying results presented above. Further, these fisheries - for example the Peruvian anchoveta that forms 9% of global landings and 24% of global reduction - have exhibited spectacular 'crashes' brought on by both intense fishing and sensitivity to volatile environmental conditions. The demand for fishmeal, and particularly fish oil, is high and increasing. Some sources from the Baltic have worrying levels of dioxin and PCBs (Weber, 2003), leaving stocks nurtured by the rich oceanic upwellings along the coasts of Chile and Peru to supply the bulk of the world's needs. More and more the use of some species for reduction is controversial in some countries, especially where factories preparing other fish products lie idle due to lack of product. In some cases 'reduction' species are being retargeted for human consumption. It is likely that the competition for these rich protein and oil sources will continue to grow (Tuominen and Esmark, 2003), and so will the pressure on these important stocks.

What we must do

Experts have largely agreed for years on what is required to prevent any further degradation in marine ecosystems and commercial stocks through overfishing. These include:

- Significant reductions in effective fishing effort (removing boats from fisheries),
- Protection of non-trivial areas from fishing (marine protected areas) and
- A halt to 'perverse' subsides paid to the fishing industry (those that encourage overfishing – 'we should not pay to have someone catch the last fish').

In order for this to happen we must recognize the social and political costs. We must find other sources of income for fishers and the increasing number of poor relying on fishing as a livelihood – often the livelihood of last resort. We must find other sources of protein than those available from fishing, particularly for poorer countries (the resource is finite). We must share marine resources and not force poorer nations to relinquish their claims with economic blackmail. We

must encourage the types of aquaculture that do not destroy critical habitats or require wild stocks as feed. We can all, as individual consumers, choose seafood wisely; several NGOs now have wallet cards to help the consumer decide which seafoods should be avoided. Unfortunately, any prescription for maintaining the health of future marine ecosystems must recognize that without limits to human population growth there can be no resource security, and ultimately, no future.

All of these steps require a strong will and most, like reducing fishing effort, have been vigorously resisted by many groups. People's 'traditional' livelihoods are at stake and voters can be swayed by public protests. We can pressure governments to support policy change, support NGOs pushing for reform, and exercise considerable consumer pressure on markets and restaurants selling species that should not be harvested as they currently are.

When faced with a tragedy there are various stages of grief that individuals pass through. The first is denial, then anger, followed by bargaining, depression, and ultimately acceptance. To ensure a future for marine fisheries, and faced with bad news about the status of global marine systems, we must pass quickly through these stages to acceptance before we can take the necessary action. It will need to be bold action. We know what to do but we must have the will to do it.

Acknowledgements
I would like to thank Peter Tyedmers (Dalhousie University) for his collaboration on the fuel intensities of fishing fleets. This work was supported by the Sea Around Us (SAU) project funded by the Pew Charitable Trusts of Philadelphia. Without Dr. Daniel Pauly, the principal investigator, and my colleagues in the SAU project, and those providing critical data such as FAO, this work could not have been completed.

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CHAPTER 3

Interactions among collapse, recovery and extinction risk in marine and anadromous fishes

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Fisheries issues from both a global and national perspective provide the focus for this chapter. Specifically, I address questions pertaining to the magnitude of fish population collapses, consequences of collapse to recovery, and the ramifications fish population collapses may have for extinction risks in marine and anadromous fishes.

Fish population collapses- Atlantic Cod

Late in 2002, the European Union received extremely strong scientific advice from the International Council for the Exploration of the Sea (ICES) regarding Atlantic cod. ICES had recommended that all targeted and bycatch fishing for cod cease, the strongest advice that has ever been given to government regarding Atlantic cod. The biological basis for the advice was the observation that Atlantic cod in the North Sea and adjacent waters had declined by 90% since the early 1970s.

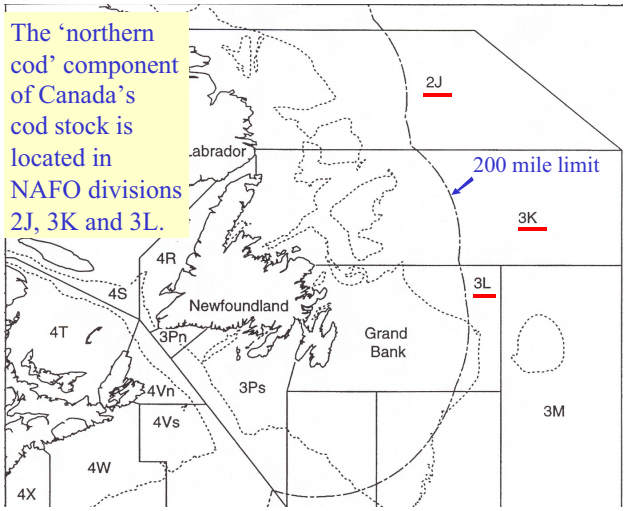


Figure 3.1. Northwest Atlantic Fishing Organization (NAFO) divisions.

This all sounded very familiar, particularly to those of us on Canada's East Coast, because it was in 1992 that the Northern cod fishery was closed to targeted fishing. Geographically, Northern cod is delineated by Northwest Atlantic Fishing Organization (NAFO) divisions 2J (southeastern Labrador), 3K (northeast Newfoundland shelf), and 3L (the northern half of the Grand Bank) (Figure 3.1.).

Estimated historical catches of Northern cod

This is a fishery that has been prosecuted for 500 years or more. Ransom Myers and I estimated historical catches from the early 1500s to the present day (Figure 3.2). From about 1750 onwards, the numbers are reasonably reliable as far as reported catch statistics go. Between approximately 1850 and 1950, catches ranged roughly between 200,000-300,000 metric tonnes before increasing dramatically in the late 1950s and 1960s with the advent of stern-hauled otter trawlers from Eastern and Western Europe, which resulted in reported catches peaking at 810,000 tonnes in 1968. Catches declined thereafter to 1977, when Canada extended its jurisdiction to 200 miles. It is noteworthy that, until the early 1970s, these catches were unregulated. Thus, the declining catches were indicative of dramatic declines in abundance. Catches throughout the 1980s were regulated by catch quotas, which peaked at just above 250,000 tonnes before the fishery was closed in 1992.

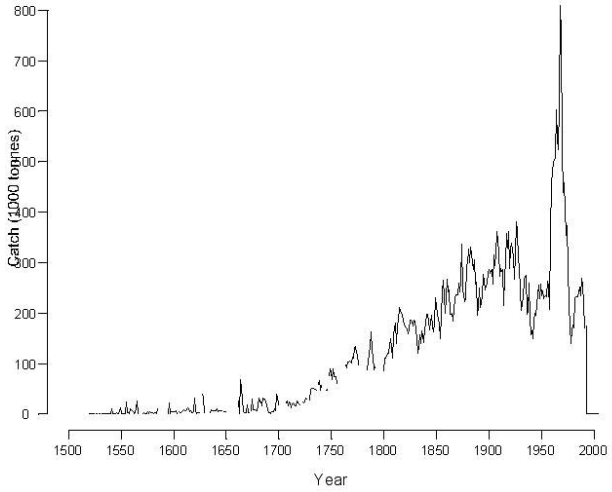


Figure 3.2. Estimated catches of Northern Cod (1508-2001). Adapted from Hutchings & Myers (1995).

The primary reason for the fishery closure was an alarming decline in spawning stock biomass. The earliest data for Northern cod extend back to 1962. Between 1962 and 1992 the breeding population had declined by 99% (Figure 3.2). What were the official expectations of recovery at that time? I ask that question because I think these expectations have contributed to what I would call the 'mythology' about the recovery of, and extinction risks faced by, marine fishes.

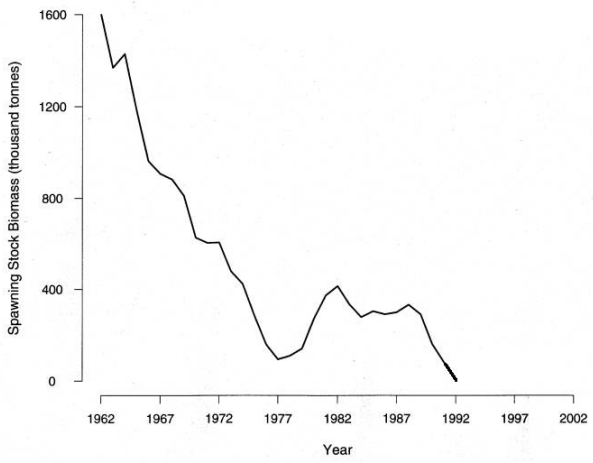


Figure 3.3. Spawner biomass of Newfoundland's Northern Cod, 1962-1992.

In the press release (July 2, 1992, DFO) which reported the closure of the Northern cod fishery, it was stated that, "A two-year moratorium offers the only chance for the spawning biomass to recover quickly to its long-term average, permitting resumption of the inshore fishery in the spring of 1994." The press release included figure 3.4, which shows spawning stock biomass from 1962 up to the early 1990s. You can see that from 1992 to 1994, over the proposed two-year recovery period, there is a high and a low estimate of the recovered spawner biomass. I draw your attention to

the observation that, according to the high estimate, the spawning stock biomass would achieve a level in two years that had not been seen since the early 1970s.

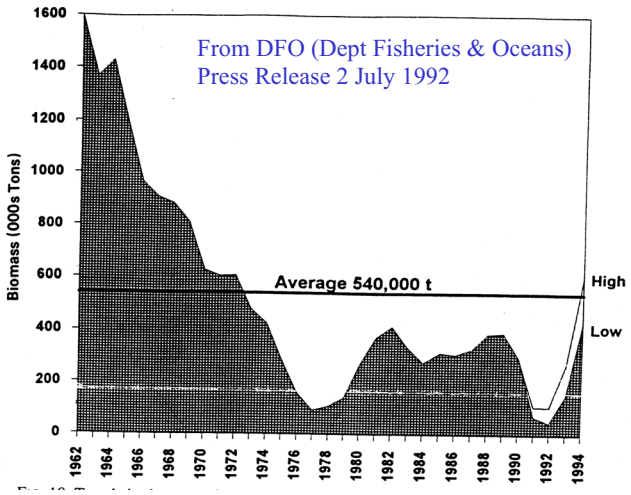


Figure 3.4. Trends in spawning stock biomass of northern cod from 1962 to 1992 with projections of the impacts of the 2-year moratorium on spawning biomass in 1993 and 1994. From DFO Press Release July 2, 1992.

As an ecologist and population biologist, it is appropriate to ask what population rates of increase would be required for the two-year recovery period to have scientific validity. The Department of Fisheries and Oceans Canada's (DFO) two-year recovery period basically necessitated population rates of increase of 126-200% per annum, which is quite an extraordinary rate of population growth for a fish that does not mature until it is five to seven years of age. Based on data available at the time, a scientifically defendable range of maximum population growth was on the order of 9-19% per annum, a range that is probably appropriate today.

It is not surprising, then, that the DFO's predicted rates of recovery were not realised. Indeed the stock has shown little or no recovery since its closure in 1992. If we compare the abundance of the stock today with that which existed in 1962, we would conclude that Northern cod has declined by a staggering 99.9% (Figure 3.5). This is, of course, just one stock. Let us put it in a broader context.

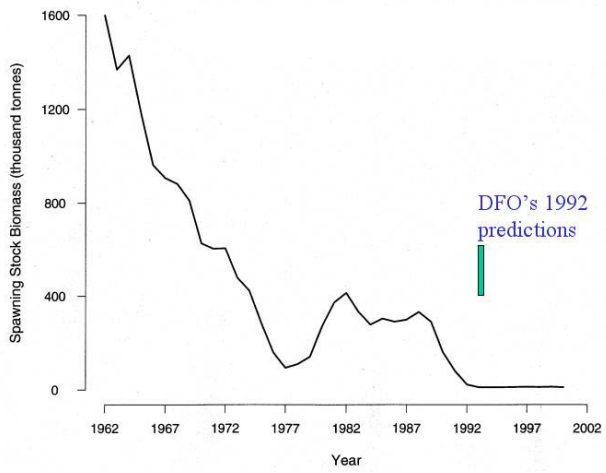


Figure 3.5. Spawner biomass of Newfoundland's northern cod 1962-2000.

How much have marine fish populations declined from "historic levels"?

John Reynolds, a Canadian colleague in the United Kingdom, and I asked the question: How much have marine fish populations declined from "historic levels"? Historic levels are in quotation marks because the highest levels of spawning stock biomass almost certainly preceded the dates on which fishery management agencies first started estimating abundance data. Nonetheless, what one can do is consult the website database maintained by Ransom Myers at Dalhousie University, which contains data on spawning stock biomass and fishing mortality, among other things, for several hundred populations of marine, anadromous, and freshwater fishes. We restricted our analysis to stocks or populations for which the time series was ten years or more, and noted the maximum population decline. For the 232 marine fish populations for which such data are available, the median historic decline was 83% (Figure 3.6) (Hutchings and Reynods 2004).

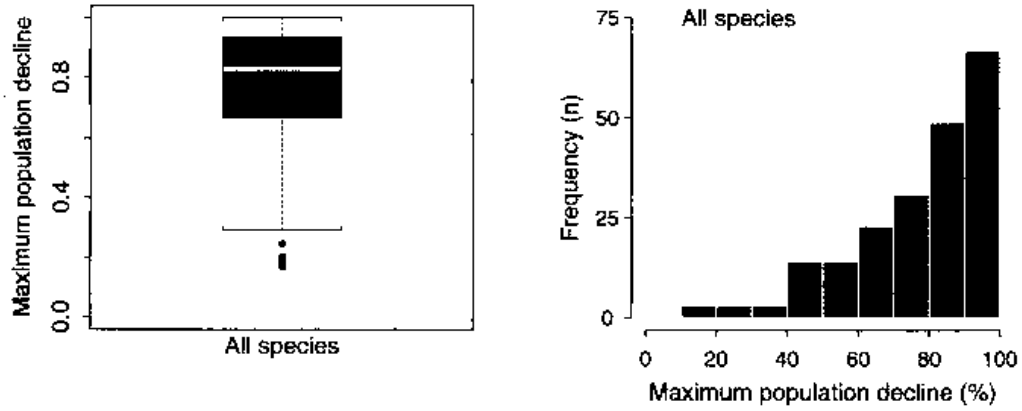
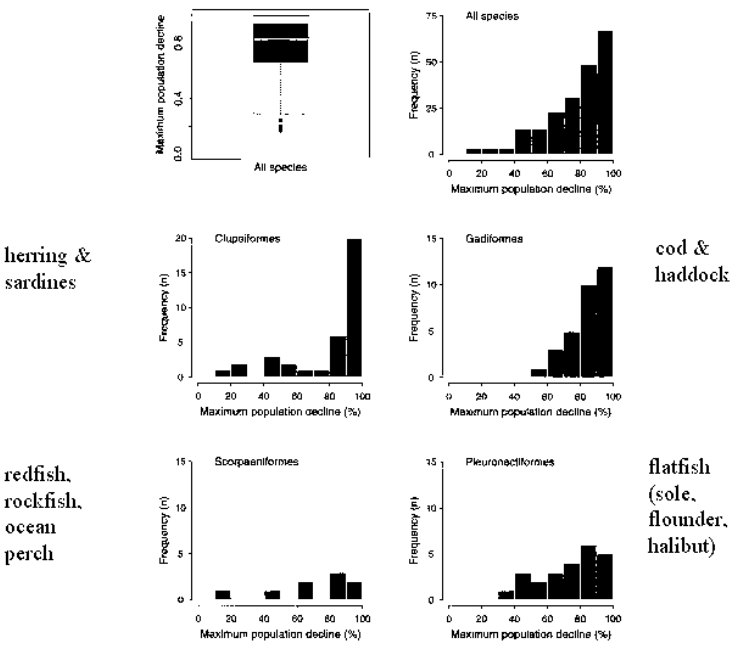


Figure 3.6. Median historic (N_{min}/N_{max}) decline= 83% (n= 232 marine fish populations).



This decline, averaged among all species, was similar to that observed within groups of related species (Figure 3.7). Among the herring and sardines, for example, four out of every five populations have experienced declines greater than 80%. Within the family of fishes that includes cod and haddock, roughly half of the populations have declined by more than 80%. Similar patterns are evident for flatfishes and rockfishes. The unassailable conclusion is that most marine fishes have declined extraordinarily through their history.

Figure 3.7. Maximum population decline for different species. Adapted from Hutchings and Reynolds (2004).

To what degree does rate of population decline inform us about probability of recovery in marine fishes?

Let us take this a step further. Firstly, the historic declines referred to above are independent of the time period over which the decline took place. Secondly, while it is certainly useful to quantify the magnitude of population collapses, it is arguably much more pertinent to evaluate the population consequences of those collapses. Among others, we can ask the question, "To what degree does rate of population decline inform us about probability of recovery in marine fishes?" To evaluate this, I consulted the Myers' database referred to earlier. I defined 'collapse' as the greatest percentage decline in spawner biomass over a fifteen-year period. The reason for selecting fifteen years as the time period is that it is long enough to encompass a three-generation time-frame for many of these species, and it is a three-generation time-frame against which the International Union for the Conservation of Nature (IUCN) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) apply one of the criteria for assessing risks of extinction. The fifteen-year time-frame was short enough that it allowed me to obtain data for a fairly large number of stocks – 90 in total. Then, I asked the question concerning recovery: What were the population sizes of each of those 90 stocks five, ten, and fifteen years after collapse, relative to the spawner biomass from which each of the collapses had begun?

Figure 3.8 shows recovery after five years (Y axis) and maximum percentage decline over fifteen years (X axis). Each point represents a different stock; each symbol represents a different family. There are two lines depicted here: the full recovery line and the no recovery line. If you take your eye to the 80% decline on the 'X' axis and follow it up to the no recovery line and go over to the 'Y' axis you will have identified a stock that had declined 80%, and that five years later was still 20% of the size from which it had declined. In other words, you would have identified a stock that had shown no recovery. Stocks or points that fall on or below the no recovery line are populations that have not recovered. Stocks falling on or above the full recovery line are stocks that have clearly attained or exceeded the sizes from which they had declined. Points in between these two lines represent stocks that have achieved some degree of recovery. The primary point is that there is a highly negative association between collapse and recovery, implying that the greater the rate of decline, the lower the likelihood of recovery. The same pattern is evident fifteen years after these collapses. Again, most of the points are clustered around the no recovery line (Figure 3.9). Therefore, based on available information, the general pattern is little or no recovery of marine fishes up to fifteen years after experiencing declines of 60-70% or more.

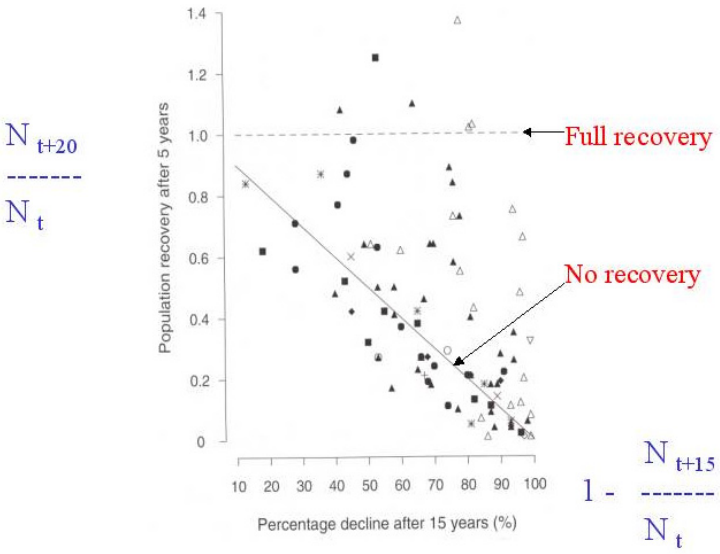


Figure 3.8 Full recovery: no recovery for 90 stocks. Adapted from Hutchings (2000).

There is an interesting taxonomic influence observed when evaluating the ability of fishes to recover fifteen years after collapse (see Figure 3.9). The clupeids, the fish family that includes herring and sardines, appear to be more resilient than other fish stocks. (Although it is important to note that there are

some herring stocks, such as the spring-spawning herring off Iceland, that have shown no signs of recovery since its collapse in the late 1960s.) This is a pattern that recurs time and time again. One reason why herring might be more resilient has to do with its life history. All else being equal, many clupeids tend to mature at a younger age than other marine fishes; the earlier the age at reproduction, the faster the population growth rate. However, it might also have to do with the way we fish for herring. Herring exist as single-species schools for which the incidence of bycatch is very low. If we wish to reduce fishing mortality to nil for a herring stock, it is relatively easy to do so. By comparison, it is very difficult to reduce fishing mortality to nil for a bottom-dwelling or demersal fish. There are many fish species associated with the bottom. As a consequence, demersal species for which we are trying to reduce fishing mortality are typically collected as bycatch in other groundfish fisheries. Therefore, the means by which we catch herring might have something to do with its apparently higher resilience.

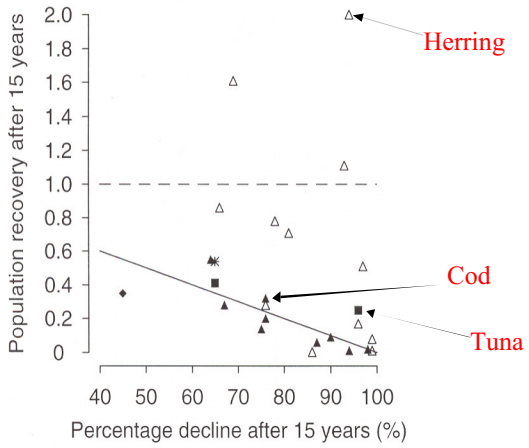


Figure 3.9. Recovery after 15 years in clupeids and demersal fishes.

To what degree are recovery rates a function of fishing mortality?

We can also ask the question, "To what degree are recovery rates a function of fishing mortality?" If we restrict this analysis to include only those populations for which fishing mortality declined after the collapse, does such a restriction in data alter our interpretation? The results described in Figure 3.10 show us that the answer is clearly *no*. The pattern is the same whether one looks at five-year or fifteen-year recovery periods. Rate of decline is highly informative with respect to telling us something about likelihood of recovery. The general pattern of no recovery after fifteen years is still evident.

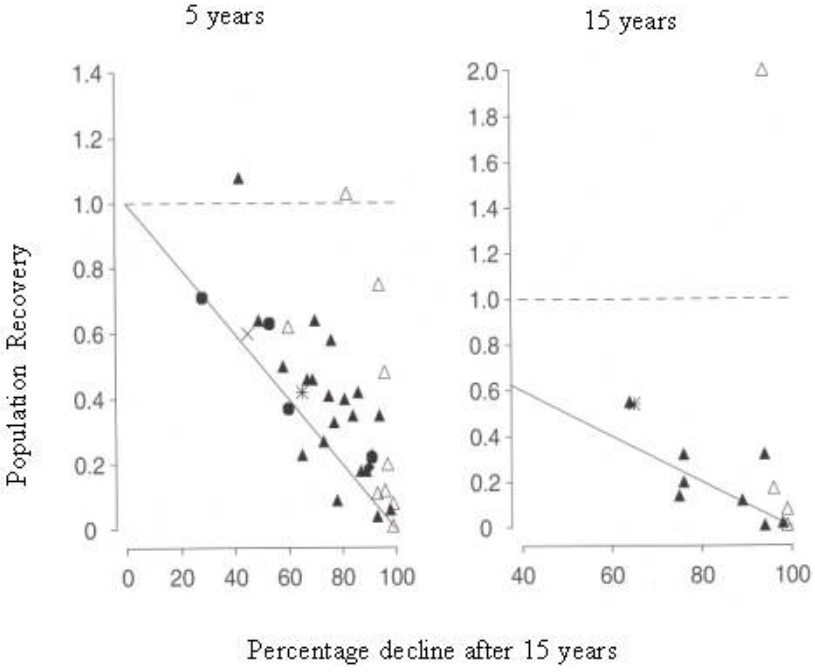


Figure 3.10. Percentage decline after 15 years for marine fish populations for which fishing mortality declined post-collapse. Adapted from Hutchings (2001).

To what degree does the rate of decline inform us about the probability of recovery in Pacific salmon?

Let us apply the same analysis to Pacific salmon, asking the question, "To what degree does rate of population decline inform us about the likelihood of recovery in Pacific salmon?" Figure 3.11 shows collapse as the maximum percentage decline in spawner abundance over three generations. Recovery is simply the size of the spawning population, one, two and three generations following collapse. This figure is the same as described above for marine fishes. Recovery after one generation is shown on the 'Y' axis and the maximum percentage decline after three generations on the 'X' axis. It is clear that there are a lot of points in excess of 70-80-90% declines. Each symbol represents a different species; for example, the open triangles are pink salmon, the closed triangles are sockeye. When one looks at all Pacific salmon species combined, the correlation between rate of decline and magnitude of recovery is highly significant, suggesting that, as with marine fishes, the higher the rate of decline, the lower the likelihood of recovery.

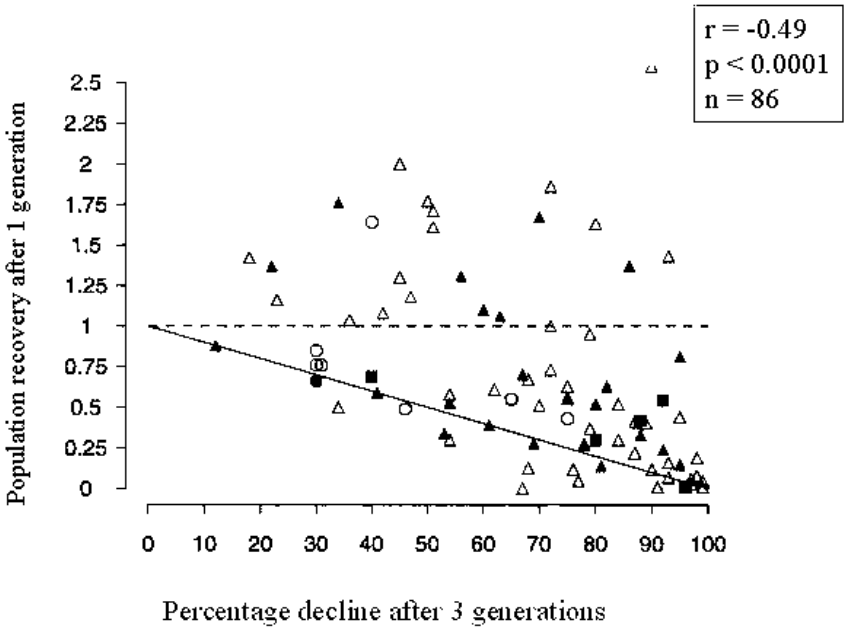


Figure 3.11. Percentage decline in spawner abundance for Pacific salmon over three generations. Adapted from Hutchings (2001).

Figure 3.12 (a,b) shows population recoveries for the individual species of Pacific salmon. Pink salmon tend to recover fairly quickly, even after experiencing dramatic declines in abundance (Figure 3.12b). This is not too surprising given that, among other things, they have an age of maturity of two years. For sockeye salmon, there seem to be two groups of populations that fall out (Figure 3.12a). There are some populations that, after experiencing 70-80-90% declines, still remain very low up to three generations following collapse, whereas other populations seem to have rebounded fairly well. From my understanding of salmon on the West coast of Canada, this may describe the Alaskan situation for those that have rebounded and the British Columbia situation for those that have not. For chum and coho salmon, although there are not sufficient data from which one can generate these types of plots, it is clear that there are a lot of populations clustered around the no recovery line.

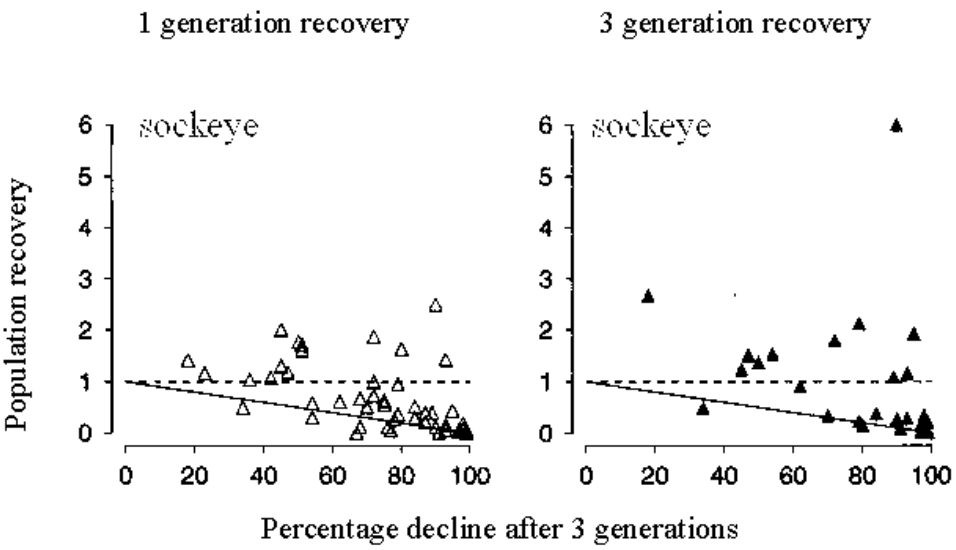


Figure 3.12a. Population recovery for sockeye salmon.

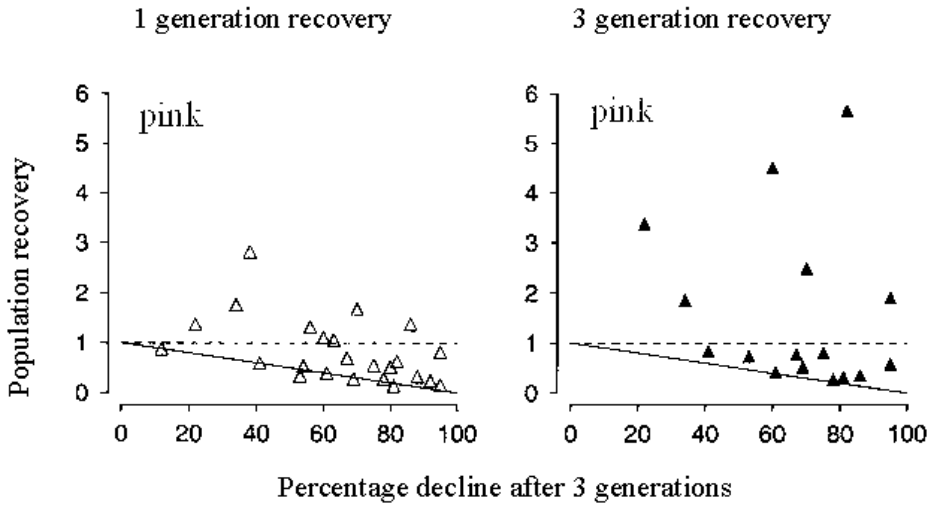


Figure 3.12b. Population recovery for pink salmon.

Does recovery always result from reductions in fishing?

I have discussed collapse and the degree to which rate of decline influences recovery. But where does fishing come into play? A primary perception underlying all conservation strategies and management measures for commercially exploited fishes is that fishing is the primary factor inhibiting recovery. It seems intuitive that if we reduce fishing, populations will recover. However, this has not really been examined empirically. I tested the prediction that the greater the reduction in fishing mortality after collapse, the greater will be the likelihood of recovery.

Figure 3.13 shows population recovery after five years on the 'Y' axis and ratio of post-collapse and pre-collapse exploitation rates on the 'X' axis for a number of marine species. I have averaged exploitation rate immediately after each collapse, in this case, five years after the collapse, and divided it by the exploitation rate over the five years immediately preceding each collapse. It is, in a sense, a ratio of fishing pressure after collapse divided by fishing pressure

before collapse, for each stock. Each symbol represents a different family of fishes. Points falling to the right of the vertical line, corresponding to an exploitation rate ratio of 1:1 or greater, represent stocks for which fishing increased after collapse; points to the left of the line, corresponding to an exploitation rate ratio of less than 1:1, identify stocks for which fishing declined after collapse.

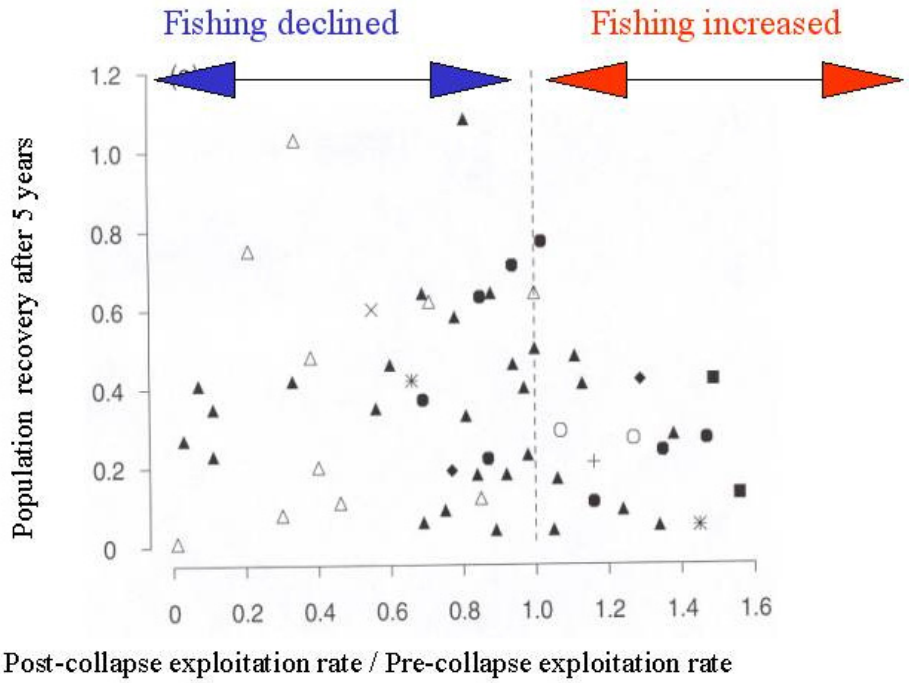


Figure 3.13. Population recovery after 5 years as a function of exploitation rate. Adapted from Hutchings (2001) *Journal of Fish Biology* 59(Suppl. A): 306-322. x, Engraulidae; Δ, Clupeidae; ▲, Gadidae; *, Scorpaenidae; +, Anoplopomatidae; ◆, Sparidae; ■, Scombridae; ●, Pleuronectidae; ❍, Soleidae.

There are several points to note in reading this figure. Firstly, if we look at the average recovery of stocks for which fishing increased after collapse, the average recovery is lower than it is for stocks for which fishing declined. That is promising. It implies that a reduction in fishing mortality is *necessary* for recovery to take place. But is it *sufficient* for recovery to take place? The expectation is that there would be a negative association between recovery and the magnitude of reduction in fishing mortality. Rather, what we see is *no* association whatsoever, implying that recovery is independent of the magnitude of the reduction in fishing mortality. This does not mean that we should not reduce fishing. Clearly, any responsible fishing management plan would reduce all known sources of fish mortality. Rather, this result reveals that, generally speaking, factors other than fishing are more important to recovery than fishing is alone.

We can take this analysis a step further by expressing fishing mortality relative to each population's ability to sustain a certain level of fishing mortality. In other words, we can express fishing mortality relative to each population's maximum rate of increase. To estimate 'r', or r_{max}, for each population, I applied the basic model of exponential growth for the ten-year period encompassing the five years immediately preceding collapse and five years immediately following collapse; in other words, the period of time when each stock is likely to be at its lowest level.

In the web database, there are estimates for 'N', spawner abundance, and estimates for 'F', fishing mortality for each of those ten years. Using these data, I can then estimate 'r' for each of those ten years, average it, and come up with an estimate of 'r' for each population. It is a debatable means of estimating 'r', but it was the only means available to me, and it is not completely inappropriate.

In Figures 3.14a and 3.14b population recovery after five years is shown on the 'Y' axis; on the 'X' axis is post-collapse fishing mortality relative to each population's maximum rate of increase. Values on the 'X' axis >1 identify populations for which fishing mortality after the collapse exceeded the maximum rate of increase; points to the left of the dashed line identify populations for which fishing mortality was less than that population's maximum rate of increase. Although the correlation co-efficient is negative, it is heavily influenced by a population of tuna in the lower right section of the figure. In fact, there is no significant correlation between recovery and the corrected estimate of post-collapse fishing mortality. Visually, this is particularly evident when you restrict your view to those points just to the left of the vertical line where fishing mortality declined relative to each population's maximum rate of increase. Again, there are no apparent associations for the 5- and 10-year recovery periods (there were insufficient data to examine the fifteen-year recovery period).

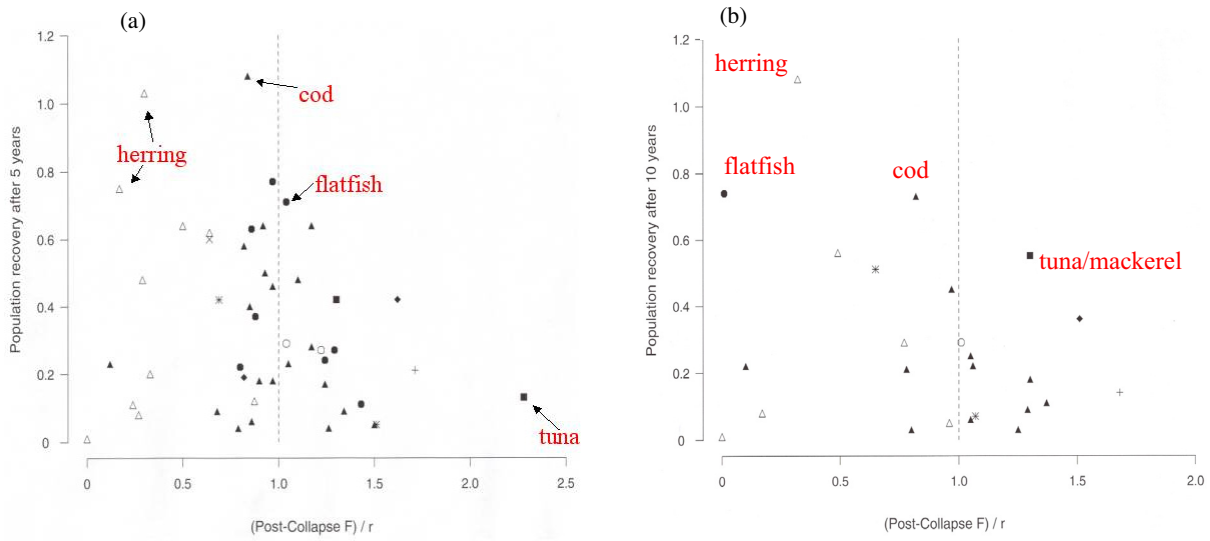


Figure 3.14. Population recovery 5 (a) and 10 (b) years after collapse as a function of the average fishing mortality.

Therefore, even when we correct fishing mortality for each population's maximum rate of increase, recovery appears to be independent of the extent to which fishing mortality is reduced. Based on these analyses, one would conclude that reductions in fishing mortality are necessary, but not sufficient, for population recovery. Depleted populations will not inevitably recover when fishing is reduced. This implies that, in general, other factors may be of greater importance to the recovery of marine fishes than is fishing alone.

Correlates of recovery in marine fishes

What are these other factors that affect recovery? What are the primary correlates of recovery in marine fish? This is a key research area that, to date, has received relatively little attention.

Recovery correlate 1: management and societal response to collapse
How do we respond to population collapses? What are the managerial and societal responses to population collapses? The influence of this correlate of recovery will depend to some degree on the population status at the time that we take action. Let us return to cod in Atlantic Canada, Northern cod in particular, where the fishery was not closed until all of the larger older fish had been captured. Norway, on the other hand, in the late 1980s, closed their fishery before they had removed all of their larger older fish. This underscores the point that the age structure of the population matters at the time that steps are taken towards recovery. What is the likelihood of reducing fishing mortality to nil? This has, among other things, something to do with the likelihood of bycatch. What I would term 'scientific and professional folklore' can also play a part in determining the response time and type of action taken. There are a lot of perceptions about the fishing intensities that marine fish can sustain. One view ascribes to the notion that marine fish recover faster than other species, a view that does not hold up empirically. Managerial and political fortitude to take appropriate and difficult decisions is clearly a factor as well.

Recovery correlate 2: life history traits
All else being equal, early maturing, relatively small-sized species can be expected to have faster recovery rates than later maturing, larger species. This is a prediction, based on theory, which appears to hold up empirically for many species, including fishes. Thus, we can expect a shark that matures at 10 or 12 years of age at sizes in excess of one metre to experience slower recovery than a herring that matures at a considerably younger age and smaller size.

Recovery correlate 3: genetic, or evolutionary, responses to exploitation
If fishing mortalities are sufficiently high, and if there is differential mortality with respect to heritable differences in phenotype (e.g., body size, growth rate, age at maturity), then we can expect to observe genetic responses to exploitation. Have exploitation rates been sufficiently high to effect such genetic change? The answer is that they almost certainly have in some instances. For Northern cod, we have seen a reduction in the age of maturity that we cannot explain as a phenotypic or environmental response to faster growth rates or better physiological conditions. The only explanation that holds to date is the genetic response. Important questions in this regard are, "To what degree do genetic responses to over-fishing influence life history traits?" and, "What are the consequences to population recovery of changes to life history?"

Recovery correlate 4: changes to species assemblages and food webs
Figure 3.15a describes a graphical model published by Carl Walters and Jim Kitchell (2001) showing adult fish producing juvenile fish of the same species. In addition, those adults are also consuming or preying upon forage fish, and those forage fish are competing with or preying upon the juveniles of the species that we are interested in. For example, if the species we are describing is cod, the adult cod produce juvenile cod, and there are also adult cod consuming herring and mackerel, and herring and mackerel consuming or competing with young cod (Figure 3.15b). The point here is that with reductions in the numbers of adult cod, not only are there fewer juvenile cod, but the predation pressure on the forage fishes is also released. One consequence of such a release in predation pressure may be an increase in abundance of forage fish and concomitant increase in predation pressure on juvenile cod.

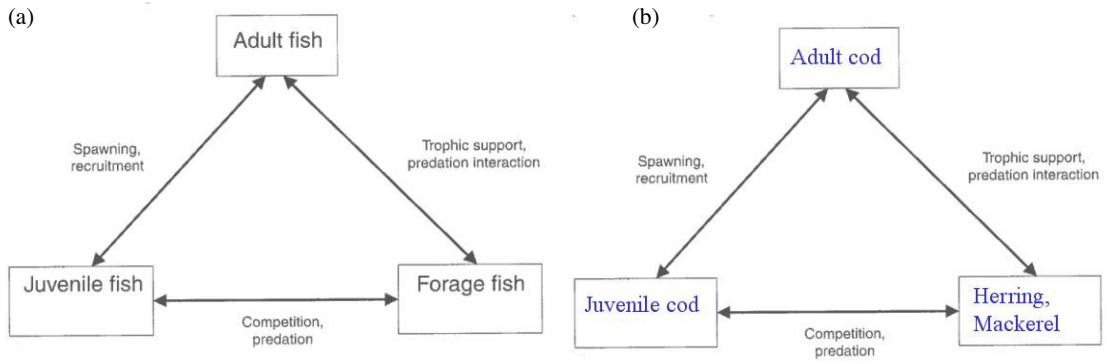


Figure 3.15 (a). Adult fish, juvenile fish, and trophic relationship between forage fish. (b) Examples of Atlantic Cod in trophic triangle model. Adapted from Walters & Kitchell (2001).

DFO scientists Doug Swain and Alan Sinclair (2000) provide data consistent with such a model for cod in the southern Gulf of St. Lawrence (Figure 3.16). Note that in the lower left-hand figure labeled 'cod juvenile survival', survival is relatively low in the 1960s, increases in the 1970s, and is low again in the 1980s. Swain and Sinclair noted that this seemed to match changes in herring and mackerel abundance, such that low cod juvenile survival was associated with relatively high levels of herring biomass and relatively high levels of mackerel biomass. It is also known that herring and mackerel consume cod eggs.

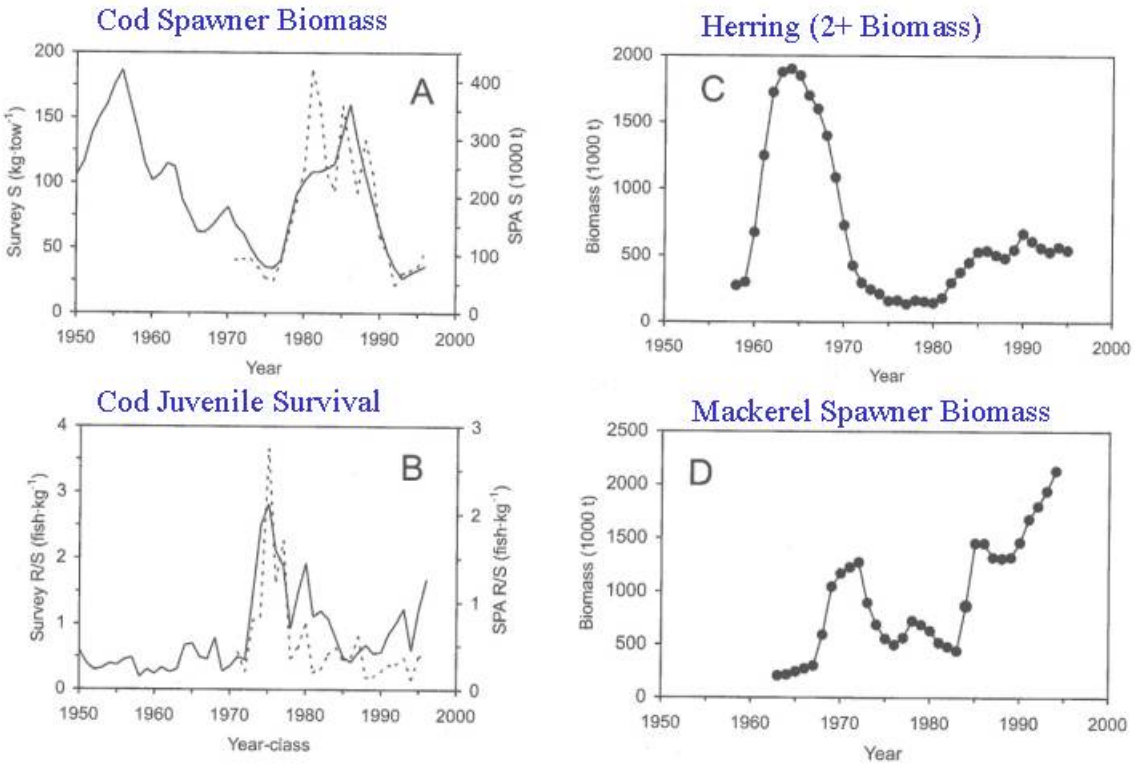


Figure 3.16. Cod stock and recruitment and pelagic fish biomass in the southern Gulf of St. Lawrence. Adapted from Swain & Sinclair (2000).

Recovery correlate 5: habitat modification
One can make the very simple prediction that if demersal habitat is more likely to be negatively affected by fishing than pelagic habitat, then bottom-dwelling fish should show slower recovery rates than pelagic species. This is consistent, so far, with what empirical data indicate. Pelagic species do indeed appear to have faster recovery rates than demersal species (Hutchings, 2000).

Why might the bottom be disturbed by the towing of nets? The photograph in Figure 3.17 shows that the doors of bottom trawls, which are required to spread the net and to keep the net open, can be fairly heavy, weighing as much as four tonnes apiece. To what degree, then, do these doors reduce the physical heterogeneity of the bottom habitat, which almost certainly provides refuge for young fishes as well as adult fishes?

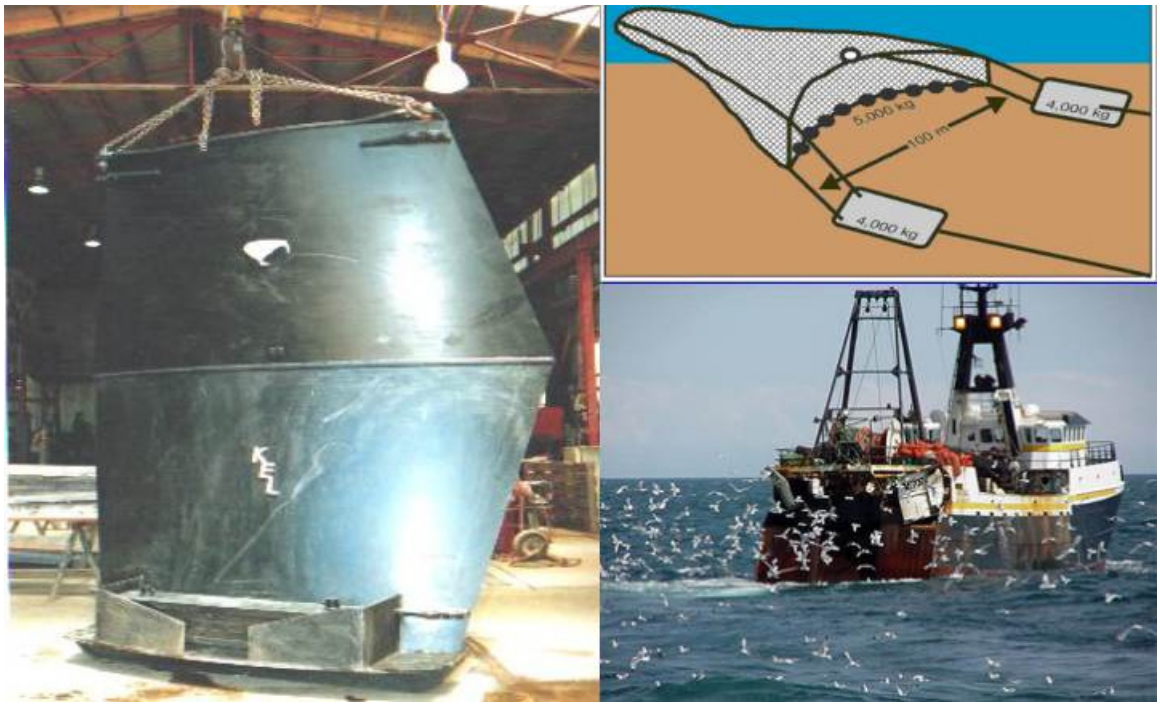


Figure 3.17. The doors of bottom trawls can significantly alter the physical structure of the bottom.

Recovery correlate 6: Allee effects, or depensation
Termed Allee effects in the ecological literature, and 'depensation' in the fisheries literature, this describes situations in which population growth rate declines, rather than increases, as population size falls – particularly below some threshold level. Stated another way, when populations fall below a critical level, they may experience reduced population growth and slower recovery because of reduced mating success or increased predation rates. Although Allee effects have traditionally not been considered very important for marine fishes, it is fair to say that there has been a shift towards thinking that they may be more important than previously thought, and that we might have passed the critical threshold sizes for some depleted populations. However, in terms of enunciating the specific biological mechanisms by which Allee effects might be expressed in marine fishes, we are very much in the dark.

Extinction risks are assessed by national and international listing organizations
Up to this point, I have discussed collapse, recovery, and correlates of recovery. What does this have to do with risks of extinction? Extinction risks are of interest to a wide variety of people, including fishery management agencies, conservation biologists, and those whose livelihoods

depend directly on the resources. Extinction risks are assessed indirectly by several international and national advisory bodies (See Table 3.1).

Table 3.1. National and international 'listing' organizations that assess extinction risk.

National and International 'Listing' Organizations	
IUCN	World Conservation Union
COSEWIC	Committee on the Status of Endangered Wildlife in Canada)/ COSEPAC (Comité sur la Situation des Especes en Péril au Canada
CITES	Convention on the International Trade of Endangered Species
AFS	American Fisheries Society

COSEWIC and species listings

The legal responsibility of COSEWIC, under the newly proclaimed Species At Risk Act (SARA), is to assess the status of each wildlife species in Canada considered by COSEWIC to be at risk, and to identify existing and potential threats to such species (see Chapter 31, Mawani et al.). Status is assigned based on a two-thirds allocation of 30 votes. Of these votes, four come from the federal government and include DFO, Parks Canada, the Canadian Wildlife Service, and the federal Biosystematics partnership, which is represented by the Canadian Museum of Nature. There are thirteen members from each of the ten provinces and the three territories. These individuals are not there to represent their provinces, territories or federal government departments; they are there as individuals. If anyone expresses views that could be interpreted as representing the views of a particular government, or government department, it would be fair to say that such views are neither well-received nor influential in the deliberations of COSEWIC. There are also three non-government members, of which I am one, nine votes for each of the species specialist subcommittees (including one for marine fishes), and one vote allocated to the Aboriginal Traditional Knowledge subcommittee. COSEWIC assigns status to wildlife species based on the information provided in species status reports: extinct, extirpated, endangered, threatened, special concern, data deficient, or not at risk. These reports are the product of at least two years of work by status report authors, each of which includes responses to reviews by the relevant species subcommittee and the federal, provincial, and territorial government jurisdictions responsible for each species.

Wolffish

Among marine fishes, the Atlantic wolffish, was listed as a *species of special concern* in 2000. This is one example of a fish that had declined in the absence of a directed fishery. In the mid

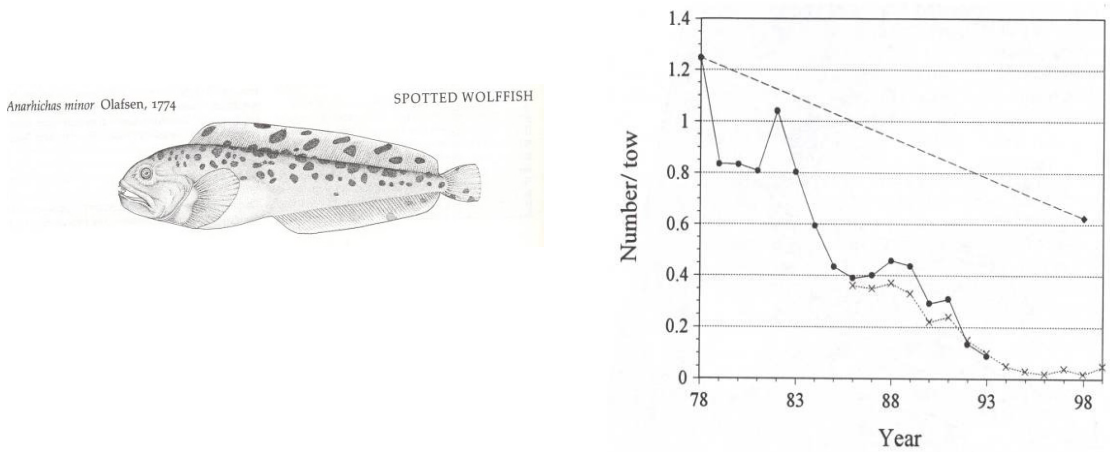


Figure 3.18. (a) Spotted wolffish *Anarhicas minor*. (b) Spotted wolffish survey catch rates from 1978-1999.

1980s, the Atlantic wolffish was one of the five species most likely to be caught as bycatch in the Northern cod fishery. One of the first two marine fish to be assigned a status of *threatened* by COSEWIC was the spotted wolffish (2001). Figure 3.18b shows why. The solid line shows the changes in catch rates from Fisheries and Oceans Canada research surveys from the late 1970s to the late 1990s. This extraordinary rate of decline was the primary basis for the *threatened* designation. Again, although not targeted directly by a commercial fishery, the species was caught as bycatch.

Atlantic cod

Very recently Atlantic cod off northeastern Newfoundland was assessed by COSEWIC as *endangered*. Again, it was rate of decline that was the primary criterion used to assign this status. The Northern cod fishery was closed in 1992 and all the other cod stocks, with the exception of western Scotian Shelf/Bay of Fundy cod, were closed in 1993. The percentages depicted in Figure 3.19 are the percentage reductions in spawning biomass from their known historic highs to their biomass at the time of the moratoria, 99% decline for Northern cod, 91% decline for southern Grand Bank cod, and 95% decline for Northern Gulf of St. Lawrence cod.

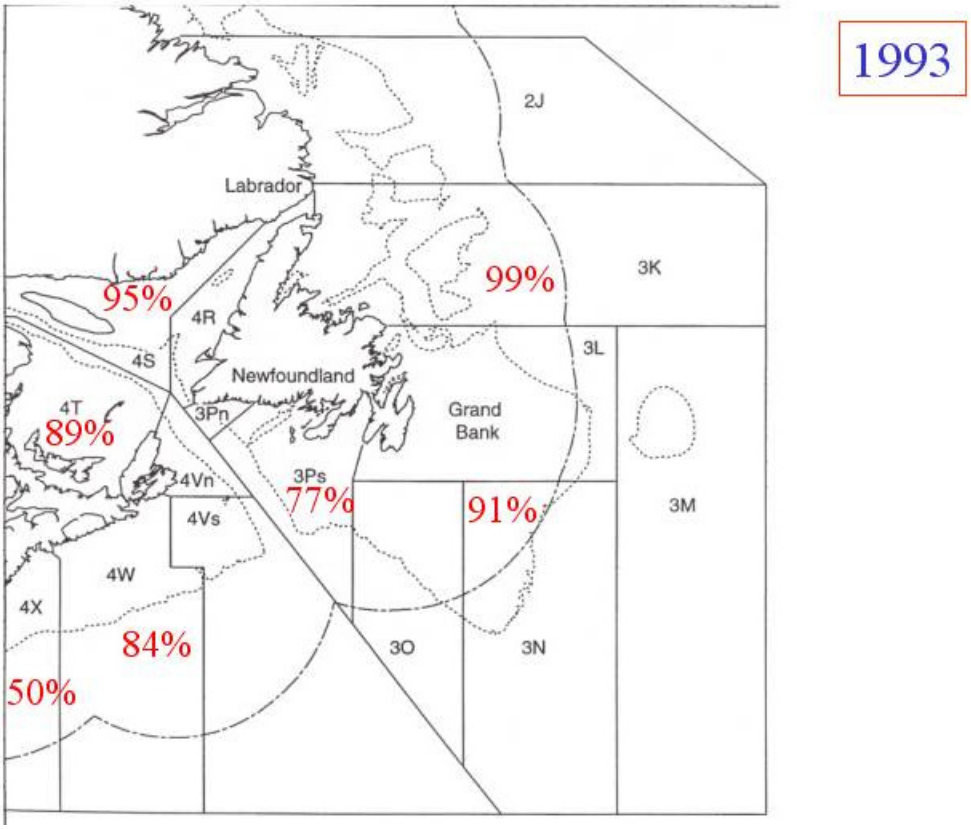


Figure 3.19. Reductions in Atlantic cod spawner biomass at time of commercial fishing closure in 1992 – 1993.

What is the status today in 2003? Figure 3.20 shows trends in the abundance of Canadian Atlantic cod stocks in terms of millions of mature individuals from 1950 onwards. The Northern cod trend is represented by the thick line at the top of the figure. In the early 1960s, Northern cod made up 75-80% of all of Canada's cod and probably numbered 1.7 - 1.8 billion individuals. Today they are clearly considerably fewer in number. Whether we calculate a rate of decline based on Virtual Population Analysis (VPA) abundance estimates, a model based on catches, or

based on DFO's fisheries-independent surveys, Northern cod have declined by 97-99.9% over the past three generations (generation time for Northern cod is estimated to be 11 years).

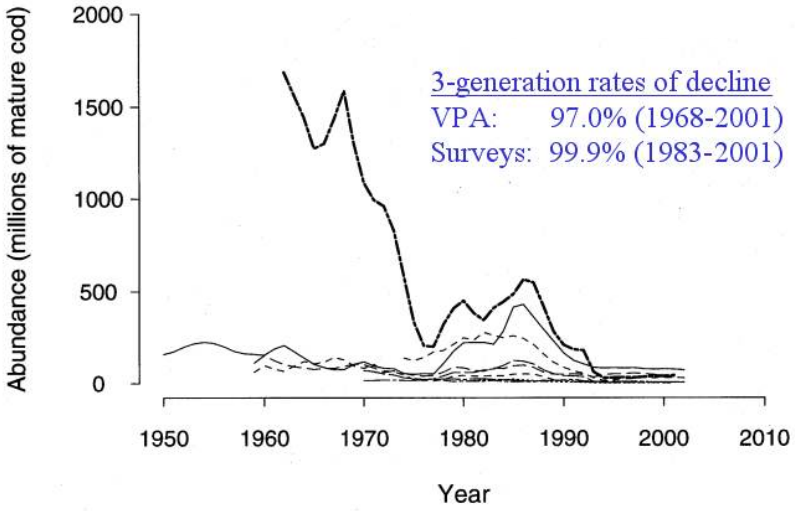


Figure 3.20. Abundance of Northern cod (millions of mature individuals from 1950-2002). Adapted from COSEWIC (2003).

The pattern for Southern Grand Bank cod is similar to that for Northern cod (Figure 3.21). Three-generation rates of decline are 98% or 95%, depending on the source of data (VPA, survey data).

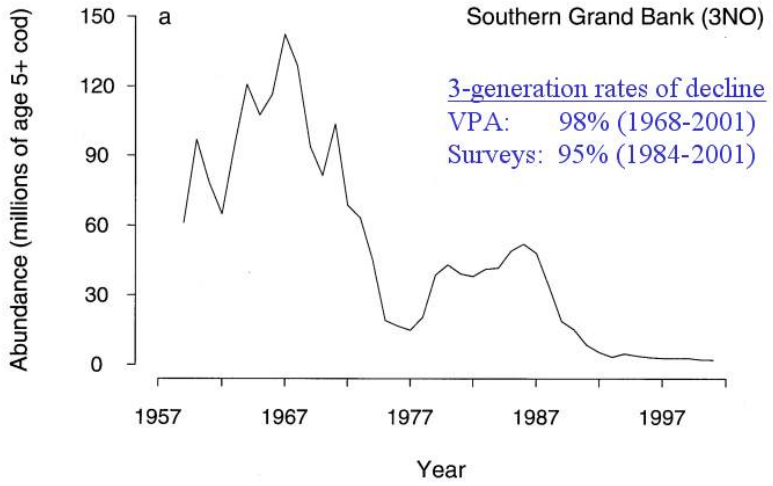


Figure 3. 21. Abundance of Southern Grand Bank cod, 1957-2002.

Figures 3.22a and b show the abundance patterns for six different cod stocks including Northern cod and Southern Grand Banks cod. The Northern Gulf cod fishery is another fishery that has been in the news lately. It was 're-closed' by the Minister of Fisheries and Oceans Canada very recently, and appropriately so. Eastern Scotian Shelf cod abundance is depicted in the far right panel of Figure 3.22a; it is potentially headed for oblivion. It has not been fished since 1993, yet it continues to decline. According to DFO's surveys, Eastern Scotian Shelf cod have declined by more than 90% in the last five or six years. These cod are maturing at smaller sizes than ever before (31-33 cm), and cod longer than 50 cm are exceedingly rare.

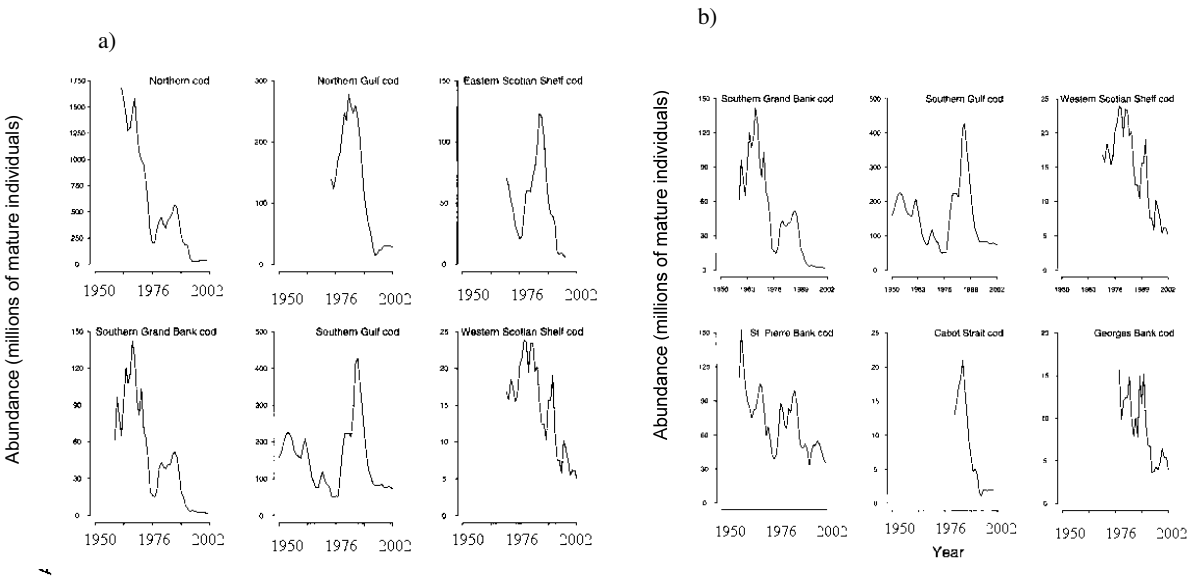


Figure 3. 22 a and b. Abundance patterns for Canadian cod stocks (1950-2000).

In 1998, the year in which COSEWIC first assigned a status to Atlantic cod, it grouped all cod in Canadian waters into a single unit for status designation purposes and assigned the status *special concern*. In 2003, it broke that designation unit into four separate units: Arctic, Newfoundland and Labrador, Laurentian North, and Maritimes populations. Northern cod is part of the Newfoundland and Labrador population. Table 3.2 shows the three-generation rates of decline for each of these populations and the status assigned by COSEWIC on May 2, 2003. The e*ndangered* status assigned to the Newfoundland and Labrador population marked the first time that COSEWIC had assigned a status of *endangered* for any marine fish, and it was the first time that any agency in the world had identified a population of Atlantic cod as being *endangered*.

Table 3.2. Three generation rates of decline for each population and the status assigned by COSEWIC on May 2, 2003.

COSEWIC Population	DFO Stocks	3-generation rate of decline	COSEWIC status (2 May 2003)
Arctic	0A, 0B	Unknown	Special concern
Newfoundland & Labrador	2GH, 2J3KL, 3NO	97%	Endangered
Laurentian North	3Ps, 3Pn4RS	81%	Threatened
Maritimes	4TVn, 4VsW, 4X, 5Ze	14%	Special concern

What was the basis for the *endangered* classification? COSEWIC bases its status assignments in part on decline-rate thresholds developed by the IUCN. Although the IUCN uses these decline rate thresholds as strict thresholds, COSEWIC uses them as guidelines for assigning status. In COSEWIC, a *threatened* status designation requires a 30% decline over the longer of ten years or three generations; an *endangered* status designation requires a 50% decline over the same time period. In 2001, in response to a variety of pleas for changing these thresholds for commercially exploited fishes, the decline-rate thresholds were increased to 50% and 70% for the *threatened* and *endangered* status designations, respectively. These decline rates will be applied to those species for which the causes of reduction are clearly reversible and understood and ceased.

Current threats to the persistence of Northern cod

The fishery for Northern cod was re-opened in 1999, a re-opening which many people were unaware of until it was re-closed in May 2003. Based on recommendations received from the

Fisheries Resource Conservation Council in 1999, the Minister of Fisheries and Oceans re-opened the Northern cod fishery in 1999 to a quota of 9,000 tonnes. The quota in 2000 was 7,000 tonnes, and in 2001 it was 5,600 tonnes. Revealingly, the total catch in 2002 was 4,200 tonnes although the quota had been for 5,600 tonnes. The fishery was even extended for a week, but the 5,600 tonne quota was not taken. These catch quotas were described as being part of a *limited* fishery. What a wretched adjective. This highly misleading phrase was used because of the observation that the quotas in the 1980s were much higher than the quotas assigned in the late 1990s. In the 1980s they averaged about 250,000 tonnes. However, the size of the quota is a meaningless thing to communicate to people. What is important is the size of the quota *relative* to the size of the population from which the quota is extracted.

How did these low catch quotas in the late 1990s/early 2000s affect Northern cod? The Department of Fisheries and Oceans undertook an extremely useful and important large-scale mark-recapture tagging experiment to estimate harvest rates brought about by these quotas. The results showed that in 2002 the 4,200 tonne catch resulted in a 20% exploitation rate on cod older than age three years and a 35% exploitation rate on cod older than age five years. If we go back to the 1980s, an exploitation rate of about 18% was considered sustainable. Clearly, with exploitation rates of 20-35%, one could not expect Northern cod to increase in abundance.

Natural mortality rates

Nonetheless, compounding these fishery-related deaths is a higher rate of natural mortality. In the 1970s and the 1980s, it is estimated that 1 in 5 cod died due to natural causes. Since the early 1990s, this death rate has approximately doubled in parts of the species' Canadian range. Almost certainly part of this increase can be attributed to increased predation by marine mammals and other fishes. However, it might also be a consequence of the fact that cod are maturing earlier than ever before in some areas. From a life history perspective, earlier maturity is associated with reduced longevity because of increased survival costs of reproduction. In any event, what we can say is that the death rate has approximately doubled and it is now very difficult to find a Northern cod older than age 10 years. For that matter, it is difficult to find one older than 6 years. These changes to longevity are extremely troubling given that this is a fish species whose persistence is dependent on reproducing many times throughout its life after reaching maturity at age 5 or 6 years.

Small population size

One of the things that one often hears about extinction probabilities for marine fish is that although some may have declined by 99%, there are still millions out there – indeed there are probably still millions of Northern cod in existence. However, this 'safety in numbers' argument bears closer examination. In one respect, we have to be cognizant of the mating system of the species of interest. This is particularly relevant for species such as cod, which are broadcast-spawning marine fishes. Upon coupling with a dominant male, the female releases her eggs directly into the ocean environment. There is no egg nest and no protection provided for the young. Satellite males release sperm amidst the cloud of eggs in the hope of fertilizing some offspring. In that type of mating system, there is very high variability in individual reproductive success. If you look at the genetic effective population size, *Ne*, and divide that by the census population size, or the number of spawners that you actually count, N_c (i.e. N_e/N_c), it has been estimated that the ratio might be 1:100 or up to 1:10,000 in marine fishes. At one extreme, for every 10,000 spawners counted, only *one* would actually contribute genes to future generations. There are not many studies that have evaluated this empirically. Ratios of *Ne* to census population size have been estimated as 10^{-3} for the red drum (Turner et al. 1999, 2002) and 10^{-5} for the New Zealand snapper (Hauser et al. 2002). What does this mean for the Northern cod? If a 10^{-2} to 10^{-5}

range is reasonable, then for every 1,000,000 cod counted as spawners, as few as 10 to 10,000 might be contributing genes to future generations.

Another thing to consider is small population size; that is, small from an historic perspective. All else being equal, small populations are more vulnerable to unpredictable, or stochastic, environmental events than large populations.

The following example illustrates what I mean. Recently, in Smith Sound, Trinity Bay, Newfoundland (which is a very small area relative to the geographic range of Northern cod), many cod of a size at which they could spawn died because they were subjected to an unpredictable, and as yet unexplained, oceanographic event. Taking into account official estimates, and allowing for many unreported recoveries of dead cod, probably at least 1,500 tonnes of cod actually died. DFO estimates that the 2003 spawner biomass for Northern cod in the inshore waters is 14,000 tonnes (DFO, 2003). Therefore, this unpredictable environmental event may have resulted in a mortality exceeding 10% of the breeding population size. If that population had been at historically high levels, this event would have had minimal impact. But, despite the fact that there are hundreds of thousands if not millions of fish in the area, this small-scale event had a major impact. This is because as populations decline, they tend to aggregate in the most suitable habitat, thus making them more vulnerable to small-scale environmental perturbations.

Extinctions and extirpations of marine fishes

What do we really know about extinction in the ocean? There are those who argue that we need not worry about marine fish because there has been no documented extinction of a marine fish in the last couple of centuries. In fact, this is not true. Nick Dulvy and colleagues (Dulvy et al. 2003) recently reported evidence that documents 57 marine fish extirpations in the last two centuries, including bony fishes, sharks, skates and rays. There have been, as far as they could judge, three marine fish extinctions in the past two centuries. The question is: Why have we not extirpated or driven more marine fishes to extinction? This has a lot to do with our ability to locate and harvest these fish relative to our ability to do so for species in the terrestrial environment, where far more extinctions have been recorded. Until the last few years, it has been relatively difficult to find every nook and cranny where marine fishes are located. This is changing with changes in technology, which are providing an unprecedented view of bottom topography. With this kind of technology in hand, it will not be too difficult to eradicate species if it is economically viable to do so.

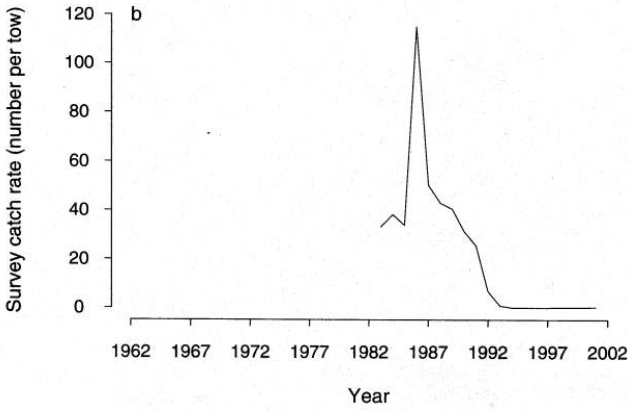


Figure 3.23. Northern cod decline in the last three generations.

Let us return to the fact that Northern cod has declined by 99.9% (Figure 3.23) over the last three generations. One increasingly asked question is: What are the potential implications of the collapse of Atlantic cod to Marine Protected Areas, or MPAs? In 1995, I suggested that we set aside a temporal and spatial refuge for Northern cod in the offshore parts of the stock's range (Hutchings, 1995). The argument against MPAs for species such as cod is that they move about a great deal; for example, MPAs might be fine for coral reef fishes, where

they remain in a certain area, but they might not work for cod.

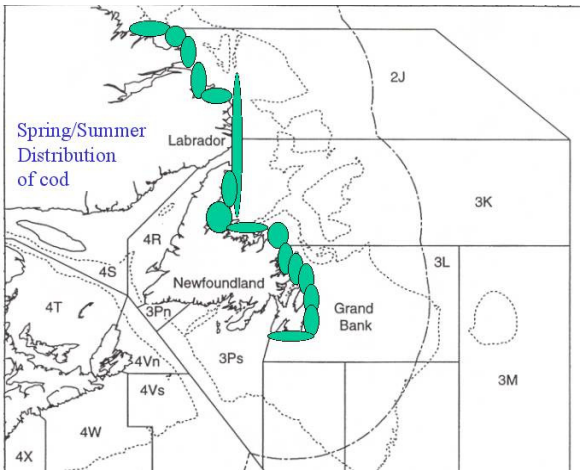


Figure 3.24. Spring/Summer distribution of cod.

In this regard, I offer the following observations. Many Northern cod (used to) spend the spring and summer months in the inshore areas, where they are vulnerable to inshore fishing gear (Figure 3.24). They are in the inshore areas feeding primarily on capelin and secondarily on herring.

In autumn, they migrate offshore and spend the autumn and winter months in offshore waters (Figures 3.25 a and b). With some exceptions, from the late 1400s until the late 1950s most of the fishery was prosecuted in the inshore area. The offshore zone was effectively a spatial and temporal MPA. In 1955, that changed with the advent of stern-hauled, bottom-trawl nets.

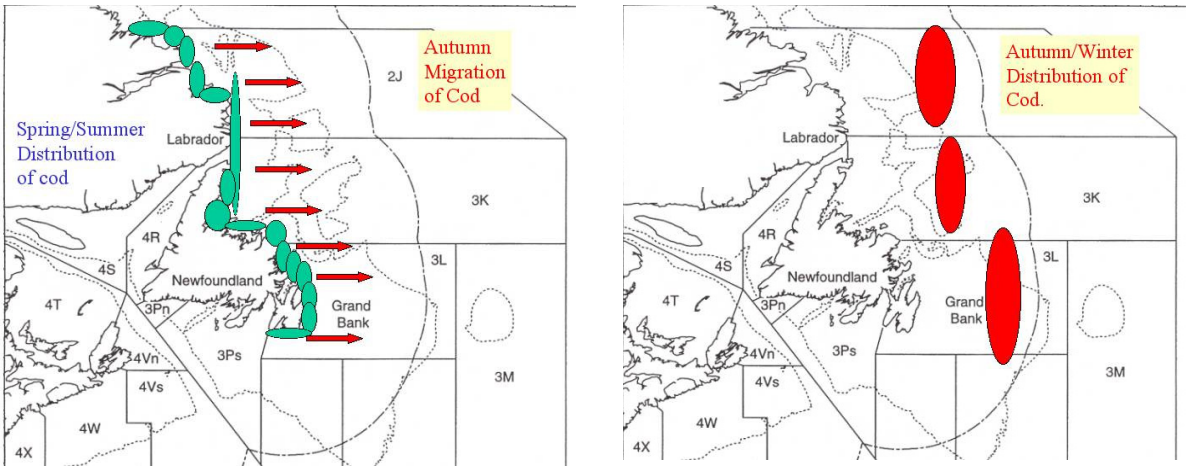


Figure 3.25. (a) Autumn migration of cod (b) Autumn/Winter distribution of cod.

In the inshore area, from the mid-19th Century to the mid-20th Century, the total annual catch of Northern cod was roughly 200,000-300,000 metric tonnes. What happened when we expanded the fishery to the offshore waters? In the 1980s, the catch was also 200,000-300,000 metric tonnes (Figure 3.26). In other words, the catches that we were able to sustain from the 1850s to the 1950s were not unsustainable in the 1980s. Having this unintended MPA prior to the 1950s clearly did not hurt catches and almost certainly provided a bulwark against population declines and some insurance in conserving a broad age structure. It also reduced overall fishing mortality.

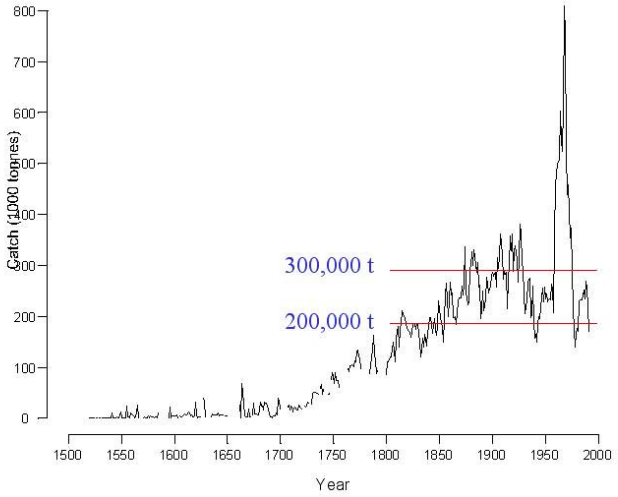


Figure 3.26. Estimated catches to Northern cod from 1508 to 1991.

One day the human-induced decimation of Northern cod may well be recognized as the marine equivalent of the hunting of the buffalo to pitiful levels of abundance. Repeated institutional failure to take marine conservation seriously will ensure that cod, and many other severely depleted marine fishes, remain ecological and numerical shadows of the marine ecosystems where once they dominated.

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CHAPTER 4
Dialogue following World Fisheries: Problems and Lessons Learned

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The effects of the British Columbia krill fishery on the food chain
Robert Kreutziger, who noted that he is one of the last commercial fishermen on the West Coast of British Columbia, commented on the krill fishery in British Columbia and expressed his concerns about the disruption of the food chain caused by this extensive fishery. He noted that while krill fishing in Washington, Oregon, California and Alaska has been banned, in British Columbia, they are still taking approximately 1,000 tonnes out of one of the richest bodies of water in the world and it is mainly being used for farm fish feed. He commented that this is feed that could be used by up to one million tonnes of hake that winter in Georgia Strait, just off Nanaimo.

He noted that he has brought this issue (the overfishing of krill) to the attention of both the provincial and federal ministers of fisheries and has not had a response. "I don't know how we can enhance our West Coast fishery until we start regulating some of these causes of collapse… What has the Government of Canada or the Province of British Columbia done to reduce the decline of our fishery?"

Reg Watson replied that it has generally been the path of least resistance to move on and fish lower down the food chain; that is, when a top predator has gone we move on to fish what was its food. In terms of the East Coast of Canada example, following the collapse of the cod fishery, there are people who have done very well in the shrimp fisheries and in other fisheries as well. These are fisheries that were not traditional fisheries in the past but they have come in when those 'fished down' predators have been removed. He noted the example of the fisheries of the Antarctic where although there are management systems in place, they are still looking at big expansions of the krill fishery. However, they are not debating what will happen to those fisheries with regard to the animals that eat krill.

He added that we seem to have this view that we can grind it all up and it all belongs to us. In the case of fisheries around Canada, we have, as human beings in the past, just adapted and moved on to something else. However, fishermen can adapt to harvesting something else. That does not mean that the ability to bring it back to its former state has not been jeopardized. In his opinion, we are guilty of being so adaptable that soon we will even forget that the Atlantic cod was a targeted species. Increasingly around the world we now have fisheries that are targeted on the low parts of the food web, for example, jellyfish, that now seem to be liberated as the top parts of the

system are removed. He noted that the fisherman in the Gulf of Mexico are now starting to have targeted fisheries for jellyfish – something that they really abhor, but they will get by, if they have to, by fishing these. In other words, we lose the incentive to try to do the hard thing which is to attempt to return the traditional fishery to its former state.

Why fisheries do not respond to closures

Malcolm Windsor commented on Jeff Hutchings presentation and his reference to the fact that the fishery did not seem to respond to closures and instead there appeared to be other bigger causes of the decline. He noted that they have noticed exactly the same thing in the North (east) Atlantic. He cited the example of the salmon fishery where despite the fact that the Greenland fishery, thought to be a major cause of decline, was cut from 2.5 thousand tonnes to nothing, the salmon have not returned at all. He commented that this suggests that there is something bigger going on.

Jeff Hutchings commented that many hypotheses have been proffered with respect to explaining why these animals have not recovered – be it salmon or otherwise. One can talk about the larger scale environmental issues and to some degree this is important, except that they happen in fairly slow time frames, at least in the northwest Atlantic, mainly because it is so cold there. What would be very useful, at one level, would be to have some good satellite imagery analyses of changes, if any, in primary productivity over the years, and at the very baseline level. He noted that there has been some work published on this topic recently in *'Nature'*. This information would be useful in assisting us to determine whether or not there is a problem at the primary productivity level.

At another level, he is always struck by the fact that the system has so completely changed. When looking at time frames it is difficult to consider what is normal and what is typical and, as Daniel Pauly put it so well a few years ago, our time frames often extend back only five or ten years and, sometimes, ten or twenty or even fifty is not far enough back to draw conclusions. For cod in the Northwest Atlantic, we have gone from just under three billion spawning individuals to a couple of hundred million; that is just one species, notwithstanding what has happened to haddock and pollack and a variety of other species. In his opinion, we have knocked things down to such low levels that such things as the Allee effect and the difficulty the populations have in terms of recovering is because 1) they are so low and 2) they have altered interactions with other species such that the Allee effect might be a lot more important than was thought previously. Therefore, this might well be keeping them down (for biological reasons), apart from any longer scale environmental changes.

Comparing cod management with salmon management

Brian Riddell commented that if we appreciate the sort of analogies and similarities that were described between large marine ecosystems and enormous abudances of cod that we have lost and if we reflect on the basic messages, in every case there are analogies to Pacific salmon management. With respect to Dr. Hutchings comments about denial of the obvious and delays in response it is clear that they knew for years that there were enormous declines in salmon abundance, and yet there were always reasons why the data were questioned or not responded to, so that now there are 'recovery' plans. These plans are showing, exactly as was shown with respect to cod and North Atlantic salmon, that recovery does not always occur. In fact, the recovery that we have seen recently in terms of Pacific salmon is not to do with good management but rather with improved ocean survival. There is a serious concern about being complacent about recovery and it does not always occur, as has been pointed out.

The value of genetic material

Referring to the comments made about the genetics of cod, Dr. Riddell noted that we currently have a debate in British Columbia around establishing a Wild Salmon Policy and the merits and value of the genetic material. In his opinon, anyone who continues to deny the value of genetic material is just ignoring the obvious and that is the future. Whether you are concerned about production, or about diversity, it is the fish that we have now and it is very likely that we are interjecting genetic change in those fish.

Shifting baselines and harvest rates

Brian also addressed the comments made by Reg Watson with respect to shifting baselines. He noted that we can become really complacent about having 'some' fish. He noted that Dr. Watson's comments with respect to the harvest rates in cod are exactly in line with what we see in fishing small salmon populations; that is, you can have small catches that do not change the long-term exploitation. Since there is a great ability to fish we have to always be cognizant that we can find those fish. We are very creative and have great capability of doing that and small populations just increase the challenge for proper management. He explained that the information presented on cod and other species fisheries is totally applicable to salmon.

We need a different default hypothesis

Randall Peterman referred to the plan for fisheries management that Brian Riddell was discussing. He commented: "The default assumption has been that if you see a large variation in the data, and cannot contribute cause uniquely to an observed decline, then you assume that it is something else until you are really sure it is that factor you are concerned about. I thought what you were leading up to was the idea that what we really need is a different default hypothesis - such as when you see enough examples of the sorts of things that Jeff Hutchings summarized that show the effects of certain factors such as fishing. Maybe the null hypothesis should be, 'there is an effect until you show otherwise and take appropriate action.' I think this is one of the syndromes we are in, referred to by Jeff Huthchings as the 'scientific professional syndrome'. We are trained to say that there is no effect until we can show it. Maybe it is a change in mindset that we need to consider, where we assume there is an effect until we cannot show it."

The perceived failure to link science and management in fisheries

Mark Saunders referred to the strong statement made by John Fraser in his opening remarks that science has failed to articulate the dangers and solutions to the public and the media. He asked the presenters if they could comment on this perceived failure in the link between science and fisheries management, and how we might improve it.

Reg Watson replied that it seems that in order to attract the attention of the public we have to come up with something that is more and more spectacular - usually it is a great catastrophe. Unfortunately, it is that kind of wake-up call that many people seem to need in order to put the pressure back up through the system to carry out the management changes that are very unpopular. And as John Fraser pointed out, if you tend to have a one-sided message, which is that it is all doom, then you can actually alienate people in the process and they will not want to know about it anymore. He believes that we have to have a message that is clear, simple and very easy to articulate. We almost have to take it to the marketing professionals and get them to distill it down, but that is something a scientist would abhor. The message is very important and it really has not changed for years - yet we have not seen the kind of response that is required. Obviously, we, as scientists, are going to have to adapt as well.

Jeff Hutchings added that it is very important to come up with solutions. He noted that when we look at the past, the trend is one of ascribing blame and saying what went wrong, as opposed to

saying, "this is what we did, here is what we have learned and let's move on – let's stop dwelling in the past and start from today and move forward." In the case of the Northern cod, we cannot change the past. However, what has not helped us is the lack of clear management objectives and targets for recovery. These can be, at the first level (and probably ought to be), socio-economic targets. From a cod fishery perspective, how many fishermen do you want to derive an income from the Northern cod fishery? What should that income level be and how many communities should be supported? Once those decisions have been made then the next approach is to ask the biologist what has to be done to have 'X' number of cod in the ocean to meet these socio-economic objectives. Right now we have no recovery objectives for cod and that has not helped us in designing responsible management plans.

Another point is, as a society, we have to bear in mind that those who make the decisions, at the end of the day, are politicians. The buck stops with the Minister. We need to make it more politically palatable for these conservation measures to take place. He described a conversation he had with an Member of Parliament three years ago with regard to the Species at Risk Act. The Minister was unsure as to whether the Act was going to be passed and indicated that the difficulty was that there was nothing to be gained for his political party. From his perspective nobody liked this bill - the environmentalists did not like it, new scientists did not like it, the agriculture industry did not like it – and the mindset was, "What is there to be gained by us?" From the political level, my perception is that there needs to be more to be gained. Right now it is just negatives. If a minister closes a fishery and reduces allocations, it is all seen as 'negative' - very few people see it as a positive. We need to engage the broader Canadian society and engender the sense that it is OK to take these strong conservation measures, such as the federal Fisheries Minister recently did with the coho - those were tough decisions to make. Whatever we can do in that regard would be appropriate.

Generation time - comparing salmon with rockfish

Jeff Marliave commented that we get spoilt with salmon, which are at the very low end of longevity and have a tendency to have good year classes fairly regularly. In contrast, on the British Columbia coast there are two species of rockfish, which are in some areas quite depressed; that is, the yellow rockfish and the quillback rockfish, which in each case have only had three successful year classes in the entire last century. Species such as these are extraordinarily long-lived and have very 'chancy' reproductive success. Is there any possibility of gleaning from whatever data may be available whether there is any truth in the critical period hypothesis wherein a constellation of ideal circumstances will result in very high larval survival and maybe something which may not have happened for Atlantic cod in the last decade and-a-half?

Jeff Hutchings replied that Jeff Marliave had identified one of the key things - generation time. Longevity and age at maturity comes back to the link between an individual's life history and the population level maximum rate of increase. The maximum level of increase determines sustainable rates of exploitation and maximum population growth rate is a consequence of what individuals do in terms of their age and maturity. Jeff Marliave is identifying a species whose persistence is dependent upon reproducing multiple times throughout a very long period of time and it is almost the worst kind of lottery possible. Given those circumstances, you are almost certainly going to be dependent upon having the larvae emerge at a time that matches algal productivity. However, this is, perhaps, less important for something as long-lived as those species than it is for shorter-lived species. Having said that, if we curtail the longevity of those long-lived species then it becomes incredibly important we give those species the time over which to play the lottery or clearly those species are going to suffer as a consequence.

Going back to the cod situation, in the 1960s there was no trouble in finding cod that were twenty years and older. In the early 1960s it was estimated that cod aged ten and older contributed more than half the total number of eggs to the Northern cod population. Today, we cannot find a cod aged ten and older. This is a species whose reproductive strategies are dependent on reproducing multiple times throughout a long life. If that life is curtailed then the number of opportunities is curtailed. In itself, it is not any more important, but if you curtail the longevity, it becomes increasingly important.

Predation as a factor affecting recovery rate

Wayne Harling addressed Jeff Hutching's comment that factors, other than fishing, are more important to recovery of the depleted stocks. He noted that he believes many of us are in denial of this and instead we seem to think that if we just curtail fishing all will be well. The impact of predators on a depleted stock is an intriguing idea. We cannot do much about factors such as climatic regime shifts but we could reduce predation, if the elimination of fishing effort is not enough to rebuild these stocks. He posed the question: For Atlantic cod, what are some of the predation sources and what might be done about it in order to help rebuild that stock?

Jeff Hutchings noted that this is the question that is on the 'phone-in' talk shows in Newfoundland on a very regular basis. Seals are clearly eating cod, harp seals are eating cod, inshore fish are eating cod, and conners are eating cod. As well, large cod eat smaller cod and in fact cod are one of the most cannibalistic species there is. The issue, from the seal predation perspective, really comes down to (notwithstanding the ethical and moral issues about increasing the hunt) taking a cold hard look and saying how many seals would we have to remove to have a demonstrable impact on recovery? There are estimated to be roughly 5.2 – 5.5 million harp seals out there. To have a demonstrable impact on recovery, we would almost certainly have to remove 2-4 million of these harp seals. It is not even physically possible to do that, let alone morally or ethically responsible. Furthermore, there is virtually no reason to believe that this would make a difference in recovery rate.

In multi-species interactions, it is too simplistic a view to identify causal relationships of such a strength between two of all of those species. One of the things that is ironic, in this regard, is that the Department of Fisheries and Oceans and many management agencies have been lambasted for taking single species perspectives on fisheries management. Many of those same individuals are then taking the two-species model and saying that if we knock seals down then cod will automatically come back. There is good reason to believe that it is not as simple as that and, secondly, you would have to remove a large number of harp seals to have any hope of seeing a demonstrable impact. This still may not be successful because of the fact that other fishes and other species are consuming cod as well.

Genetic implications for the Northern cod

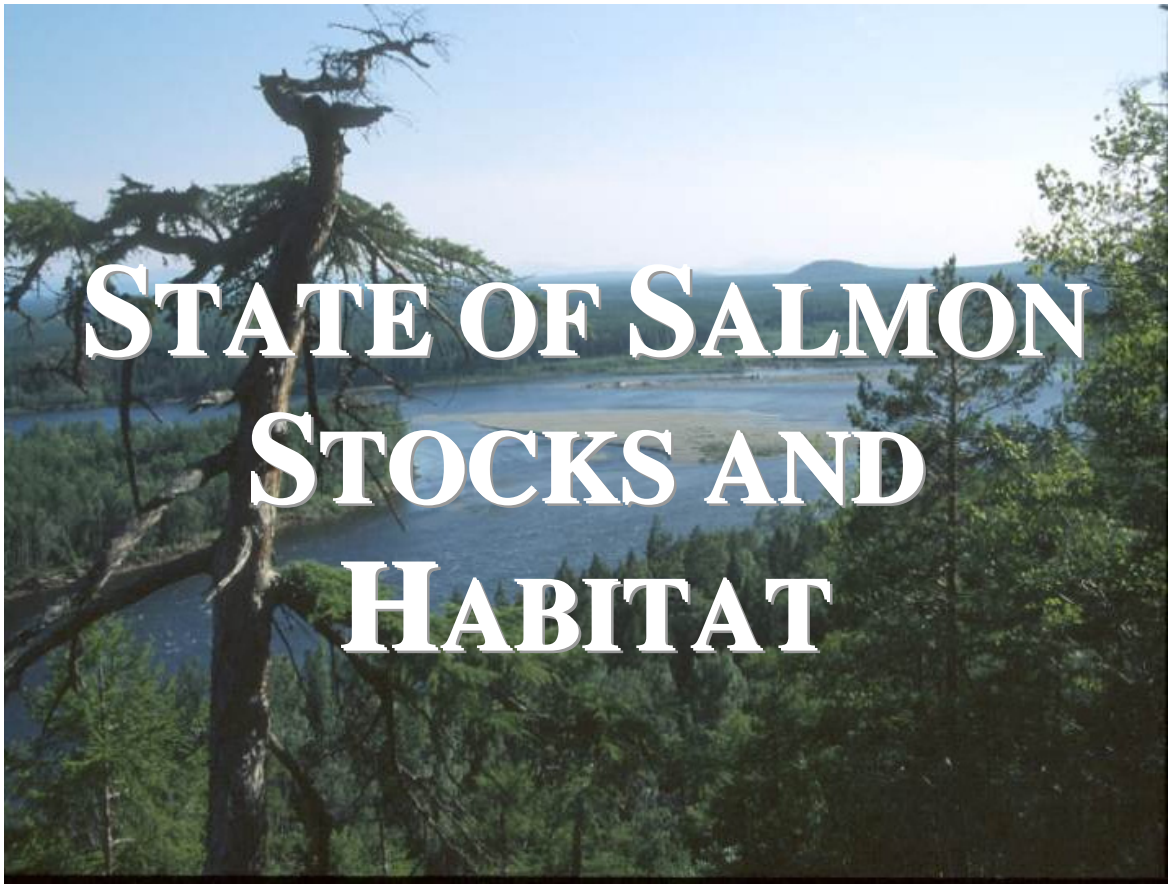
Noel Wilkins posed the questions: In the case of the cod, if there is a significant Allee effect and it is in a serious decline, then you might expect genetic evidence for changes in the allele frequencies or the variance of frequencies in the populations. Do you see that? Secondly, is it biologically legitimate to take the Northern cod population and treat it as a closed entity to which there is no recruitment from outside and nothing from inside to other stocks?

Jeff Hutchings replied that there have been no genetic studies which examined large-scale temporal variability in cod. There have been some studies to look at five or six microsatellite low Si not selectively neutral low Si but not selectively important quantitative genetic traits. He noted that they actually have cod samples that go back (from archaeological work) to the 18th Century

and it would be instructive to take that time frame. In terms of whether there have been any broad scale studies at this time, the answer is “no”.

With reference to the second question as to whether that is an appropriate biological unit, he replied that the answer is, almost certainly no. However, having noted that it probably contains a meta-population model, which is probably a more appropriate way to describe Northern cod with reference to the question. Is there evidence that recruitment is coming from outside into this area; the answer is “no”, not in the past, and certainly not today. There is some evidence of mature fish moving up from the south coast into the northern cod zone but then they go back again at spawning time and are not actually contributing offspring to that area. The better way to view the Northern cod situation is as one that was historically made up of many sub-populations. Some cod stayed inshore all year round, some stayed offshore all year round, and some moved back and forth and there were many in the latitudinal gradient that really did not mix very much at all. What has probably been observed is a loss of a number of those sub-populations, which will almost certainly impact the likelihood of recovery. This ties in with Brian Riddell’s comments with regard to the lack of genetic variability.

SECTION II



Tugur River, Khabarovsk Territory, Russia. Photo by Mikhail Skopets, Wild Salmon Center

CHAPTER 5

Wild Atlantic salmon in Europe: status and perspectives

Kjetil Hindar, Senior Research Scientist, Norwegian Institute for Nature Research

Abstract

Despite its status as a flagship species, wild Atlantic salmon (*Salmo salar*) has been in decline in most of Europe for the last three to four decades. Better catch records during this period, and increasing numbers of escaped farm salmon, suggest that the actual decline in wild salmon has been stronger than that estimated from catches. The decline has been particularly strong in some rivers producing high proportions of late-maturing salmon. The causes for the decline are manifold and include both natural environmental variation and man-made changes. Among the former, marine conditions are believed to have been unfavourable for both growth and survival of salmon since the early 1980s. Among the latter, negative effects associated with the build-up of salmon farming, such as the spread of diseases and escape of farm fish, are believed to be major contributors, together with the more "traditional" causes like pollution and watercourse regulation. Moreover, by-catches of salmon at sea may contribute to the decline of some populations. There are, however, some positive trends, in particular in rivers previously affected by local or long-transported pollution. The future of wild Atlantic salmon seems to depend on better inter-departmental co-operation in recognizing and controlling the man-made factors affecting wild populations, and on research which improves our understanding of the regulating factors in salmon populations. A major challenge lies in developing salmon farming into a sustainable industry.

Introduction

Atlantic salmon (*Salmo salar*) is a highly valued species, and has probably been so since humans colonised the Atlantic coasts of Europe and North America many thousands of years ago. The current use of the species is clearly not sustainable. Many populations have gone extinct, and a mixed-stock fishery depresses the size of many populations. Efforts to restore lost populations have been only partly successful. Aquaculture, which originally was seen as a relief to wild populations, has brought other problems related to competition, gene flow and disease transmission between farm and wild fish.

Population trends have been negative on a broad geographical scale since the 1970s, and total catches have declined to their lowest level for probably more than a century. Populations composed of a large proportion of late-maturing salmon seem to be most strongly affected by this decline. The negative trends, and little control over some of the factors affecting salmon populations, have led to concerns about future population viability. The picture is not completely bleak, however, as some populations seem to be recovering, concerted management efforts are emerging both nationally and internationally.

The objectives of this paper are (1) to provide information of the current status of Atlantic salmon populations in Europe, (2) to discuss causes for the changes in population abundance, and (3) outline some critical factors for successful management.

Status and trends of Atlantic salmon populations

Atlantic salmon are distributed in rivers and in the ocean from northern Portugal in the south to northern Norway and Russia in Europe, and from New England in the south to the Ungava Bay of northern Quebec in North America (MacCrimmon and Gots 1979). In the ocean, Atlantic salmon are found over large areas in the North Atlantic. The life cycle of Atlantic salmon consists of the following stages: adult atlantic salmon migrate upstream in rivers during spring and summer; eggs are laid in gravel in late autumn and incubated in the gravel during winter; alevins hatch in spring and 3-4 weeks later start feeding as fry; parr establish territories and remain in fresh water for 2-4 years, occasionally 1 year in the warmer rivers and 6-8 years in colder rivers; when attaining a size of 12-18 cm and 20-60 g, they migrate to the sea as smolts in the spring. Salmon travel long distances in the sea and feed there for 1-4 years before returning to fresh water to spawn at sizes ranging from 40 cm and 1 kg to 140 cm and 35 kg.

In contrast to Pacific salmon (*Oncorhynchus* spp.), Atlantic salmon can survive spawning and 70-80% migrate to sea a second time. Only about 10% return to spawn a second time. The population size of Atlantic salmon usually ranges from 20 to 2,000 anadromous spawners, and very few rivers have more than 10,000 spawners. This is in contrast to several species of Pacific salmon, which may have population sizes on the order of hundreds of thousands to millions.

The current status of Atlantic salmon has been assessed by WWF (2001) which collated information on 2,600 rivers from national representatives in all of the countries holding self-reproducing populations of wild salmon. Of these, information was considered sufficient for a rough classification of status in 2,005 rivers. This information is summarized as country-by-country averages in Figure 5.1.

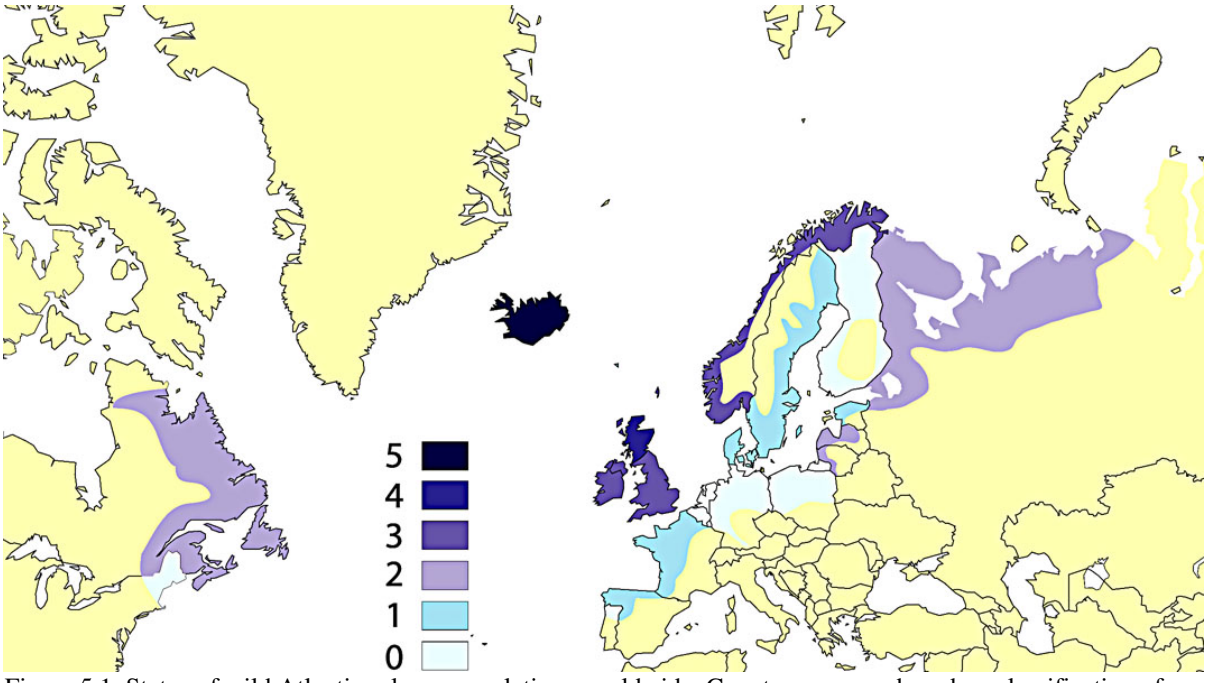


Figure 5.1. Status of wild Atlantic salmon populations worldwide. Country averages based on classification of 2005 rivers by WWF (2001) as being 5 – Healthy, 3 – Vulnerable, 2 – Endangered, 1 – Critical and 0 – Extinct.

Atlantic salmon populations are considered to be *extinct* from 309 rivers (15 %) and from the following countries: Germany, Switzerland, Netherlands, Belgium, Czech Republic, and Slovakia. They are considered to be *endangered* in Estonia, Portugal, Poland and the United States. At the other end of the scale, Atlantic salmon populations are considered to be *healthy* in 867 rivers (43 %), most of which are located in Iceland, Scotland, Norway, and Ireland (WWF 2001).

During the period from 1970-2000, worldwide catches of Atlantic salmon fell by 70% from approximately 10,000 tonnes to 3,000 tonnes. Better catch statistics, and an increasing proportion of farm escapes in the catches during this period (Hansen et al. 1999) mask a possibly stronger negative trend of wild fish in some areas. Large-sized fish, or multi-sea-winter (MSW) salmon, appear to be the stock component showing the most rapid decline in many rivers (Youngson et al. 2002). These negative trends have initiated international reports to protect wild Atlantic salmon (NASCO 1999) as well as government reports in Norway (NOU 1999) and the USA (USFWS/NMFS 1999), among other countries.

Causes of changing population sizes

Natural and man-made causes have probably interacted to produce a downward trend in abundance of Atlantic salmon during recent decades. Among the natural environmental changes affecting salmon, marine conditions are probably a primary cause. Long-term tagging studies of outmigrating salmon smolts have shown highly correlated return rates between two rivers in Scotland and Norway (Friedland et al. 2000). The authors suggest a link between ocean climate and both survival and growth of the salmon during the first months at sea. In particular, high sea surface temperatures (that occurred during the 1970s) during May in the North Sea and along the Norwegian coast seem to have led to increase in survival, whereas low sea surface temperatures (1980s and 1990s) have led to a decrease in survival. Moreover, conditions that favour survival also seem to favour individual growth rate. The mechanisms linking climatic conditions to both growth and survival are not clear but could, for example, be related to a higher growth rate resulting in an improved ability to avoid predators.

The man-made changes affecting the abundance of Atlantic salmon are numerous and only partly understood. Overharvesting may be a problem locally, but on the whole, the fisheries for Atlantic salmon have been greatly reduced since the 1970s. The high-seas fisheries have been bought out or controlled by quotas. Coastal fisheries are also being controlled (often by method), and in the rivers, recreational fisheries have been limited in fishing season or even closed down completely.

Recently, some authors have pointed to the possibility that Atlantic salmon are inadvertently harvested in the high seas during the post smolt stages, as they have been found to co-occur with herring and mackerel in some areas of the North Atlantic (Holm et al. 2003). Thus, bycatch may be a larger problem for Atlantic salmon than hitherto recognized.

Habitat changes in fresh water have for many years (centuries in urban Europe) been a major cause for declining salmon populations. Domestic and industrial pollution affecting water quality, and watercourse regulations obstructing migration and changing spawning grounds and temperature/flow, have reduced smolt production dramatically over large regions. In the rivers draining to the Baltic Sea, it has been estimated that the numbers have decreased from a historical 8-10 million wild smolts produced annually to the current numbers of approximately 0.5 million (Anon. 1999). Damming and pollution are probably the major causes for the decline. In Norway, freshwater acidification (> 25 rivers) during the 1900s has been the major cause for extinction and population reduction. Several acidified rivers are now being limed to a water quality that is acceptable to salmon, providing an example that some remedial actions have the capacity to re-establish self-reproducing populations (Hesthagen and Larsen 2003).

The high level of escapes of farm salmon, outnumbering wild salmon in many rivers in Norway and elsewhere, has led to concerns about the impact of salmon aquaculture on wild populations (Hindar et al.

1991; Hutchinson 1997). Production of Atlantic salmon in fish farms increased from 100 tonnes to 700,000 tonnes between 1970 and 2000. Escaped farm salmon are capable of spawning in the wild. Their offspring outgrow and partly displace those of wild origin, but also show maladaptive behaviour and may suffer higher mortality during some life stages. In a whole-scale river experiment in Norway, the lifetime reproductive success of farm salmon was 16 % compared to that of the native salmon (Fleming et al. 2000). The smolt productivity of the population was depressed by 30 % relative to expectation from stock-recruitment relationships in this river (Jonsson et al. 1998). Similar results concerning growth and survival have been found in a whole-scale experiment in Ireland, where second generation effects suggested a cumulative fitness depression of the population (McGinnity et al. 2003).

These genetic and ecological effects come on top of occasional epidemics following transmission of parasites and pathogens between farm and wild environments. As long as fish farming does not operate in fully enclosed systems there is always a possibility that disease organisms may be transferred from farm to wild fish (or from wild to farm and back to wild at considerably higher densities). The Norwegian experience regarding endemic and introduced diseases shows that it is difficult to operate large-scale aquaculture without disease-related problems for wild fish. Notably, veterinary certificates were given for both introductions which have had the largest effect on wild salmon in Norway, i.e. *Gyrodactylus salaris* from Sweden and *Aeromonas s. salmonicida* from Scotland (Johnsen and Jensen 1991, 1994).

Critical factors for success in sustaining Atlantic salmon populations

Research Needs

More research needs to be conducted in order to understand better both the environmental and biological basis for stock-recruitment (S/R) relationships in Atlantic salmon. Despite many decades of research on Atlantic salmon, representative stock-recruitment relationships and dynamic S/R models are still lacking for the large majority of rivers holding salmon populations. This is a serious hindrance to making informed predictions about how many spawners need to be present to avoid extinction of the population, and what the optimum number is for producing a harvestable surplus that can be sustained in the longer term. Some progress in this area has been made through statistical modelling with an aim to transfer information from a few well-studied European rivers to data-poor rivers (Prévost et al. 2003).

Understanding the effects of disease transfer between farm and wild populations is another important research area. We know a great deal about diseases in captive environments (hatcheries and fish farms), but still very little about diseases in the wild and how fish culture alters transmission routes and pathogen-host dynamics (Bakke and Harris 1998).

A third area of required research is at the level of metapopulations; that is, understanding the genetic and ecological dynamics of a group of populations exchanging a limited number of migrants. Models for genetic conservation and population viability are quite well developed for single populations, but are poorly developed at the metapopulation level. The latter seems more appropriate for salmon populations. Tufto and Hindar (2003) developed a model that maximizes the harvest of a group of populations, subject to constraints set by maintaining the total effective population size (a measure of genetic conservation). They showed that considerable gain may be made in total effective size through harvesting based on knowledge about genetic structure. For example, when populations differ in their degree of isolation it pays to harvest relatively less in isolated populations. In a source-sink system, where one population (the source) emits more migrants than it receives from its neighbours (the sink), it pays to harvest the source more strongly than the other populations.

Management Actions

Management needs to recognize and better control the man-made factors affecting wild populations of Atlantic salmon. This depends to a large extent on inter-departmental and international cooperation. A major challenge lies in developing salmon farming into a sustainable industry, which it is not at the

moment (Naylor et al. 2000). The most important measure for salmon aquaculture in the longterm, is to base it on closed culture where the possibility for escape is eliminated and where in-flowing and out-flowing water is controlled. A shorter-term measure could be to base aquaculture on sterile (all-female) fish, which can be produced at a large scale through simple, inexpensive technology. Whereas this measure cannot alleviate problems related to competition in the sea and transmission of parasites and pathogens, it would be an efficient and rapid way of reducing genetic problems. Sterility should at any rate be used while developing a technology that targets full containment.

Several recent initiatives at the national or international level provide some hope for a brighter future for wild Atlantic salmon. In the Norwegian governmental report on the status and future of Atlantic salmon, a number of rivers and fjords were targeted as being 'national salmon rivers or protection zones' (NOU 1999). In these areas, management plans for other areas such as agriculture, aquaculture, hydropower development, and transportation, need to adjust to the protection of the local salmon population(s). In the Baltic area, an international "Salmon Action Plan" has been set forth to restore wild salmon populations (Anon. 1999). The goal is to increase salmon production to at least 50 % of the potential capacity of each river by year 2010. In the European Union, much hope is attached to the Water Framework Directive (Directive 2000/60/EC) which has the potential to achieve good ecological status for whole river basins, and sets a time frame for its implementation. Thus, even though Atlantic salmon have declined in many European countries, some concerted management actions on both the national and international level provide some hope for the future.

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CHAPTER 6

Wild Atlantic salmon in North America: status and perspectives

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Abstract

Wild Atlantic salmon abundances in North America are presently at their lowest levels ever. Actions are urgently needed in the southern part of the species distribution where many populations are now officially listed as endangered in both Canada and the USA. In a number of instances, the most probable causes responsible for a major part of the declines of a salmon run are known. These causes include dams and acid precipitation, and remediation methods are available. However, the remediation costs are expensive, and it is a big challenge to raise the necessary money. New research is beginning to point to possible solutions to other difficult challenges. By focusing on key river systems and point source causes it should be possible to achieve large increases in North American wild Atlantic salmon returns.

Introduction

Wild salmon are one of North America's great treasures, a source of natural capital that has benefited generations of humans on the continent. For something so valuable, it is quite difficult to believe that we have permitted the abundance of wild salmon on both coasts to decline to their present levels (e.g., Montgomery 2003, Lichatowich 1999). This paper briefly reviews the status of wild Atlantic salmon populations in eastern North America, focusing in particular on the most troubled areas. It explores some aspects of what is being done, and what can be done, to attempt to restore populations in areas where they are troubled or lost.

A brief history of North American Atlantic salmon

Historically, sea run Atlantic salmon occurred from the Hudson River up into the Hudson Bay region, and there were landlocked populations of the species in freshwater lakes throughout this region, including Lake Ontario (Christie 1973, Dunfield 1985, Scott and Crossman 1973). We do not know what the pre-European abundance of Atlantic salmon runs was for sure, but it could have been in the range of five to 12 million returning spawners per year (Dunfield 1985). Native Americans in the region were heavily dependent on the resource.

The first instance that I have found of a European modifying a North American salmon river occurred in 1606, when Samuel de Champlain dammed part of the Annapolis River to create a trout pond, two years after he arrived in present day Canada with the first French colonists (Morison 1972). Subsequently, impact rates picked up. Watt (1988, 1989) estimated that by 1870,

due to dams, habitat destruction, pollution, water diversions and other impacts the North American production capacity for Atlantic salmon had been reduced to 52% of its original value. By 1970, we were down to only 32%.

Since 1973, the declining abundance trend has continued for wild salmon returning to North America (ICES 2003, Figure 6.1). Returns of fish are well below the biological reference points that scientists believe should be maintained to insure the conservation of the species. The cause or causes for the trend remain speculative, but increased mortalities of the fish at sea appear to be a major contributor. A "regime shift" appears to have occurred in the ocean in the late 1980s, or early 1990s, and this is associated with a large deterioration in the stock-recruit relationship (ICES 2003).

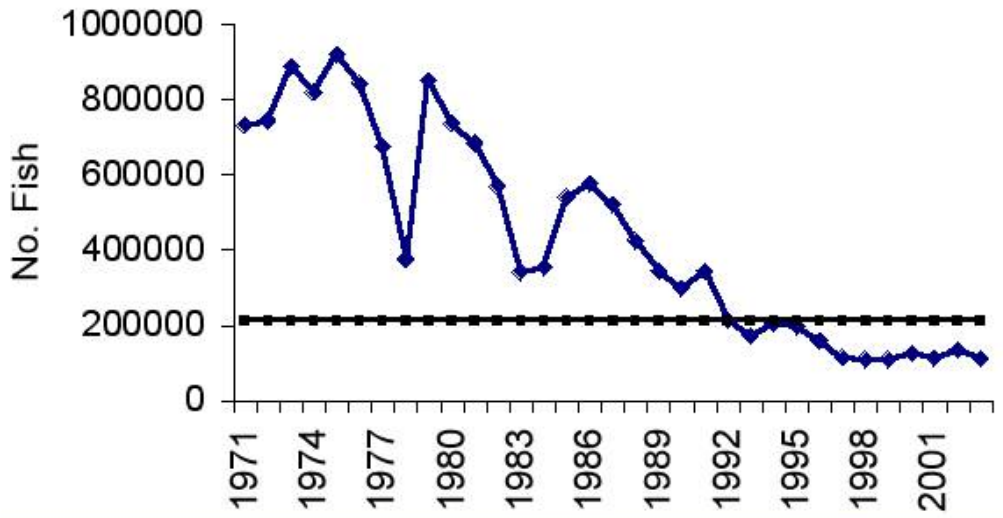

Figure 6.1. Trends in abundance for wild Atlantic salmon from all rivers in North America at their feeding grounds off the coast of Greenland, prior to returning home for spawning. The conservation threshold, the biological reference point below which managers do not wish to see fish abundance fall, is given by the constant value line. Data from ICES 2003.

While the abundance of Atlantic salmon is generally depressed in both Europe and North America, the depth of the depression is much greater in the south than in the north (ICES 2003). In North America, there is a real possibility of biological extinction of virtually all Atlantic salmon populations south of Cape Breton Island, Nova Scotia. About 65 rivers in southern Nova Scotia have been impacted by acid rain, which is apparently compounding the impacts of the other stressors that have caused the general decline (DFO 2002, Watt 1987). The drainage basins of these rivers fall in whole or part on the Southern Uplands. Previously, this area had a limited natural buffering capacity, but acid depositions from anthropogenic sources have stripped away much of it. The pH values in several of the region's rivers now fall below those where salmon reproduction can occur, and they are at levels that impede reproduction to varying degrees in most of the other rivers.

In Canadian rivers draining to the Bay of Fundy, salmon populations are severely depressed (DFO 2003). The populations of 32 rivers in the inner Bay region were officially listed as *endangered* in 2001 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (for background, see Kenchington 1999, Amiro 2003). The precipitous declines of these runs began as recently as 1990. Most of the other populations in the region are similarly depressed (DFO 2003) and may be candidates for listing by COSEWIC. Across the border in

northern Maine, which harbors most of the United States remaining wild, self-sustaining salmon populations, eight population segments were listed as endangered in November 2000.

Salmon farming

The potential impacts of the intensive sea cage rearing of domestic strains of Atlantic salmon upon wild salmon populations remain an area of great concern. On the east coast of North America, the sea cage industry in the USA is concentrated in northern Maine, and in Canada in the Quoddy Region of New Brunswick. Wild salmon populations in both of these areas are severely depressed and many are listed as endangered.

The principal fears for wild Atlantic salmon revolve around the potential of escaped farmed salmon to breed with wild fish, reducing individual fitness for the offspring and depressing population sizes (Fleming et al. 2000, McGinnity et al. 2003 a,b), and the potential of the large biomasses present on the farms to foster out-of-control parasite and disease problems (e.g., Holst et al. 2003) that could in turn impact wild fish.

The debates about the potential environmental impacts of salmon farming have frequently been acrimonious (e.g., Goode and Whoriskey 2003), which has impeded making progress on the issues. However, measures are available to address many substantial issues, and tangible improvements are occurring in some places and areas (Goode and Whoriskey 2003, Lord Lindsey and Rae 2003).

Two examples of these improvements come from the east coast of North America, and involve minimizing the impacts of escaped farm salmon. The Atlantic Salmon Federation maintains a counting facility on the Magaguadavic River in New Brunswick. This river is situated in the heart of Canada's East Coast salmon farming industry, and is in close proximity to the core of the US industry in Maine. Since 1992, we have been counting the number of wild and farmed salmon running to this river to provide an indicator of the potential interactions between wild and escaped farmed salmon in the region (Carr et al. 1997). Historically 800 – 1,000 wild salmon returned to the river annually. Since 1992 however, there has been a desperate decline in the size of the wild run (Figure. 6.2). During this same period, as many as 1,200 escaped farm salmon were captured entering the river. However, improvements by the industry in cage technology and in their operating procedures have steadily reduced the number of escapees that were detected (Figure. 6.2).

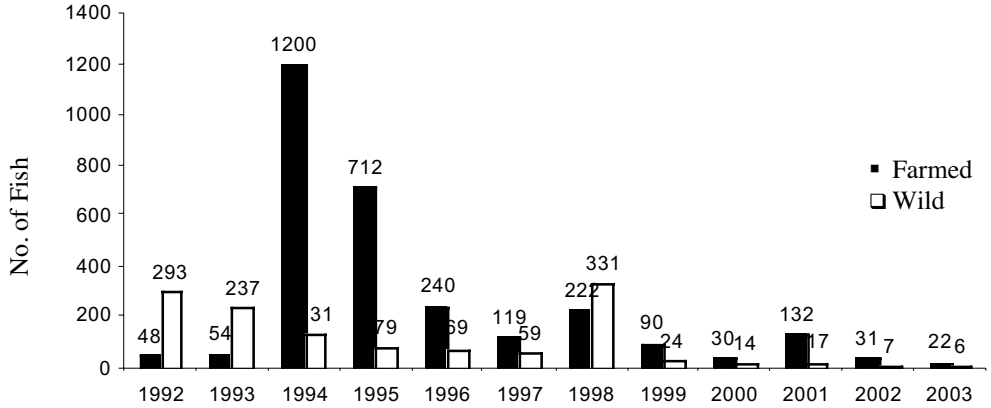

Figure 6.2. Numbers of wild and farmed fish caught annually entering the Magaguadavic River, New Brunswick, since 1992. Numbers of fish are plotted on the top of each histogram.

The second example involves the development of a cooperative agreement between the industry and environmental groups entitled "Framework for a Salmon Aquaculture Containment Policy in the State of Maine" (Goode and Whoriskey 2003). The framework outlined a Containment

Management System (CMS) designed to minimize interactions between wild and farmed salmon, and it has now been implemented. The agreement set standards, but let industry use its expertise and choose the feasible and cost effective ways to implement them. The process was successful because of the direct involvement in the negotiations of senior salmon farm company executives (as opposed to trade association representatives), because of the pivotal role the salmon growers played in the drafting and implementation of the CMS, because the agreement occurred in a non-regulatory arena, because a neutral, outside expert in Hazard Assessment Critical Control Processes (HAACP) was engaged to facilitate the development of the CMS, and because of a timely grant that paid for the expert.

These steps clearly do not resolve all the issues surrounding salmon farming. However, we acknowledge as well the efforts of the industry to coordinate their efforts on disease control and other environmental impacts (e.g., New Brunswick's Bay Area Management Strategies, Ireland's CLAMS (Coordinated Local Area Management Strategy), and Scotland's Scottish Quality Salmon mandatory commitment to its Environmental Management System (Goode and Whoriskey 2003, Lord Lindsay and Rae 2003). I believe the key to making continued progress is to focus on issues and the development of mutually acceptable ways to resolve them.

The way forward

The steps for recovery of wild Atlantic salmon are conceptually simple, but very difficult to put into practice. In my opinion, they basically boil down to:

- Keep what we have got
- Claw back what we have lost
- Do not let it happen again.

The first task involves adopting management measures that insure that we maintain the populations that are presently healthy, and stabilize those that have been declining. To meet the second, recovery plans are needed for areas in which production capacity has been lost. The third is dependent on developing better monitoring networks to provide good data on salmon population status, and timely interventions when the data show that problems are developing.

The availability of resources to meet these missions has been declining. This puts a premium on "strategic" intervention, especially in recovery attempts. For the Atlantic salmon, we will most probably obtain the biggest bang for our buck by intervening as early as possible. In North America there are a number of restoration efforts using "foreign" donor stocks presently underway at sites where wild salmon populations have gone extinct. These are all long-term and expensive efforts and so far have been not nearly as successful as desired (e.g., the Connecticut River, aux Rochers River). Interventions in rivers in areas such as the inner Bay of Fundy, where some native donor populations are available, are very new (Amiro 2003). Hope for all these efforts stems from the fact that a number of spectacular range extensions of Atlantic salmon within their home rivers have been obtained by opening up new habitat and colonizing it with fish from the same watersheds (Mullins et al. 2003).

I suggest that the biggest restoration benefits will occur in sites where a clear cause ("point source") is badly damaging a salmon population, over a significant portion of its range. The principle is not new. It is the same approach that has been adopted for dealing with industrial pollution. Three areas that meet some of these criteria, and which are becoming a major focus of the Atlantic Salmon Federation's attention, are 1) the inner Bay of Fundy salmon populations including a restoration of runs to the Petitcodiac River, 2) dealing with fish passage on the Saint John and Penobscot Rivers, and 3) mitigating for acid rain in Nova Scotia's Southern Uplands.

Inner Bay of Fundy salmon

In the upper Bay of Fundy region, about 32 rivers were home to a unique Atlantic salmon complex, now referred to as "inner Bay of Fundy salmon". These fish differed from those in surrounding rivers in their marine migration routes (they mostly stayed in the Bay of Fundy and Gulf of Maine region as opposed to migrating to waters off Greenland), life history characteristics (early maturity, high rates of repeat spawners in the populations), and genetics (see Amiro 2003). As recently as 1990, up to 40,000 salmon may have returned annually to these 32 rivers. Subsequently, populations crashed, and fewer than 500 adult fish are now believed to be entering the rivers, and the COSEWIC listed these fish as *endangered* in 2001.

Following the listing, a recovery team chaired by the Department of Fisheries and Oceans was formed. It draws its membership from government agencies, First Nations, non-governmental organizations, and local stakeholder groups. Key activities of the group include the establishment of a live gene bank containing Inner Bay lineages for restoration purposes and to provide animals for necessary, ongoing monitoring of the success of restoration activities, research into the potential causes of the declines, and development of a communications strategy for the public.

The Petitcodiac River historically accounted for approximately 30% of the freshwater habitat for the inner Bay of Fundy salmon. Its runs probably averaged about 2,000 – 3,000 salmon annually (Amiro 2003). In 1968, a causeway was completed across the lower section of the river, effectively blocking access by salmon to most of the 3,000 km^2 watershed (www.petitcodiac.org). The causeway was fitted with a series of gates that could control upstream water levels upstream, and a fish ladder (Niles 2001). The impounding created a freshwater reservoir that became a focal point for recreational activities, and the gates have mostly stayed closed since the causeway went into operation.

It rapidly became evident that the fish passage that was provided was ineffective for the anadromous and catadromous fishes using the river, including Atlantic salmon. The presence of the causeway also affected the river's tidal exchange, sediment transport, and other ecosystem functions (Niles 2001). Canada's Department of Fisheries and Oceans repeatedly called for free flow, at least during the anadromous fish migration period, but this did not happen (Niles 2001). Sometime in the early 1990s the wild native salmon population of the river went extinct.

Clearly, the restoration of inner Bay of Fundy salmon lineages to the Petitcodiac River could have a significant positive effect on the population demographics for the group as a whole. Championed by the Petitcodiac Riverkeeper (Daniel LeBlanc, see www.petitcodiac.org), an effort is currently underway to restore the natural flow regimes to the river by replacing the causeway with a bridge. Over 140 studies have been conducted on the impacts of the causeway since it was built, all basically concluding that free passage is the only option that will help restore the migratory fish populations to the river (D. LeBlanc, personal communication). An environmental assessment is presently underway to evaluate options for the river (these range from *status quo* to providing free passage), with the draft and its recommended solutions due to be made public in December 2004. A final decision will be made in 2005. No solution will satisfy all stakeholders, and some are adamantly opposed to free passage.

Saint John and Penobscot River passage

Dams, by blocking or delaying fish passage, and by grinding fish up as they pass through hydroelectric turbines, can have terrible impacts upon salmon populations. In eastern North America, the Saint John and Penobscot Rivers are the two large wild Atlantic salmon rivers whose native strain of salmon remain, but which are in need of relief from the impacts of multiple

large dams. If these problems can be corrected or significantly improved, big benefits for wild North American Atlantic salmon would result.

The Saint John River, named by Samuel de Champlain and the Sieur des Monts in 1604, is the largest river system in the Province of New Brunswick. It has a drainage area of 54,930 km^2, of which 53%, 38% and 9% fall in New Brunswick, Maine and Quebec, respectively (Carr 2001). Atlantic salmon production in the system has been severely impacted by the presence of hydroelectric dams, in particular (in order from the headwaters to the sea, with year of completion in parentheses) the Tobique Narrows (1953), Beechwood (1957) and Mactaquac (1968) dams. No firm estimates are available for historic salmon run sizes in the river. They were clearly abundant (Peabody 2003) and may have historically gone as high as 100,000, and within the last few decades were in the tens of thousand range. Now the returns are totaling a few thousand fish (2,734 fish returned to Mactaquac dam's passage facility in 2002, see DFO 2003).

While upstream passage is provided at each of theses facilities, smolts moving downstream must either spill over the dams or pass through turbines. Turbine passage mortalities as high as 18% have been recorded, although they are generally lower. However, the major problem for migrating smolts appears to be migration delays. As water currents slow or disappear in the headponds, the smolts appear to lose their orientation and downstream movements stop. The Mactaquac headpond, located closest to the ocean, is over 80 km long. Up to 100% of sonically tagged migrating smolts that entered this reservoir failed to find the downstream exit. Delays of lesser magnitude were detected at the other sites (Carr 2003).

The power produced by these facilities is critically important to New Brunswick; hence the dams are here to stay. What is needed is an innovative guidance system to encourage smolts to continue their downstream movements in the headponds. Scientists from Oak Ridge Laboratory are working on an acoustic guidance system that just might be able to guide the fish from point to point, leading steadily towards the reservoir exit (Whoriskey 2003). We hope to initiate a trial of it in the Mactaquac headpond in the near future.

A panel of the US National Research Council (Committee on Atlantic Salmon in Maine 2004) has just completed a review of the status of the Atlantic salmon in Maine. Their report singled out the Penobscot River as the place that should be the "primary focus for rehabilitating the species in Maine" (p. 160). The Penobscot River drains about 23,310 km^2, and is the second largest river in New England. It has about 805 km channel of spawning and rearing habitat for Atlantic salmon, and salmon occurred as far as 240 km upstream from the sea. Salmon runs historically may have numbered as many as 100,000 fish, but recent returns are hovering at 1,000 or less (ICES 2003).

An agreement involving the corporation owning the dams, conservation groups and government has just been signed to put in motion a $50 million (US) project to comprehensively restructure the hydropower capacity of the river. The key is to reconfigure and rebuild the network so that a smaller number of dams can generate about the same amount of power as the present scattered network. If the funding for the program can be raised, it will remove two large dams on the lower river, decommission a third and provide it with a natural fish bypass channel, and improve existing fish passage on several others where hydropower generation would be increased to make up for taking the others out of service. This has been termed the "last, best chance for saving wild Atlantic salmon in Maine" (A. Goode, quoted in Watts 2003). The hard part is coming up with the money.

Acid rain

One potential solution to the acid deposition problem in the Southern Uplands region of Nova Scotia is liming (e.g., Watt 1986). The Nova Scotia Salmon Association, a Council of the Atlantic Salmon Federation composed of individual watershed groups dedicated to the conservation of wild Atlantic salmon, is striving to get efforts underway to deal with the acid problem in their region (Acid Rain Committee 2002).

Their first attempts at liming involved distribution of lime into lakes within acid-impacted watersheds. The idea was that with a good lime load, the lake could act as a source of buffer for the waters downstream of it for a period of up to a year. There was little money to support the effort, so the operation ran on a shoestring budget. Council volunteers obtained the lime, and would move it onto the lake's surface with trucks or tracked vehicles over the ice during the winter. The spring ice melt would release the lime to the lake, immediately buffering the spring runoff acid pulse and hopefully providing longer term relief as well. The effort had to be abandoned when another environmental problem intervened. Because of warm winter temperatures (probably linked to global warming), the surface of lakes in the region was not freezing solidly enough to support the weight of the vehicles necessary to distribute the lime.

At present, the Council is developing partnerships and looking to get liming pilot programs underway on a few watersheds in the region. As a first step, a Norwegian expert was brought in to evaluate the situation (Hindar 2001). The liming strategies being considered include the direct dosing of either cement kiln dust or crushed, slurried limestone into rivers on a continuous basis, and the intriguing possibility of a whole watershed aerial distribution of lime from aircraft that could provide relief for 60 or more years. These are very expensive projects, and the focus at this time is to develop the business plans and raise funds to make execution of the plans possible.

New research is showing that the acid rain problem is more daunting than anticipated. Recent work has shown that even short exposures to acidified stream water can strip a smolt of its ability to osmoregulate once it enters sea water, resulting in death (Magee et al. 2003). In addition, model simulations suggest that even under the most optimistic projects of reductions of acid deposition, it will take over 100 yeasrs in the Southern Uplands regions to recover the acid buffering capacity that it has lost (T. Clair, in Arter 2003). These findings highlight the need for quick actions, which will have long-lasting benefits.

Conclusion

Technology is opening previously undreamed of opportunities to study salmon, especially during their migrations at sea. Remote sensing devices are going to revolutionize our capacity to document where fish go, and what the environmental conditions are like around them (Copley 2004). This may open a window that helps us understand why salmon survival at sea is currently depressed. However, the significant potential gains for wild Atlantic salmon that I have outlined above are not dependent on new research. The solutions are known; what is lacking is the will or the resources to implement them. Time, the most precious commodity of all, is slipping away for these menaced populations.

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CHAPTER 7

State of Pacific salmon and their habitats: Canada and the United States

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Introduction

In a short paper, no one could pretend to do justice to the diversity and status of Pacific salmon from California north through Canada and Alaska. But four brief publications in the American Fisheries Society's journal, *Fisheries*, provide excellent background to these salmon and their status into the 1990s (Nehlsen et al. 1991, Huntington et al. 1996, Baker et al. 1996, and Slaney et al. 1996). These reviews each have their strengths and weaknesses, but each provides a concise summary of the array of spawning populations and the pressures on these species over the past century. As an alternative source, several chapters in Stouder et al. (1997) provide more detailed commentary on the status of Pacific salmon by geographic areas.

For background, a broad overview of these stocks and their status is presented. But we suggest that the more important considerations should be "Do we know what determined the present status of a 'stock'"? and "What have we learned for the future?" The first hundred years of managing Pacific salmon focused on their economic importance, in the later quarter of the 1990s conservation issues lead to substantial allocation debates, and now the focus is clearly on conservation of "wild" salmon, intra-specific diversity, and ecosystems. The intensity of this change in North America decreases from the southern distribution of Pacific salmon to their northern distribution, but problems in the south are likely to be those in the north in the next 20 or more years. The focus of this paper then will be on what we have learned and what can be done to conserve and benefit from Pacific salmon in the future.

The simple task of just counting stocks of salmon is actually not so simple. Issues involve both temporal and spatial scales for identifying each salmon stock. Here we will not even consider the temporal issues and rely on published accounts as our background. The spatial scale is also a difficult and continuing issue when considering diversity of Pacific salmonids. In each of the references used in counting populations in this report, the spatial strata counted were species in each spawning stream. For a salmon species, each of these localized spawning groups is assumed to be largely isolated from the next and adapted to their local environment (due to the high fidelity of Pacific salmonids returning to natal streams, i.e. homing). As a measure of geographic variation or spatial diversity of Pacific salmonids, there is likely nothing wrong with this counting convention. Some people would argue, however, that this is an inflated accounting of diversity in Pacific salmon because salmon in nearby streams must be very similar genetically and each constitutes a very small portion of a species' diversity. Further, if any one of these populations became isolated, it would have an increasing likelihood of extinction over generations as

genetic relatedness within the population increased. These considerations lead to the question of how valuable the counting of spawning groups within streams actually is and whether it is a useful indicator of status in Pacific salmonids. The response to this question is embodied throughout this paper, but we suggest that the diversity of these individual populations is critical.

The geographic regions included in this paper are outlined in Figure 7.1. The southern (blue) oval includes the Pacific coastal states (including Idaho and Montana) that were included in Nehlsen et al. (1991) and Huntington et al. (1996). The central (red) oval includes British Columbia (BC) and the transboundary rivers of northern BC and southeastern Alaska, and the northern-most oval (yellow) includes the Canadian Yukon River and the Laird River (Slaney et al. 1996). The oval that includes southeast Alaska and coastal Alaska indicates the breadth of distribution of Pacific salmon in Alaska but the counts of species and streams (in this report) are limited to southeast Alaska (Baker et al. 1996, also see Halupka et al. 2003). To our knowledge there is no current accounting of Pacific salmon stocks through central and western Alaska but it is obvious that many other stocks would have to be included from those regions. In total, the known distribution of Pacific salmonids along the North American coast is from California north to Norton Sound (Alaska) and eastward to the McKenzie and Laird rivers in the Canadian Arctic.

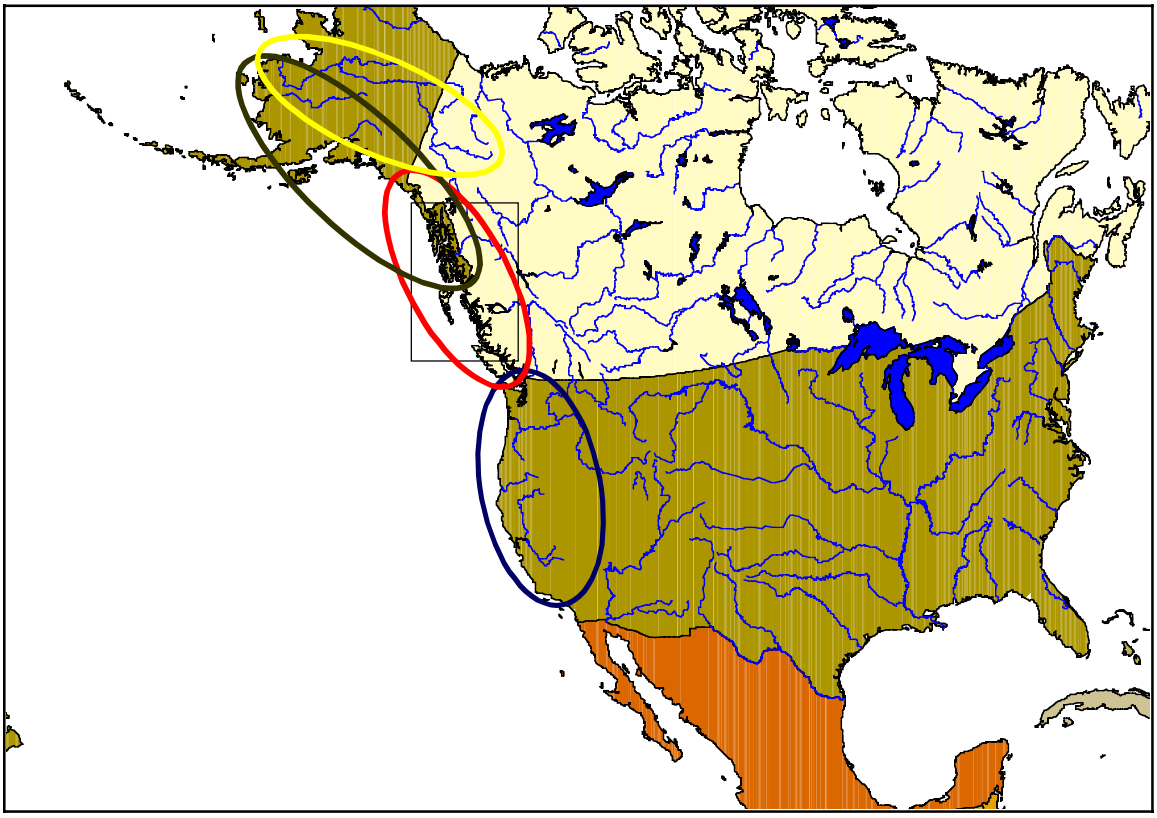


Figure 7.1. Geographic distribution of Pacific salmonids included in this paper. The ovals include major geographic areas identified. The box encompassing central and north coastal British Columbia identifies the area used in an example later in this text.

Summary of Numbers and Status of Populations

Waples et al. (2001) provided a detailed review of salmon diversity in the Pacific Northwest U.S. and a summary table for the area defined above, including an earlier accounting of populations in central and western Alaska. Their accounting of populations in the southern states was based on published literature and recent status reviews conducted by NOAA Fisheries, as well as Slaney et al. (1996), Baker et al.

(1996), and Atkinson et al. (1967). However, since some of the status reports included salmon populations in the Canadian portions of the Strait of Georgia, those Canadian populations were accounted for in the Pacific Northwest states (and removed from counts in Slaney et al). Waples et al. (2001) report an impressive total exceeding 22,300 individual spawning populations that existed in these regions (Table 7.1). Those interested in understanding diversity within the Pacific salmonid species are referred to Waples et al. (2001) and Halupka et al. (2003). These authors present a hierarchical structure to defining diversity by using information on ecological conditions, life history variation, and biochemical genetics in the characterization of intra-specific diversity or variation.

Table 7.1. Approximate number of populations of the seven anadromous salmonids in the study area and other regions of North America (extracted from Table 1, page 7, Waples et al. 2001). In the table, a question mark (?) indicates unknown, N/A indicates not accounted for in the reference.

Pacific Salmonid Species	Pacific northwest study area [a]	British Columbia & Yukon [b]	Southeast Alaska [c]	Central & Western Alaska [d]	North American Total
Pink	65	2100	4800	1200	8200
Chum	350	1450	1500	300	3600
Sockeye	60	900	200	240	1400
Coho	480	2400	2400	120	5400
Chinook	500	780	60	60	1400
Steelhead	340	850	340	?	1500+
Cutthroat	200+	600	?	N/A	800++

References: (a) Waples et al. 2001; (b) Slaney et al. 1996 excluding the Strait of Georgia, (c) Baker et al. 1996 and (d) Atkinson et al. 1967.

The only common basis for summarizing the status of these populations is to use the articles described above which were published in *Fisheries*. Each of these followed definitions and categories of risk from Nehlsen et al. (1991) that were defined based on a 1980 policy paper on biological thresholds of endangerment. These include:

1) *High Risk of Extinction*: Populations whose spawning numbers are declining. Less than one adult fish returns to spawn for each parent spawner. Populations which have recent escapements under 200, in the absence of evidence that they were historically small, were also placed in this category.
2) *Moderate Risk of Extinction*: Populations whose spawning escapements appear stable after previously declining more than natural variation would account for, but exceed 200 spawners.
3) *Special Concern*: Populations were included if:

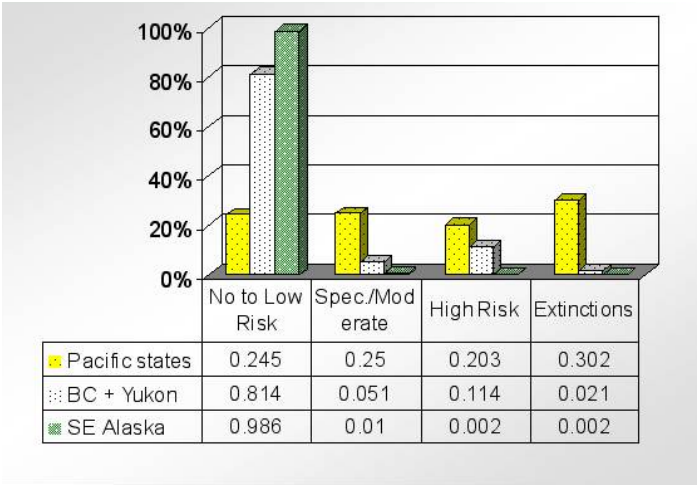
- Relatively minor disturbances could threaten them, especially if a specific threat is known.
- Insufficient information on population trend exists, but available information suggestions depletion.
- There are relatively large ongoing releases of non-native fish, and the potential for interbreeding with the native population exists.
- The population is not presently at risk, but requires attention because of a unique character.

4) *Extinct:* Populations known to exist previously but the native fish are known to no longer spawn in their original habitats.

Since these categories require evaluation of recent data on the numbers of salmon spawning in a population, many of the species/stream strata included in the source references could not be assessed. Figure 7.2 presents a summary of species/stream strata by geographic regions that could be assessed and

categorized as defined above. The numbers of populations included in Figure 7.2 were: 404 stocks identified in Nehlsen et al. (1991) and Huntington et al. (1996), 5,358 species/streams combinations or 59% of the total number of populations in Slaney et al. (1996), and 930 species/streams in Baker et al. (1996) or only 13% of the total number of populations identified in southeast Alaska. When comparing data from Slaney et al. (1996) and Baker et al. (1996), it should be noted that they count pink salmon populations differently. For BC, Slaney et al. (1996) only count one population for pink salmon spawning in a stream, whereas Baker et al. count pink spawning in even-and-odd-years in the same stream as two populations. Since pink salmon have a fixed two-year life cycle, it may be more appropriate to count each year-line as a separate population, but for this paper we have not revised the Slaney et al. (1996) results.

By geographic area, these results do not provide any new insights. Most people will have been aware of the decline in Pacific salmonids in the Pacific Northwest states. However, it is notable that the extinction frequency (for the populations that could be assessed) declined by an order of magnitude between the Pacific states and Canada (BC + Yukon), and again between Canada and SE Alaska. The same trend exists for each other category but to a lesser extent. In summarizing data for these figures, populations in the *Special Concern* and *Moderate Risk* categories were combined. This represents some loss of information but the counts in these categories were so small that without pooling the results there would have been zeros in for these regions and categories.

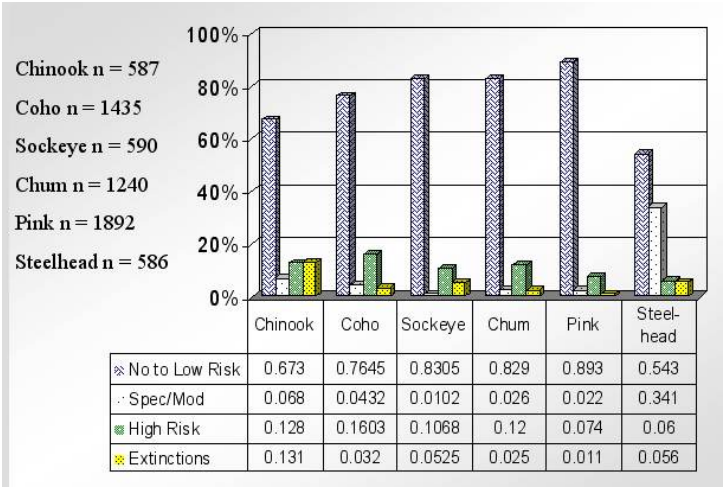


	No to Low Risk	Spec./Moderate	High Risk	Extinctions
Pacific states	0.245	0.25	0.203	0.302
BC + Yukon	0.814	0.051	0.114	0.021
SE Alaska	0.986	0.01	0.002	0.002

Figure 7.2. Summary of risk categories for Pacific salmonid populations that could be assessed within each geographic area. Category definitions and sample sizes by geographic areas are included in the text. Anadromous cutthroat trout have been excluded from this summary as the species was not included in Huntington et al. (1996) or for southeast (SE) Alaska.

The populations assessed and included in Figure 7.2 can also be presented by species across all of the geographic regions (Figure 7.3). The *Special Concern* and *Moderate Risk* categories could be presented separately for this figure. The sample sizes by species for Figure 7.3 were: Pink n = number of populations assessed = 2,254; Chum n = 1,240; Sockeye n = 590; Coho n = 1435; Chinook n = 587; and Steelhead n = 586.

Overall, these results present a more optimistic picture than many people may have been expecting. In terms of populations at high risk of loss or those that are now extinct, these categories comprise between 7% of the pink salmon populations and up to 26% of the chinook salmon populations. If the pink salmon



	Chinook	Coho	Sockeye	Chum	Pink	Steel-head
No to Low Risk	0.673	0.7645	0.8305	0.829	0.893	0.543
Spec/Mod	0.068	0.0432	0.0102	0.026	0.022	0.341
High Risk	0.128	0.1603	0.1068	0.12	0.074	0.06
Extinctions	0.131	0.032	0.0525	0.025	0.011	0.056

Figure 7.3. Summary of risk categories for Pacific salmonid populations that could be assessed by species over the geographic range included in Figure 2. Category definitions and sample sizes by geographic areas are included in the text. Anadromous cutthroat trout was excluded as the species was not included in Huntington et al. (1996) or for southeast (SE) Alaska.

populations and year-lines were treated equally in each report, then these results would indicate that generally between 10% and 26% of the Pacific salmon populations along the Pacific coast of North American have been lost or are at risk of loss. However, as Figure 7.2 indicates, these results should not be extrapolated throughout the coast as the situation is much worse in the Pacific Northwest than elsewhere.

In considering the status of Pacific salmon, it should also be considered that these reports only assess the populations, relative to their risk of extinction. Undoubtedly people could argue with the criteria used to assess extinction and our ability to even evaluate risk of extinction, given the uncertainty of most of the spawning escapement data and our ability to project future trends. However, changes to the category definitions are unlikely to change the general results presented above. It is reasonable to ask, however, if this is an adequate evaluation of status in Pacific salmon, and it is likely not. This overview relies on trends in spawning escapements over time, but the numbers of spawners in a population must be related to fishing pressures. An assessment of production (catch plus spawners) would be a preferred basis for assessment, but for the vast majority of the spawning populations along the Pacific coast, the catch associated with each stream (population) is unknown and seldom estimated. Other characteristics that could be considered include the biological traits in populations (i.e., the size and age of returning adults, juveniles produced per female spawner, and the distribution of spawners in time and space). Also, there are status criteria that the public relates to more directly, such as the ecological values of salmon or just their perception of the "health" of local salmon populations (i.e., that they continue to return in numbers that are observable where they have been for years before). Clearly, the various types of status measures have differing levels of scientific rigour, but in many cases people are likely to suggest that extinction risk is an overly coarse measure of status and not sensitive to earlier indications of decline and problems in local populations.

Causes of Change in Pacific Salmon Status

While many will be familiar with the impacts of development and fisheries on Pacific salmon in the Pacific Northwest states (for example, see NAS 1996), they may be less aware of concerns in British Columbia. The level of impact in BC is certainly less but there are now three populations or stock groups of salmon listed as *Endangered* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, www.cosewic.gc.ca) and historically important commercial fisheries have been severely curtailed in the past decade. Commercial catch of Pacific salmon in BC has in the past three years declined to below the catches recorded at the start of the 1900s (Figure 7.4).

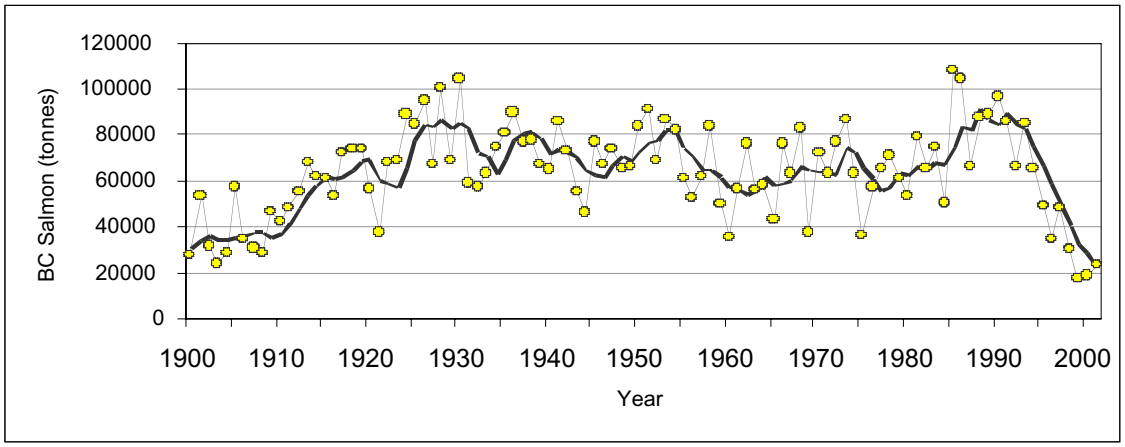


Figure 7.4. Total catch of Pacific salmon (metric tonnes) by the BC commercial fishery from 1900 through 2002. The solid line is a 4-point moving average of the past four years, for example the 2002 average value is the average of 1999 to 2002 landings.

The immediate implication of this graph is that production of Pacific salmon has declined precipitously. The decline was associated with poor survival of Pacific salmon in the ocean during the early to mid-1990s and the resulting reduced production, but the extent of the decline exaggerates the change in status of these salmon populations (with a few exceptions). Catch is a function of salmon production, management regulations and markets. During the past decade, each of these factors has influenced the catch. When production declined due to poor marine conditions, management actions were taken to protect the spawning population sizes and limit fishing impacts. For Thompson River coho salmon and late-run Fraser River sockeye, the management goal was to minimize fishing impacts. Actions for these populations reduced catches in any fishery impacting these salmon. Further, reduced market demand for BC pink and chum salmon also contributed to the decline. Ironically then, while the initial impression of the catch reduction may have been that the status of Pacific salmon is poor, the changes in this figure largely result from a shift from maintaining fisheries to maintaining spawning escapements and improving the status of Pacific salmon populations, even during years of poor recruitment.

The status of a Pacific salmon population reflects the cumulative impact of many factors over many years, and the resource management policies of a region and time. Depending on where someone is from, the individual impacts of greatest concern will certainly differ. It may have been dams in Washington State (such as the Elwha River dam in the photograph on the left, being built in 1903), the California gold rush, or logging in British Columbia, and approximately 150 years of commercial fishing along the Pacific coast and rivers. Actually, in each of these areas, the status of salmon is unlikely to solely reflect a single event (although there are obvious exceptions such as the eruption of Mount St. Helen) and will reflect the net cumulative impacts from many sources. But rather than focus on a list of specific types of impacts, we considered more generalized problems that have contributed to the state of salmon resources along the coast, and ones that managers and others could address. We suggest that these issues, broader than single-types of impacts, have contributed significantly to the decline of Pacific salmon populations along the Pacific North American coast. Five broader considerations were identified:

1) Over 100 years of exploitation and development impacts preceded the biological understanding and analytical assessments needed to evaluate and manage Pacific salmonids. The early social decisions clearly favoured economic development of the Pacific coast but the consequences of these decisions could not be fully understood because the knowledge had not been acquired. Information on salmon biology and aging began in the early 1900s but the information that established the "modern" management paradigm for salmon management came much later. For example:

- the first scientific meeting on salmon homing and "stocks" occurred in 1939 (Mouton 1939),
- the introductory paper on production dynamics in Pacific salmon was in 1954 (Ricker 1954),
- evidence of locally adapted salmon populations and the "stock concept" was summarized by Ricker (1972),
- our ability to assess populations of chinook and coho salmon followed development of the coded-wire tag in the late 1960s and development of the coast-wide recovery program in 1975, and
- models and assessments applying these data were generally developed in the 1980s.

Obviously over those early years, people became aware of the impacts of their developments but debate over what should be done and who should do it prolonged not taking necessary actions.

2) For over 100 years, depending on the location along this coast, competition between user groups, both domestic and international, and multiple fisheries on single populations, resulted in over-fishing of Pacific salmonids. The profile of this extensive competitive fishing, mostly by the commercial users, focused the "blame" for declines in salmon production on fisheries, largely independent of the other developmental impacts that accumulated. For example, the linkage between the productivity of a salmon population and its habitat was seldom made, and reduction of fishing pressure was frequently seen as the desired solution to reverse declining salmon production.

3) Since the 1870s, production of juvenile salmonids in hatcheries has been used to mitigate losses of freshwater habitats or simply to increase the numbers of salmon that could be produced from the freshwater systems (Lichatowich 1999). During the 1990s, hatchery programs throughout the North Pacific Ocean released approximately five billion juveniles a year (see North Pacific Anadromous Fisheries Commission, www.npafc.org). These programs have contributed significantly to fisheries but what has been the impact of these releases on the status of natural populations of Pacific salmon? This question remains one of the major debates in salmon management today.

4) In the processes of managing salmon fisheries, the quality of data and assessments were frequently inadequate to support the intensity of fisheries that continued to be conducted. Uncertainty about the data or assessments allowed extensive debate about levels of exploitation, status of the stocks, causes of the declines and denial between user groups and management agencies. Uncertainty about information and denial amongst users commonly resulted in decisions favouring the continuation of fisheries. This issue of data sufficiency has been a serious limitation to the management and conservation of Pacific salmonids, and the burden of proof was placed fully on the managing agencies. Users successfully argued that escapement data was too inaccurate, catch surveys too imprecise, or they simply used the data to identify other users that were the greater cause of an issue (for examples see: Wright 1981, Fraidenburg and Lincoln 1985, Walters and Riddell 1986).

5) The issue of data quality also lead to failures of institutional processes. These processes varied substantially between jurisdictions but most involved multiple user groups, fractured consultations with the different groups, long lag-times when dealing with technical information, and resulted in inadequate responses to conserve the resource bases. Along the Pacific coast, one of the most graphic examples of institutional problems was the acknowledged interception of U.S. and Canadian salmon by the other country with an inability to limit these impacts. The history of this conflict goes back to early 1900s fisheries on Fraser River sockeye salmon in the international waters between Washington State and British Columbia (Roos 1991). However, similar problems influenced management and conservation of each species along the coast (see Pacific Salmon Commission, www.psc.org).

Comment on Data Quality and Quantity

The issue of data adequacy is a pervasive problem in managing Pacific salmonids and assessment of their status. How do we establish data sufficient to assess over 22,300 populations of Pacific salmon? Agencies have addressed this problem by different means in different geographic locations and species. Generally, the most rigorous data have been collected for sockeye salmon. But even for this species, the most quantitative assessments have been limited to the few large most important economic fishery resources, which may have been fully appropriate given past economic objectives.

It is clearly impractical to comment on individual assessment programs in this paper, but given the limits of past practices there are issues that we can anticipate for the future. The most notable change has already been the diversification of objectives from principally economic to multiple objectives, including:

conservation of biodiversity and inclusion of ecosystem objectives in salmon management; recognition of individual "stock" objectives to meet allocation or legal priorities and/or to restore production from listed stocks; increased needs to understand changes in population dynamics relative to climate change on both local and global scales; and to provide fishing opportunity but at more controlled rates and impacts. Fisheries science and the development of tools for management (computing, electronic monitoring systems, tagging methods, genetic markers, etc.) has evolved enormously during the past few decades but the ability to apply this knowledge for these new objectives will continue to challenge science, managers, and policy makers.

We can easily anticipate that most salmon populations will continue to be monitored qualitatively (but hopefully within a survey design) and that trends in escapements will be the common measure of status over time. In principle, this is not very different from what occurs now, but are the current data comparable between years, streams, and agencies and is the value of this data fully used? We cannot comment on these issues for all agencies along the Pacific coast, but within British Columbia and the over 9,660 populations (Slaney et al. 1996), we can report that the data are of highly variable quality and not fully used due to the scale of the task.

Without addressing the data quality problem, we have been developing a computer system to allow examination of all the data and to summarize results in an informative way. The analysis combines extensive effort by the BC Provincial government to map (1:50,000 scale) the 19,000 watersheds in BC, to describe habitat parameters within each watershed, and to link this mapping system to salmon escapement data maintained by the federal Department of Fisheries and Oceans (DFO data, 1950 through 2002). A watershed coding system now accounts for each stream recorded in the DFO spawning escapement records and allows summarization of the data by various geographic scales (e.g., major river system, watershed within the system, or tributary). At present, the BC Provincial government staff have developed software to plot the recorded escapement value by species and year for every stream in the database (Trellis plots presently present up to 16 species/stream strata per page). For each plot, a linear trend and a Lowess non-linear trend is fit to the data for specified years. These trend lines can be included in each plot and the coefficients are also recorded in data files for subsequent analysis. For example, for each species and stream in the box (north and central BC) superimposed on Figure 7.1, we conducted the analysis described and developed a histogram of the slope coefficients (based on the linear trends only). The histogram allows examination of the pattern of changes in a geographic area chosen by the analyst and reduces the need to select specific streams. In this example, if an analyst chose to examine each sockeye spawning stream, then trends would be calculated for 188 streams. The results could then be summarized as in Figure 7.5, which has collected coefficients in increments of 0.05 (i.e., the average rate of change was 5% per year over the duration of the data record). Figure 7.5 would indicate that 144 of the 188 streams had declined in escapements over time. We should note for this example, however, that the linear trend frequently does not capture the more recent trend in escapements, but the Lowess trends are more informative if the trend changes over time. These coefficients may also be presented graphically on watershed maps that provide information on the spatial patterns of the escapement changes.

The capability to analyze the trends in large numbers of streams may provide useful insight into changes in distribution and diversity in a species, but there is also likely to be a need to explain the causes of a trend. Explanation will require more information (i.e., monitoring of other parameters) and more quantitative data. This level of information can not be collected for each species/stream stratum but most management agencies already recognize the need for this data and collect it from individual populations, typically referred to as "indicator stocks". However, indicator stocks are expensive to maintain and are frequently challenged as to whether the additional information is necessary. In BC, for example, there are 7 to 8 indicator stock programs for coho salmon, one for steelhead trout, a few for sockeye salmon depending on how such programs are defined, and no natural stock indicators for chinook, chum, or pink

salmon. There are other programs for each species that provide quantitative estimates of spawning escapements and some hatchery tagging programs that provide estimates of marine survival rates.

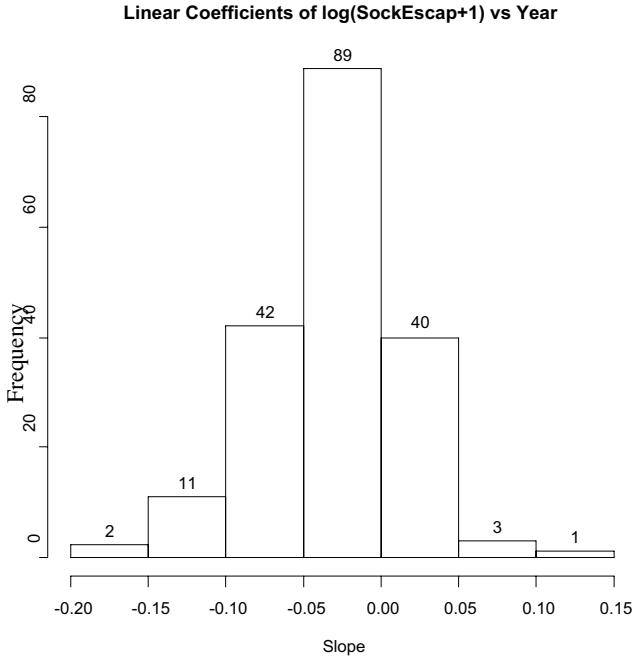


Figure 7.5. Demonstration histogram of linear coefficients for sockeye spawning escapements (1950-2002) for all spawning streams in north and central British Columbia (area identified in box in Figure 1). The numbers above each bar are the numbers of streams in each bin.

These quantitative indicator stocks are essential to explain trends. Consider a simple and obvious example. The escapement to a population is declining steadily over time and the managing agency is expected to take appropriate action to conserve the population, but what should they do? Is the decline due to freshwater habitat impacts that reduce the production of juveniles, is it because of continued over-fishing, or is it due to declining survival in the ocean (it could of course reflect all of these)? Simply monitoring trends in numerous populations is not likely to provide the information needed to separate these different "causes" or direct the appropriate management action. The study needed to separate these effects would include quantitative estimations of the natural spawning population, monitoring of the juvenile salmon produced that emigrate to the sea, and estimation of fishery exploitation rates and marine survival rates. Only intensively monitored indicator stocks will provide this level of information. Without them, management agencies may resort to trial-and-error to conserve the escapement and may impose significant (and ineffective) disruption to users for the wrong reasons.

To meet the multiple objectives that agencies will continue to contend with requires more careful design of qualitative monitoring of trends and increased commitments to the indicator stocks. Any expectation that information quality and quantity can be reduced to meet budget limitations, while meeting the evolving management objectives, is very poorly advised and is not considering the full impact and cost of not having the necessary data.

Lessons for the Future

If we want to conserve Pacific salmonids and the related social values, in the face of anticipated future challenges, what have we learned from the past? As noted above, fishery science has learned an enormous amount in the past century and a wide variety of institutional processes have been tried with varying successes and failures. It is not our intention to review those individual experiences, rather, we have deliberately worded our "Lessons" to stimulate thought.

Lesson 1: The impact of information is inversely related to its availability.

During past conservation debates, the absence of proof and limited information have been used to perpetuate debates and deny the need for management actions, or it has resulted in negotiated but inadequate responses. The value of very good information is commonly appreciated, but the full costs of no information are seldom understood. In some situations, it is likely that the indirect costs of poor or no

data are greater than the cost of actually acquiring the necessary information. In the first report of the Pacific Fisheries Resource Conservation Council (PFRCC, www.fish.bc.ca), Walters and Korman (1999) provided a forceful statement that exemplifies this issue:

> *Ultimately, the wages of poor escapement information systems extend far beyond issues of harvest management, and severely limit our ability to objectively determine the impacts of a wide variety of factors on salmon production and health. Ultimately, we will pay the price in terms of inadequate or unnecessary harvest regulations, failure to deal with ecosystem management issues effectively, or inappropriate responses to perceived habitat damage risks.* (Page 103, Background Papers)

Understanding of this issue continues to be poor and the issue is likely to remain contentious in the near future. The lesson from past experience, however, should be that investment now in long-term monitoring and quantitative assessments, is a necessary investment for successful conservation in the future. Clearly, each management agency will continue to be faced with budget decisions and trade-offs, but when considering the value of stock assessment and management information, the associated costs of not acquiring the data must also be considered.

Lesson 2: Pacific salmon cannot survive or thrive on their own.

Pacific salmonids exist in highly dynamic environments and utilize a set of complex ecosystems. Yet, how many of us have been accused of being overly "salmon-centric" in our scientific interests and overly narrow in our management and biological perspectives of salmon? Stock and recruitment and optimum escapement targets (Ricker 1975) suggested that managers could, on average, maximize their annual yield from a stock by achieving this fixed target. The stock concept emphasized the differences between salmon populations and focused attention on local adaptations (Ricker 1972, Larkin 1981, Riddell 1993). A premise of the enormous expansion of hatchery production in the Pacific was that the ocean capacity for salmon must have been much greater before the advent of commercial fishing and could support increased juveniles if the freshwater bottleneck could be by-passed.

Each of these topics has provided significant benefits to the management of Pacific salmon and fisheries, but each also has its limitations. Biases in stock/recruitment analyses have contributed to the over-fishing of Pacific salmon and this lead Hilborn and Walters (1992) to conclude that "We think that bad stock-recruitment analyses have been a significant factor leading to over-exploitation and stock collapse for some major fisheries" (pg. 287). Over time, declining numbers of spawners led to concerns for the health and productivity of freshwater ecosystems due to the significant decline in marine-derived nutrients (Larkin and Slaney 1997, Cedarholm et al. 1999, Gresh et al. 2000, Naiman et al. 2002). Gresh et al. summarized the concern:

> *While these statistics [fishery statistics] are useful measures of performance, they are incomplete because they ignore the ecological processes that determine ecosystem health and ultimately the production of salmon. They focus primarily on economic ends while ignoring ecological means.* (pg. 15)

The "stock concept" has been fundamental to understanding the population structure of Pacific salmonids and the importance of local adaptations to the productivity of local populations. However, the adaptations observed today are the result of genetic and ecological processes through past generations. Evolutionary processes, however, are continuous, particularly if environments and external pressures continue to change over time. Consequently, the stock concept should not be viewed only as a static set of adaptations in local populations, but should be broadened to include the demographic and genetic processes that will provide for the adaptability of populations to future change. In recognition of the latter, scientists now refer to conservation units of Pacific salmon, for example the evolutionary

significant unit (ESU, Waples 1995) or adaptive evolutionary conservation (AEC, Fraser and Bernatchez 2001). In most cases, these units will be larger than stocks typically defined for fisheries management, but the essential difference to understand is the need to maintain adaptive genetic variation and the processes required to preserve salmon in the future.

These examples should be sufficient to demonstrate this lesson. Salmon researchers, managers, and policy makers must be willing to expand their thinking and scope of assessments. The successful conservation of Pacific salmonids requires the maintenance of evolutionary genetic processes, not just the current differences, and their associated freshwater habitats. Management planning for Pacific salmonids must evolve to include all sources of mortality, recognize that ocean survival rates are highly variable, and consideration of multiple objectives for Pacific salmonids. Much of this has already begun to occur.

Lesson 3: Practice humility, acknowledge uncertainty, and take precautions.

While fishery scientists and managers have certainly learned a great deal over the past century, there remains much that we do not know, cannot predict, and have limited ability to control. Unfortunately, the latter is not frequently acknowledged and managers seldom take adequate precautions to allow for uncertainty in data or ability to control fisheries. These are issues that scientists and managers are aware of, but to be cautious usually implies a loss and cost to fishers or not allowing development of freshwater habitat.

As already noted in this paper, these trade-offs between conservation needs and social and/or economic values have not tended to favour the Pacific salmonids. But this situation has not been limited to Pacific salmon and has been recognized as significant reason for the depressed state of many of the world's fisheries and aquatic resource. Ultimately, these observations lead to the "Precautionary Approach" expressed in Principle 15 of the 1992 Rio Declaration of the UN Conference on Environment and Development[1]:

> *In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*

The Precautionary Approach has evolved and matured considerably in the world of fisheries as a strategy to ensure that conservation objectives will not be jeopardized by other (short-term) objectives (for example, see: Richards and Maguire 1998, Hilborn et al. 2001, Coleman and Travis 2002). A notable example of applying a precautionary approach in British Columbia has been the recent development of the management framework for steelhead trout (Johnston et al. 2002).

Given the limits of our knowledge, the extent of uncertainty in data and parameter estimates, plus a highly uncertain future for salmon habitats and environment (see McCarthy et al. 2001 or website for Intergovernmental Panel on Climate Change[2]); the continued development of precautionary approaches for managing Pacific salmonids and their habitats is strongly recommended. This approach should account for all sources of uncertainty (to the best of our knowledge), but to apply the precautionary approach in management also implies managing risk. This is a topic that combines biological knowledge, management capabilities, and public policy. Decisions concerning how certain the public wishes to be to avoid an unacceptable outcome will strongly influence the costs associated with accounting for

[1] www.un.org/documents/ga/conf151/aconf15126-1annex1.htm
[2] www.grida.no/climate/ipcc_tar/

uncertainty. A very risk adverse approach will cost substantially more than a risk neutral approach, for example. However, establishing these value-based social decisions requires public processes that have not functioned well to date. Science can assist by providing the technical background to an issue and can assist decision making by evaluating alternative decisions, but ultimately a process is essential for making the final value-based decisions. This will be one of the major future challenges in resource management.

The overall message of this final lesson is that successful conservation and use of Pacific salmonids relies as much on acknowledgment what we do not yet know, as it does on what we have learned. By recognizing our limits and accounting for uncertainty in a precautionary process, we can reduce the risk of short-term impacts and increase the potential for future benefits (however one wishes to define their benefit). For this process to work, however, requires that appropriate public consultation and decision-making processes be implemented.

Possibly the only certainty in the future is that we should, as the saying goes, expect the unexpected … but with continued research and development of more precautionary processes we may be better able to prepare the Pacific salmonid resource for whatever occurs. If not, then management of Pacific salmonids may become one population recovery program after another.

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CHAPTER 8

Salmon stocks and habitat in the Russian Far East

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Introduction

I was to have given one of two presentations about the status of salmon stocks and habitat in the Russian Far East. However, my colleague Dr. Vladimir Radchenko from Sakhalin who directs the Sakhalin Applied Fisheries Research Institute, was unable to participate and he would have presented a very different approach from what I am going to present today. He would have taken a time-series-based approach focused largely on pink salmon – by far the most abundant and widespread species in the Russian Far East. I will provide a spatial approach, based on a qualitative stock status assessment that the Wild Salmon Center has been involved with for the last few years.

The Pacific Rim project started when I was a graduate student at Oregon State University and involved many players, among them, Robert Lackey, EPA; the Oregon Department of Fisheries and Wildlife; Oregon State University; and many other partners across the Russian Far East, Canada, and Japan. Our goal was to describe the North Pacific salmon ecosystem and to try to think much more broadly about the salmon habitat use. The status review component of the Pacific Rim Project had not been completed before the funding ran out, and fortunately Guido Rahr at the Wild Salmon Center picked it up. We continued on, initially thinking it was going to be a quick effort – but it was not. We are still working on getting the publication out (it is in draft, and I provide here a preview of part of the results).

I will present only the Russian results, although I will place them in context of the Stock Status Review across the Rim, and I have many caveats for this assessment. I will then briefly present some of the threats to salmon stocks in the Russian Far East and mention an effort that we are currently undertaking to develop a common salmon monitoring protocol across the North Pacific, so that the next time we try to do an over-arching stock status assessment it is not merely qualitative but may also include quantitative data.

Native distribution of salmon

One of the first things we did in the Pacific Rim project was to determine the extent of our study area. Figure 8.1 depicts the distribution of salmon in this large area. We focused primarily on Pacific salmon species including *Oncorhynchus mykiss*; this includes the distribution of both resident and anadromous forms of *O. mykiss*. The most southerly population of *Oncorhynchus masu* on the western Pacific side is the Tachia River in Taiwan and the most southerly North American *Oncorhynchus* population is represented by the rainbow/steelhead complex in Baja California's Santo Domingo River. Our stock status assessment is skewed toward relatively abundant, commercially harvested salmon stocks.

The first international workshop occurred at Oregon State University (Corvallis, Oregon) in 1999, with the objective of developing a geographic framework to gather stock status information and to determine what criteria we would use to assess status.

8.1. Native distribution of *Onchorhynchus spp*.

Salmon ecoregions

The regionalization framework we adopted was developed by Jeff Rodgers, Oregon Department of Fish and Wildlife. It is a framework designed for compilation and analysis of salmon data on an ecological basis, to circumvent jurisdictional boundary effects that sometimes bias our understanding of stock status trends. The salmon ecoregions incorporate the sequence of habitats where salmon survival is determined and they represent a spatial hypothesis about intraspecies ecological variability and life history adaptation, as well as variation in freshwater and marine. We have not yet validated the framework with biological data although we intend to do so in the next year.

The salmon ecoregions are based on contemporary oceanographic understanding of the North Pacific salmon ecosystem. The zone classification criteria that we used is shown in Table 8.1. At the first level we split the North Pacific into Arctic and Pacific river drainages. At the second level we looked at seas and large-scale circulation systems similar to the large marine ecosystem project of Sherman and Duda (1999). At the third level we looked at coastal discontinuities including smaller features such as fjords, straits, and finer scale circulation patterns (such as distinct regional discontinuities in sea surface temperatures and variations in upwelling strength). The fourth level, the level at which I am going to review stock status in the Russian Far East, is the level of major drainage basins and aggregations of drainage basins. We chose a somewhat arbitrary cutoff at the Kanchalan River, a river in Chukotka in the Russian Far East that is 22,230 square kilometers in area. If we broke out river basins at a smaller size, we would have almost doubled the number of ecoregions in the fourth level of our hierarchical classification. Figure 8.2 shows the salmon ecoregions or Level 4 zones,

Table 8.1. Zone classification criteria for salmon ecoregions

Level 1:	Arctic versus Pacific Ocean drainges
Level 2:	Seas and large-scale ocean circulation systems
Level 3:	Coastal discontinuities, including fjords, straits, finer-scale circulation systems
Level 4:	Drainage basins > Kanchalan River (22,230 km^2)

and includes the major circulation features that were used at the Level 2 break. This same map will appear again in the stock status figures for the Russian Far East.

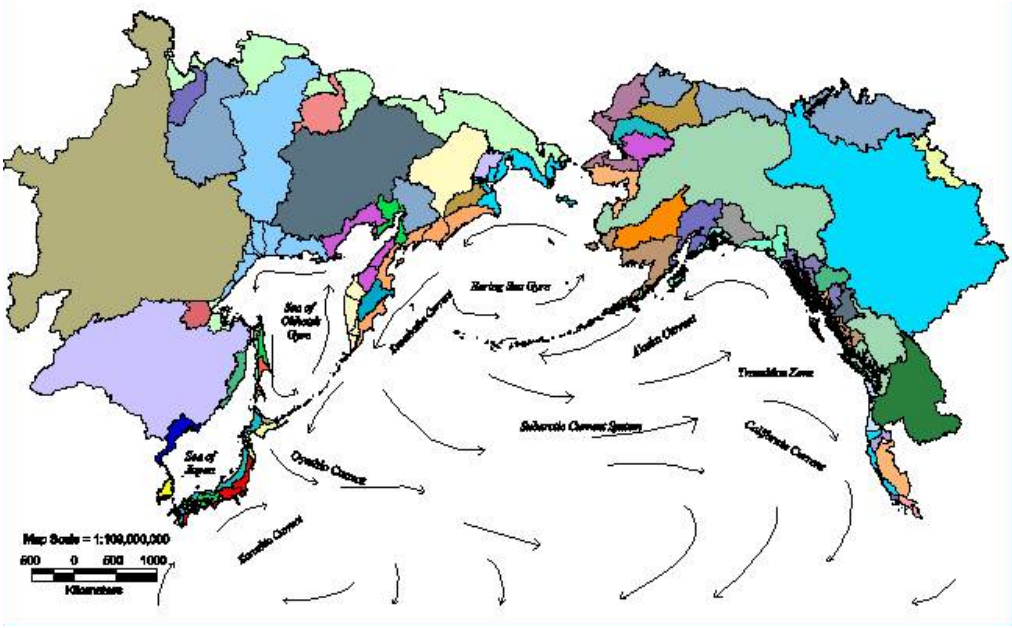

Figure 8.2. Pacific salmon biogregions – level 4 classfication.

Stocks defined

Given the qualitative, best expert judgment nature of our stock status assessment, one of the most important tasks for ensuring comparability across regions was to ensure that a common definition was used for "stocks". Our written survey instrument suggested using the Ricker definition (1972); that is, a population of fish that spawns in a particular river system or segment and does not interbreed to any substantial degree with other populations, and is segregated by either space or time. We focused on wild salmon populations, and wanted contributors to identify census units that were locally adapted and not heavily affected by hatchery propagation. In the Russian results, this meant that biologists ascribed one population per species to each river basin in their region. In some of the larger river basins, such as the Amur River, multiple stocks were described for fall chum (which is the best studied of the Amur salmonids). Kamchatkan biologists can be characterized as 'splitters', breaking out stocks on a finer scale than in other jurisdictions. Generally, quantitative information about stock status is sparse in the Russian Far East.

Risk of extinction

We asked contributing biologists to classify stocks by risk of extinction (Chapter 7, see Brian Riddell's description of the Nehlsen approach). We used the same classification that was used in Nehlsen et al. (1991), Slaney et al. (1996), and Baker et al. (1996) – an *unthreatened* stock is at no risk of extinction, has never been at any risk of extinction, and has not experienced any dramatic declines in recent history. A stock at *moderate risk* is one in which the stocks have declined more than natural variation would account for but at the same time spawner numbers appear to be stable, the population numbers over 200 adults and the spawner-recruit relationship is at least one-to-one. *High risk* is defined by a declining trend in the number of spawners and fewer than one adult fish returning for each parent spawning with a total abundance less than 200 adults.

These classifications are biased by the status of Pacific salmon in the contiguous United States, given the focus of Nehlsen et al. (1991) on Washington, Oregon, Idaho and California populations. For example, coho often form naturally distinct populations not far above the 200 fish threshold, which may not be an indicator of extinction risk. While this is a reasonable threshold for moderate risk-high risk states for coho, it might not be for other species – as Brian Riddell stated (Chapter 7), some people might place

stocks of other species at a population level of approximately 200 spawners into a *high risk* category. At the other end of the abundance spectrum, pink salmon populations in northern salmon ecoregions may number in the millions and may be at risk at abundance thresholds far above those prescribed by Nehlsen et al. (1991).

Figure 8.3 depicts the status synthesis across the North Pacific. This graph depicts the same trends as observed for North America. In the histograms each bar represents one of the salmon ecoregions arrayed in such a way that they begin at the southerly latitudes on the western Pacific side, continue up to the northerly latitudes, (you can see the break between Chukotka and Alaska) and then continue south on the eastern Pacific (North American) side. You can clearly see that there is a latitudinal pattern in risk and much higher extinction rates in California, Washington and Oregon. There is a similar, though less pronounced, latitudinal pattern on the Russian side. The highest risk of extinction rates are present in the southernmost zones in Primorye Territory in Russia and in the Amur River basin, which hosts the oldest Russian commercial fishery in the Far East.

The fishery began in the 1900s, and Amur River salmon have been heavily over-fished and, indeed, some fall chum stocks are extinct. There are some curious artifacts for the cluster of stocks listed as moderate risk at the northerly latitudes, which I will explore next at the species level.

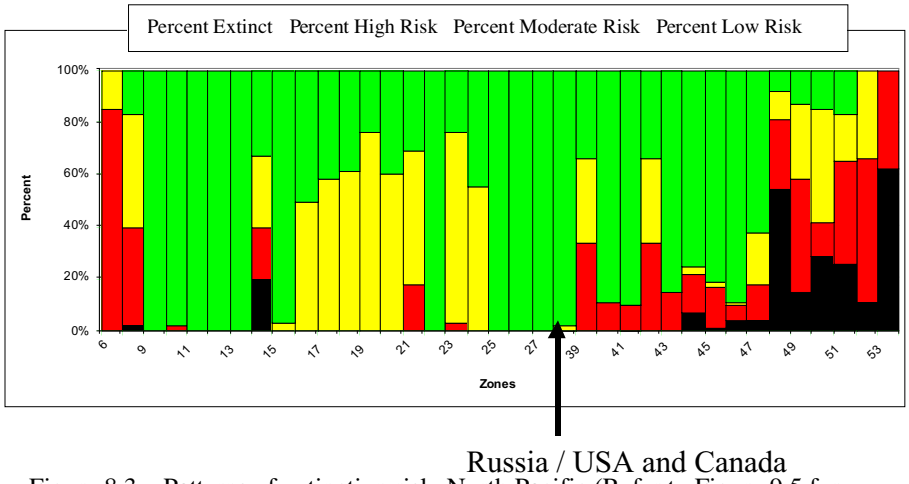

Figure 8.3. Patterns of extinction risk, North Pacific (Refer to Figure 9.5 for geographical identification of zone numbers).

Overall extinction risks by species

At the top of each bar of the histograms in Figure 8.4 are numbers denoting the number of stocks represented for that species or ecoregion. Pink salmon are the most widespread, abundant and at the lowest risk of extinction. At the other end of the spectrum are chinook salmon - they are the most endangered. They are not the least widespread – that honour goes to steelhead. Chinook salmon are found primarily on the Kamchatka Peninsula to the north in Chukotka Kamchatka. Chinook stocks in western Kamchatka have been closed to commercial harvest since the mid-1980s; nonetheless, they are still in tough shape. I will present the species by region and provide more detail.

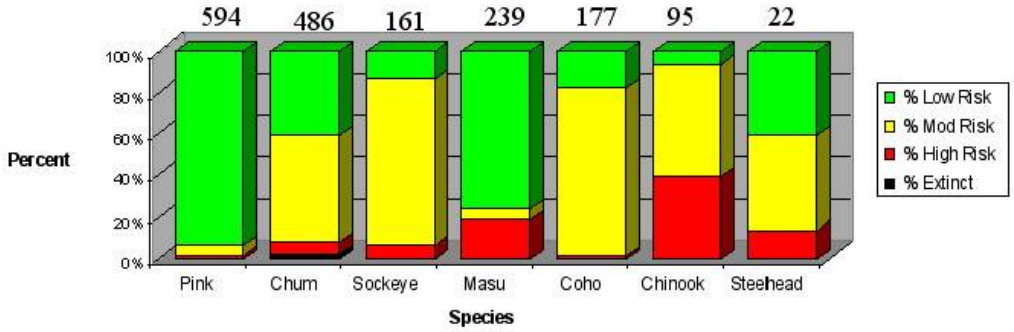

Figure 8.4. Overall extinction risks by species.

Pink salmon
Displayed against the background of the salmon ecoregions, you can see in Figure 8.5 that there is a cluster of pink salmon stocks at high risk of extinction in southern Primorye Territory, the region where human population pressure is the greatest. These stocks are very close to the southern edge of the range for pink salmon.

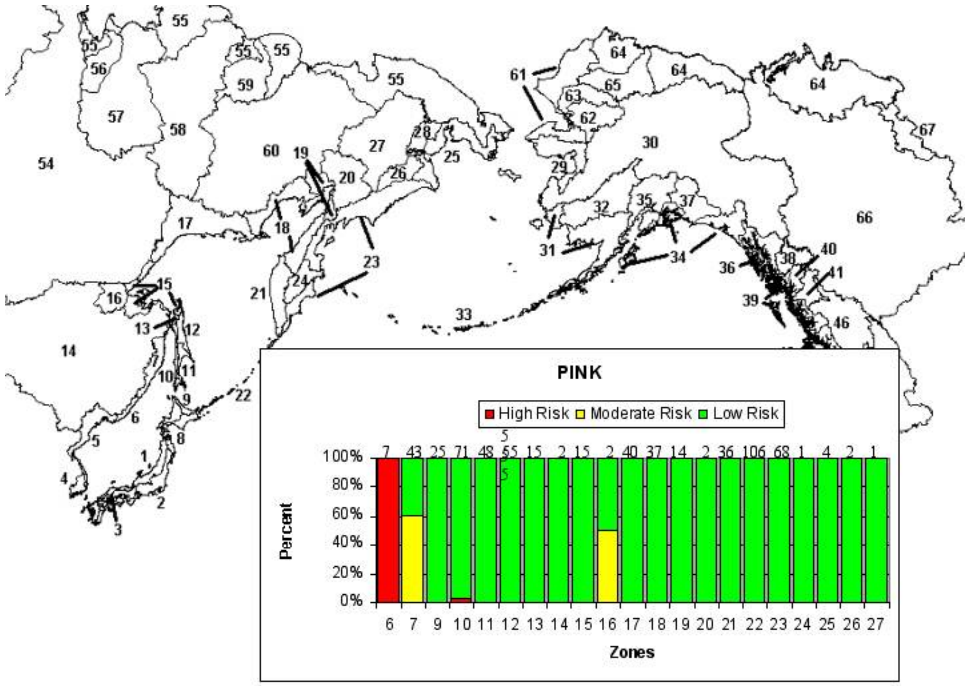

Figure 8. 5. Risk of extinction for pink salmon.

Chum Salmon
Figure 8.6 shows a higher extinction risk for chum salmon at the southern edges of the range, where the human population density is highest. In order to put the population density in perspective, I should point out that compared to the United States, the Russian Far East has about one-third the territory and only three percent of the population. However, when we refer to the higher population densities in the southern Russian Far East, they are actually much lower than anything we know in the western United States - ranging from 0.1 person per square kilometer in Koryakia (northern Kamchatka Peninsula) to 13 people per square kilometer in Primorye.

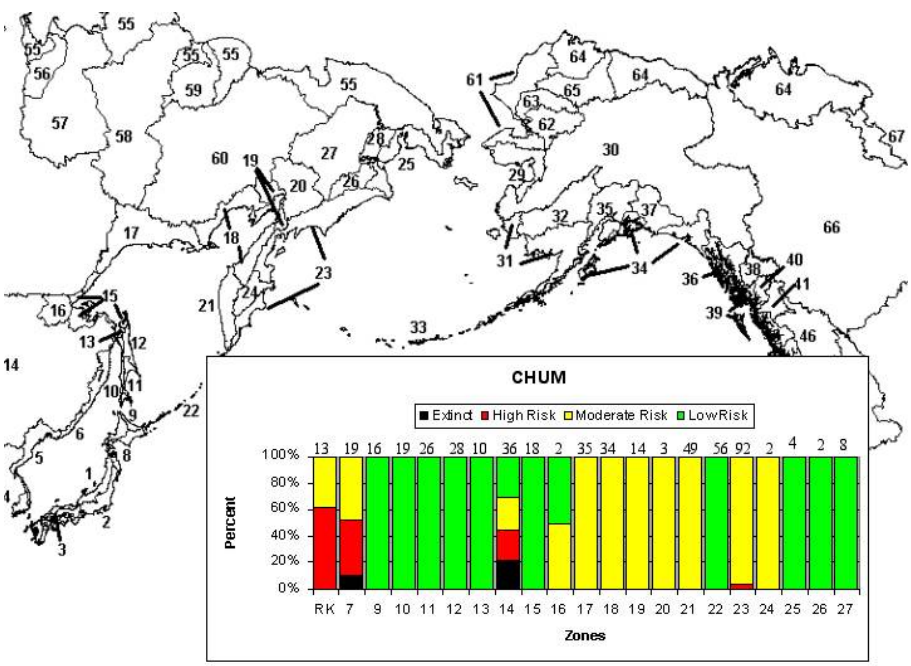

Figure 8.6. Risk of extinction for chum salmon.

Chum salmon stocks are at their most depressed in the Amur River system. The fishing pressure has been very intense for about one hundred years, and the fishery is chronically depressed. There have been transboundary fishery management problems with the People's Republic of China, including an ongoing

battle over who can take how much of the catch. In practice, this has amounted to a free-for-all. After a falling out with the People's Republic in the late 1960s, the Russians chose to harvest as much as possible. That has had dire repercussions for the Amur River fall chum salmon stocks, particularly the upriver components in Russia and China.

Sockeye salmon

The center of sockeye distribution is on the Kamchatka Peninsula; numerous small populations are scattered across the mainland shores of the Sea of Okhotsk and the western Bering Sea in Chukotka (Figure 8.7). Kamchatkan biologists assessed most sockeye stocks as threatened, despite their relative abundance, due to declining harvest rates in the major fisheries (in the Kamchatka and Bolshaya River basins and Kurilskoe Lake). Most of the other biologists around the Sea of Okhotsk also believed that their sockeye stocks were at least at moderate risk of extinction. Sockeye is highly sought after in the Russian Far East as a premium market species.

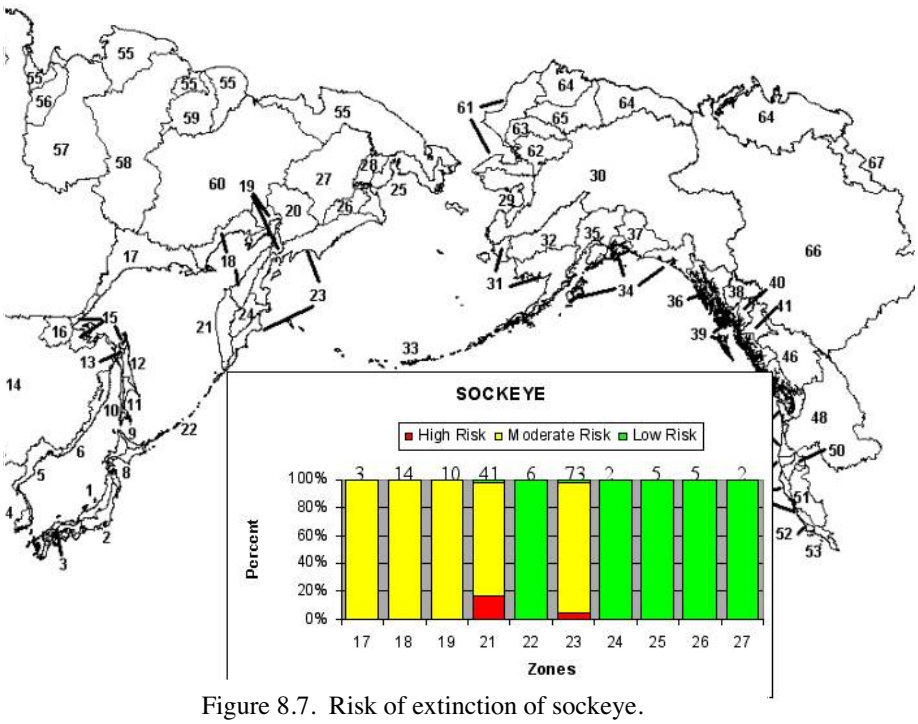

Figure 8.7. Risk of extinction of sockeye.

Masu salmon

Cherry or masu salmon, *Oncorhynchus masu*, are found only in the western Pacific, and their distribution extends around the Japan Sea, including Hokkaido, Honshu, the mainland Russian shores, Sakhalin Island, and on Kamchatka. They are most abundant in the salmon ecoregion along the northern Japan seacoast, where there are two distinct seasonal races and a resident component to local populations (Semenchenko 1989). Commercial fishing for masu salmon has been prohibited in Primorye since 1957 due to declines in abundance. In fact, it was reserved as a delicacy fish for the Communist Party in this region and therefore it was not available on the market. Although officially there are still no commercial quotas for masu salmon in this area, there is a fishery for local consumption and for caviar. Masu is also caught as bycatch in the opening days of the pink salmon fishery. The populations of masu on Sakhalin Island and Kamchatka are small and widely dispersed, analogous to many of our coho populations on this side of the Pacific.

The Kamchatkans believe masu populations on the Peninsula are at least at moderate risk of extinction due to small size, poor information, and poor regulation of the fishery. However, the biologists formally surveyed on Sakhalin Island felt that masu were at no risk of extinction. Other Sakhalin field biologists who work with the Wild Salmon Center believe that many masu salmon stocks are probably at moderate risk if not at high risk of extinction on Sakhalin due to heavy personal use harvest pressure, interception in the pink salmon fishery and, as in Japan, recreational harvest of juvenile masu salmon in freshwater.

The case of masu salmon risk of extinction rankings (Figure 8.8) demonstrates the potential fallibility of best expert judgment stock status assessments. It appears that there is a systematic perception bias in our survey. In the absence of commercial fisheries for masu salmon, there is a paucity of information available to federal fish biologists to accurately assess stock status. The Kamchatkan biologists were the most conservative, ranking most of their salmon stocks at moderate or greater risk of extinction. Our Sakhalin respondents had the most optimistic views, ranking all but two stocks at no risk of extinction.

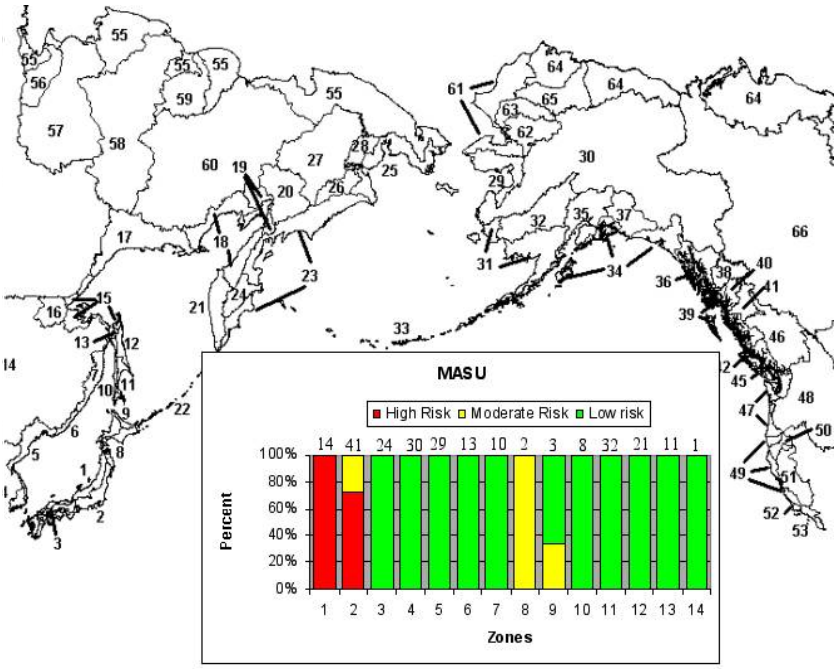

Figure 8.8. Risk of extinction for masu.

Coho salmon

Coho salmon are fairly widespread across the Russian Far East, but they are not abundant. The center of abundance is on Sakhalin and on Kamchatka where coho are harvested commercially. Because they are a late-run fish, coho are not as heavily targeted by the commercial fisheries as are the other species. (Migration timing ranges from September to December.) The only place where there were any stocks considered to be at high risk of extinction was on the east coast of the Kamchatka Peninsula (Figure 8.9). On western Kamchatka and the northern part of the Sea of Okhotsk, they were considered at moderate risk of extinction.

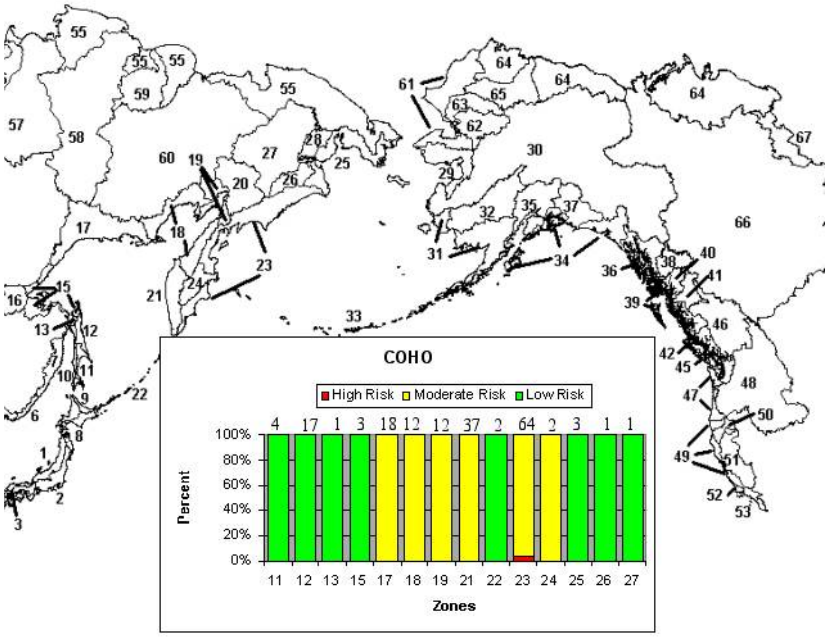

Figure 8.9. Risk of extinction for coho salmon.

Chinook salmon

Our Kamchatka colleagues ranked all of the chinook stocks on the west coast of Kamchatka and some east coast stocks at high risk of extinction, and the remainder at moderate risk (Figure 8.10). Chinook stocks are in better condition in Chukotka to the north. There is limited fishing pressure on the most northerly chinook stocks; the populations are very small and therefore poorly studied.

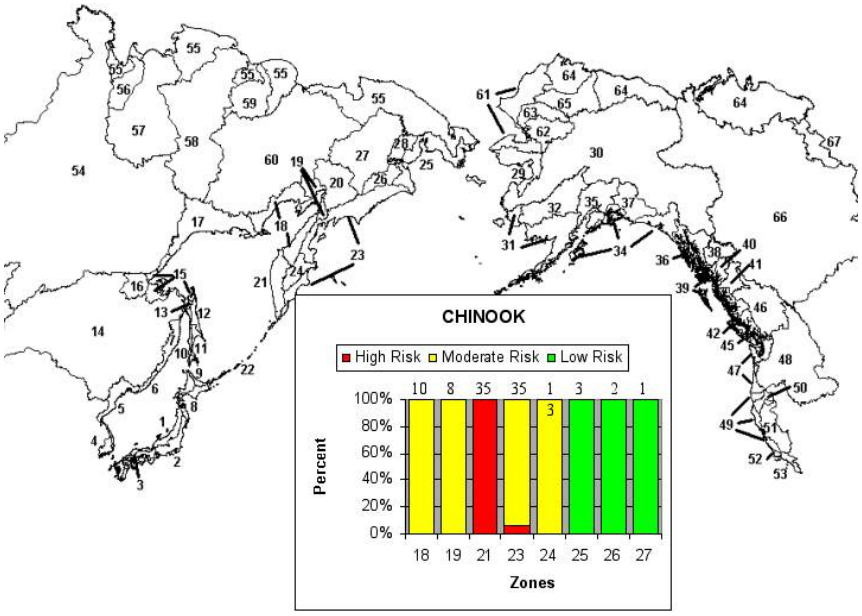

Figure 8.10. Risk of extinction for chinook salmon.

Anadromous Oncorhynchus mykiss, steelhead

Anadromous *Oncorhynchus mykiss* or steelhead salmon are present only on the west coast of Kamchatka, though intermediate estuarine-anadromous phenotypes may occur in some rivers on the east coast. The Wild Salmon Center in collaboration with researchers from Moscow State University and the University of Montana's Flathead Lake Biological Station, continue to collect field data regarding the distribution and phenotypic diversity of the rainbow-steelhead complex. Our colleagues at Moscow State University assessed steelhead for the Wild Salmon Center stock status assessment, given the absence of regional data for *O. mykiss*, which is not a commercial species.

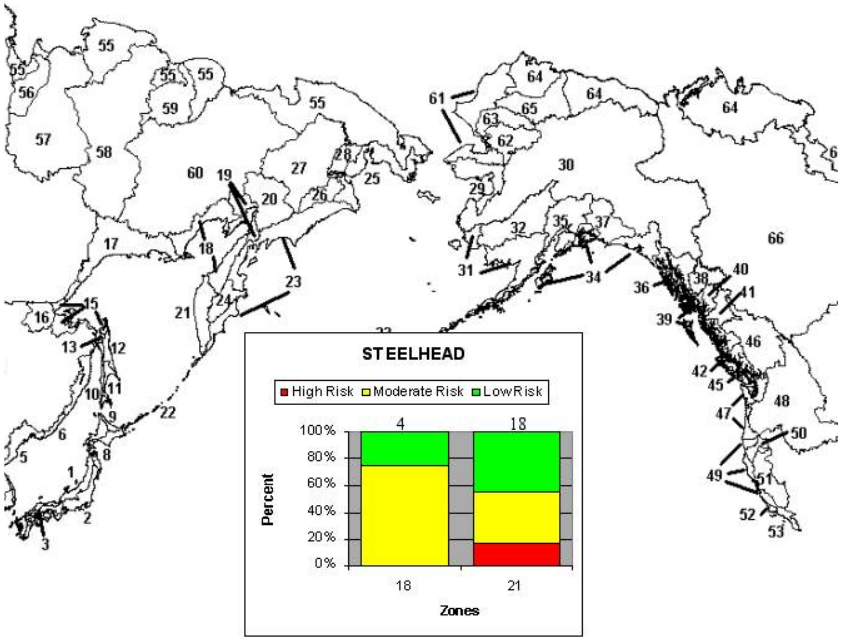

Figure 8.11. Risk of extinction for steelhead salmon.

The academic biologists ranked southern Kamchatka stocks at high risk of extinction due to documented declines in abundance over the past thirty years, associated with the proximity of towns and heavy poaching pressure. Most of the remaining stocks, found in sparsely settled river basins further north were ranked at moderate risk of extinction (Figure 8.11). The anadromous form of *O. mykiss* was listed in the Russian Federation's "Red Book" as a rare form deserving federal protection in 1984; harvest is prohibited.

In summary, our biologist colleagues ranked 1 percent of the Russian species as extinct; 7 percent at high risk; 35 percent at moderate risk; and 57 percent at low risk of extinction. Our estimates across species are shown in Table 8.2.

Table 8.2. Across species estimates.

1%	extinct
7%	high risk
35%	moderate risk
57%	low risk of extinction

Risk factors

Overharvest

The primary risk factor for salmon in the Russian Far East is overharvest – a broad category including commercial overharvest, interception, poaching, personal use and recreational fishing. Most of the commercial fishing in the Russian Far East employs beach seines and net traps, similar to those once used in Alaska. In theory, Russian net traps are selective – catching live only those fish bound for the nearest river, and facilitating the release of non-target species. In practice, most Russians do not release any fish that find their way into the heart of the trap and, therefore, they have not been used selectively.

Illegal fishing

Illegal catches are estimated to represent a volume equal to 25-50% of the commercial fishery, varying significantly by region. The primary objective is the production of caviar for lucrative domestic and export markets. Many rural households earn a significant portion of their income from caviar through roe stripping. Unemployment rates have been high since the collapse of the Soviet Union; about 40 percent of the residents of the Russian Far East live below the poverty level. Poaching operations vary greatly in scale. Some are organized and well-financed operations from major cities, fielding purchasing camps at remote locations, employing local residents to catch and strip fish, and to process roe. Others are household-based operations, catching and processing small batches of caviar for markets in local towns and cities. The third type is high-grading and roe-stripping of females in the formal commercial fisheries. The fish flesh is not worth shipping back to market and the males are discarded altogether. I have seen several photographs of carcass piles from most regions of the Russian Far East - it is most depressing.

Salmon habitat

Habitat, on the other hand, is generally in excellent condition. The Krutogorova River on the Kamchatka Peninsula is a good example of the multi-channel river systems meandering across the alluvial plain of western Kamchatka. These systems afford a complex and diverse system of off-channel habitats, supporting incredible salmonid diversity at the species and life history levels. Jack Stanford has been working with the Wild Salmon Center and Moscow State University to assess the trophic dynamics in these dynamic salmon rivers. The abundant fish of the Russian Far East support a diverse ecosystem including dense and verdant riparian forests providing habitat for Steller sea eagles, Blakiston's fish owls, and multitudes of bears and other wildlife. Returning salmon provide food for invertebrates which in turn feed juvenile salmonids, such as the Siberian trout *Brachymystax lenok*. Salmon feed directly on two species of taimen present in the Russian Far East – resident Siberian taimen and sea-going Sakhalin taimen. Siberian taimen consume chum salmon in the Tugur River basin, attaining sizes up to 55 kilograms. Anadromous salmon also provide nutrients to support a large number of rainbow trout and anglers.

Habitat degradation has contributed to salmon declines in the southern portion of the Russian Far East but even there many systems are largely unaltered. In large, complex river basins such as the Amur River basin, it is likely that localized habitat degradation played a role in a cumulative process of chum salmon declines, driven primarily by overfishing and exacerbated by variability in marine rearing conditions.

Logging practices

Habitat alteration associated with logging has not been as significant a factor on Russia's Pacific coast as in the United States. Currently, logging occurs primarily in the southern Far East, where there are extensive larch and spruce-fir forests; the further north one travels, the sparser the forests, and other issues become more of a threat, such as mining and oil and gas development. Fortunately for the river systems of the Russian Far East, the Russians are increasingly using a form of strip logging that alternates 50-meter 'leave-strips' with 50-meter harvested strips. This system evolved because clear-cut logging leads to soil desiccation, altered stream flows and poor forest regeneration. Most of the cut areas are not artificially re-seeded and are left to regenerate on their own. 'Leave strips' provide a seed source for the cut areas and minimize erosion. This system that was adopted from Finland and it is commonly used in Primorye and southern Khabarovsk Territory. The Wild Salmon Center hopes to support studies regarding the effects of this type of logging on salmon systems in the southern Russian Far East, in collaboration with NGO, academic and agency colleagues.

Road construction

As in North America, one of the most visible and pervasive effects of logging is the road network and potential road failures, an example of which can be seen in this image of the Khor River, a tributary of the Amur River basin (Figure 8.12). Fish passage is not a central design feature for culverts, and many become obstructions for anadromous fish; this is becoming more of an issue with increased road building occurring as a result of timber sales, oil and gas infrastructure development, and new mine construction.

Figure 8.12. Forest road failure in the Rhor River region.

Mining

Mining is of great concern to salmon biologists from northern Khabarovsk Territory north to Chukotka, all along the shores of the Sea of Okhotsk and the western Bering Sea. Hydraulic mining destroys salmon habitat directly, and leachate from mining operations poisons river systems over time. Although restoration requirements exist on paper, in practice they are seldom enforced.

Oil and gas development

The photograph in Figure 8.13 is a gas field on the Kamchatka Peninsula, located on western coastal plain, the region in Russia with the highest salmonid diversity – six Pacific salmon species plus Oncorhynchus mykiss, and two char species reside here. This is also potentially one of the most prospective areas for oil and gas development, both onshore and offshore. The first pipeline associated with an onshore gas development is presently under construction, fording dozens of rivers. It is likely that this project has heightened Kamchatkan biologists' perception of risk to stocks.

Figure 8.13. Gas field on Kamchatka Peninsula.

Dams
The Russians are very fortunate not to have mainstem dams like the Bonneville Dam on their salmon rivers. There are three major dams on the Amur, but they are in tributary systems just beyond the anadromous range of fall chum and, therefore, have had very little effect directly on salmon spawning habitat. It is not likely that there will be much major dam development in the future. The Russians are looking to other potential sources of energy – primarily hydrocarbons.

In summary, overfishing is the greatest threat to the productivity of salmon stocks across the Russian Far East. Logging and forest roads are more of a threat in the southern regions, and mining is a concern across the territory but presents a more immediate threat around the shores of the Sea of Okhotsk and the western Bering Sea. Oil- and gas-associated infrastructure development is an issue almost everywhere, although for now most activity is centered on Sakhalin Island. Exploration leases have recently been let in the Sea of Okhotsk off Magadan and western Kamchatka. This is causing much concern.

The State of the Salmon Program
The Wild Salmon Center, together with Ecotrust, is launching a new State of the Salmon program. The Program is a logical continuation of the Pacific Rim work that has been done at the Wild Salmon Center and the work conducted by Ecotrust in its Salmon Nation project. Our mission is to collect and synthesize existing information and to strategically develop new information to create a vastly improved understanding of the dynamics of the North Pacific salmon ecosystem. We will also support review, debate, and strategies for reform of salmon management policies. This workshop is exactly what we, as a partner organization with Ecotrust, would like to see more of. I am hoping that we can build collaborative relationships with institutions here in British Columbia and all around the North Pacific to host this type of event on a regular basis.

Monitoring protocol development
One of the key aspects of our work in the State of the Salmon Program is to develop an overall sampling design and common monitoring protocols for salmon around the North Pacific. We held our first workshop on this theme in February 2003 in Portland, Oregon, and anticipate holding our next workshop in March 2004. We struggled in this group to figure out what it was that we were trying to monitor – whether we were monitoring biodiversity in terms of genetics and phenotypic variability around the North Pacific across salmonid species or whether we were measuring trends in abundance of adults and juveniles, and at what spatial scale. The problems are many and it is a very complex question. We have chosen to focus on 1) periodic biodiversity mapping across the North Pacific and 2) a stratified approach to sampling trends in adult abundance, using the salmon ecoregions and our knowledge of existing research and monitoring efforts to develop a representative data set across species for the North Pacific. We hope that the biodiversity mapping will alert us to the disappearance of phenotypes/genotypes or constriction of their distributional range.

In the long term, we intend to develop a robust framework so that future North Pacific stock status assessments can be conducted on a quantitative basis. First we must determine where there are long-term, extensive surveys of escapement adequate for stock status assessment. Although southeast Alaskan and Canadian salmon stock assessments were the only quantitatively derived classifications in our North Pacific-wide assessment, even in Canada assessments are based upon scant data, which may not be representative of status by species as a whole. Raincoast Conservation Society's report "Ghost Runs" describes the Canada Department of Fisheries and Oceans indicator runs by species – in the central and north coasts of British Columbia there are currently 281 indicator streams, representing 2,500 + stocks, with uneven representation across species. Collaboratively with colleagues in British Columbia and elsewhere around the North Pacific, we intend to map known indicator streams and assemble metadata about the data types, collection protocols, and length and reliability of record, as a basis for designing a Pacific-wide salmon status sampling design. We will be undertaking a range of data synthesis and

analysis in preparation for the next workshop. The report from the first North Pacific Salmon Monitoring Workshop is available at the State of the Salmon website, www.stateofthesalmon.org in Russian, Japanese and English.

In conclusion, I would like to thank our many colleagues around the North Pacific for their help with the work that we have conducted to date in trying to assess stock status in these far-flung regions, including those who attended our monitoring workshop, colleagues from the southern Russian Far East, and Vladimir Radchenko, who was not able to join us for the present workshop.

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CHAPTER 9

Salmonid status and conservation in Japan

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** presenter*

Introduction

In 1886 Mr. Ito, the first director general of the Fisheries Department of the Hokkaido Government, came to North America to the Brook Creek Hatchery in the state of Maine, USA, to learn about the modern hatchery techniques for salmon enhancement. In the period since then, Japanese scientists and technicians have been constantly updating their hatchery technology resulting in the modern Japanese salmon enhancement program that is in place today.

Salmonid stock status in Japan

Historically in Hokkaido, an ethnic group, the Ainu, caught salmon for subsistence. However, in the 1600s, commercial fishing in freshwater and estuaries began with people who came from the southern part of Japan and after the introduction of coastal set net fishing around 1800, commercial salmon fishing was expanded to the coastal waters. Interestingly, since the 17th Century, Japanese salmon was conserved by 'Tanegawa No Seido', which was a kind of Wild Salmon Conservation Act (Kaeriyama and Mayama, 1996). Under this 'Act' commercial fishing was not allowed in the 'Tanegawa' rivers. Unfortunately, at the end of the 19th century, 'Tanegawa No Seido' became almost ineffective as there was overharvesting of salmon due to incomplete fishing regulations (Kobayashi, 1988). At about that time, salmon resources were enhanced as salmon hatchery programs began as discussed above.

Chum salmon

The graph in Figure 9.1 shows the historical catch and stocked juvenile data for Hokkaido chum salmon from 1870 to the present time. From the 1890s to the 1940s the numbers of stocked chum fry increased with increases from private hatcheries but the chum salmon population never recovered. Since 1950, the private hatcheries were replaced by the National and Hokkaido government programs that are directly responsible for hatchery and research operations in Japan.

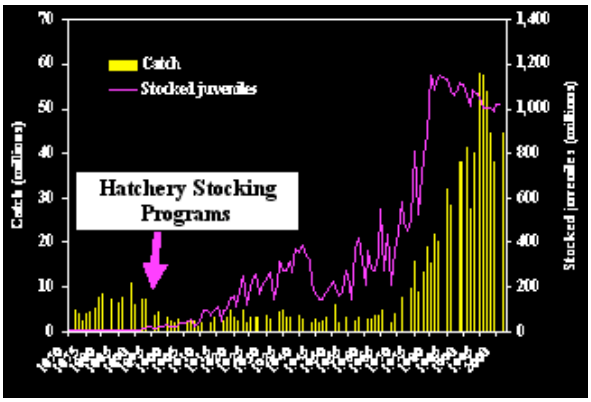

Figure 9.1. Historical catch and stocked juveniles in Hokkaido chum salmon – 1870-2000.

Figure 9.2 describes the status of chum salmon, distributed mainly in Hokkaido and northern Honshu, from 1965 to 2002. The total catch of chum salmon by commercial and enhancement programs in Japan over this period of time is also shown. The total catch increased linearly, from approximately 10 million in the 1970s to greater than 60 million in the 1980s, with the increase in stocked juveniles. However, since the early 1990s the numbers have fluctuated between 40 million and 90 million despite the fact that there has been almost the same number of stocked fish every year.

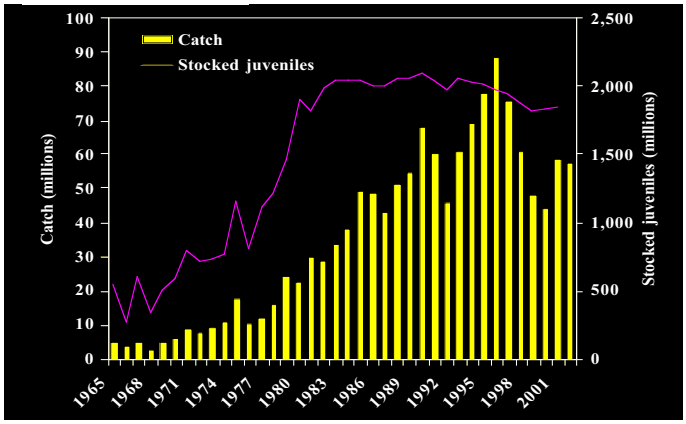

Figure 9.2. Catch and stocked juveniles in Japanese chum salmon.

Figure 9.3 shows that in the period from 1950 to 1965 the brood year was characterized by unfed, newly emerged fry, as they used to be stocked. However, no positive relationship was observed between the number of stocked fry and the number of adults returning four years later. Salmon scientists observed a large gap in downstream migration time between wild and unfed hatchery fry and it appeared that hatchery fry migrated so early that they could not survive in the ocean. Consequently, swim up fry were reared with artificial feed (Kobayashi, 1980) with the result that the number of returned adults from the 1966 to 1979 brood years increased sharply with the increase in the number of fed chum salmon. In the recent period (1980 – 1995) with the decrease in stocked juveniles, there was a negative relationship between fry number and returned adults. This may suggest that when there are too many releases, rates of survival decrease.

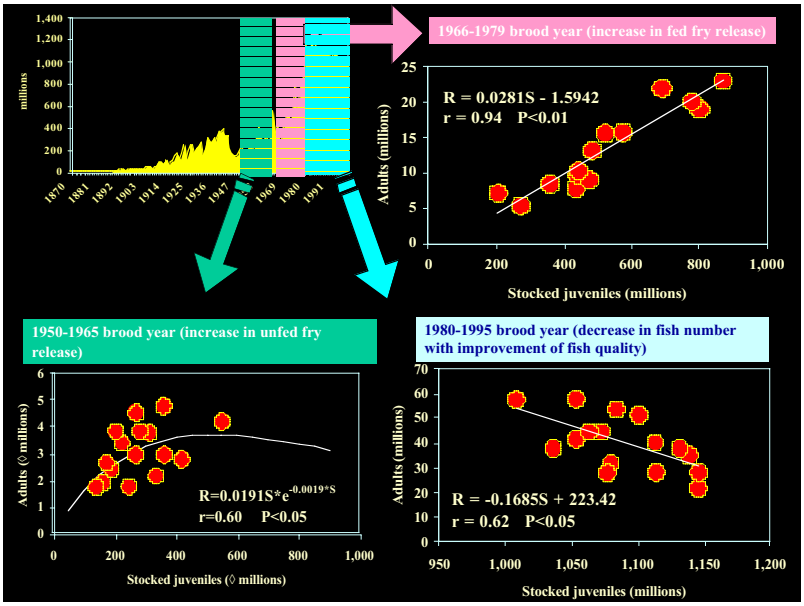

Figure 9.3. Brood year (1950-1965).

Figure 9.4 shows that the return rate from 1963 onwards has been increasing from 2 – 5%. Moreover, a significantly positive relationship was observed between the size of stocked juveniles and adult return rates, suggesting that fish quality is an important factor in determining high survival rates (Kaeriyama, 1999).

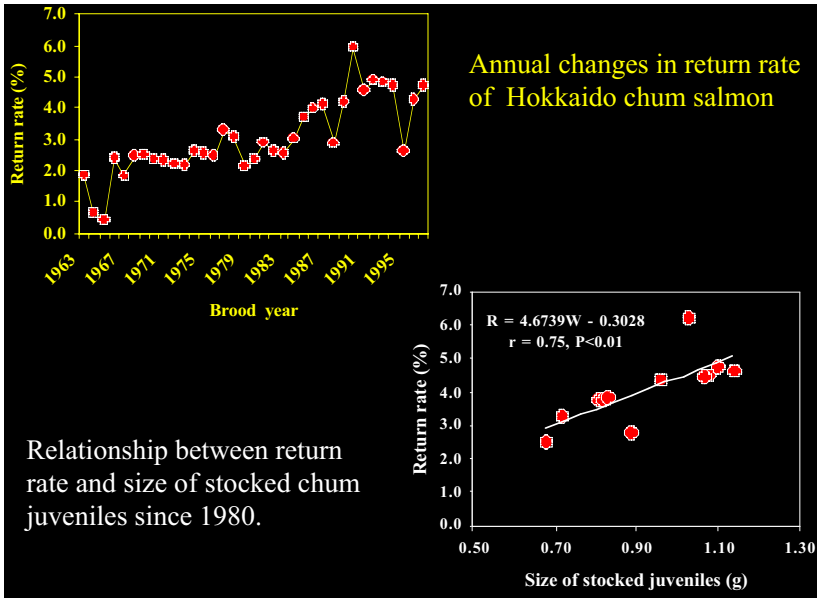

Figure 9.4. Annual changes in return rate in chum and relationship between return rate and size of stocked chum.

Pink salmon

Pink salmon are distributed mainly in eastern Hokkaido. Figure 9.5 shows that the population size of pink salmon remained low from the 1970s to the 1980s, but in the early 1990s they increased sharply, especially the population size in even years which exceeded 10 million. Subsequently, a shift from odd to even year dominance occurred. Interestingly, this two-year cycle dominance in even years has been maintained despite the similar recruitment of hatchery fry every year. Perhaps natural spawning also contributes here.

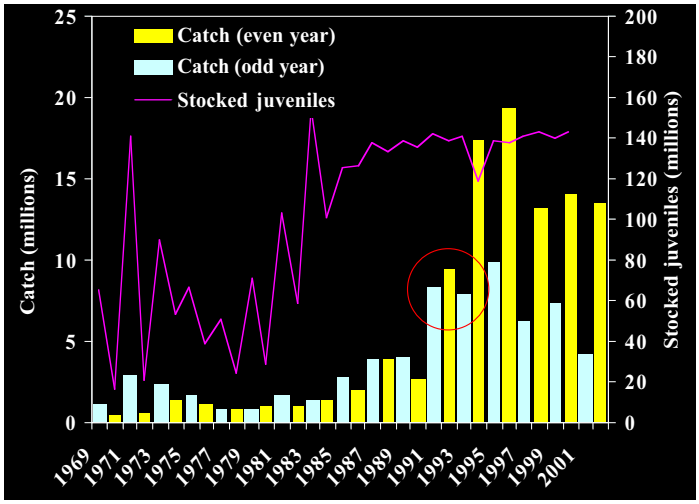

Figure 9.5. Historical catch and stocked juveniles in Hokkaido pink salmon.

Factors affecting chum and pink salmon population dynamics

It is well-known that the annual total catch of Pacific salmon in the north Pacific Ocean is showing a long-term change; specifically, the catches of pink, sockeye and chum salmon indicate a 40 or 50-year

periodicity (see Figure 9.6). This periodic change in biomass is thought to possibly coincide with the climate regime-shift years (Minobe 1999, 2002). During the period of increase in catches of Japanese chum and pink salmon since 1970, Alaskan wild sockeye and pink salmon catches have also increased (Figure 9.6). Therefore, we think that mass-produced chum and pink salmon numbers in Japan are due not only to the successful hatchery program but also to the better ocean conditions.

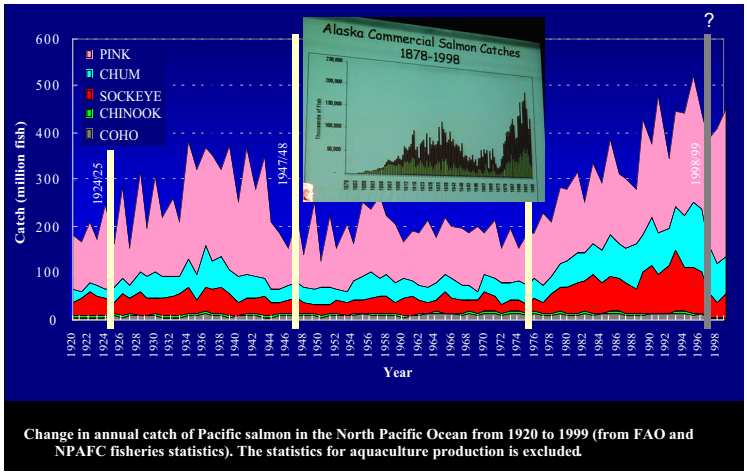

Figure 9.6. Total catch of Pacific salmon in the North Pacific Ocean.

We have tried to estimate the carrying capacity of Pacific salmon using the replacement level (K) on the Ricker reproduction curve. Figure 9.7 shows the carrying capacity of three species, sockeye, chum and pink salmon, in the North Pacific Ocean. The red and yellow lines indicate total carrying capacity of chum, sockeye and pink salmon and the mean Aleutian Low Pressure Index (ALPI) (Beamish and Bouillon 1993), respectively. This shows that the total carrying capacity was significantly synchronized with the ALPI (Kaeriyama 2001) and moreover that recent carrying capacity is decreasing together with the decreases observed in the ALPI.

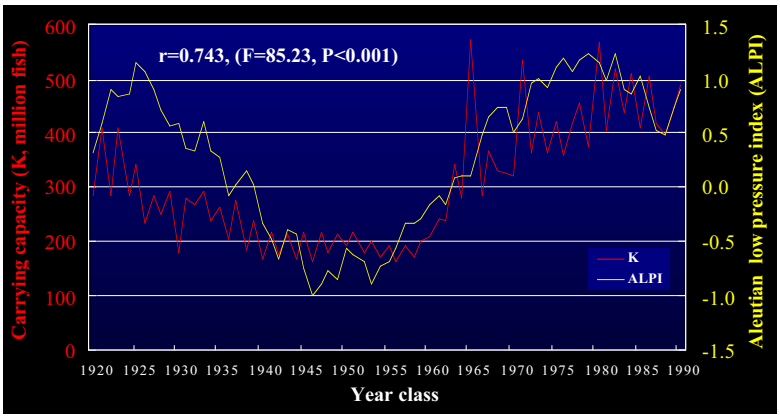

Figure 9.7. Changes in the Aleutian low pressure index (ALPI and carrying capacity (K) of three species (sockeye, chum, pink salmon) in the North Pacific Ocean.

We have also studied biological changes in salmon in relation to population changes. Figure 9.8 shows that mean fork length of female chum adults (age 4) returning to eleven rivers in Hokkaido decreased as population size increased until the early 1990s. However, beginning in the late 1990s as the chum salmon population size has decreased, their fork lengths have increased. Therefore, the relationship between population size and body size is negatively correlated (Kaeriyama 1999). Moreover, a significant positive relationship was observed between the population size and average age of a population at maturity in the

Hokkaido chum salmon. These results suggest that a population density-dependent effect may be the cause of the individual growth reduction in the Japanese chum salmon population (Kaeriyama 1999). A biological problem of great concern is that many wild chum and pink salmon populations have decreased or disappeared as the result of hatchery activity, habitat loss and other factors.

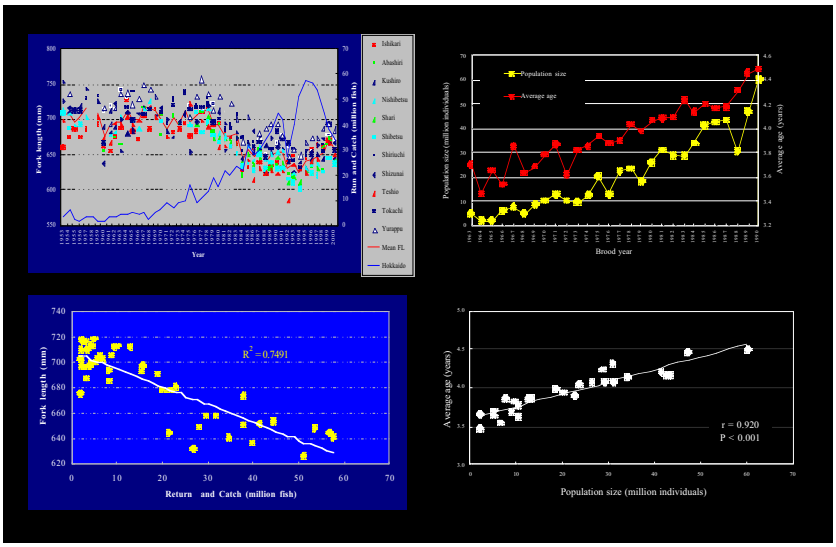

Figure 9.8. Population density-dependent effects.

Masu salmon

There is another species of Pacific salmon in Japan, the masu salmon, *Oncorhynchus masou*, which is prevalent in northern Japan, particularly in Hokkaido. Masu salmon is considered to be a primitive species of *Oncorhynchus* and it has a very unique life cycle. In contrast to pink and chum salmon, masu salmon have not only a sea run form but also a resident form. Sea run masu spend only one year in the ocean, but they live in streams for more than two years before their seaward migration. Interestingly, there is a difference in dispersal patterns between male and female fry soon after emergence (Nagata and Irvine 1997). Most males remain near the spawning nests and tend to mature early in freshwater; in contrast, other males and females tend to move downstream and most of these smolt for seaward migration. This divergence might be determined genetically before emergence (Nagata 2002). The photographs in Figure 9.9 show the different forms of masu salmon. Figure 9.10 depicts the life cycle of masu salmon.

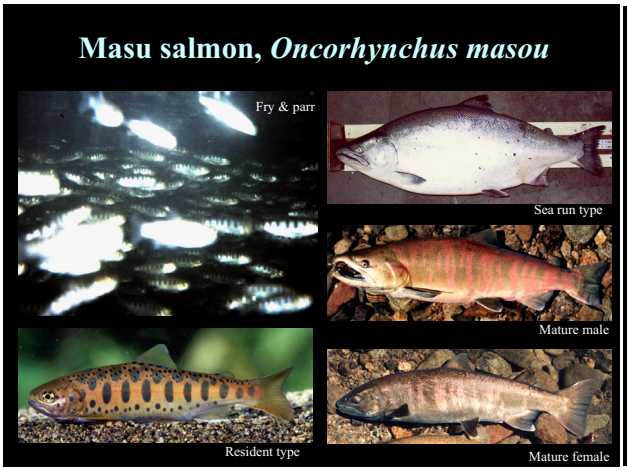

Figure 9.9. Different forms of masu salmon.

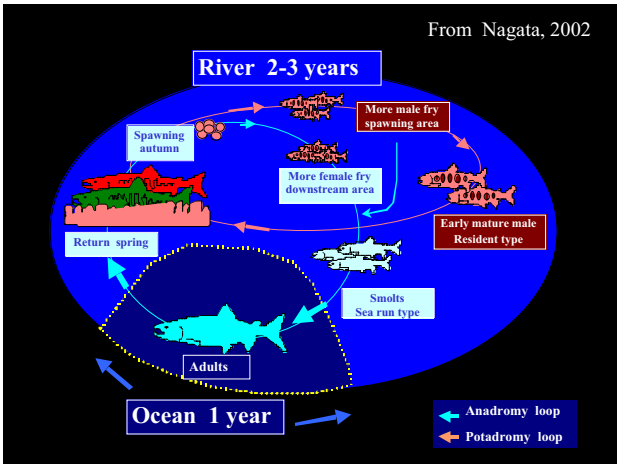

Figure 9.10. Life cycle of masu salmon.

In contrast to Japanese chum and pink salmon which have shown increases in numbers due to successful hatchery programs and favourable ocean conditions, masu salmon have been steadily decreasing despite many costly efforts to reverse this trend, including hatchery activity (Figure 9.11).

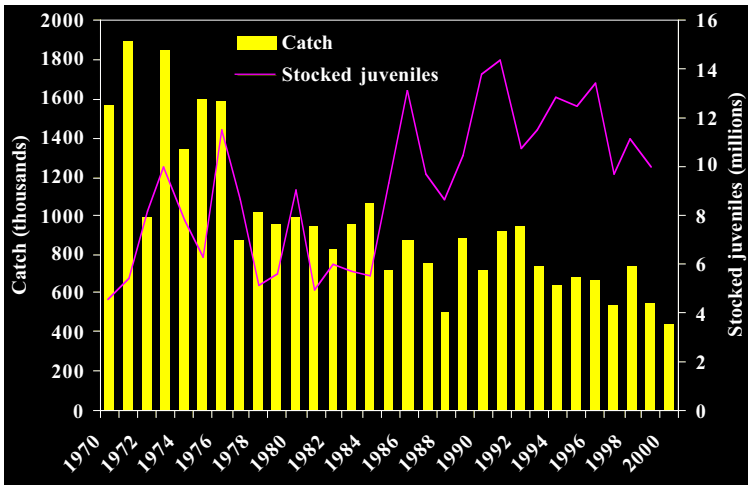

Figure 9.11. Historical catch and stocked juveniles in Hokkaido masu salmon.

On the other hand, wild masu populations continue to be healthy. This can be explained by the life cycle; adult masu tend to ascend in almost all streams around Hokkaido in the spring with floods resulting from the snow melt, so it is very difficult to catch masu salmon in weirs. Figure 9.12 shows the natural spawning areas in three rivers. Although masu salmon can spawn in the whole area of the river, they particularly favour the middle and upper portions and tributaries (Yania et al. 1996; Omori 1998; Sugiwaka et al. 1999).

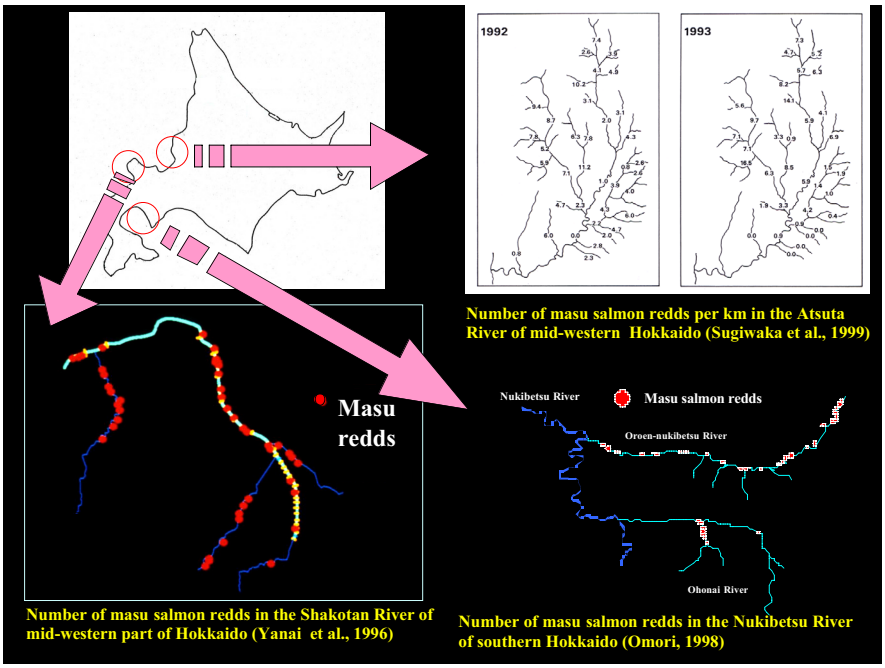

Figure 9.12. Natural spawning areas for masu salmon.

Future prospects of Pacific wild and hatchery salmon populations

It is predicted that salmon carrying capacity will decrease in the North Pacific Ocean. Nobody knows exactly how the population density-dependent effect will progress when the carrying capacity decreases with the climate regime shift. It is true that hatchery programs play an important role in meeting the food demands of an expanding human population in the 21st century. However, we have to conserve not only

the wild salmon populations but also the biological diversity of hatchery salmon to maintain the salmon resources. Therefore, people should pay more urgent attention to the biological interactions between wild and hatchery salmon to avoid negative impacts. Harmony with the ecosystem and coexistence of wild and hatchery populations are extremely important issues for the North Pacific Rim nations.

To advance such basic ideas, in Japan we are now undertaking ecosystem-based conservation and management programs. The biological monitoring program deals with carrying capacity in the ocean, body size and age composition of populations and genetic and reproductive characteristics. The program which deals with the separation of management of wild and hatchery salmon populations in freshwater addresses protection of genetic diversity and endemism and recreational and commercial salmon fisheries in rivers. The program which deals with rehabilitation of wild salmon populations and restoration of natural riparian habitat includes establishment of nursery and spawning areas in rivers, rehabilitation of wild chum salmon, conservation of wild masu salmon and exclusion and non-introduction of exotic fishes.

The Japanese Hatchery Salmon Monitoring System was established in 1993. A database of biological assessment information for Pacific salmon populations (chum, pink, masu and sockeye) in Japan has been developed. It provides information on escapement, total catch, and total run, including for rivers number captured by sex, number of eggs taken, and for coastal samples, numbers and weight of each catch. It also includes information on breeding characteristics, including fork length, body weight, gonad and somatic weight, fecundity, and egg size, and information on age composition. There is also a database of information on juvenile Pacific salmon (chum, pink, masu and sockeye) released from Japan. This information provides numbers of released juveniles by development stage, and origin (native compared with other populations). There is also a database of information on early life history of Pacific salmon (chum and pink) in Japan. Information here includes basic capture data for juveniles such as date and location, number, fishing gear, SST, fork length, body weight, stomach content index, and dominant prey animals. As well, there are data regarding the basic recapture of marked juveniles such as date and location, fishing gear, SST, fork length, body weight, stomach content index, dominant prey animal and marked fins.

Chum salmon information

Figures 9.13 and 9.14 provide examples of information obtained by this kind of monitoring data. For example, according to the chum salmon database on escapement time, the escapement period of the northern population tends to be earlier than for the southern population (Figure 9.13). In Hokkaido there were both early and late populations of chum salmon until the early 1980s but unfortunately, as the result of hatchery selection, the late run population has disappeared in recent years (Figure 9.14).

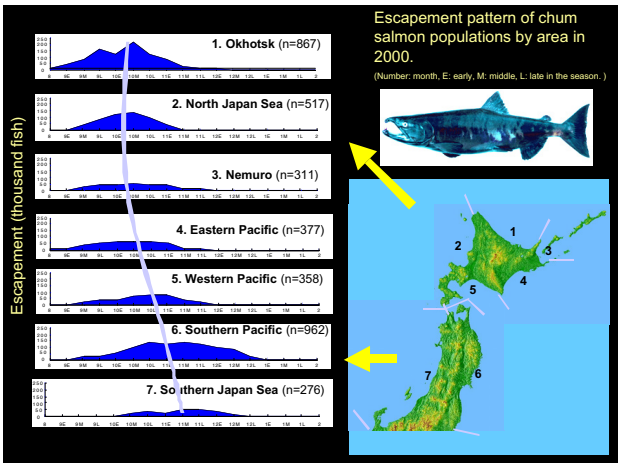

Figure 9.13. Escapement pattern of chum salmon populations by area in 2000.

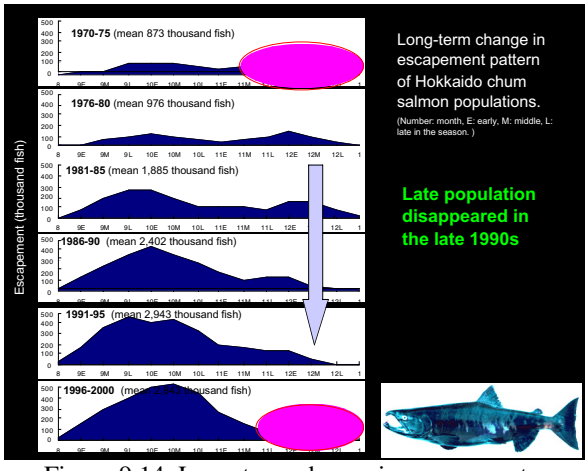

Figure 9.14. Long-term change in escapement patterns of Hokkaido chum salmon populations.

Masu salmon information

Because of a shortage of egg production for enhancement two types of masu salmon have been used in recent years; one is from spawners that spend time in the ocean and are captured in natural streams, the 'hatchery' type; the other is from spawners that have been reared for successive generations in artificial ponds, the 'domestic' type. We are now monitoring genetic variability in wild and domestic masu salmon. Figure 9.15 shows the recent results of this monitoring (Okubo 2003). Clearly, there is no significant difference in average heterozygosity (expectation) between the two varieties, suggesting that there is no evidence for a decrease in genetic diversity of domestic masu. This monitoring project continues.

Population	Number of alleles per locus	Proportion of polymorphic loci	Average heterozygosity
Wild			
Shokanbetsu R.	1.44	0.333	0.039
Atsuta R.	1.48	0.296	0.048
Toshibetsu R.	1.48	0.296	0.042
Nodaoi R.	1.52	0.370	0.072
Yurappu R.	1.26	0.222	0.037
Shiribetsu R.	1.46	0.259	0.034
Domestic			
Mori strain >F6	1.37	0.259	0.037
Mori strain >F6	1.48	0.333	0.042
Shokanbetsu strain F1	1.51	0.333	0.044
Shiribetsu strain F2	1.33	0.286	0.044
Shiribetsu strain F3	1.37	0.333	0.035

Figure 9.15. Genetic variability in wild and domesticated masu based on electrophorectic analysis using the 11 loci (Okubo, 2003).

Some fishing regulations and rehabilitation programs have been put in place in order to conserve wild masu salmon. In all Hokkaido streams, people are prohibited from catching adult salmon over the whole year so as to attain escapement goals for enhancement and to help natural spawning. In particular, this regulation contributes to natural spawning of masu salmon which are a problem in hatchery programs. Sport fishing for juvenile masu is very popular in Hokkaido because of traditional food culture as well as a recreational activity. Therefore, people are not prohibited from fishing masu except in the spring season when masu salmon smolts migrate to sea. In addition, there are 32 Conservation Rivers that have been designated by the national government to conserve masu salmon and their habitat. This is a very powerful regulation, particularly for the sport fishers and river developers – in this case, people are not allowed to catch any aquatic animals or to alter river structure without permission from the Hokkaido Governor. Other initiatives have been taken to protect masu salmon including the rehabilitation of channelized streams in cooperation with the River Management Sector. Figure 9.16 shows the effects of this program for one stream restoration project. Before restoration, the stream was straight and uniform with slow water. After rehabilitation, plunge pools 50 cm in depth or greater were created using log dams. Water velocities and depths were more complex (Yanai 1997) and as a consequence both masu and chum salmon redds were found in the tails of the plunge pools. Last spring there were many masu juveniles in this area; the juveniles 0+ tended to stay in restored sections rather than unimproved sections (Nagata et al. 2002) indicating that rehabilitation programs with log dams can contribute to increases in wild salmon populations.

In conclusion, we must continue these important biological monitoring programs of wild and hatchery salmon and rehabilitation programs of wild salmon and riparian ecosystems in order to maintain Japanese salmon resources.

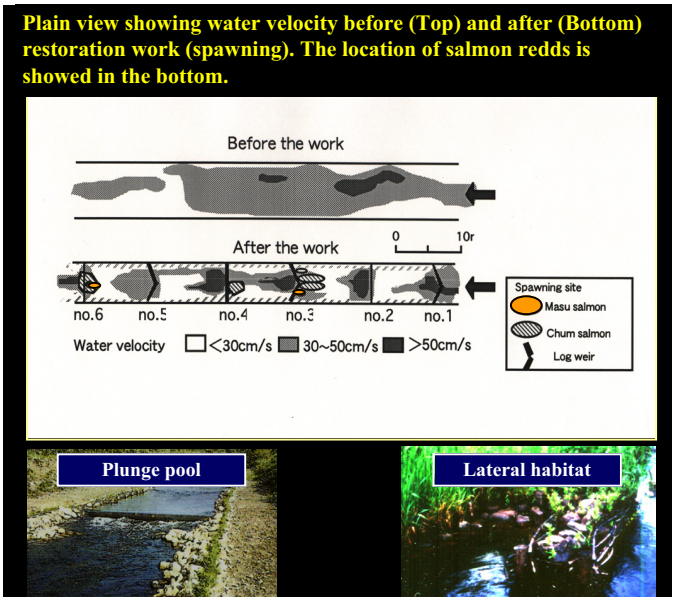

Figure 9.16. Examples of the effects of the stream restoration program.

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CHAPTER 10

MYS, no net loss and the future of Fraser River sockeye

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Introduction

I have worked with Fraser River salmon for most of my career as a harvest manager and stock assessment biologist and, for the last five years as the Stock Management coordinator for the Fraser River Aboriginal Fisheries Secretariat. In addition, for the last year I have served as a science advisor to the BC Chapter of the Sierra Club of Canada. In my capacity as Stock Management Coordinator I have no management authority at all. I simply review the management plans of DFO, and advise my clients concerning potential problems. I had originally intended to focus on the general difficulties that arise when applying 'partial' general models to the problems of setting management goals and protecting and managing salmon stocks and their habitats; however, recent developments in the planning of fisheries for Fraser sockeye have not only surprised me, but also provided me with a concrete example of the problem at hand, so I have adapted this paper accordingly.

The concept of Maximum Sustainable Yield (MSY)

Maximum Sustainable Yield (MSY) was the standard dogma when I was an undergraduate in the 1970s, although this concept was already under attack. Criticism was based on the fact that the MSY models are stationary, or assume stability over time, and that applying these models to aggregates of mixed stocks with varying and different productivity leads to the systematic overharvest of less productive stocks in the mix.

I have seen the concept of MSY described as discredited, but I agree with the view of Gunderson and Holling (2002) that MSY is simply an incomplete explanation based on a myth that nature is stable. Because it is an overly simplistic and incomplete explanation that assumes inherent stability and constant productivity, MSY tends to make managers overconfident, because they assume, and the model assumes, that nature will correct for any mistakes. For example, a Ricker curve assumes that the stock will become more productive at small run sizes, making the run very difficult to fish into extinction. Depensatory processes that might quickly drive stocks to extinction when runs become small are not even considered.

Discredited or not, MSY remains a compelling management model for many and the concept is deeply institutionalized in the management of salmon. In Alaska, MSY is government policy. MSY is part of the language of the Pacific Salmon Treaty, and it is central to the Pacific mandate of the National Oceanic and Atmospheric Administration (NOAA). MSY is still the management philosophy that drives salmon

management on the Pacific coast. Actually, NOAA's mission statement now says "at or above the levels necessary for maximum sustainable yield'. The NOAA website provides the following information,

> *Currently, of the 201 fish stocks managed by NOAA Fisheries, 85 are at or above this level, according to Our Living Oceans 1995. However, there are 43 additional stocks for which we do not have scientific population status information.*

I do not intend to be critical of NOAA. Quite the contrary, I wish I could be as clear about the objectives for management of Fraser River sockeye and our progress in achieving these goals. The fact is, we have little insight into the MSY of most of our salmon stocks, and try as we might to harvest in a precautionary manner and maintain sustainable exploitation rates, the conservation concerns with Pacific salmon, Fraser sockeye salmon in particular, are growing. We have lost stocks, and we are continuing to lose stocks. In the last two years the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has listed upper Fraser/Thompson coho as *endangered*, and they have also listed both Sakinaw Lake sockeye on the Sechelt Peninsula and Cultus Lake sockeye in the lower Fraser as *endangered*. In fact, many salmon populations in BC appear to meet the criteria to be listed as *threatened* and *endangered*. Many more are data deficient. Some are already extirpated.

On the habitat side, we have had the 'no net loss' policy in place for almost as long as I can remember, yet I would be surprised if you could find many habitat biologists that think that we have not lost huge amounts of habitat. The consensus is clear - we have habitat problems all over the place. A recent publication by the United Nations Environmental Program's Division of Early Warning and Assessment, "Visualizing Global Environmental Change", uses satellite imagery to track habitat change. They found that between 1976 and 2000 the human population of the lower mainland of BC grew from 1.3 to 2 million, and that an average of 1.6 hectares of land were developed in this geographic region each day. I am willing to admit that this was not all fish habitat in the way that we usually define it, but it all contributes to the quality of our fish habitat in some way, however small. It is all part of the drainage. The simple fact is that the inexorable process of human population growth is likely to continue into the foreseeable future, along with the steady decay in the quality and quantity of our habitats (see also Chapter 13, Lackey). And habitat loss is not just restricted to major metropolitan areas. We are losing habitat in rural areas as well. In short, "no net loss" is to habitat what MSY is to harvest, a convenient illusion.

MSY lives on

Despite the efforts of some to kill MSY as a theoretical model for managing salmon fisheries, the concept still staggers down the halls of power like a zombie in "Night of the Living Dead" leaving chaos in its wake. The problems that we are facing today on Canada's Pacific coast were foreseen by Ricker and Larkin and others. They saw that fishing a mixture of different biological populations of salmon at or near the rates that can be sustained over at least the short term by the stronger stocks, leads inevitably to the overharvesting of less productive stocks in the aggregate. Over the longer haul this leads to chronic conservation concerns for the weaker stocks in the group. What happens next depends on the management response, or lack of, which in turn depends on a complex set of objectives, policies and processes. This is the real subject of this paper.

I wonder if Peter Larkin and Bill Ricker foresaw that Cultus Lake would be the first major Fraser sockeye stock to be classified as *endangered*. Cultus Lake is a very significant late run sockeye stock in the Fraser River. It has routinely produced more than 100,000 adults with spawning escapements of 10,000 to 30,000 or more, and Cultus Lake is also where so much famous sockeye biological research has been conducted. Last but not least, Cultus sockeye once sustained the Soowahlie First Nation people and they view the collapse of this stock, and our failure to protect it, as a clear case of 'structural infringement'. In

simple terms, the Soowahlie people cannot exercise their aboriginal rights to harvest Cultus sockeye because there are too few Cultus sockeye for them to fish.

Where MSY and 'no net loss' are taking us

Fisheries for Fraser River sockeye are in trouble because Fraser River salmon stocks are in trouble. Fraser salmon stocks are in trouble because we continue to overharvest them, at least from the single stock perspective, and the overharvesting is exacerbated by the loss of productive habitat. Cultus Lake sockeye are an excellent example of what is wrong with our process for managing Fraser sockeye and provides a useful illustration of the roles of politics, economics, stock assessment and habitat protection in the conservation of all Fraser River sockeye stocks.

Cultus and Sakinaw Lake sockeye were listed as *endangered* by COSEWIC via an emergency listing in the fall of 2002 as recommended by the Marine Fish Species Specialist Committee. These listings were confirmed by COSEWIC in the spring of 2003 following the preparation and review of formal status reports. These listings recognize explicitly that these stocks are in immediate danger and require immediate protection from threats. The most immediate threat for both stocks was and remains over-fishing although habitat degradation appears to have played a role in the decline of both stocks. Habitat degradation has the effect of reducing stock productivity, which exacerbates the problem of overfishing. These issues are detailed in COSEWIC status reports which will be available soon on the COSEWIC website (www.cosewic.gc.ca). Although Sakinaw Lake is located on the Sechelt Peninsula and Cultus Lake is located in the lower Fraser River valley both stocks are harvested primarily in fisheries for Fraser River sockeye.

The Species at Risk Act (SARA) was proclaimed into law on June 5, 2003 (See Chapter 31, Mawani et al.). Provisions of SARA prohibiting the killing or harming of listed fish or their habitats were delayed by one year and should come into force on June 5, 2004. Under SARA, the Minister has 90 days to respond to the proposed listing and nine months to make a decision. Failure to make a formal decision should lead to the automatic listing of Cultus and Sakinaw Lake sockeye and upper Fraser coho no later than June 5, 2004. Following legal listing, there will be twelve months in which to develop recovery plans, but the prohibitions take effect immediately upon listing or on June 5, 2004, whichever is later.

Before I discuss our management plans for these stocks for 2003 I will review the status of both Cultus and Sakinaw Lake sockeye.

Status of Cultus Lake sockeye

Cultus Lake is located in the lower Fraser River valley near Chilliwack (Figure 10.1). Cultus Lake sockeye have been intensively studied and represent one of the most data rich sockeye stocks in the world.

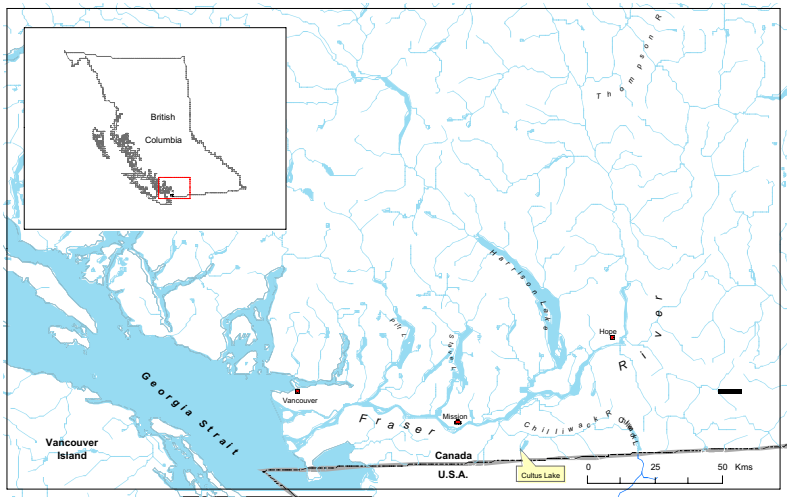

Figure 10.1. The location of Cultus Lake in the Lower Fraser Valley, BC.

The status of Cultus Lake sockeye was reviewed in detail by Cass et al (2002). Cultus sockeye have been in decline for decades. During the 1950s and 1960s, spawning escapements were seldom less than 10,000 and frequently exceeded 30,000 adults (Figure 10.2). The off-cycle years collapsed in the mid-1980s, and the steady decline in the dominant and sub-dominant cycles were accelerated in the mid-1990s as large numbers of Fraser late run sockeye began entering the Fraser River early and dying prior to spawning (Figure 10.3).

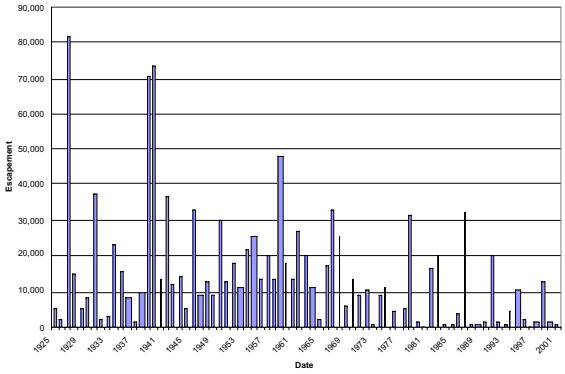

Figure 10.2. Cultus Lake sockeye escapement.

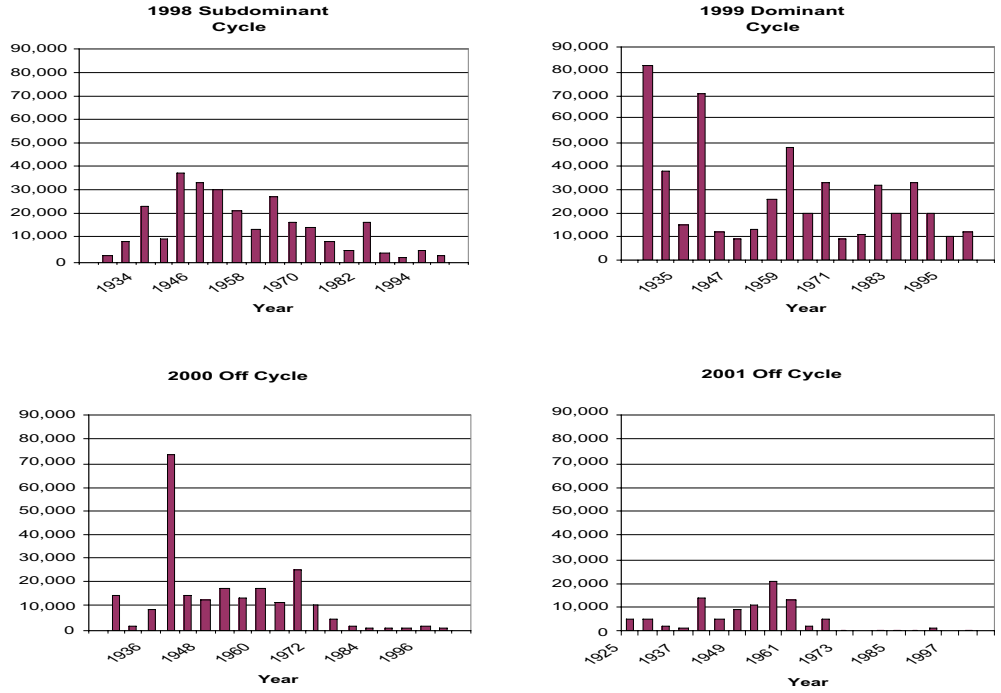

Figure 10.3. The spawning escapement of Cultus Lake sockeye by cycle year.

Cultus sockeye have declined by 93% in three generations due to overharvesting, pre-spawn mortality and habitat loss (Figure 10.4), and throughout most of this time exploitation rates ranged from 70% to > 90% (Figure 10.5).

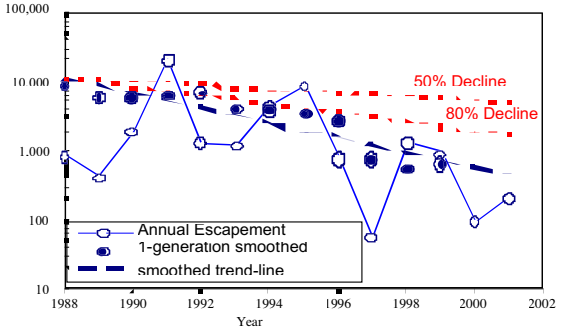

Figure 10.4. Sockeye spawning escapement to Cultus Lake, 1988-2002.

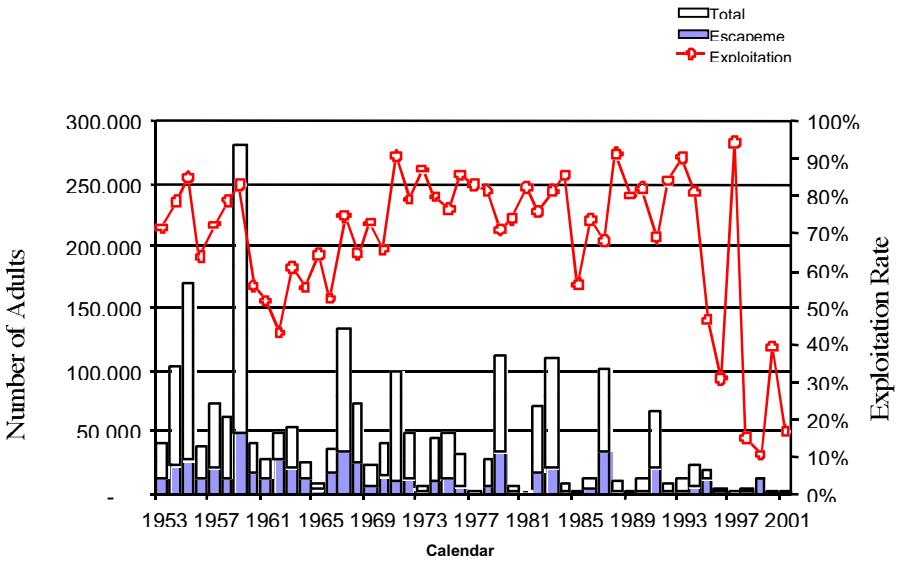

Figure 10.5. Total run, escapement and exploitation rate of Cultus Lake sockeye, 1953-2001.

To put this in a broader context, there are over 50 spawning populations of late sockeye in the Fraser River (Figure 10.6) and only a handful of these are assessed on an annual basis. It is very unlikely that the Cultus sockeye are unique in terms of recent declines; in fact, it is most likely that the Cultus Lake sockeye are representative of many of the smaller late Fraser sockeye stocks. All of these stocks are harvested at high rates in mixed stock ocean fisheries. Figure 10.7 shows the major approach routes for returning Fraser River sockeye.

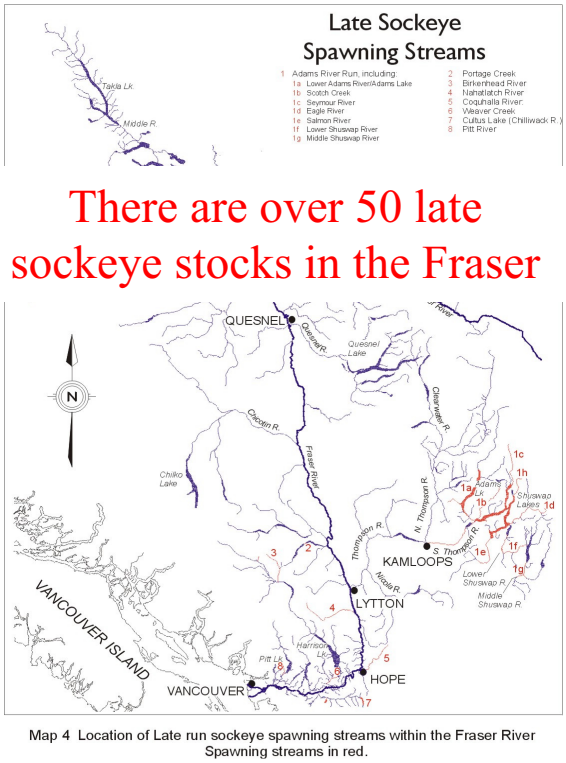

Figure 10.6. The locations of major late run sockeye stocks within the Fraser River watershed.

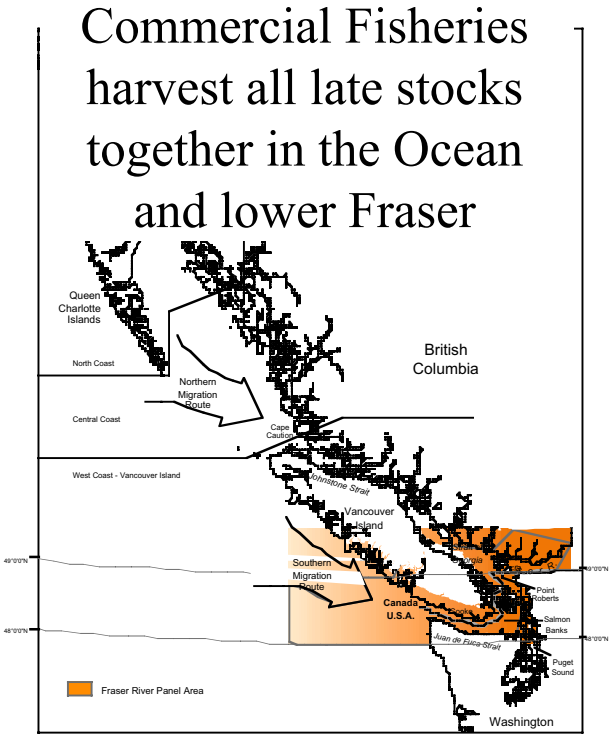

Figure 10.7. The major approach routes for returning Fraser River Sockeye.

The migration timing of Cultus sockeye has shifted dramatically since 1995 (Figure 10.8) and this shift is associated with very high levels of pre-spawn mortality as shown for Weaver Creek sockeye in Figure 10.9. This combination of pre-spawn mortality and high exploitation rates leads to a significant short-term probability of extinction for this stock (Figure 10.10). DFO has estimated the productive capacity for Cultus Lake sockeye at between 56,000 and 115,000 spawners, and has estimated the MSY exploitation rate at 56%.

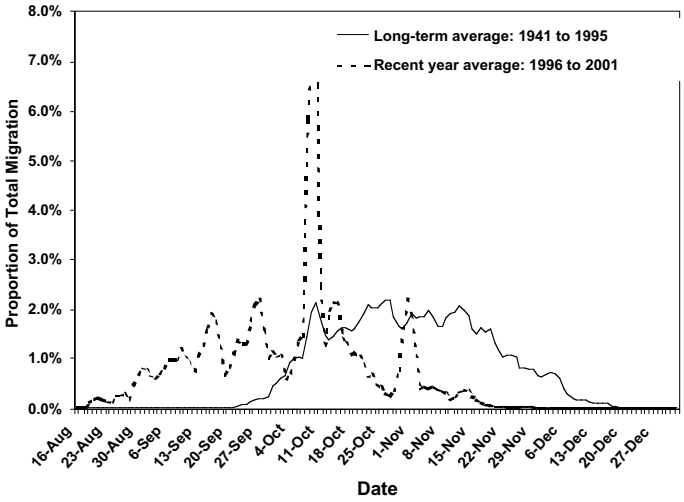

Figure 10.8. Timing of the spawing migration of Cultus sockeye showing the shift to earlier migration timing in recent years.

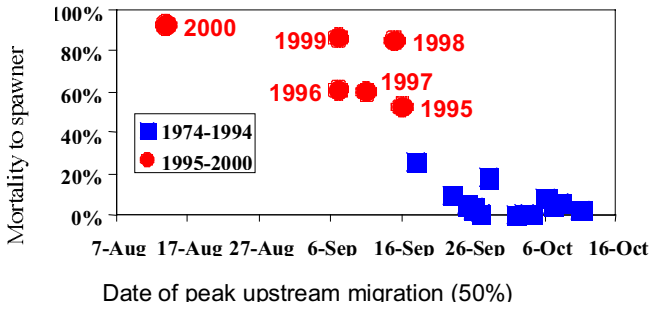

Figure 10.9. Estimates of pre-spawn mortality of late run Fraser sockeye associated with earlier river entry (Weaver Creek).

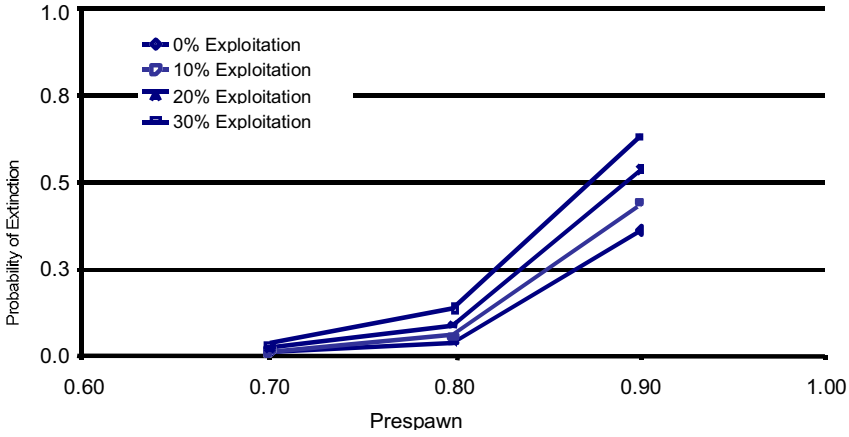

Figure 10.10 Probability of extinction of Cultus sockeye after three generations with varying exploitation rates and levels of pre-spawn mortality.

Status of Sakinaw Lake sockeye

Sakinaw Lake sockeye spawn and rear in Sakinaw Lake located on the Sechelt Peninsula in the south coastal region of British Columbia (Figure 10.11). Murray and Wood (2002) reviewed the status of Sakinaw Lake sockeye for COSEWIC which led to its listing as *endangered*.

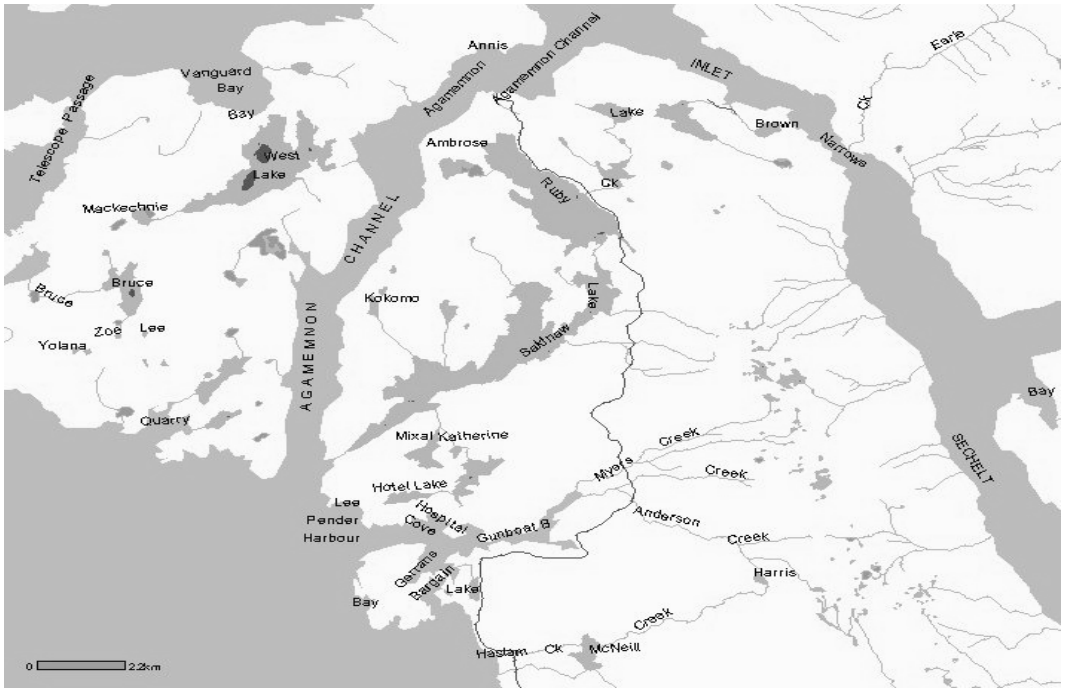

Figure 10.11. The location of Sakinaw Lake on the Sechelt Peninsula, BC.

Prior to the 1980s, spawning escapements on the dominant cycle regularly exceeded 10,000 spawners and the sub-dominant cycle regularly exceeded 5,000 spawners. In the late 1980s, all cycles collapsed (Figure 10.12). Escapements have declined by 98% over the last three generations or 12 years (Figure 10.13).

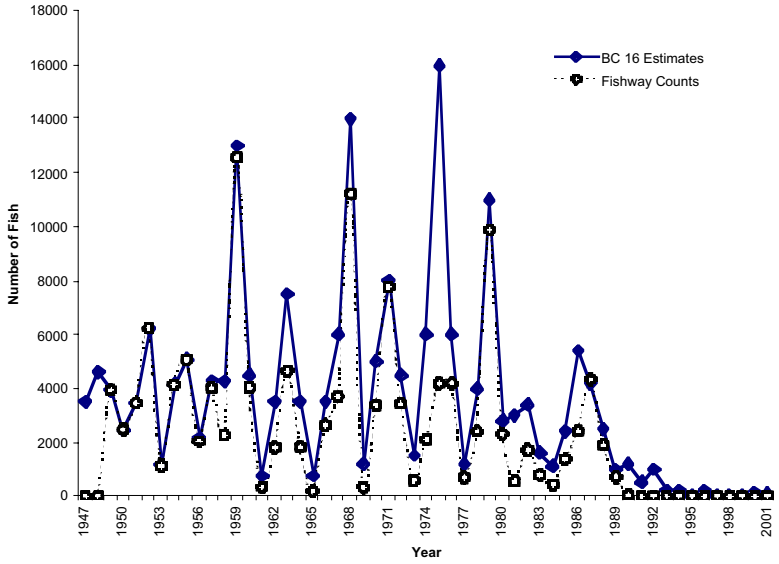

Figure 10.12. Sockeye spawning escapement to Sakinaw Lake BC.

While habitat loss is clearly implicated in the decline of Sakinaw sockeye, Murray and Wood (2002) identified commercial harvest as the proximal cause of decline. Sakinaw sockeye share their migration route (Figure 10.14) with Fraser sockeye and are primarily harvested in fisheries for early summer and mid-summer run Fraser sockeye in Johnstone Strait.

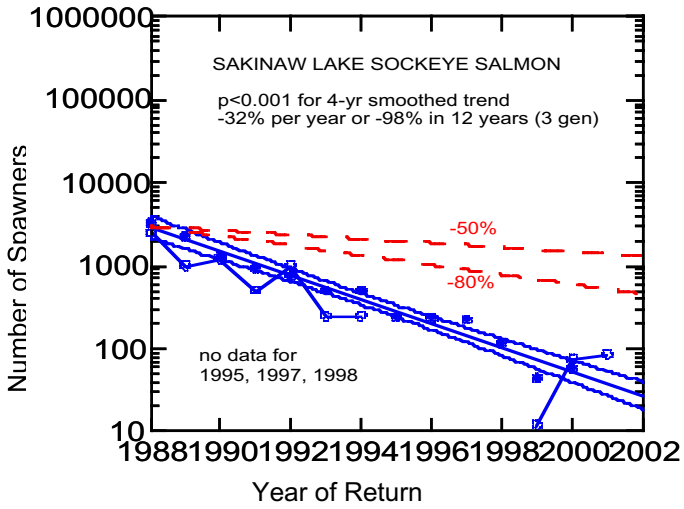

Figure 10.13. Sockeye spawning escapement into Sakinaw lake BC, 1988-2002.

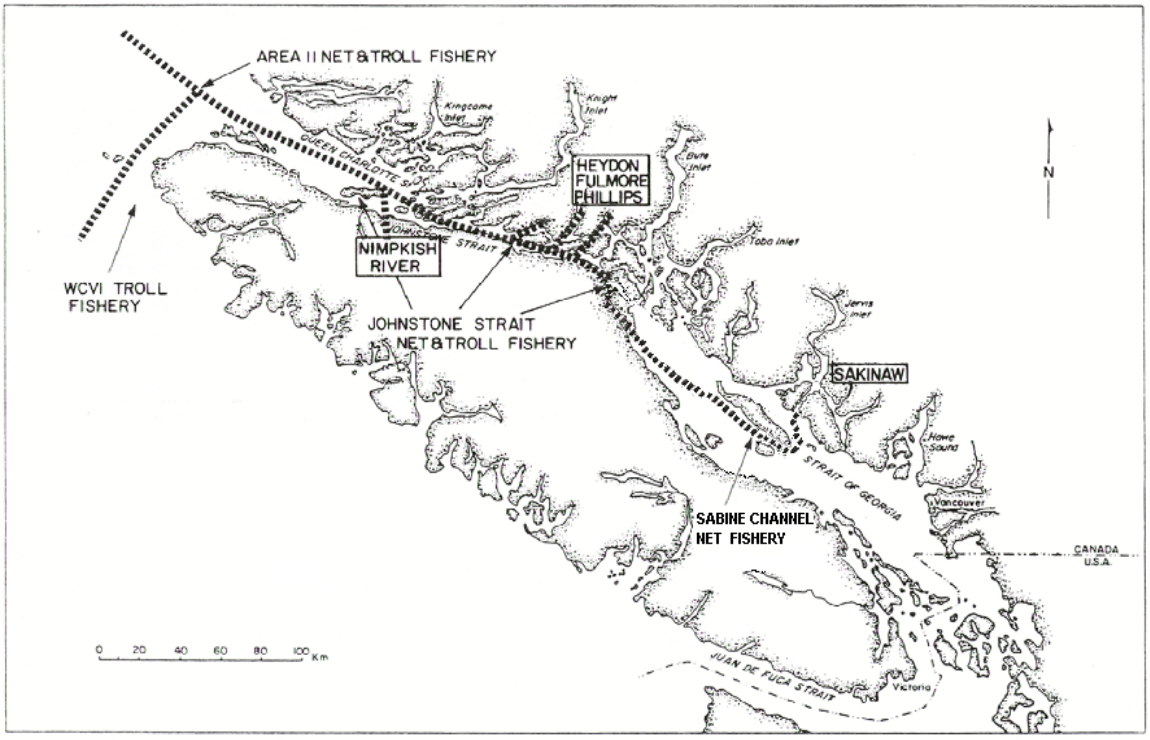

Figure 10.14. Migration route of Sakinaw sockeye.

First Nations issues and concerns

Protection of Sakinaw Lake and Cultus Lake sockeye is a priority issue for First Nations. Both of these sockeye stocks formerly supported food, social and ceremonial fisheries for local First Nations, and can no longer do so. The Soowahlie Band lives on and around Cultus Lake and was a co-proponent of the emergency listing for this stock. Protecting these fish is also a priority issue with conservation organizations including the Sierra Club of BC. These stocks are genetically unique and significant locally

adapted populations, and are an important part of the biodiversity of salmon populations that Canada has committed to protect.

Management implications

The management implications of listing and protecting salmon stocks that are harvested primarily in mixed stock commercial fisheries are enormous. Sakinaw Lake sockeye migrating home are mixed with Fraser bound sockeye and are harvested along the northern approach to the Fraser, primarily in Johnstone Strait (See Figure 10.14). Based on the best available data, Murray and Wood (2002) have concluded that Sakinaw sockeye are vulnerable to all sockeye fisheries in Johnstone Strait prior to early August. Cultus Lake sockeye are one of the Fraser late sockeye stocks and are harvested in Fraser sockeye fisheries beginning in early August in Johnstone Strait and Juan de Fuca Strait and continuing through to the end of the Fraser River sockeye run. Impacts of Fraser sockeye fisheries on both Sakinaw and Cultus lake sockeye must be carefully limited if these stocks are to be protected and rebuilt for the benefit of Canadians.

Management response

In response to the profound conservation concerns with late run Fraser River sockeye in 2002, DFO attempted to limit total fisheries impacts to 15%. The commercial fleet was furious that fisheries for the dominant Adams River late run sockeye were curtailed in order to protect the endangered Cultus Lake sockeye. Protest fisheries erupted, and when the dust settled, the Minister of Fisheries and Oceans ordered an 'all stakeholder' review. The Minister accepted all 14 recommendations of this review. The recommendations covered process (greater involvement of stakeholders in management planning), consultation (new consultative bodies to assist in the development of Integrated Fisheries Management Plans), a renewed commitment to conserve Cultus and Sakinaw sockeye (including a commitment to a science-based risk assessment prior to the development of fishing plans for 2003), and a formal Wild Salmon Policy (to be finalized by the end of December 2003).

The problem facing fisheries managers is very difficult. Figure 10.15 shows migration timing for Sakinaw Lake sockeye. Figure 10.16 shows the timing of major Fraser sockeye runs with the windows of vulnerability for upper Fraser coho in marine water and in-river, including the run timing for Cultus Lake sockeye. The common migration routes and run timing make the harvest of Fraser sockeye, at least in the traditional mixed stocks commercial fisheries, extremely problematic if conservation concerns (just for the three COSEWIC listed stocks) are to be addressed effectively. There are other stocks of concern in the Fraser.

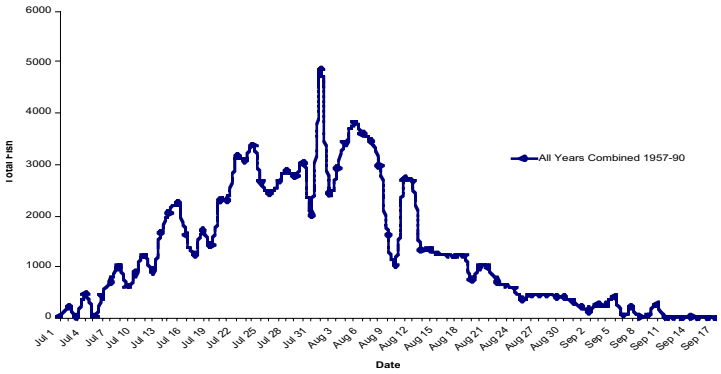

Figure 10.15. Migration timing of Sakinaw sockeye.

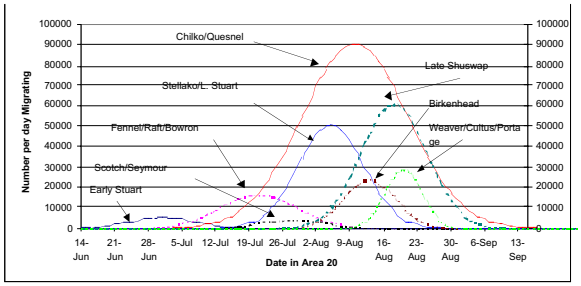

Figure 10.16. Migration timing of major Fraser sockeye stocks showing overlap with COSEWIC listed stocks (Upper Fraser coho, and Cultus sockeye).

Where are we now?
From the ground it appears that the 2002 Fraser Sockeye review never happened. The Integrated Fisheries Management Plan (or IFMP) was released on April 28, 2003. It contained no clear statement of the priority of conservation, and is ambiguous with respect to the management intent of DFO and process for 2003. The IFMP did not attempt to assess the impact of proposed harvest scenarios on stocks of concern with a view to selecting appropriate harvest strategies. No discussion of consultations concerning the management objectives for Sakinaw or Cultus Lake sockeye were provided. In fact, this document provided almost no useful indication of the management intent of DFO.

The joint Fraser Panel of the Pacific Salmon Commission met on Quadra Island from June 2 to 5, 2003 to develop fishing plans for Fraser River sockeye for the 2003 season. On June 5, the same day that SARA was proclaimed into law, an agreement was reached over the expressed objections of Fraser First Nations representatives on the Fraser Panel. This agreement provides no specific protection and provides no statement of management objectives for either Sakinaw or Cultus Lake sockeye, and will lead to a significant increase in harvest impacts when compared to recent years. In 2001, late impacts were limited to 17%, and in 2002 to 15%. The 2003 plan agreed to by DFO could lead to impacts on Cultus Lake sockeye that exceed 25%. With the levels of pre-spawn mortality observed in recent years, the fishing impacts agreed to by the Fraser Panel will continue to push Cultus and Sakinaw Lake sockeye towards extinction. No assessment at all of the impact of the proposed fishing plan on Sakinaw sockeye was provided in the fishing plan.

Practical politics
Relationships among the people that harvest Fraser River sockeye are strained. There appears to be very little trust between the parties. There is no agreement on an escapement strategy for Fraser River sockeye. However, a process is now underway to develop escapement goal strategies for Fraser River sockeye stocks with participation from Fraser First Nations and environmental non-government organizations (ENGOs). An escapement strategy is a difficult undertaking because it requires a clear understanding of the management objectives. This process has become bogged down because there is no clear statement of the management intent of DFO with respect to wild salmon stocks. The Wild Salmon Policy (WSP), which was supposed to provide this direction is still missing in action. We saw the first draft of the WSP five years ago - it contained a list of principles that were to guide the management and exploitation of wild salmon stocks, and established wild stock conservation as an absolute priority. After being reviewed by the Commission of Aquaculture Development (who reports directly to the Minister of Fisheries and Oceans) the Wild Salmon Policy surfaced briefly and then went missing in Ottawa where it remains to this day.

There is no real agreement concerning the allocation of Fraser sockeye. After conservation, food, social and ceremonial (FSC) fisheries by First Nations have an absolute priority. Because many First Nations fish in near terminal areas they favour larger terminal runs which makes their food fishing more productive, but equally important, larger terminal runs benefit the entire ecosystem in ways that Indian people, and most conservationists for that matter, appreciate. As First Nations people get involved in setting escapement goals for salmon stocks that they depend on, and that spawn in their territories, escapement goals are likely to increase. So are the food social and ceremonial needs of First Nations. They will find strong support from ENGOs. Treaties are taking forever, but some tables are making progress. These treaties can and do include obligations to provide for FSC fisheries, provisions for economic benefits from harvesting surplus fish, and processes to engage First Nations in management of the resource. Managing a patchwork of treaty obligations and formal management boards and technical committees will be a fisheries management challenge, no matter how well conceived.

First Nations struggle to find a common voice. There is no clear agreement concerning which First Nations people have an aboriginal right to harvest Fraser stocks. Within the community of Fraser First

Nations successful fishermen harvest mixed stocks in the lower Fraser, while in some upstream areas food fish are sometimes hard to come by. Commercial benefits from fishing salmon are restricted to only a few First Nations in the lower river, but many First Nations want to find ways of improving the opportunities for band members without necessarily selling their food fish. Many are frustrated at trying to find common ground among the multiple objectives at play within Fraser First Nations. Most are frustrated at the glacial pace of change, DFO's approach to sharing decision-making power, and DFO's tendency to protect the *status quo* by minimising the impact of court decisions that recognize First Nations rights.

The commercial fishermen must be afraid for their jobs and families. Strong stocks of salmon are going unfished in order to protect very small populations at risk. They wonder if they can survive until these small stocks recover. They see First Nations, sports fishermen, and even environmentalists getting involved in managing their fisheries, and I don't suppose they like it one bit. I am sure they particularly resent being managed by people that have never set foot on the deck of a working fish boat. They like what they do, are proud of what they do, and they do not want to lose it. They are subjected to complex and ever-changing regulations and restrictions. And nobody listens to them, even when they are trying to offer solutions to problems in their own fishery.

The sports fishermen are busy consolidating their position in the fishery. They are well-organized, and understand and use their political and social capital well. They can adapt to change very quickly, and they can have a fishery with surprisingly few fish. However, there would be a lot more money to be made if stocks were healthy. They are tired of quickly changing, even quirky, regulations that upset holiday plans and empty fishing lodges. They do not like sport fisheries to be closed on short notice, even to mollify First Nations concerns about priority of access. They generate a lot of money for the local economies of places that really need the money and feel that these economic benefits are under-appreciated. They have to pay for a salmon conservation stamp but almost none of the money goes towards salmon conservation.

DFO is a house divided. They have multiple objectives and no clear mandate. Habitat people are frustrated at being unable to stop the steady erosion of habitat and are bogged down by an ineffective and inefficient referral system, and a complex and overlapping system of jurisdiction over water flows. Stock assessment funds are stretched to the limit and DFO is struggling to reallocate funds to address new conservation priorities. The struggles to define a Wild Salmon Policy and disagreements about how to apply the precautionary principle have been divisive, as have budget cuts and strategic (but not revenue neutral) redeployment of fisheries staff into the regions, particularly in the Thompson River and upper Fraser River. DFO is obligated to consult, but does not really have the manpower or a clear understanding of exactly what is involved in good faith consultation. Nor do they have a clear and transparent process to incorporate the advice they receive during their consultations into the development of management plans.

The Pacific Salmon Commission (PSC) process is arcane. The PSC staff is a good professional team but their mandate and focus are limited to matters set out in the Pacific Salmon Treaty and annexes. They recommend, as much as manage, and their carefully worded advice sometimes falls on deaf ears.

Where to from here?

As much as I would like to tell you that Fraser sockeye management would benefit immediately from the development of more complex and descriptive management paradigms and models, I do not think that is the case. Given the political and social complexities of this problem we seem unable to take full advantage of even the limited and dubious insight that MSY models provide into the dynamics of salmon populations.

In an essay entitled "Dynamic Interaction of Societies and Ecosystems- Linking Theories from Ecology, Economy, and Sociology", Scheffer et al (2002) observed that the social system that interacts with the

ecosystem has a dynamic at least as complex as that of the ecological system itself. He noted that stability in such systems might be aided by the emergence of values that have an overriding significance for all members of the 'field'. To paraphrase, we can manage complexity, and uncertainty, but we have to have clear values to help us navigate what Scheffer describes as a 'turbulent field'. We need to work on clarifying the objectives and positions of each of the parties so that we can identify opportunities to work towards common goals. Perhaps more importantly, we need to begin to build some trust.

Fraser First Nations are eager to see the balanced rebuilding of Fraser River sockeye stocks and hope for and expect to share in, benefits. Commercial and sport fishermen want certainty of allocation. Everyone's interests are compromised by putting stocks at risk, but until First Nations, stakeholders, and DFO can sit down and agree on management objectives, we are likely to see continued conflict in the management of Fraser River sockeye. In the meantime, DFO has an obligation to protect and conserve all salmon stocks but particularly Cultus and Sakinaw Lake sockeye and Upper Fraser coho. This obligation does not flow from SARA, but it is strengthened by it. The delays incorporated into the implementation of the Species At Risk Act are intended, in my view, to provide time for orderly implementation and not to provide an opportunity to harvest stocks at levels inconsistent with their long-term survival. Sakinaw and Cultus Lake are more than emergency listings by COSEWIC - they are clear indications of a management process in crisis. Above all, we need to find ways to put fish first, without putting people last.

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CHAPTER 11

State of Canada's freshwater fishes

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Introduction

This paper addresses freshwater recreational fisheries. I generally hear a collective sigh when I mention freshwater recreational fishing suggesting that these fisheries are not very important in the bigger scheme of things. I believe that this is not true. In Canada, the freshwater recreational fisheries involve approximately a million Canadians who like to fish and, depending on the spin that the economists use in their economic evaluation of recreational fisheries, they have been valued somewhere between $4.4 and $7 billion annually. In fact, when you compare this to the economic value of Canada's aggregate commercial fisheries, the recreational fisheries are worth the same if not more. As discussed by Carl Walters (Chapter 16), it is likely that dollars do not follow in the direction of the problems that are developing in fisheries.

Canadian recreational fisheries - the invisible collapse?

I will first provide evidence of the collapse of recreational fisheries, then describe this collapse as largely invisible, and describe the key mechanisms of collapses that Jeff Hutchings and Reg Watson (Chapters 2) referred to and describe the need to understand the mechanisms behind the collapses so that we can adapt our management systems to them. Finally, I will discuss the scientific and management responses to the findings discussed in Post et al. (2002) with respect to fisheries collapses in freshwater recreational systems. This is the first science that I have carried out that has really attracted substantial public attention, and it has been an eye opening experience for me.

Examples of freshwater recreational fisheries decline

British Columbia

I will begin with British Columbia rainbow trout and describe some anecdotal information about collapses. The rainbow trout fishery in Puntzi Lake (Figure 11.1) had fewer than 2,000 anglers annually in the 1960s where it was possible to catch five or six fish in one hour. Two decades later however, the fishing pressure on this system had more than doubled and the catch was only one fish every four hours, a substantial reduction. A similar example occurred further north in the central interior of British Columbia, at Carp Lake (Figure 11.1). Here in the 1970s there were 10,000 anglers and the catch for a recreational fisher was two to three fish per hour but a decade later the pressure more than doubled and it took two hours to catch a fish.

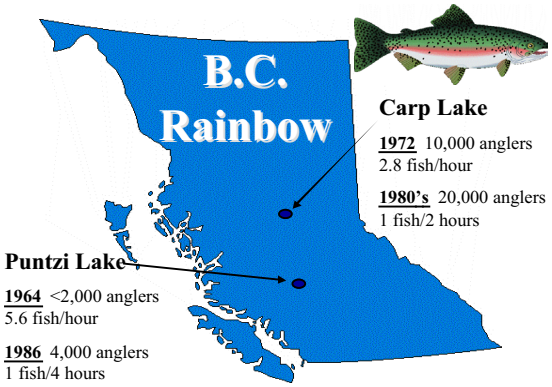

Figure 11.1. Numbers of anglers and fishing success at Puntzi and Carp Lakes in British Columbia.

Alberta

In Alberta the bull trout (*Salvelinus confluentus*) is now a species of *special concern* and in parts of the United States it is listed as *endangered*. In 1995, the province of Alberta instituted a catch-and-release regulation for bull trout province-wide.

However, there is also an example of a good news story for this species in the Lower Kananaskis Lake in Alberta, where we have been conducting biological work for more than a decade. Here in 1991 the population had collapsed to about 60 adults and this stock was about to go extinct. However, we instituted catch-and-release regulations in 1992 and a decade later the population had recovered to 1,700 individuals. This is a population that had clearly collapsed and was on its way to local extirpation, but is now recovering.

This is not the case for the Alberta walleye (*Stizostedion vitreum*). Michael Sullivan, a biologist at the the Alberta Fish and Wildlife Service, has done extensive stock assessment work for this species and he lists the majority of the fisheries in the province as 'collapsed', as the result of overfishing. As shown in Figure 11.2, at Wolf Lake, Alberta there has been an increase in angler pressure by about six-fold over a fifteen year period resulting in a reduction in the quality of the walleye fishery by about 95%, as based on catch rates (Sullivan 2003). This is strong evidence of a collapsing recreational fishery.

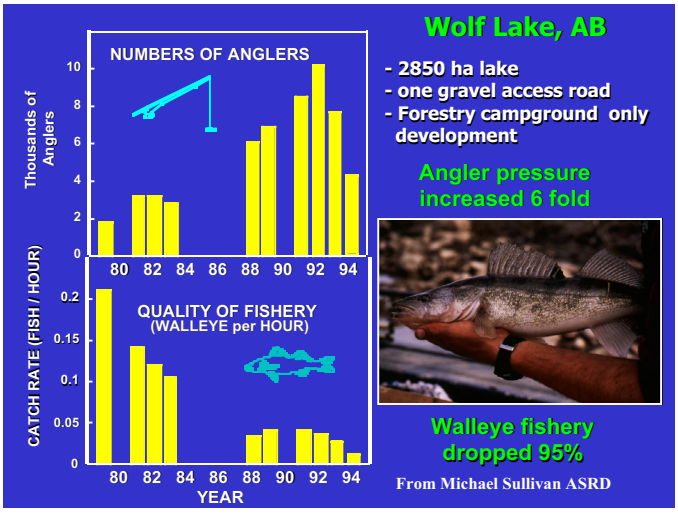

Figure 11.2. Changes in numbers of anglers and quality of fishery, Wolf Lake, AB (1980-1994).

Ontario

There are also examples of collapsed freshwater recreational fisheries in Ontario. In Southeastern Ontario the majority of the lake trout (*Salvelinus namaycush*) lakes are primarily supported by hatchery stocks. Southern Ontario is where the majority of Ontario's population resides. In contrast, in Northwestern Ontario where the human population is less dense, less than 1% of the lakes are stocked. In fact, it has been proposed that we could look at stocking history as evidence of the spatial and temporal spread of collapse of these fisheries. Nigel

Lester and colleagues have carried out stock assessments for a number of lake trout systems in the province where they examined both the abundance and the productivity of the stock and the amount of fishing effort. They also categorized lakes into pristine, transitory, overexploited and collapsed. In Ontario, by far the majority of lake trout populations are either currently over-exploited or have already collapsed.

Why invisible?

These collapses seem to be largely invisible to the general public and to management agencies and they really have not appeared to any great degree in the local press. Why is this? We have learned about Daniel Pauly's idea of the shifting baseline syndrome (See Watson, Chapter 3). Figure 11.3 shows a typical catch rate for lake trout 100 years ago from a lake in Northern Saskatchewan that our grandparents or parents might have seen.

Figure 11.3. Catch 100 years ago at one family's fish lodge at a northern Saskatchewan lake. Source Post et al. 2002.

There are very few areas in Canada now where we or our children or grandchildren will ever see catch rates like this. This photograph was taken by a lake where the primary fishery was for lake trout 80 years ago and, within 30 years, the lake trout had been extirpated. Then a walleye fishery developed and within 25 years the walleye fishery had been extirpated. Now this same lake is primarily a pike fishery and, if it goes the direction of many of the pike fisheries in Alberta, then it will also be extirpated in a relatively short period of time. We just do not remember what the past held.

For a large number of reasons, these collapses have been largely invisible to the public. There are tens of thousands of fish populations in Canadian freshwater fisheries and yet we have too few biologists - the bottom line is, we do not know what is going on in most places at most times. There are tens of thousands of individual fisheries and each one is small and only of local importance. If there is a collapse in a particular fishery, it is the bait dealer or the cottager, who lives on that particular lake, that is affected and it really does not resonate at a larger regional or national scale. Also, there seems to be a strong focus on habitat enhancement projects - I think of this as the engineering approach, "do not worry, we can fix it" and, in many cases, we cannot "fix it" and we often mask the problem with stocking.

Angler behaviour

We have studied the behaviour of anglers relative to travel time effort and fishing quality (Post et al., 2002). One of the advantages of working in the sourthern interior of British Columbia is that there are about 800 rainbow trout lakes in the area and we can easily study fish population dynamics as well as the behaviour of the predators – the anglers, in these systems. We have found that there is a clear relationship between the amount of fishing effort and the quality of the fishery, or the fish density itself, and that systems closer to the Lower Mainland of British Columbia, and the city of Vancouver, attract much more fishing effort than do those that are further away (Figure 11.4). For rainbow trout lakes that are close to the Lower Mainland and a

short travel distance (two to three hours away), there is relatively low catch per unit effort of fishing quality compared with those that are six to eight hours away. One might suggest that the more northerly lakes have higher productivity and therefore result in this higher quality but, indeed, that is not the case at all; in fact, it is just the opposite.

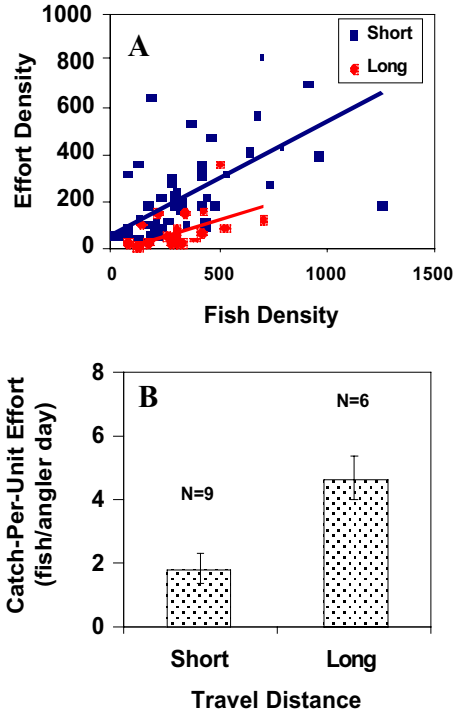

Figure 11.4. Travel time, effort and fishing quality for rainbow trout in south interior BC.

If fisheries behave in this way, one would suggest that, as angling quality declines due to over-harvest, the efforts would dissipate and the anglers would go off either to other systems to angle or else choose another recreational activity. Systems that work this way, one might suggest, should be self-regulatory and we should not have to worry about collapse. Carl Walters might suggest, with his rubber mallet model for regional dynamics, that if we use some enhancement procedures, such as through stocking, or if we are lucky environmentally and we get several good years of recruitment, that populations would rebound within a region. However, if anglers behave the way that I suggest they do, then essentially the rubber mallet comes out and whacks it back down within a very short period of time. What this means to the regional management people is that it is very hard for them to present a mosaic of fishing opportunities - everything gets reduced to the lowest common denominator. This is a difficult system in which to manage.

A good numerical example is the walleye fishery in Alberta where there is information from approximately 24 different lakes (Figure 11.5). The red lakes depicted are all in central and eastern Alberta; the 'Y' axis represents the success rate of anglers or the proportion of anglers that can catch and harvest a walleye in these systems.

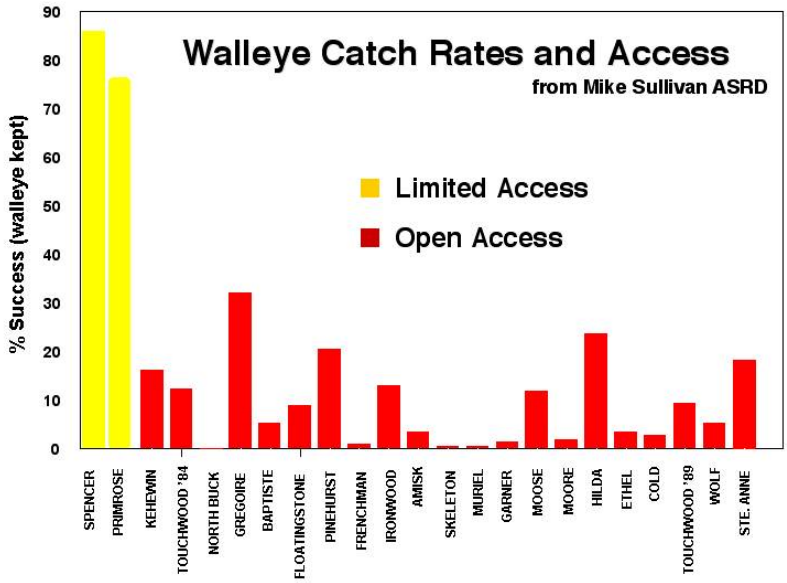

Figure 11.5. Walleye fishery catch rates and access for 24 different lakes in Alberta.

The two that stand out on the far left-hand side are on the Cold Lake military range. These lakes are side-by-side and share equal productivity. However, one has very limited access and one has open access, so the access component is obviously a very important part of this story.

If effort really works this way, then we should expect these fisheries to be self-sustaining, albeit in a state that is inversely proportional with distance, or access. The core message here is that there are a series of processes that might hinder this recovery. We have already learned about this example and it is one of the key mechanisms that has been identified for the collapse of the cod off the east coast (Chapter 3, Hutchings).

Mechanisms that can lead to collapse or hinder recovery

We know that fish populations aggregate and they either aggregate behaviourally or around high-quality habitat. When there are a lot of fish, you have a fishery with high population size. As we harvest these populations and reduce their abundance and the size of the population goes down, as shown in Figure 11.6, as more fish are harvested the populations continues to decline. There are two key points: the first is that the per capita mortality increases as the abundance of the fish stock goes down (left hand line graph, Figure 11.6) and, second, anglers' catch rates, which are the density-dependent catchability equivalent to the Allee effect described by Jeff Hutchings (Chapter 3) do not decline as the fish stocks decrease and, in fact, remain relatively constant until they reach the point of collapse (left hand line graph, Figure 11.6). This is what population biologists would call a depensatory process and the implication is that, as populations decline, their ability to rebound actually decreases and there is a higher per capita mortality or higher catchability. Clearly this is a mechanism that can lead to collapse.

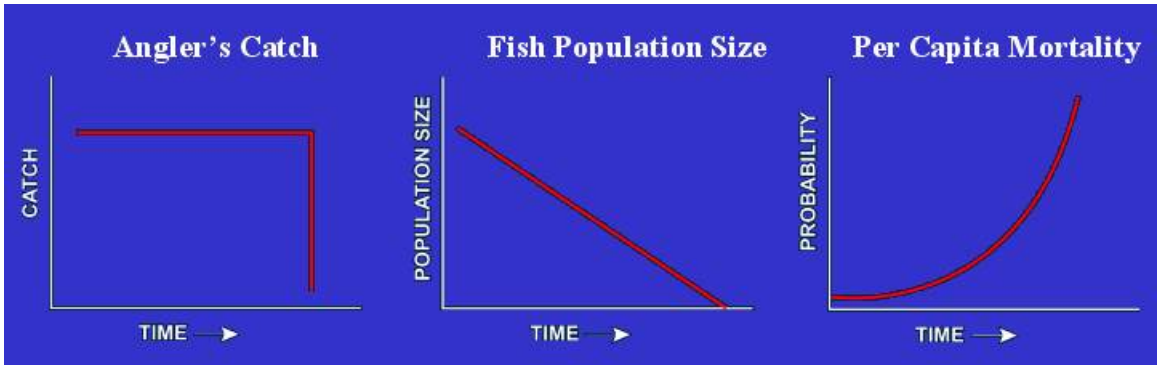

Figure 11.6. Depensatory process.

Depensatory mortality

Do populations actually work that way? As Jeff Hutchings discussed (Chapter 3), there is some evidence of this in the literature, although it is not particularly strong. One of the advantages of working in small inland lakes is that it is relatively easy to do experiments and get good quality data. This is exactly what Brian Shuter et al (1998) have been doing in northwestern Ontario where they show very clearly that, as fishing pressure reduces the abundance, it is actually the inverse of what you would expect; as the abundance is declining the per capita mortality or catchability goes up leading to this mechanism of depensatory mortality (Figure 11.7).

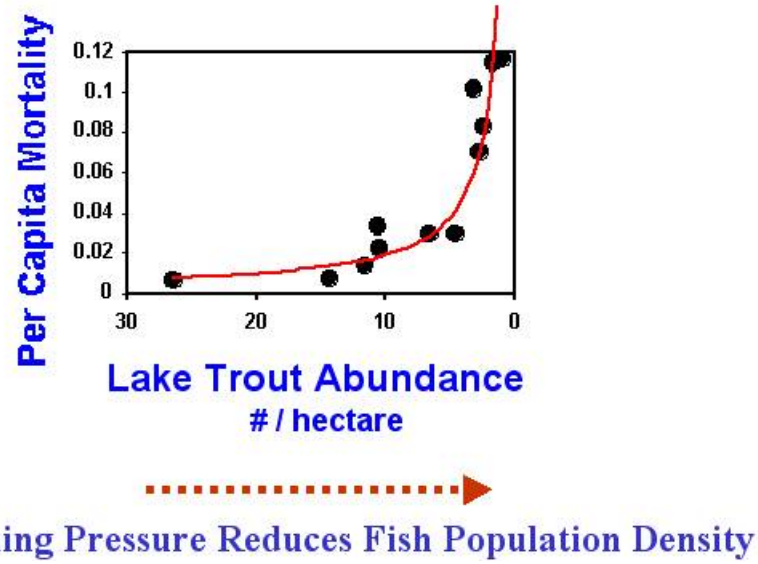

Figure 11.7. Evidence of depensatory mortality in lake trout populations in Northwestern Ontario (Shuter et al, 1998).

Non-compliance with regulations

Michael Sullivan in Alberta has shown that a common management response to overfishing in recreational walleye fisheries is to put in minimum size limits to protect the stocks (Sullivan 2002). He has used some clever "test fisheries" to determine what the proportion of illegal harvest is in these fisheries. He showed clearly that once catch rates decline to a low level, such as one fish per day, non-compliance mortality increases dramatically (Figure 11.8). This is another mechanism that is depensatory; there is greater negative effect on the walleye population as the population declines. This represents another mechanism that can lead to collapse.

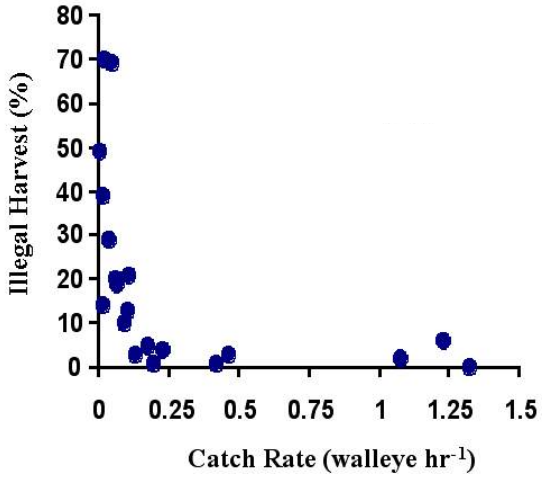

Figure 11.8. Effects of non-compliance with regulations on catch rates for a recreational walleye fishery (n=20; Sullivan 2002).

Food web alterations through exploitations of producers

Another process discussed by Carl Walters and Jim Kitchel (2001) was based on the hypothesis that unexploited fish populations of recreational fisheries, which tend to be large-bodied and piscivorous, manage to suppress the abundance of their forage fish species through predation, and these forage fish species are competitors and potential predators on juveniles of the sport fish.

When these populations are exploited the size structure is reduced and the abundance of the large predators and the forage fish species rebounds and there is a dramatic increase in the competitive and predator/prey effects of the forage fish on the recreation fish (Figure 11.9). This is also depensatory because this competition and predation has a much stronger negative effect on the species of interest to recreational fisheries when populations are low than when populations are high. This is a mechanism that can lead to collapse and also potentially (not dissimilar to the seals on the east coast) has the effect of suppressing the recovery of the fish populations.

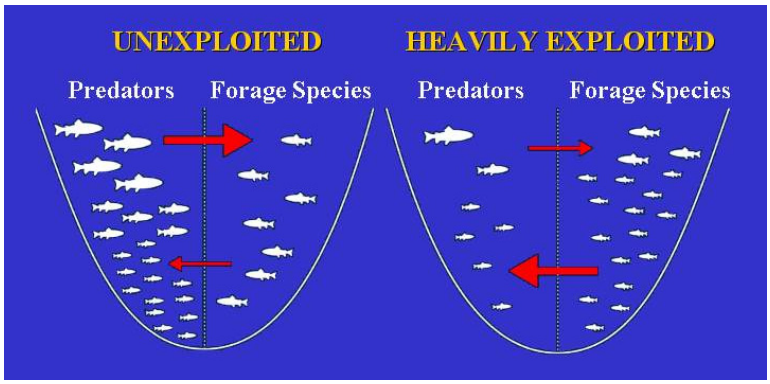

Figure 11.9. Food web alterations through exploitations of producers.

Do populations work this way? Again, we are collecting data to test these ideas (Post et al. 2002). In the lower plot (B) of Figure 11.10, for a small number of systems, we have collected information that shows that minnows are exponentially higher and have an exponentially greater competitive predator/prey effect on the eggs and larvae of the sport fish when the walleye abundance is low through overfishing. It appears to be a mechanism that, at least in some situations, is at play. This is depensatory.

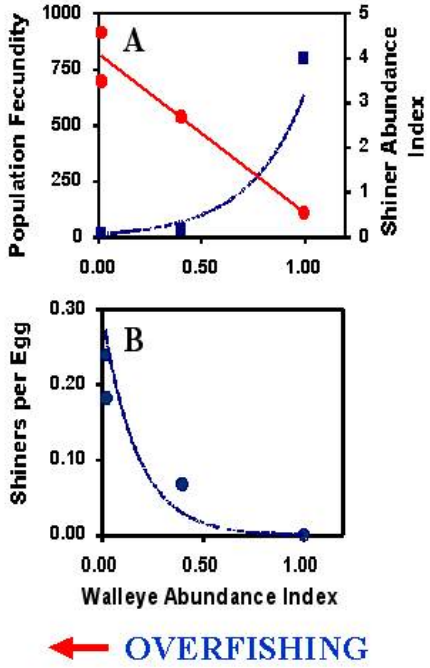

Figure 11.10. Food web impacts. Population fecundity and shiners per egg as a function of walleye abundance index.

When the angler effort response is combined with these mechanisms of collapse, density-dependent catchability or per capita mortality, cheating on regulations, food web interactions and others, I suggest it is not unexpected that we will see the collapse of many Canadian recreational fisheries. I also suggest that these are not very different from many of the commercial fisheries.

Depensation and compensation

In Figure 11.11 the upper plot on the right-hand side, the dash line, incorporates how we think many populations in nature work with strong compensation - the highest per capita population growth is when the population is small. That is the resilience that we expect to see in ecological populations and we suggest that populations would grow to some sort of equilibrium or carrying capacity, 'K'. If we recognize and agree that there is a series of depensatory processes that act on top of nature's capability to rebound, then that pattern changes dramatically - that is the solid line on the upper plot in Figure 11.11. When these depensatory processes are

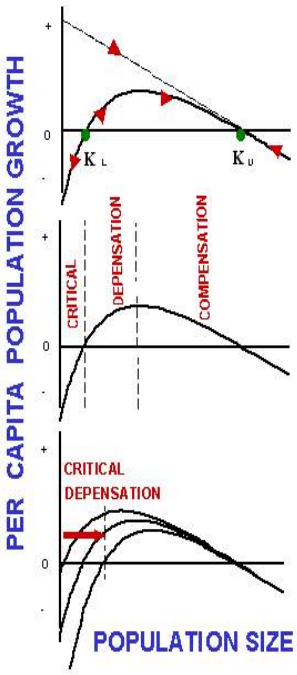

Figure 11.11. Logistic population growth with depensation and compensation. Source Post et al. 2002.

added in, we get into a situation where, when populations are high-density, there is compensation and populations can recover from overharvest. At some intermediate densities, there is a zone where there is depensation; that is, the per capita population growth is reduced as populations decline until the point is reached where the line dips below a per capita population growth of zero (in the ecological literature, this is called the predator pit). We learned earlier that in many fisheries, we are digging deep holes. This is a numerical example of one of those holes and the suggestion would be that, once into this area, populations cannot rebound, and actually have negative growth rates. A couple of very important implications of this are that, if we all agree that these depensatory processes are key parts of the systems we are working on, then we have to maintain higher populations than we would expect (if we think populations are strictly compensatory) in order to achieve a maximum production and that, overall, the production is declining. Models used to assess sustainable harvest rates must contain these depensatory processes if they are occurring in our systems.

Conclusion

What do we really know?

Fishing quality in recreational fisheries seems to be driven largely by angling effort and productive capacity (not discussed here). I would argue that recreational fisheries are not self-sustaining and should collapse when overexploited. This is exactly the opposite message from what you read in journal articles about recreational fisheries.

Public response

The outcome of the work that we published over a year ago (Post et al. 2002) has been to raise public awareness about the state of Canada's freshwater fishes. Canadians like to fish and these findings have been picked up by the media, resulting in my participation in more than fifty interviews and talks, including TV, radio, print and electronic bulletin boards Canada-wide and in the US. Some of the responses are very illuminating. We have heard everything from "This isn't news, we have known it for years", "Fishing is better than it has been for decades", "Finally someone has the 'guts' to tell it as it is", to "Those darn academics should get out of their ivory towers".

One of the most interesting responses was an article written by Andrew Nikiforuk, which was published in Canadian Business Magazine in November 2002 and focused on the economic value of Canadian recreational fisheries. He asked the question, "Why are multibillion dollar sport fisheries in trouble?" That media outlet made its way onto the desks of many individuals.

Equally interesting, if not more so, has been the response of science and management people from across the Canada and the US. For example, the response came as, "I guess those Canadians don't know how to manage their fisheries". This was from a reviewer of our article. This person most likely manages fisheries and productive reservoirs in the southern United States that mature at age 2 and produce tons of eggs. That type of system is easy to manage. Contrast that to the lake trout that we are currently studying in the lakes of the Yukon and Northwest

Territories, that mature at somewhere between 14 and 18 years of life. These are very different system in terms of their productive capacities. Another response was, "This is blown all out of proportion– fisheries in my province are in great shape". This came from a senior manager of a province that has many lakes and few people. If you have low fishing effort, no matter what management approaches and regulations you use, you are going to be successful.

The key part of these responses is that 1) we have to know what the productive potential of the fisheries is, and 2) we have to understand that these systems (and this applies equally well to commercial systems) are made up of the dynamics of the fish and the dynamics of the harvesters and you really have to be able to put the two together. Here is another example that is a little more heartening, "This is great, it should increase the profile of funding for fisheries research and management".

The bottom line is that there are things that we need to do differently when we are managing fisheries, whether they are recreational or commercial.

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CHAPTER 12
Dialogue following State of Salmon Stocks and Habitat

How to move the discussion forward and give clear direction to the politicians and managers?
Karl English asked: How do we get there? We have a problem associated with getting all the scientists on the same page with conservative approaches to fisheries management and fisheries advice to politicians. We have to have a fair degree of culpability in the demise of these stocks. How can we improve our ability to get on the same page and move the discussion forward to give clear direction to the politicians and managers?

Brian Riddell noted that he does a lot of work in the Columbia basin in the US side in addition to his work in BC - a process that is useful there is their use of independent science organizations. These are people, largely from outside the Columbia basin, who are brought in for their proven scientific capabilities and background; they are very diverse groups of 9-12 people who try to give a credible balance as to the pros and cons and, from there, it goes to the decision-makers. In his opinion, the only thing a scientist can really do is try to provide the clearest, most honest, objective assessment of the situation that they can and to write that in such a way that people can understand. These organizations actually proved to be quite successful at doing that and, in the Columbia, that has really helped the people there. We do not have a process like this in Canada as yet.

Getting the right message to the public
John Fraser commented on the importance of getting the message out to the public. He explained that three years ago, when the Pacific Fisheries Resource Conservation Council prepared a report on the state of the salmon stocks in British Columbia, they had to point out that, on the data available to them at the time, the salmon stocks along the west coast of Canada, British Columbia, were at the lowest in recorded history (see also http://www.sfu.ca/cstudies/science/salmon.htm). Then last year, reminding everybody that is what they had said three years ago, they had to record that as a consequence of increased ocean survival, a lot more fish were coming back from California right up through British Columbia. He stressed the importance of focusing on whether we are doing better or worse and in what context; otherwise the public will not understand what we are talking about.

What is the scale of overfishing in the Russian Far East and how much of it can be attributed to the change in political regime?
Terry Glavin posed the following question to Xanthippe Augerot: In the Russian far east, how much of the overfishing is attributable to the collapse of order since the Soviet Union fell apart? What is the generally accepted view of what the scale of overfishing is in the Russian Far East?

Xanthippe Augerot replied that one would find varied statistics about the extent of overfishing in the Russian Far East. It varies by region in terms of access and just how expensive it is to get to the rivers. Many places are only accessible by helicopter. For example, based on the estimates from the Amu River, that she has heard about from her biologist colleagues, in some river reaches the real take rate is five to seven times the reported rate in the commercial fisheries and in the so-called sports fisheries, which are really personal-use fisheries. In other areas, the estimates are that the real catch rate is anywhere from 20%-70% more than the reported catches. This makes it particularly hard to be straightforward, in addressing John Fraser's comments, because it is difficult to calibrate what the reported catch rates mean across the Russian Far East. Different calibrations in different places would be needed in order to tell the true story.

The overharvest and poaching is associated with the collapse of the Soviet Union, although there was also some poaching prior to this. The collapse of order is at least as important as the collapse of the economic system. The collapse of the economic system, and the lack of livelihoods in many remote locations, has been blamed for most of the problem, but it is also due to inattention and a culture benefiting or profiting from natural resources wherever this is possible, with a short-term view. That attitude goes from the regions all the way up to Moscow and it has shown up recently in the political murders of the Governor of Magadan and a General in Sachaline as well as the border guards and in various kinds of investigations of different fisheries and management agencies. This has resulted in turf battles between groupings of people trying to dip into the buckets of profits from salmon and other fisheries.

Risk of extinction – timing of measurements

Guido Rahr commented that when Xanthippe and her team were looking at the data for the Russian Far East on salmon stocks, at first, it did not look so bad – that was, until they realized that they were measuring a risk of extinction and that is a pretty high bar. Long before the fish are extinct there are big food web impacts and cultural impacts. He noted that he is not absolutely sure that the risk of extinction is the only thing they should be measuring and that maybe there are other metrics that will reveal the true magnitude of the declines. An additional comment is that, by the time the fish are noted on the risk of extinction chart and observable declines have been catalogued over some period of time, the impacts are entrenched - there are 100,000 people in the watershed or there is a serious harvest factor or some development in the watershed. He noted that they are behind the curve at that point and, by the time they notice what is going on, the ability to do something about it may not be effective.

The problem lies with management

Robert Kreutziger commented: I have a document produced by the Department of Fisheries and Oceans which states that 75% of salmon fry are cannibalized by the predation of Dolly Varden and the trout in Adams Lake. That left, after the ocean migration, only 5% returning. At one meeting I asked the question of a DFO scientist, "What is the migration route of exiting salmon fry out of the Fraser River, lower mainland and American side of the Gulf of Georgia?" The unequivocal response was Johnstone Strait. But then I read a report also written by DFO scientists where they opened up the stomachs of the farm fish in pens from the lower part of Johnstone Strait – and they found salmon fry in the stomachs of those fish. How did they get into the stomachs? This is confusing. The one report it says that only 5% of the fish that went to the ocean came back but that was in 1986. Since then, we have exposed these fish to fish farms and pitlamps - if we cut that 5% in half that is 2.5%. What are we doing to stop the diversion and decline of our salmon fry? The information is here but you can't use it. This is a management problem, and not just a fisherman's or a conservation problem. We should open our eyes - we can save this fishery.

John Fraser replied that the participants at this workshop are all here because, maybe not as explicitly and perhaps not as vehemently, they want to be sure that there are wild fish on this coast well into the future for as far as we can see. Secondly, many of us believe that the value of the wild fish, if properly managed, can continue to benefit the people on the coast for generations to come. The notion that there is no more

traditional commercial value for the wild salmon stocks is, in his view, something that is propagated by those who, first of all do not want to spend any money on the management of wild salmon stocks and, secondly, do not understand anything about the economic base of British Columbia. While it is true that the revenue from the wild salmon stocks and the traditional types of commercial fishery have gone down, relative to some years ago, the value of the wild fish stocks is still extremely important - the tourism, outfitting, guiding and sportfishing industry depends on it – let alone the concern of First Nations. Certainly, to abandon the potential for a useful commercial fishery on wild salmon would be a great mistake. He assured Mr. Kreutziger that it is important that he is here and that he said what he said and he thanked him for coming a distance to come and speak to us as frankly as he has, and also speaking to us with a lifetime of experience.

Brian Riddell replied that he could not comment on the specific examples without seeing the material; however, he noted that if we come back to the value of the commercial fishery, anyone who is not familiar with fishing in British Columbia should understand that, in the past decade, there have been enormous changes. In different people's minds, some of these are positive and some negative, but there has been a lot of attention paid to trying to provide a better future for the fishery. There have been enormous costs, in the short term, because of the poor marine survival. However, we would not have achieved a number of escapement goals and we would not be seeing as many fish on the spawning grounds, if it were not for the sacrifice of the commercial fisheries. These commercial fisheries, of course, have to be managed so that they are sustainable. Many conservation groups will point out that it is not a 'right' to actually go fishing, it is an 'opportunity' to go fishing. We want to ensure that the fish are preserved for the future for everyone and that there certainly is an expected future for commercial fishing in British Columbia. He believes that we are seeing as many impacts from market value changes, as we are with the salmon runs and there is no question that salmon farming has affected markets, such as for pink and chum salmon. All of these things come into the big picture. We are not giving up on the commercial fishery - it has been important for 120 odd years of history in British Columbia and will continue to be.

Can recent increases in pink salmon returns be attributed to increased ocean survival?
Lee Montgomery noted that three presentations referred to recent increases in pink salmon and asked if the presenters could speculate on the reasons behind that?

Mitsuhiro Nagata commented that this could be attributed to both better ocean conditions and hatchery improvements. This is supported by their data about the relationship between the size of the juvenile stock and returning rate. There are some indications that in recent years however ocean conditions may be getting worse and it is possible that pink salmon may decrease with this shift.

Brian Riddell replied that the recent returns in Puget Sound, Southern BC, and the central coast of British Columbia up to Prince Rupert have all been substantially increasing in the past couple of returns. In the 1990s pink salmon went through one of their all time lowest periods of marine survival. The only place where they can actually measure marine survival at all is in the Fraser River and, in 2001 in the absence of any real commercial fishing, there were in excess of 22 million spawners in the Fraser River – that is the largest ever number recorded in recent time (although possibly not back in the turn of the century). Clearly, across the board because of the wide distribution, it was a marine event that allowed for it. To get that many fish back, one had to have successful recruitment from fresh water as well. He noted that Bill Heard may be able to comment about poorer return in the Southeast Alaska region last year.

Bill Heard replied that the pink returns in Southeast Alaska last year were below the last ten-year average. However, this last ten-year average has been relatively high. In the Prince William Sound SouthCentral area, the run was about normal last year.

Xanthippe Augerot noted, with the caveat that she was not an expert in pink salmon dynamics, that the catches have been very good for pink salmon at the southern edge of their range in the Russian Far East, in the Northern part of the Japan Sea and on Sakhalin Island. In fact, they have attained some peak run sizes on Sakhalin Island for this recent history. On Kamchatka, they have had not had such strong run sizes and there have been some disappointments. She believes that on Sakhalin Island they attribute part of their success to their very active hatchery program - they have recently renovated almost all of their hatcheries with the help of Japanese technology and funding assistance. Given the pervasiveness of the pattern, it is also very likely due to marine conditions.

Ocean Survival

John Fraser commented: Studies have shown that we have had for a number of years a better marine survival from California North. However, we are in a period of El Nino and I am wondering if anyone wants to speculate whether or not that is going to affect the ocean survival of salmon that are out there in the ocean now and due to come back sometime this coming fall or the following year?

Brian Riddell noted that in preparation for the upcoming report of the Pacific Fisheries Resource Conservation Council, he had discussed the developing El Nino with scientists at the Institute of Ocean Sciences and their sense was that it was starting to show development but really did not mature - that it was a very small El Nino and they are not expecting a major change in production. We should be clear that El Nino is not the only determinant of the production. It can be related to certain populations in British Columbia but the big changes that we are talking about, in pink salmon for example, are largely related to the north central Pacific regions. Some of the other environmental indicators actually do a better job of predicting change. He referred to Mitsuhiro Nagata's comment about indications of decline and noted that he had not yet heard that for North American salmon.

The relationship of the BC Treaty Negotiation process to salmon management

Karl English noted the troubles on the Fraser River that Ken Wilson had referred to and the difficulties and challenges that lie ahead with Treaty Negotiations and the lack of resources and asked: Do you see the Treaty Negotiation process as a part of the solution or a part of the problem?

Ken Wilson replied that the Treaty process is proceeding and at some point we will begin signing treaties in the Fraser. At that point we will have to start managing our fisheries to address the goals and obligations that are incorporated into those treaties and therefore management on the Fraser River will become more complex. It will create some problems but it will also create some opportunities because the benefits will be redistributed and people will start to take some ownership for the problem.

On endangered status and Cultus Lake sockeye

Terry Glavin noted that he was a member of the 2002 Fraser Sockeye Review Committee, and he commented that it was his experience that the availability of data can sometimes confuse issues almost as much as the lack of appropriate data. For example, the Cultus Lake sockeye is a data rich population, but what can we say about the status of Cultus Lake sockeye in relation to the other co-migrating populations of sockeye within that late run timing group? Since the Cultus Lake sockeye stock is the only one that is officially declared as *endangered* , on the face of it, a lay person would say that this is the stock that is in the worst shape, but is that what we should be assuming?

Ken Wilson replied that he did not think it is safe to assume that. There are a number of late stocks and they have all been suffering under the burden of 80-90% pre-spawn mortalities for the last five years. The biggest stocks, such as the Adams River run, have the biomass to put up with this load for a little while but smaller stocks are the ones likely to be most affected. There are lots of other stocks that are far smaller than the Cultus Lake sockeye, such as stocks from the Widgen Slough, and there are 50 or so places in the lower Fraser where there are what they believe, late stocks, and these stocks are subject to

the same sorts of mortalities. In his opinion the Cultus sockeye probably, in some ways, is representative of other late stocks that are too data impoverished to really assess.

What about lake fertilization?
Robert Kreutziger asked why lake fertilization could not be used to rebuild the Cultus Lake sockeye? He gave the example of the rebuilding of Weaver Creek – he referred to a document that says, "Dead salmon are removed from the channel daily and the carcasses are buried upstream beside the Weaver Creek." He told the story about a man in Campbell River fifty years ago who told him that he was assigned the job at Babine Lake of raking carcasses out of the lake. He said to the Fisheries Officer, "You can't do that. You are starving the fish." Sockeye don't eat each other, they work off the ecosystem. He suggested that we should try to recapture some of that mentality of lake fertilization and the transplantation of carcasses so that there is no waste - that would help to replenish the whole ecosystem.

Ken Wilson agreed that these were good suggestions but commented that before we go too far down this road, we all have to be able to sit at the same table and have a civil conversation about what we are trying to accomplish with the management of these stocks.

Is there any hope and can it be turned around?
Otto Langer asked if it is possible to design a recovery pilot program for DFO in face of all the challenges that Ken had outlined in his presentation. He noted that they have resource cuts and a confused will, and the complexity of their job has increased greatly over the last twenty years in addition to real problems at the management level. Is there any hope that it can be turned around?

Ken Wilson replied that when two ends of the string don't meet, you have to re-think the problem. It is fairly clear that DFO is struggling in a lot of different directions but they are trying to do too many things, too much of the time. That is why he was arguing that DFO needs to sharpen its mandate so that the resources they have are sufficient to fulfill it – to do this they are going to need to off-load a lot of things. He added that we are also going to need to find creative ways of funding things because DFO is not going to be able to do it. We can all yell at the government and urge them to do their job and provide us with the money we need to do ours but, realistically, he believes that we will have to find ways of accommodating the changing (diminishing) budgets of DFO and we are going to have to do it through changing our priorities and policies and partnerships. The first task has to be soul-searching.

Is the regional management approach part of the solution?
Wayne Jacob asked: Could you comment on the fact that DFO is quite likely going to be moving to regional management, which takes a broader perspective in management and increases the participation of multiple parties and leads to models that are based more on economics such as the multi-attribute style of resource evaluation. How do you see that process working in the future and, in particular, for the Fraser River sockeye stocks?

Ken Wilson replied that he supports this move, and gave the example of the recent movement of more DFO staff to Kamloops, in interior BC. He noted that over the next ten or fifteen years we are going to see a lot more of the activity that surrounds salmon management occurring further away from Vancouver and in the interior of the Province. He believes that it is helpful, efficient and sensible to have DFO staff located in the places where the work needs to be done. It also allows them to do one of the most important jobs and that is to build solid relationships with the people that they will have to work with and that are going to be harvesting the resource in their area. He commented: I am positive that we will be able to work this out and I think DFO made the right move in decentralizing people into the Fraser, although it may not always look like that, particularly given the costs involved and the budget constraints. I support the philosophy of decentralizing DFO and moving management staff into the regions and into the watersheds.

Who is responsible for recovery planning?
Brian Riddell asked: What does SARA say about who has involvement in recovery planning?

Chris Wood replied that once the stocks are legally listed, there is an obligation to complete a recovery strategy within a certain time-frame and that is done by appointing a recovery team, which under SARA has to include quite broad representation of people who can provide information that is relevant to making sure that the recovery strategy is broad enough to include all the factors that need to be considered. It also has to include some consideration of the socio-economic impacts and would require people with that type of expertise. The answer is that it will have to be quite broad and will involve consultation.

Day One Wrap-up Comments –John Fraser
During today, we have gone from very wide-ranging and general observations about the state of the global fishery and, more specifically, the salmon – both Atlantic and Pacific – and what I think is very great interest with respect to Pacific salmon, North America, Russia and the Orient. Also, we have been addressing some very specific problems and, inevitably, we have been involved in a discussion about the resources available to the Department of Fisheries and Oceans. If the net result of all these discussions is that, within our area of responsibility, the Pacific salmon stocks are low or, in many cases, declining and badly need attention, especially with respect to stocks such as the Sakinaw Lake and Cultus Lake sockeye salmon and some coho stocks, the question is: Do we have the resources to do it? If we haven't, is that partly because we are not making it clear enough in the public domain that this magnificent heritage needs to be preserved, sustained and advanced?

For example, what kind of money would it take to carry out a study, covering the last five years, of what was happening to these late returning sockeye and to determine why they entered the Fraser early and why is it they were behaving in that pattern, which was unusual? We don't have the answer to this question. Ken Wilson mentioned that the Adams River run, which is a late run, came in this past autumn with many more fish than was expected and was so abundant that, perhaps, the 80-90% pre-spawning mortality that had affected the late run sockeye stocks for several years before, was not noticeable or not measurable or maybe didn't even happen. I wonder what will happen this coming autumn? There is certainly something going on there and we probably do not have the answers. With respect to the Cultus Lake sockeye, even with your best efforts, one has to wonder if those declines have been coming for a long time. Was it overfishing? Why, when fishing patterns have been much the same as they have been for decades before, did it not happen a long time before? Is there some genetic problem?

Last year, the Department of Fisheries and Oceans and the Pacific Salmon Commission were very worried about the late run sockeye - they were worried about pre-spawning mortality and, as a consequence, told the commercial fishery that they had a concern and therefore were only going to give them 15% of what they estimated the run to be. They estimated it to be 3 million and then it came in at 8-9 million. This led to complaints from the commercial fishery and others who questioned the fact that DFO could not more accurately approximate how many fish were coming back. However, what was not explained, no matter how hard some people tried to do it with the media, was that the reason DFO and the Pacific Salmon Commission said only 15% of the fish coming back should be taken, was because of the tremendous concern over the 80-90% mortality of those late fish for the four or five years previously. In other words, there were a number of people trying to do the right thing, such as exercise the precautionary principle, and it was very difficult to get that message across to the media - they were, frankly, more interested in frightening and dismal stories about how many dollars some people had lost because they could not fish. Eventually, it was adjusted and then the Minister, reacting to the agitation, held an Inquiry and there was a great deal of attention paid to it. There had been more attention paid to the fact that they misjudged the returning numbers of Adams River sockeye than has been done to find out why, for four or five years before, the sockeye were dying before they could spawn.

That is the kind of thing that, with the best will in the world and the most benevolent and generous commentary upon the Department, makes those of us who are concerned about this, wonder about where the priorities lie? We should be able to define some priorities. The other thing to keep in mind is that what seems like a lot of money is really not; for instance, the stewardship program, which is now being sunsetted, cost $8-9 million. That may seem like a lot of money if you are in DFO headquarters trying to figure out how to keep this program going but it is an infinitesimal percentage of the total budget of DFO and if you want to start adding up some of the things that the federal government spends money on, then maybe we, as citizens here, have to say that we have identified a number of areas that badly need attention and they cannot get the attention unless something is done about this budget. We are not talking about hundreds of millions of dollars - we are talking about some millions, and that is a very small percentage when one considers that we have just spent nearly a billion dollars to get mostly law-abiding people to register their shotguns and rifles. I think we can find some money to look after the fishery resource.

SECTION III

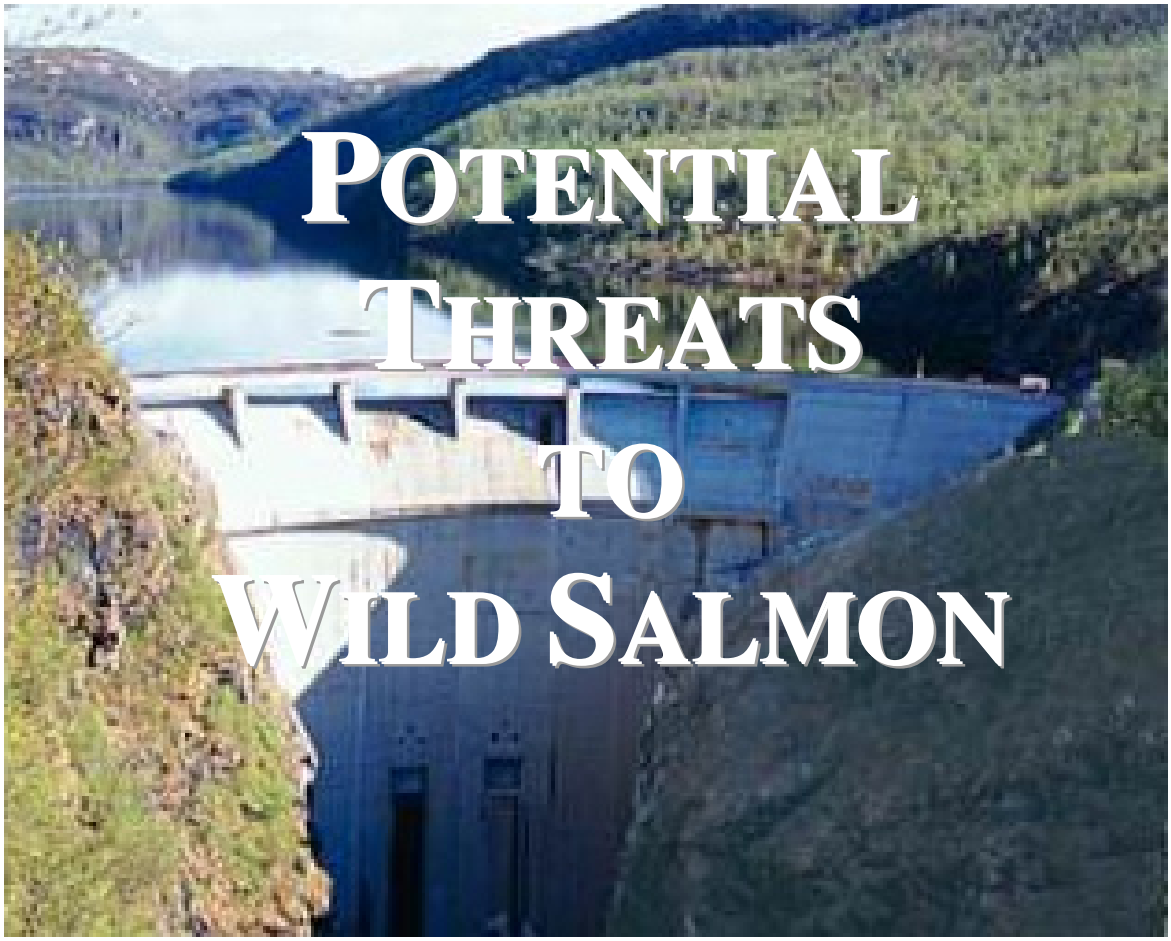

Photo by Tor Næsje, NINA

CHAPTER 13

A salmon-centric view of the twenty-first century in the western United States

Robert Lackey, Fisheries Biologist, National Health and Environmental Effects Research Laboratory, US Environmental Protection Agency, Corvalis, Oregon, USA

Introduction

Previous chapters have focussed on the current status of salmon, the causes of past declines, and the relative importance of various causal factors. In short, the how and the why of how we got to where we are today. Now it is time to move to the future.

This presentation will look forward, to speculate on the most likely future of salmon through this century, and to identify those factors that would have to change if the long-term downward trajectory is to be reversed.

A century ahead

For sure, most of us secretly have a forecast about the long-term future of wild salmon, but we keep it to ourselves or perhaps share it with a few close, discrete colleagues. Most of us are not willing to speculate publicly about wild salmon over the longer term. After all, how can anyone credibly speculate about what life will be like a century out? For wild salmon, however, it is easier, at least in some ways, to forecast the longterm. Looking at patterns over a century or more does tend to dampen the confusion caused by year-to-year and decade-to-decade variations in ecological and social factors that often mask fundamental, underlying trends. It often takes 50 years or more to see the effect of human actions on salmon runs so the long term is much more realistic. In a sense, it is arguably easier to predict the status of salmon in 2100 than it is in 2010.

Whatever the intellectual or practical value, the big risk is that the forecaster will be highlighted a century from now in one of those *Believe It or Not* cartoons about how naïve people were in the old days. You know the kind of forecasts, like the one by the leading urban planner of 1900. He predicted that disposing of mountains of horse manure could be the great engineering challenge facing cities in the 20th century. It is easy to make fun of such a forecast now, but at the time it was based on a reasonable extrapolation of current knowledge.

To cut my risk, I am going to limit my policy focus to the future of *wild* salmon in California, Oregon, Washington, and Idaho. I will slip occasionally into including southern British Columbia because many of the same forces that will drive the future status of wild salmon below the 49th parallel also apply in southern British Columbia. I will also try to be candid and frank. You may well argue with my take on

the rest of this century, but I do not want to be delusionally wishful, nor despondently fatalistic about it. So forget optimism, forget pessimism; here is my stab at realism. And just to be sure, in case anyone out there is taking names and notes, my comments are my own and not necessarily those of any organization.

To begin, let me start with a simple statement of fact, one that, even in an audience of contrarian scientists, will likely engender little argument:

> In spite of abundant uncertainty about the relative importance of the various factors that drove the decline of wild salmon in California, Oregon, Washington, and Idaho, we fundamentally recognize, we fundamentally know, the direct causes of the long-term decline.

The causes have been, and often still are:

- intense commercial, recreational, and subsistence fishing and, especially these days, mixed stock fishing,
- freshwater and estuarine habitat alteration due to urbanizing, farming, logging, and ranching,
- dams built and operated for electricity generation, flood control, irrigation, and other purposes,
- water withdrawals for agricultural, municipal, or commercial requirements,
- stream and river channel alteration, diking, and riparian corridor modification,
- hatchery production to supplement diminished runs or produce salmon for the retail market,
- predation by marine mammals, birds, and other fish species, often exacerbated by unintentionally concentrating salmon or their predators,
- competition, especially competition with exotic fish species, many of which are better adapted to the highly altered aquatic environments we now have in these four states,
- diseases and parasites,
- reduction in the annual replenishment of nutrients from decomposing, spawned-out salmon and,
- just to be safe, possibly others.

To no one's surprise, it is a long list and covers most of the entire human enterprise. We also know that ocean and climatic conditions have a big influence on salmon abundance even if we do not understand exactly how they work.

But we know even more, even if many of us do not like to acknowledge it. We know about the trajectory. Let me offer a second statement of fact:

> As we move into a new century in California, Oregon, Washington, and Idaho, in spite of ups and downs, good years and bad years, favourable and unfavourable ocean conditions, and newspaper headlines proclaiming record runs, wild salmon have been on a 150 year downward trend and wild runs are now at very low levels.

Certainly, newspapers regularly trumpet the fact that runs of both wild and hatchery fish in the Pacific Northwest are generally higher than the past several decades. This is not surprising because of shifting ocean and climatic conditions, but for assessments of the future, we need to focus on long-term trends and not get distracted by short-term variations in background conditions. In these four states, wild salmon are well on their way to attaining a status enjoyed by some of their notable brethren, such as wolves, condors, grizzlies, and bison; all wild animals that are unlikely to disappear entirely, but struggle to hang on as remnants of once flourishing species in small portions of their original range.

In a nutshell, these are my two scientific facts:

(1) We pretty much know the direct causes of the decline, and
(2) Wild salmon runs have been in a century and a half decline and are now at very low levels.

How can it be that the direct causes of the decline are reasonably well-known, have been studied in great detail, and the public appears to be supportive of altering the long-term downward trend, yet the recovery prognosis is poor in these four states? The answer, as we all know, is a simple policy statement of fact:

> Effecting any change in the long-term downward trend for wild salmon is futile in the absence of shifts in the core drivers.

Core policy drivers

It is the core policy drivers, the root causes, that have determined the status of wild salmon and will continue to determine the status of wild salmon through this century. Habitat alteration, dams, water withdrawals, fishing, hatcheries, and many more, are simply the way in which the core policy drivers are expressed.

What are these elusive drivers of the future status of wild salmon in California, Oregon, Washington, and Idaho – these agents of decline that must also be the agents of any recovery? I will make the case that there are six core policy drivers. I will describe briefly two cases that society really cannot do much about, and then explain the other four cases which fall, at least potentially, within the public policy arena and then defend why each must be at the crux of any serious effort to restore wild salmon in California, Oregon, Washington, and Idaho.

The first are *changes in climate* and *changes in ocean conditions*, two core drivers over which society has minimal control. In a policy sense, these are largely 'givens', essential for assessing the relative importance of the direct causes of the decline, but pretty much beyond our control. To be sure, to the extent that human actions are affecting changes in ocean and climate patterns, we could conceivably do something about that, at least over the longterm. Reducing greenhouse gas emissions may have some effect on wild salmon by the end of this century, but climatic and ocean cycles are predominantly independent of human influences as the 500-year reconstructions of salmon, sardine, and anchovy abundances clearly demonstrate.

The other four core drivers are ones that society does control and could change.

Core driver #1 — rules of commerce

The first core driver is an overarching one and, like everything else in salmon science and policy, difficult to rigorously quantify as to its influence on wild salmon. It is:

> The rules of commerce, especially trends in international commerce and trade and reflected in increased market globalization, tend to work against increasing the numbers of wild salmon.

The drive for economic efficiency and low cost production is a widely professed approach to trade, both within nations and between nations. My purpose is not to argue for, or against, such a philosophy of commerce, but rather to note its impact on wild salmon.

My assumption is that economic efficiency, and the corollary of "free trade," will continue to be a dominant government policy through this century. One upshot of such an approach to commerce is that non-economic values, such as the preservation of remnant wild salmon runs, tend not to get weighted very heavily in decision-making. We obtain our computers from where they can be manufactured most cheaply. We move our automobile assembly plants to where they can produce cars most inexpensively. We tend to produce electricity in the most cost-effective way. We obtain most of our wheat where it can be grown most productively and consistently. We obtain wood products where they can be grown and harvested most efficiently and sold at the lowest price, the current North American dispute over softwood trade notwithstanding. Even closer to home, we buy our salmon from Chile, Scotland, Norway, and

British Columbia. Most consumers are not willing to pay a premium for wild fish nor are they willing to limit their salmon consumption to only a few months of the year.

The benefits of public policies that favour economic efficiency are well-recognized, but there are also consequences that are not all that favourable to wild salmon. How much more are people willing to pay for bread, electricity, or automobiles produced in ways that will help restore wild salmon? Don't hide behind the 'pablum' that bread, electricity, and automobiles can be produced just as cheaply in a salmon-friendly manner. As with all policy choices, there are winners and there are losers and we should make that point clear to the public. Each of you can also speculate, but as I observe consumer behaviour today and guess about the future, I do not see much willingness on most people's part to pay much more for salmon-friendly products.

Core driver #2– increasing scarcity of key natural resources
The second core policy driver is reflected in many of the past, current, and likely future proximal causes of the decline of wild salmon. It is:

> The demand for critical natural resources, especially for high quality water, will continue to be great (and increase) through this century.

Many rivers in California, Oregon, Washington, and Idaho suffer from severe water shortages, especially shortages of high quality water. Our seemingly insatiable demand for fresh water shows little sign of letting up nor do I expect it to do so anytime soon. I am not arguing that allocating water for salmon is more, or less, important than allocating it for alternative uses. However, as competition for scarce water continues and gets much more intense, how will advocates for wild salmon fare relative to advocates for competing priorities, water for drinking, irrigation, manufacturing, generating electricity, or any of a thousand other needs?

The on-going water war in the Klamath Basin, along the California/Oregon border, gives us an indication of the future problems: farmers defying law enforcement agents and illegally opening locked valves and releasing water to irrigate their fields; streams choked with dying salmon caused by low water flows and poor water quality; and lawyers from various competing interest groups dueling in court over who will get how much water. At the end of the day, every faction in the battle is dissatisfied with the result and feels their interest did not get a fair share of the water and they plot ways to be more politically effective in next year's battle. It is not just water that is becoming increasingly scarce. We also demand land, somewhere to build a second home, a place to build the next Disneyland, or a mountain watershed to accommodate the next Whistler.

Life for an individual, as well as for society, is a series of trade-offs, choices, and selections between appealing alternatives. As key natural resources become more scarce through this century, the individual and collective choices that permit long-term salmon abundance will become increasingly unacceptable to more and more people. At least, that is the way I read society's collective current and likely future behaviour.

Core driver #3 —regional human population levels
The third core driver which will determine the status of wild salmon through this century is:

> The number of humans in the region will continue to increase and their aggregate demands to support chosen life styles will constrain the abundance of wild salmon.

The most probable scenario for the human population trajectory through this century in this region is substantially upward. As core drivers go, population growth is right up there at the top, but it is not popular to raise this issue these days. It has become a taboo subject in most circles. Environmental

advocacy groups avoid it like the plague, even though it dwarfs most of the human behaviours they are trying to modify. Wild salmon advocacy groups rarely even mention it, much less take policy positions.

Advocacy groups avoid raising it for some very good reasons. As one of my colleagues told me when we talked about what I might say here:

> *Bob, you are absolutely right, most people already know it, and that's exactly why you should let it rest. Back off. You'll leave the proponents of wild salmon restoration depressed. Worse, you'll have the rest of the audience wondering why you are pontificating on the intuitively obvious. And you run the risk of being attacked as a racist, nativist, xenophobe, cultural imperialist, or, at the least, an economic elitist.*

Undoubtedly very good advice. However, if society wishes to do anything meaningful about moving wild salmon off their current trajectory then something must be done about the unrelenting growth in the number of humans in the Pacific Northwest. I am not arguing that we collectively ought to change any policy, but the simple and inescapable fact is that the human population level in this region that we should realistically anticipate through the rest of this century is a serious barrier, the achievement of any significant long-term wild salmon recovery.

Many of you may wish it otherwise, but that is the way it looks to me. The latest demographic forecasts do show a flattening of the world population growth rate toward the end of this century and such may well be the case. For example, most countries in western Europe have declining and ageing human populations and the attendant economic and social consequences are the focus of policy debate. For the Pacific Northwest, however, there is another story. It is largely one of continuing immigration from all directions.

Currently, Washington, Oregon, Idaho, and British Columbia are home to 15 million humans. Assuming a range of likely human reproductive rates, migration to the Pacific Northwest from elsewhere in Canada and the United States, and continuing immigration policy and patterns, by 2100 this region's human population will not be its present 15 million, but rather will be somewhere between 50 and 100 million. Visualize 50 or 100 million people in this region, and their demands for: housing, schools, tennis courts, football stadiums, expressways, planes, trains, automobiles, Starbucks, McDonalds, WalMarts, electricity, drinking water, pipelines, marinas, computers, DVDs, 12 screen movie theaters, ski resorts, golf courses, weed-free lawns, big city hotels, and university conference centers.

Let us speculate about the year 2100 and the footprint of the human population for which we should plan.

Visualize Washington and southern British Columbia in 2100 with its metropolis of 'SeaVan'. You know 'SeaVan', it mushroomed into a truly great city as smaller, discrete cities back in 2003 grew together. 'SeaVan' in 2100 stretches from Olympia in south Puget Sound northward through the once stand-alone cities of Tacoma and Seattle, and on to Vancouver, east to Hope, and west to cover the southern half of Vancouver Island. Rather than the 6 million people back in 2003, 'SeaVan' in 2100 rivals present day Mexico City and Tokyo with its 24 million inhabitants.

Visualize Oregon and southern Washington in 2100 with 'PortGene', the other great metropolis in the Pacific Northwest. 'PortGene' extends from its southern suburbs of what was once the stand-alone city of Eugene northward to Portland and across the Columbia River to Vancouver, Washington, and onward to sprawling suburbs to the east, west, and north. Remember back in 2003, of what was to eventually grow into 'PortGene', its population then was a mere 3 million. In 2100, it is a whopping 12 million.

You do not have to visualize California. We already have similar metropolises there today.

Regardless of whether my assessment turns out to be right or wrong, population issues are not easy ones to raise, much less discuss without resort to policy advocacy. There are understandable, strategic reasons why the big environmental groups, most groups in fact, stay clear of population issues these days. But the current and expected population level in this region is at the core of any credible analysis of potential recovery strategies, or at least those strategies that are offered as serious attempts to actually recover wild salmon.

Core driver #4 – individual and collective preferences
The fourth and final core policy driver – one that is very closely tied to the prior three:

> Individual and collective preferences directly determine the future of wild salmon, and substantial and pervasive changes must take place in these preferences if the current long-term, downward trend in wild salmon abundance is to be reversed.

This core driver is perhaps the most obvious and arguably the most important. Among most people like us, it is easy to assume that salmon are near the top of the public's priorities. Just look at the polling results. Everyone supports salmon and especially wild salmon. But, the fact is that salmon recovery is only one of many priorities that society professes to rank high. It is difficult for me to conceive of this, but that is the situation out there. Even my kids who I've had three decades to inculcate, regularly admonish me:

> *Dad, get a life. Most people out here in the real world just don't care that much about restoring wild salmon. They have other things to worry about!*

Society's collective behaviour, its actions, not public opinion polls or thick recovery plans, give us the best indication. Let me offer a recent example for California, Oregon, Washington, and Idaho.

Remember what happened in this region in 1991. The first salmon "distinct population segment" was listed under terms of the U.S. Endangered Species Act. With this listing of salmon as a protected species, the policy debate in these four states shifted away from restoring salmon runs in order to support fishing, to protecting wild salmon runs from extinction, two very different policy objectives. In 1991 protecting at-risk runs of wild salmon won out over providing fishing opportunities through supplemental stocking or other efforts to put fish on the hook, or fish in the net. The residents of the western United States apparently made a choice. Or, did they?

Jump ahead 10 years to 2001. Just a decade after the first salmon listing, a severe drought, combined with ongoing electrical blackouts, provoked the Bonneville Power Administration to declare a power emergency, abandon previously agreed upon interagency salmon restoration commitments, and generate electricity flat out using water reserved to help salmon migrate. In one of the most striking recent barometers of competing societal priorities, air conditioners and electricity won out over both wild and hatchery-bred salmon, and with scant public opposition. There were no street protests and no legal challenges. There were no elected officials publicly pleading for salmon and no environmental group blanketing the Internet with calls to mobilize fax machines in defense of salmon. There was complete silence.

Over the past 150 years, we have made plenty of these kinds of choices, contradictory, opposing, apparently inconsistent, and these choices roughly reflect our collective and relative priorities for wild salmon. These choices are tradeoffs, and we continue to make them, and these choices are a real measure of the relative importance of salmon to society.

I am not here to cheerlead for wild salmon, electricity, property rights, hatcheries, dredging shipping channels, or for having a McDonalds, Tim Hortons, and Starbucks on every corner. It is naïve to consider

salmon recovery as anything but one element, an often minor element, in a constellation of competing, often mutually exclusive wants, needs, and preferences.

Conclusion

You have now heard my take on the 21st century from a salmon-centric perspective, a perspective driven by assessing four core drivers that will largely determine the future of wild salmon in this region.

The core policy drivers are:

(1) the economic rules of the game, especially the international and domestic drive for economic efficiency through market globalization;

(2) the increasing scarcity and competition for key natural resources, especially for high quality water;

(3) the rapidly increasing numbers of humans in the region and meeting their basic needs; and

(4) individual and collective life style choices and priorities.

For those of you who have a policy predilection to restore wild salmon, I am sure that it is not a cheerful message. For those of you who rank restoring wild salmon as just one of many societal priorities, my forecast also may not be all that uplifting because we will probably continue to spend billions of dollars in a restoration effort that will likely be only marginally successful over the long-term. I recognize that by making a few different assumptions about the future, my salmon forecast would be different, but in making the assumptions that I did, I struggled to avoid succumbing to unfounded pessimism, or to baseless optimism.

Nor should we fall into the trap of equating the well-being of wild salmon with overall environmental health from a human perspective. Good water quality is much easier to maintain than large runs of wild salmon. Just because runs of wild salmon in California, Oregon, Washington, and Idaho almost assuredly will be reduced even more in 2100, it does not inevitably follow that we will have worse water quality.

I will end with a prediction and also offer a challenge to wild salmon advocates, but also an opportunity:

> Any policy or plan targeted to restore wild salmon runs must at least implicitly respond to these four core drivers or that plan will fail. It will be added to an already long list of prior, noble, earnest, and failed restoration attempts.

Look down the road to the end of this century, to 2100:

- less than 10 decades away;
- only a few dozen generations of salmon beyond today's runs;
- just 2 or 3 Pacific Decadal Oscillations from now;
- to a time when this region's human population will not be its present 15 million, but rather will be somewhere between 50 and 100 million;

Even given all this, there are still salmon recovery options that are likely to be ecologically viable and probably socially acceptable, but the range of options continues to narrow. The message for professional fisheries experts, fisheries scientists, technocrats, analysts, and managers, and for those of us who are involved with salmon issues in California, Oregon, Washington, and Idaho is this - it is a time for neither crippling pessimism, nor for delusional optimism. Rather it is a time for uncompromising ecological realism and forthright policy analysis.

The views and comments presented in this Chapter are those of the author and do not necessarily represent the views of any organization.

CHAPTER 14

Net-Pen salmon farming: Failing on two fronts (and why this is just the latest stage in humanity's terminal ravaging of the seas)

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Introduction and Purpose

Although I am not a fisheries biologist, much of my work bears both directly and indirectly on the issues at hand. The direct part is reflected in the title of this chapter which suggests that my primary focus will be on the net-pen salmon farming industry.

The main purpose of this paper is actually to highlight the forcing mechanism behind the apparent collapse of global fish stocks. I am in good company in taking this tack. Much of Robert Lackey's contribution to this volume also focuses on what he refers to as the "drivers" damaging salmon stocks in the Pacific Northwest—habitat destruction, overfishing, climate change, etc. (see Chapter 15 Lackey). "Forcing mechanism" (a term I borrow from climate change science) implies much the same thing, but I am exploring the concept on a more general level than is Lackey. While Lackey describes the proximal factors driving the decline of salmon I am concerned with the distal cause. This paper makes the case that collapsing fisheries are merely symptomatic of a much deeper problem that we moderns find difficult to acknowledge: that marine fish are just the latest casualties of what might be termed *gross human ecological dysfunction*, a malaise that emerges, ironically, from our species' remarkable evolutionary success.

Recognizing *Homo sapiens* as an ecological entity

To understand this thesis fully we have to accept the simple fact that once we clear away the fog of technological and cultural sophistication, human beings remain biological entities—i.e., 'animals'—to the core. And what a wondrous beast we are! Modern *Homo sapiens* has evolved to become the most astonishingly successful predatory mammal ever to stalk the lands and waters of Earth. And the story doesn't end there. Not only do humans take top prize among carnivores, but we also dominate the competition among terrestrial herbivores. In fact, any human ecologist (that

is, an ecologist who studied humans as s/he might study any other lifeform)[1] would discover that this same ecological reality prevails on every continent. With the continuous expansion of the human enterprise, powered by extra-somatic energy and continuous technological advances, *H. sapiens* has long been the dominant macro-consumer in all of the major eco-system types on Earth. In this light, an alternative title for my paper might have been: "**Dominant terrestrial predator makes successful transition to marine habitat."**

Why is this a critically novel insight? Because not only are we moderns generally ignorant of the astonishing breadth of our *de facto* ecological niche, but techno-industrial society actually promotes the belief that the human enterprise is all but independent of nature. Economists, for example, observing that an increasing proportion of our incomes and GDP are derived from the so-called knowledge-based sectors, argue that the economy is "decoupling" from nature, that it is "de-materializing." Although quite untrue, this is the kind of cultural myth that shapes the policy decisions that help to propel the continuous expansion of the human enterprise.

It is worth reflecting a little more on our economic models because they illustrate as well as anything else modern humans' psychological estrangement from nature. Keep in mind that economic models, like all conceptual models, are what psychologists would refer to as "social constructs." That is, they are products of the collective human mind and, as such, they reflect prevailing cultural perceptions and understandings at least as much as they reflect reality.

The particular model that I have in mind is commonly found in text-book chapters on environmental or resource economics. It shows the economic and "the environment" as separate systems linked only by a counter-current flow of resources from the environment to the economy and of wastes from the economy to the environment. To many readers this example of "Cartesian dualism" will all seem very natural. But again, this model, this way of thinking, is merely an expression of mind—the western mind. It reveals how techno-industrial society tends to conceive of the economy as essentially separate from "the environment" (and it is just a short step from there to believing the "decoupling" myth that technology can make us independent of it too).[2]

The important thing to realize is that there are still cultures today with whom we could not have a conversation about "the environment" as a discrete entity *out there* separate from the human enterprise *over here*. Other peoples see themselves not in isolation but rather as an integral part of "nature" and, if we think about it for a moment, this is actually a more physically (and therefore scientifically) valid way of perceiving reality. The fact is that, despite our technological hubris, humans are functionally very much a part of nature. What we call "the economy" is merely our description of how we organize socially to interact with the rest of the material world. From this perspective, the economy can be conceived as a fully contained, totally dependent, open, growing sub-system of a materially closed, non-growing ecosphere (Daly 1990, Rees 1995). Our relationship with nature is as an embedded dependent sub-system, not as an independent entity existing in splendid isolation from everything else. Recall my argument above that people have become the dominant macro-consumer in all the major ecosystems on earth. It should now be clear that, within the confines of the non-growing ecosphere, the continuous growth of *H. sapiens*

[1] Regrettably, there are very few human ecologists. Academic ecology, betraying its Cartesian roots (and modern humans' reluctance to acknowledge their biological selves) focuses almost exclusively on non-human species.

[2] As Canadian ecologist Stan Rowe once observed, in our ecologically estranged culture the very word "environment" becomes its own pejorative, meekly setting itself apart from something else more important.

and his economic infrastructure can proceed only at the expense of many other species, including fish, with which we share the planet.

To appreciate humans fully as biological beings requires an introduction to some basic facts of human nature, those inherited qualities that help determine both individual and social human behaviour. Like all other species, humans evolved in response to the pressures of natural selection and we have accumulated certain qualities over time that account for our spectacular evolutionary success. It is true, of course, that human evolution differs from that of non-human species—human evolution has long been governed as much by cultural as it has by purely biological factors. Nevertheless, humanity's biological heritage continues to exert powerful influences. Most importantly (and, again, like all other species) *H. sapiens* has a hard-wired genetic predisposition to expand into all of the "niche" space available to it. (This was Reverend Malthus' famous insight.) Arguably, culture has actually had its most dramatic effect working in tandem with this expansionary predisposition. Human inventiveness and cultural adaptations have worked steadily for thousands of years to mitigate the effects of negative feedback – disease, resource shortages, extreme weather events – that would normally inhibit the growth of human populations beyond the capacity of local ecosystems to sustain them. In fact, technology and trade (including its most recent morph, "globalization") have enabled many human populations to expand to the point where they can completely degrade their local habitats and still survive – indeed, grow and prosper – because they can import the material requirements (and luxuries) for life from elsewhere.

This pattern of local 'patch disturbance' and increasing reliance on imports may come back to haunt us (Rees 2000). However, most economists and politicians do not seem much concerned and, since a particularly persuasive form of technological optimism prevails in the world today, society generally does not display any sense of urgency to the inexorable sprawl of cities over prime farmland or to the latest example of a fisheries collapse. (Basically, we would rather have the money.) Humans may have evolved to expand to their ecological limits but they have neither evolved nor acquired any general inhibition against them destroying their own habitats.

The 2nd law of thermodynamics as the first law of resource dissipation

We are getting close to being able to show why the collapse of fish stocks is virtually inevitable but first we need to bring a little more science into the picture. The science I am referring to is modern interpretations of the 2nd law of thermodynamics, particularly as they apply to "far-from-equilibrium" self-organizing systems (see Prigogine and Stengers 1997). We have come to realize that all living systems, from cellular organelles to the ecosphere itself, share certain common properties as complex, open, self-producing, far-from-equilibrium dissipative structures. That is a fancy way of saying all that living systems, including our own bodies, can organize, maintain themselves and grow only by importing useful resources from their environments and by "dissipating" their wastes back into their environments (Schneider and Kay 1994).

We also recognize that each of these systems exist as a subsystem (or quasi-independent "holon") within a loosely overlapping hierarchy (or holarchy) of such systems, the highest level of which is the ecosphere (Kay and Regier 2000). This means that the "immediate environment" for any holon is actually the next level up in the holarchy. We can now restate the fundamental relationship between adjacent subsystems levels in thermodynamic terms: subsystems grow by importing available energy and matter (essergy) from their host systems and by exporting degraded energy and material wastes (entropy) back into their hosts. (In effect, each holon is a potential thermodynamic parasite on the next level up in the holarchy.)

In an ecosystemic steady-state, the rates of resource consumption and waste discharge by any sub-system (e.g., a species population) are maintained by negative feedback within a range that is compatible with the rates of production and assimilation by its host system. The total holarchy therefore retains its long-term functional integrity. However, as noted, the hierarchical relationship between sub-systems and their hosts contains the seeds of potential pathology. If a sub-system (e.g., the human enterprise) demands more than its host system can produce, or discharges more waste than its host can assimilate, then the development and growth of that sub-system will *necessarily* result in the destructive dissipation of the higher level in the holarchy (Rees 2003).

Let us bring this to ground. The ecosphere (i.e., the aggregate of all ecosystems) is a thermodynamic sub-system of the solar system. It evolves and maintains itself by dissipating exogenous solar energy. In short, the ecosphere feeds on an extra-terrestrial external source of essergy. By contrast, the human enterprise – the economy – is an embedded sub-system of the ecosphere. It grows and maintains itself and by dissipating available energy/matter exogenous to itself but endogenous to the ecosphere. In short, the human enterprise is thermodynamically positioned to consume the ecosphere from the inside out (Rees 1999). Fish stocks are just the most recent casualties of this inevitable process.

Unsustainability is an old—and continuing—problem

This conceptualization of human-environment interaction provides a novel framework within which to reinterpret both our species' ecological history and present reality. There is, of course, increasing recognition that modern society is trending steadily downward ecologically. However, the evidence is that this is by no means a unique situation for human societies. Indeed, given that complex human societies in all their guises have always been dependent on supportive ecosystems that the human enterprise is everywhere predisposed to expand and that this tendency is reinforced by technology, it would be surprising if history were not filled with examples of at least regional ecological crises. In fact, unsustainability *is* an old problem for humans and if my thesis that the primary drivers are in our genes is correct, then things are not likely to change any time soon. This may be a pessimistic assertion, but if we are ever to create the circumstances that would justify optimism for modern society, we must come to understand the forces driving human history.

And our history is a rich source of instruction indeed. One of the more relevant lessons – one that even makes it to the popular press from time to time – is the story of Easter Island. Easter Island is little more than an isolated rock scarcely 165 square kilometres (65 square miles) in area stuck in the middle of the South Pacific Ocean 2,250 kilometres (1,400 miles) from the nearest land mass, another smallish rock, called Pitcairn Island. Virtually denuded today, Easter was once a verdant subtropical paradise, heavily forested with at least two very important tree species and many plant and animal species useful to humans. It was first inhabited by a canoe-load or two of wandering Polynesians only around the year 450 or 500 A.D. The new colony took hold and flourished to become a complex culture in microcosm. As written in its genes, the human population of Easter Island expanded to perhaps 10,000 people by A.D. 1400-1500. Over those 10 centuries, the Easter Islanders developed class structure, division of labour, religion, agriculture, science and art, including some of the finest stonework – both fitted stones for buildings and platforms and carvings – known to preindustrial times. In short, Easter Island culture evolved most of the basic manifestations and characteristics of the much grander and earlier human societies of Europe, Africa, Asia and even the Americas (Incas and Aztecs), with which most people are more familiar.

Then, at the very height of their cultural evolution, the Easter Islanders did something that seems truly bizzare. They cut down the last palm tree growing on their isolated rock. Now, this was a society dependent on trees for many things, including the dugout canoes by which they obtained most of their animal protein – Easter Islanders ate porpoises and fish that could be obtained only by active pursuit in boats. How could these people have possibly reached the stage where there was nothing for it but to cut their last trees and, with the trees, any hope of cultural survival? When the Dutch explorer Roggeveen "discovered" Easter Island in A.D. 1722, there were only about 2,000 survivors, most living in rude reed huts and caves. These sorry remnants of the Easter Island culture that had been thriving just 200 years earlier now lived in part by making cannibalistic raids on each others' encampments. Having failed to develop suitable cultural constraints on their economic growth, the Easter Islanders had predictably consumed their island ecosystem "from the inside out."

Many articles have been written about Easter Island. The authors often wonder at the socio-cultural dynamic at work in a society numerically no larger that a minor town, where everyone was aware of their total dependence on the limited local resources of their tiny island, and yet where apparently nothing was done to prevent their self-destruction. Historian Clive Ponting (1990) was mystified that the Easter Islanders seemed "…unable to devise a system that would allow them to find the right balance with their environment." Considering that modern humans also inhabit a tiny island isolated in space with no hope of finding alternative supplies and that almost everyone is aware that we are facing an ecological crisis, anthropologist Jared Diamond's (1995) asks a chilling question: "Are we about to follow [Easter Island's] lead?"

Does Easter Island represent the cultural norm?

It might be easy for technological man to dismiss this question as absurd if Easter Island were a singular case. After all our technological prowess and mastery over nature distinguishes us from more primitive cultures. Ominously, however, Easter Island is by no means exceptional. As Joseph Tainter observes: "what is perhaps most intriguing in the evolution of human societies is the regularity with which the pattern of increasing complexity is interrupted by collapse…" (Tainter 1995). It seems that ignominious collapse may well be the norm for complex human societies.

Tainter argued that societies evolve and "complexify" as a problem-solving strategy in response to various problems (e.g., irrigation is invented to overcome the impediment to food production represented by seasonal rainfall). Eventually, however, as expansion continues, societies reach the point where they can no longer cope effectively with mounting pressures. Such cultures suffer from diminishing returns to investment in complexity (lower payoffs despite increasing commitments of resources). In these circumstances, a society becomes increasingly brittle and unstable—socially, politically or ecologically—and therefore more vulnerable to collapse in the face of the next major challenge (Tainter 1988).

In light of Tainter's findings, the modern record of resource exploitation is hardly encouraging. A decade ago, Ludwig, Hilborn and Walters (1993) reported that while there is a considerable variation in detail, there is remarkable consistency in the history of resource exploitation: "Resources are, inevitably, over-exploited often to the point of collapse or extinction." Despite this dismal history, grossly diminishing returns to fishing effort, and the unambiguous warnings of fisheries scientists, there is no evidence that the pattern of exploitation is changing. Recently, Christensen et al. (2003) and Myers and Worm (2003) report that after only fifty years of industrial fishing the large predatory fish biomass of the world's oceans is only about 10% of pre-industrial levels. (Humans, as top carnivores in the sea, are shredding the marine foodweb from the inside-out.) Do people today even begin to understand the potential consequences of global

resource depletion? Are we incapable of taking a lesson from the repeated collapses of previous complex societies? Is it conceivable after all that we are on a tack that might lead to global crisis and collapse?

Hypothesis: *Homo sapiens* is inherently unsustainable

Tainter has provided a satisfactory answer to the question: "What is the socio-cultural dynamic that leads to collapse in the face of crisis?" However, the question I want to address here is - "What is the bio-cultural dynamic that drives human societies to expand to the point of crisis?" Contemplating this question has previously led me to the following general hypothesis: Humans, particularly techno-industrial humans are inherently unsustainable. That is, the modern form of unsustainability is an inevitable emergent property of the interaction between techno-industrial society, as presently conceived, and the ecosphere (Rees 2002).

A bio-evolutionary factor—the maximum power principle

We can assess this hypothesis by examining two critical mechanisms that underlie humanity's predisposition for continuous growth. The first is purely biological and can be summarized in terms of the so-called "Maximum Power Principle" (see Odum 1983, Ch. 1 and 7). Ludwig Boltzman, one of the fathers of thermodynamic theory, was familiar with Darwinian natural selection and recognized in the early 20th century that the struggle for existence is really a struggle for free energy available to do useful work. From this perspective, all species are competing for energy (you can see it in plants as they lean towards the sun) – food getting among animals is a struggle to obtain the low-entropy energy and matter they need to grow and reproduce. Alfred Lotka, one of the great ecologists of the 20th century, reformulated this idea into the *maximum power principle* (Lotka 1922): Systems that prevail (i.e., successful systems) are those systems (individuals, species, ecosystems) that evolve or develop in ways that maximize the flow of useful energy available to them.

What has this to do with the human condition? Almost everything. To begin, *H. sapiens* has long had a significant leg-up in the competition for free energy. No other large mammal comes close to matching the human capacity to appropriate useful energy/matter from our host, the ecosphere, for use in the expansion of our own population and the accumulation of manufactured capital, the vital infrastructure of the human economy.

Humans have at least four qualities that confer this competitive advantage (Rees 2002). First, humans have a very catholic diet. We can eat many kinds of plant and animal matter and if we can't eat something then we feed it to some other animal and then eat that animal or its products. In this way, humans have access to more food energy than any other large vertebrate macro-consumer. Second, we are uniquely adaptable, being able to live in virtually any habitat on the planet. This gave even pre-agricultural humans unparalleled geographic access to all potential wild food sources on Earth. Third, and perhaps most important, humans have complex language, particularly written language. This is "most important" because the written word leads to humanity's fourth critical quality—cumulative knowledge and continuous technological development. Human beings are unique among species in that language and culture enable us to get continuously better at appropriating bio-energy, other forms of energy and, consequently, all the other resources needed by society, from the ecosphere.

(N.B. If there was more time, I would elaborate on the importance of fossil energy in this game because for the last 150 years techno-industrial society has become increasingly dependent on non-renewable forms of fossil energy to sustain itself and fuel growth. Without fossil fuel, it is unlikely we could have depleted the seas, deforested so much of the planet, and so significantly

increased agricultural production. Modern techno-industrial society would simply not be possible. On the one hand, then, we have used fossil fuel to grow ourselves and "dissipate" many other resources at the expense of the ecosphere. On the other, global society itself may now be at risk partly because accessible reserves of cheap petroleum and natural gas are being depleted and there are no ready substitutes for many uses of these premium fuels.)

The biodiversity costs of human expansion

It should not be a surprise that on a finite planet, humanity's expansive evolutionary success imposes huge costs on non-human species. First, the demand for food-energy needed to grow the human population necessarily indirectly displaces competing species from their ecological niches. Where, for example, are the 50 million bison, the millions of pronghorns, the grizzlies, and so on that used to inhabit the Great Plains of North America? Well, at least their energetic equivalent is sitting in your seats. The native grassland that used to support that great abundance of non-human biomass has been replaced by introduced wheat, oats, barley etc., that mainly feed humans and their domestic stock. In this light, anyone who tells you there is no inherent conflict between the continuing growth of the material economy and the conservation of nature, does not know about the second law of thermodynamics. Human appropriations of the free energy flows through ecosystems are irreversibly unavailable to other species.

Humans also directly eliminate remaining competitors. We cull seals and sea lions that threaten wild fish and fish-farms; we shoot wolves that prey upon wild ungulates or domestic stock that we would prefer to eat ourselves; and we even poison our own food to eliminate insect pests that would otherwise ravage our cereal and other crops.

Finally, the human enterprise also grows by depleting both self-producing and non-renewable natural capital stocks—which brings us back to far-from-equilibrium thermodynamics. As emphasized earlier, the human enterprise is a self-producing dissipative structure that, beyond a certain point, can maintain its own growth only by consuming its environment.

The human ecological footprint and competitive exclusion

We can further illustrate human domination of the ecosphere using ecological footprint analysis (EFA). EFA is a quantitative tool that estimates the total area of ecosystems appropriated by any designated human population to produce the resources that it consumes and to assimilate the wastes that it produces. The Worldwide Fund for Nature (now known as the World Wildlife Fund, WWF) has recently applied the method to trace the growth of aggregate human ecosystem demand since 1960. Most significantly, the WWF study reveals that the steady increase in the human "ecological footprint" over the last 40 years has been accompanied by a corresponding decline in the WWF's own "Living Planet Index," an indicator of non-human species diversity/biomass (WWF 2002).[3] This relationship holds for both terrestrial and in aquatic ecosystems. In effect, the WWF study illustrates what ecologists call "the competitive exclusion principle"—the displacement of one species from part of its range by a superior competitor—when it is observed between two competing non-human species. In this case, however, we are observing the displacement of just about all other macro-consumers by the growth of the human sub-system. To repeat, it is not possible for one sub-system in a finite global systems holarchy to expand indefinitely except by appropriating increasing quantities of energy/matter that would otherwise be available to support other sub-systems.

[3] According to the WWF, the human ecological footprint now exceeds the long-term human carrying capacity of the earth by about 20%. The empirical evidence is declining resource stocks and rising pollution levels.

It is worth noting that modern human-induced biodiversity loss is actually a hyper-extension of an ancient legacy. The recent paleo-ecological, anthropological, and archeological literature tells a convincing story that the initial settlement of a new habitat by human beings was generally accompanied by the extinction of previously dominant large mammals and (particularly flightless) birds. "For every area of the world that paleontologists have studied and that humans first reached within the last fifty thousand years, human arrival approximately coincided with massive prehistoric extinctions" (Diamond 1992). It seems that even early humans, with their relatively primitive weapons and tools, were able to alter significantly the species composition of the ecosystems that sustained them.

The socio-cultural factor: myth-making and the human capacity for self-delusion

Mythmaking is a universal property of all human societies, including our own (See Grant 1998). Obviously, the natural propensity for human societies to expand is a powerful force, but the story does not end there. The cultural norms of industrial society reinforce the biological drive to fill all available ecological space. Our prevailing mythology is heavily biased toward unlimited economic growth *in spite of the evidence that we may have already exceeded safe limits*. Indeed, it is probably fair to say that most of the modern world subscribes to a common myth of perpetual material economic growth fueled by open markets and expanding trade. "Globalization" is the prevailing watchword and anyone who objects on the face of the evidence is swept aside as naïve, stupid or merely quaintly reactionary. The irony here is that we profess to be a knowledge-based culture—modern society claims to have abandoned myth for the safety of solid science. This itself may well be our greatest cultural myth.

The propensity to create grand overarching myths is only one dimension of a general human capacity for self-delusion. Humans generally prefer illusion to reality if the latter is likely to inconvenience them. As Gustave Le Bon wrote in the 19th century: "The masses have never thirsted after truth. They turn aside from evidence that is not to their taste, preferring to deify error, if error seduce[s] them. Whoever can supply them with illusions is easily their master; whoever attempts to destroy their illusions is always their victim." (Le Bon 1960 [orig. 1896]). Today, we are seduced by our big houses, our SUVs, our VCRs, our computers and all the other material trappings of modern society. Advertising continuously reinforces our illusions and the socially constructed consumer mentality serves as armour against the cascade of evidence that the price of our material bounty may be the destruction of the very systems that sustain us. Derrick Jensen put it this way: "For us to maintain our way of living, we must… tell lies to each other, and especially to ourselves… [the lies] are necessary because without them many deplorable acts would become impossibilities" (Jensen 2000).

Unfortunately, globalization and trade do indeed obscure the truth and prolong the reign of the dominant myth. Ecological footprint analysis shows that much of the consumption enjoyed by inhabitants of wealthy countries is derived from distant ecosystems often in other countries half a world away. Indeed, rich countries live, ecologically, on an area several times the size of their domestic territories, on land and waters that they effectively appropriate through trade and natural material cycles. The overharvesting of British Columbia's forests and the collapse of Canada's northern cod stocks are not the result of domestic consumption, but rather of economic exploitation to satisfy export markets. The associated forest and marine ecosystems have been incorporated into the ecological footprints of the importing countries.

There are two problems here. First, trade removes negative feedback that would otherwise mitigate unsustainable growth by blinding wealthy importers to the fact they have exceeded their domestic carrying capacities. Second, the material lifestyles of the rich can simply not be

extended to the entire human family. It is physically impossible for every country to be a net importer of biophysical goods and services. Again, the growth myth has placed the global economy on a collision course with ecological reality (Rees 2002).

There is yet another mythic construct that undermines efforts toward ecological sustainability. Recognizing that some resources may actually become depleted, economists have fostered belief in what has become known as the principle of near perfect substitution. This principle was stated in a rather mild form by Nobel Laureate economist Robert Solow as follows: "If it is easy to substitute other factors for natural resources, then the world can, in effect, get along without natural resources so exhaustion is merely an event, not a catastrophe" (Solow 1974). I have a number of quotes like this from economists and other technological optimists arguing that if we simply allow markets to work, human ingenuity will find a substitute for any scarce product of nature, including salmon. Here is a statement by Mark MacDonald writing in a recent issue of "*The Business Examiner"* (June 2003): "Wild stocks, which are a major source of food for people throughout the world, are diminishing. Production of farmed fish, an obvious replacement for wild, could be stepped up significantly." In other words, humans can substitute for nature; with existing technology we can do a better job at raising salmon.

The case of net-pen salmon farms

The substitution principle thus provides a cue for us to return to fish and develop the final focus of this paper. The question is, does the substitution of salmon farms for wild stocks really do a better job? In addressing this question I want to acknowledge the doctoral work of my former student, Dr. Peter Tyedmers now at Dalhousie University. Tyedmers (2000) undertook a massively detailed comparative analysis of the energy and material flows, and the ecological footprints, associated with the wild salmon fishery and the net-pen salmon farming industries in British Columbia. To develop my argument, I need refer to only a few highlights of Dr. Tyedmers' study.

To begin, a key requirement of the salmon farming industry is feed pellets. Several points stand out from Tyedmers' analysis:

- At the time of the study, feed pellets for farmed salmon were typically 56% rendered fish by weight (e.g., Peruvian anchovy, South Pacific sardine, Araucarian herring, Inca scad, chub mackerel).
- Approximately 1,800 kg of whole fish were required for fishmeal and 3,000 kg of whole fish for fish oil per tonne of salmon pellets (1997 data).
- Only one kg of farmed salmon is produced for every four to five kg of other fish (wet weight) incorporated in feed.

In short, the feed industry represents a significant diversion of high-quality animal protein, much of which might otherwise be available for direct human consumption. Today a full 12% of the total global wild fish catch is sold to produce feed for farmed carnivorous fish. Most importantly, the 20% trophic level transfer efficiency associated with the conversion of feed-stock fish to salmon shows that salmon farming actually reduces the total amount of food available to humans. (Political and consumer pressure has therefore forced several major feed producers to pledge to replace 50% of the fish-meal in their feeds with alternative protein sources by 2010: Powell 2003.)

Energy dissipation

Turning to the energy costs of raising of farmed salmon, it takes 48,000 megajoules of energy (the equivalent of 1,300 litres of diesel fuel and 3.3 tons of carbon dioxide emissions) to produce a tonne of salmon feed. The approximate industrial energy investment for cultured Atlantic salmon is 94,000 megajoules per tonne of fish and for chinook salmon, 117,000 megajoules per

ton. In both cases, 90% of this energy is associated with the production of the feed alone. A single kilogram of farmed chinook salmon fillet ready for the plate has an embodied industrial energy content equivalent to 5 litres of diesel fuel.

Figure 14.1 compares the industrial energetics of farmed Atlantic and wild Pacific chinook salmon with the energetics of the capture fishery for chinook, coho, sockeye, chum and pink salmon. Note that the wild salmon fisheries are several times less energy intensive than is salmon farming and even the wild fishery is more energy intensive than it needs to be. (Salmon, after all, could be caught with little energy expenditure if we employed river-mouth trap fisheries as First Nations fishers once did.) The data below the graph show the protein Energy Return on Investment (EROI) for each salmon production method. None of these methods returns more that 11% of the energy consumed in the production process. However, the 6% to 11% EROIs associated with the various capture fisheries are all vastly superior to the 2.0% to 2.5% EROIs of farmed Atlantic salmon and farmed chinook salmon respectively. Indeed, salmon farming positions the production of salmon at the same level as intensive factory farming of chicken and beef, which are among the most energy-intensive forms of livestock-rearing.

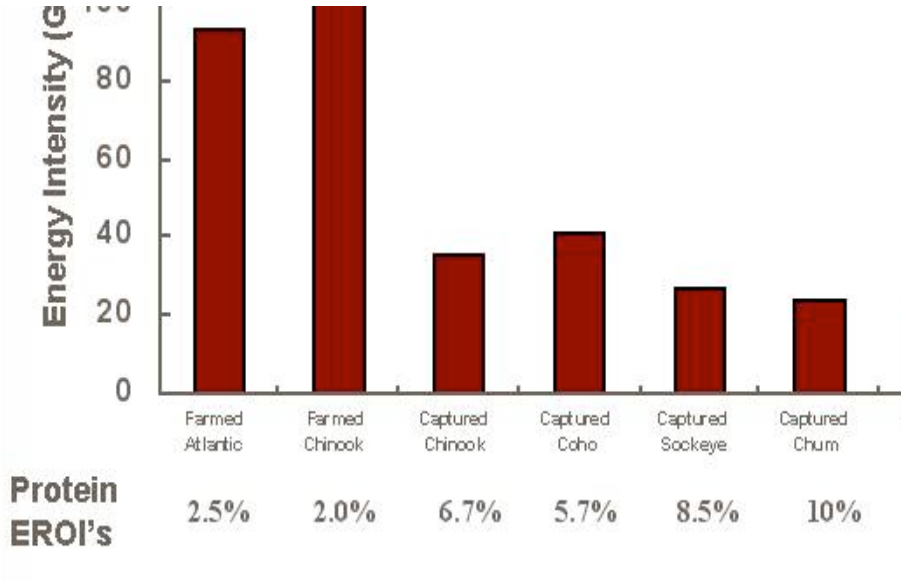

Figure 14.1. Energy inputs to BC salmon and protein Energy Return on Investment (EROI) for BC Salmon.

Industrial ecological footprints

Ecological footprints are usually calculated for defined human populations but it is also possible to estimate the total ecosystem area "appropriated" to sustain consumption/production by a specified industry or economic sector. Figure 14.2 compares Tyedmers' estimates of the total ecosystem demand by farmed Atlantic and chinook salmon with those of each of the five major wild salmonid species caught by the BC salmon fishing fleet. Clearly, the ecological footprints per tonne of product produced by salmon farms are larger than those of the fleet fishery, regardless of species. It takes between 12 and 16 hectares of land and aquatic ecosystems, in photosynthetic production and assimilative capacity, to produce a ton of farmed salmon per year. The fleet fishery is more generally efficient by a factor of two to three. These data hint at the fundamental unsustainability of salmon farming—the global ecological impact of this technology is significantly greater than that of commercial fishing, three-fold greater in the case of farmed chinook compared to captured pink salmon. This analysis again suggests that food production for

humans, as exemplified by salmon farming, is moving in the direction of greater energy intensity per unit product (i.e., diminishing returns).

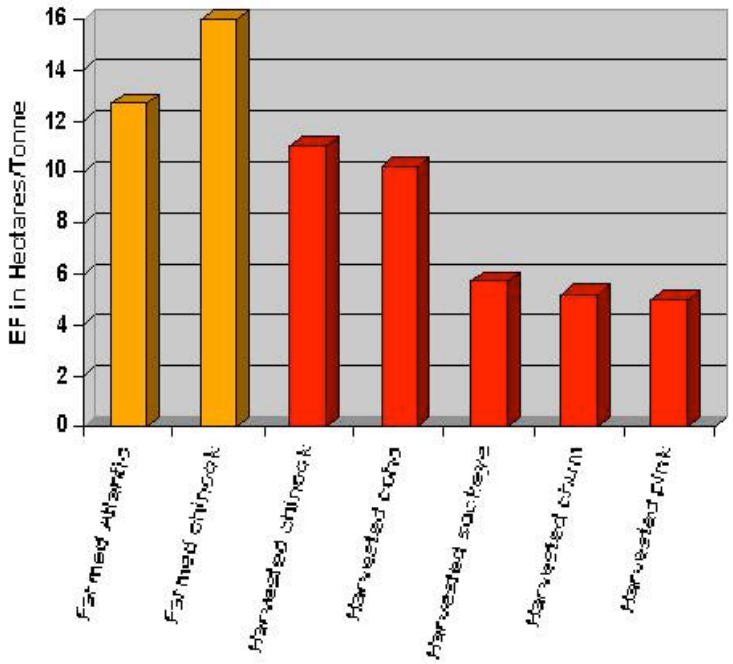

Figure 14.2. Ecological footprints (EF) of farmed and harvested (captured) salmon.

The socio-economic dimension

We have already noted that salmon farming actually reduces global food supplies. Much of the southern hemisphere fish-catch destined for fish meal could be consumed directly by the poor in the exporting countries rather than be used to produce a smaller quantity of salmon for rich consumers in the North. I recall at least one study showing that, in the 1990s, as more and more caught fish were being diverted to the animal feed industry (currently about 38% of the global total catch), the quantity of fish in the diets of the average Peruvian declined by 50%. Poor people were simply being priced out of the marketplace. Moreover, high global prices and export demand for South Pacific catches, has apparently closed dozens of small domestic fish packing plants in both Chile and Peru. In BC, while we welcome the salmon farming industry as an economic shot in the arm, it is effectively helping to shut down the packing industry in Chile and Peru. In 2002 a survey 102 of these plants in Peru showed that only 24 were operating because of a shortage of feedstock. The Peruvian government was forced to declare that certain species, such as Jack Mackerel and Pacific Club Mackerel, be reserved exclusively for domestic human consumption in order to keep these plants open.

More generally, what these data show is that as northern countries deplete their own fish stocks, they simply extend their marine ecological footprints ever further into the world's oceans to maintain domestic levels of consumption. (Another example: eastern Canadian fish processors now use catches from Asia and the South Pacific.) This illustrates a grotesque social dimension of globalization—under prevailing terms of trade, we now achieve through commerce what used to require territorial occupation. It is time to ask ourselves whether it is morally acceptable for the wealthy—that 25% of the human population who consume 86% of global economic output—to

use their economic power in ways that effectively deprive poorer people of the basic requirements for life.

Micro Conclusions: Net pen salmon farming and the fallacy of near-perfect substitution
The forgoing data show that in 2000, net pen salmon farming was failing on both biophysical and social grounds. Salmon farms are a costly and inefficient technological substitute for a superior service of nature. That is, the salmon farming industry expends large quantities of costly and increasingly scarce fossil fuel to do several jobs that wild salmon do for free, particularly foraging at sea to catch their own food. This represents a waste of scarce financial and energy resources that could be used for other socially productive purposes. Salmon farming also generates considerable carbon dioxide emissions and therefore contributes to potential climate change and simultaneously depriving poorer people of food.

The data also serve to illustrate the fallacy of the principle of near-perfect substitution. They are compatible with economist Robert Kaufman's observation that substituting manufactured capital for depleted natural capital requires investment that could otherwise be used to build additional (not replacement) productive capital or for consumption. Kaufman showed that, because of the hidden costs of shifting from consumption to investment, "it is not possible to substitute capital for environmental life support and maintain material well-being" (Kaufman 1995). In other words, substituting technology for nature is ultimately a losing proposition.

Macro Conclusions: Humankind is inherently biased against sustainability
I started out by arguing that the collapse of ocean fish stocks is merely the more recent marine equivalent of humanity's historic usurping of terrestrial ecosystems. It has taken humans a little longer to dominate the marine ecosystem, but it has finally been made possible by technological advances and cheap plentiful fossil fuel. Even the motivation is similar. Most people are under the illusion that agriculture was a great invention, one that was readily adopted by people everywhere. However, there is much evidence to the contrary—agriculture may well have been forced upon us by necessity. With the shift from stone to metal tools and weapons, human hunter-gatherers apparently became so effective that they frequently depleted game populations and otherwise overharvested their habitats. This forced them to start growing food to feed their expanding populations. However, this, in turn, made more food available, enabled the development of complex societies and allowed populations to expand even further. Are we not repeating some of this process in the sea? Is it not the overharvesting of wild fish that has forced us to turn to industrial-scale mariculture and is not this "advance" actually accelerating the exploitation of marine ecosystems? (I suspect that if we still had our original stocks of salmon and cod, we would not dream of fish-farming.)

The history of marine fisheries also tends to support my assertion that when it comes to human expansionary behaviour we are not a science- or knowledge-based culture. The global community has the data to show that the world's oceans are being emptied, but like the Easter Islanders, people today seem "…unable to devise a system that would allow [us] them to find the right balance with [our] environment."

Why does the torrent of scientific data showing the fundamental unsustainability of the human growth dynamic receive so little attention? What does it tell us about ourselves when reports that we have mined 90% of the fish biomass from the sea barely make the news and even then promptly drop from public consciousness? Why are our fisheries ministers not organizing urgent international meetings to deal with this crisis? As noted, humans have evolved no inhibitions to destroying their own ecosystems, terrestrial or marine. And this evolutionary blind spot is

expanded even further by the promise of "near perfect substitution" and perhaps even more by the big money to be made in industrial aquaculture. (At least one Canadian fisheries official actually remarked that the persistence of capture fisheries is a threat to the development of aquaculture.)

Finally, the history of fisheries and aquaculture supports the conclusion that at least some of the behavioural tendencies that conferred competitive superiority upon "the naked ape" in the relatively empty world of 50,000 years ago, have become maladaptive in today's ecologically full world. The inclination of humans to expand to the capacity of their environments and to accumulate possessions (the qualities that move economists to refer to people as "self-interested utility maximisers with insatiable material demands") presumably helped to ensure survival in technologically limited times but are depleting the planet today. Arguably, there is no solution to the (un)sustainability conundrum until we acknowledge and counter these root causes of contemporary human ecological dysfunction.

We hear a great deal about climate change, water scarcity, overfishing, and other so-called "environmental problems" but these are mere symptoms of the greater malaise. If we do not come to see unsustainability as *an emergent property of humans in nature* and to assert social control over the causal predispositions, we are destined to deplete our entire habitat and repeat the cycle of societal collapse on a global scale. And a global collapse would be very different in consequence from a regional one. Global failure has the potential to bring misery to billions of people and may even preclude the emergence of future civilizations. In the sobering words of Sir Fred Hoyle (1964): "It has often been said that, if the human species fails to make a go of it here on Earth, some other species will take over the running. …this is not correct. We have, or soon will have, exhausted the necessary physical prerequisites so far as this planet is concerned. With coal gone, oil gone, high-grade metallic ores gone, no species however competent can make the long climb from primitive conditions to high-level technology. This is a one-shot affair. If we fail, this planetary system fails so far as intelligence is concerned."

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CHAPTER 15

History and effects of hatchery salmon in the Pacific

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Abstract

There has been a long history of production of hatchery salmon along the Pacific coast - from California's first efforts in the 1870s using eggs from chinook and rainbow trout to the recent large-scale production hatcheries for pink salmon in Japan and the Russian Far East. The rationale for this production has also varied from replacement of fish lost in commercial ocean harvests to mitigation and restoration of salmon in areas where extensive habitat alteration has reduced salmonid viability and abundance. Over the years, we have become very successful in producing a certain type of product from salmon hatcheries, but until recently we seldom questioned the impacts the production and release of hatchery fish may have on freshwater and marine aquatic ecosystems and on the sustainability of sympatric wild salmon populations. This paper addresses the history of hatcheries around the Pacific Rim and considers potential negative implications of hatchery-produced salmon through discussions of biological impacts and biodiversity, ecological impacts and competitive displacement, fish and ecosystem health, and genetic impacts of hatchery fish as threats to wild populations of Pacific salmon.

Background

Aquaculture has a long and diverse history, dating from early Chinese fish culture around 2000 BC, pre-Columbian fishponds in Central America, Roman military carp ponds, moat-culture of fish in medieval castles, and extensive aquaculture systems developed by early Hawaiian kings (Nichols 1943; Hickling 1968; Bardach et al. 1972; Balon 1974). Marine fish farming is thought to have started around 1700 AD with the Indonesian culture of juvenile milkfish brought in on the high tide. In many considerations fish culture parallels the human culture of plants and agricultural animals, with early innovative activities dedicated to the appreciation and consumption of fish by select individuals within a greater society. Over the last century we have seen increased development of production hatcheries to supplement commercial fish harvest, ocean farming of millions of salmon, and supplementation of freshwater fish for recreational purposes. Today fish farming is a worldwide industry and aquaculture accounts for approximately 20% of the world's fish production. Since the end of World War II new technologies and mechanized opportunities for the culture and harvest of fishes have had broad economic and social effects, not the least of which is the impact of hatchery fish on wild populations.

North American commercial fish culture started in Ontario, Canada. Samuel Wilmot began selling Atlantic salmon (*Salmo salar*) eggs and young throughout New England following a decline in commercial harvest of North Atlantic salmon along the Eastern seaboard in the mid-1800s (Bottom 1997; Dr. M. Gross, personal communication). Pacific salmon and trout hatchery developments in western North America officially began in 1872, when the U.S. Fisheries Commission under the direction of Spenser Baird sent Livingston Stone to began taking fish eggs for culture at Baird Station on the McCloud River in Northern California (Stone 1896; Hedgpeth 1941). Driven by his need to address the decline in New England's commercial fishes and a limited supply of Atlantic salmon eggs for culture, Baird's directive to Stone was to obtain "large numbers of eggs of the best varieties of Salmonidae and other food fishes" on the western coast for culture and shipment to the eastern U.S. (Hobart 1995; Figure 15.1).

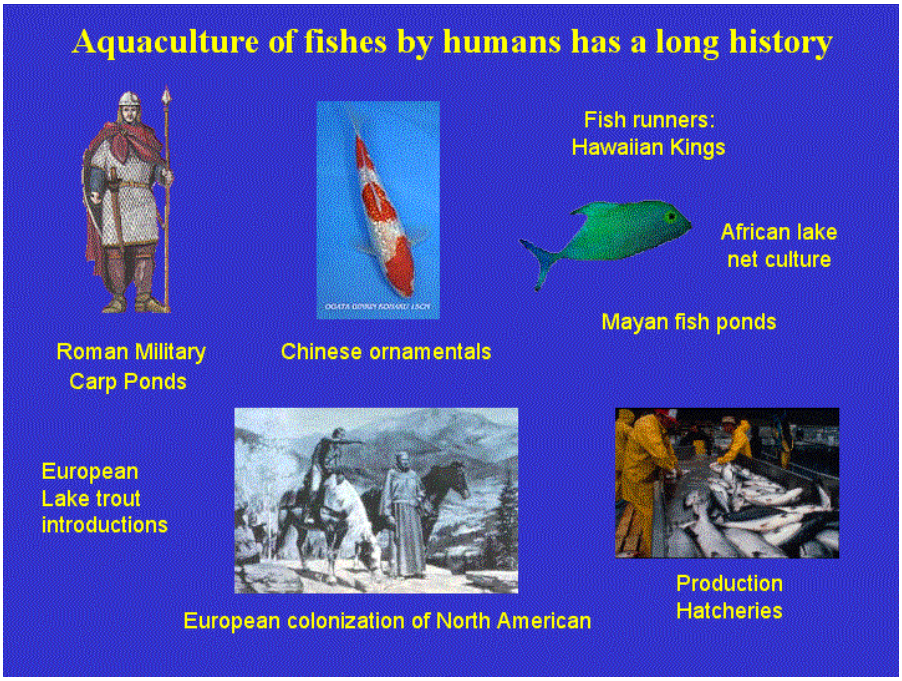

Figure 15.1. Aquaculture of fishes by humans.

Stone quickly developed production for trout (*Oncorhynchus mykiss*) and chinook salmon (*O. tshawytscha*) at Baird Station. Egg shipments from Baird Station were sent by rail and steamboat to many locations throughout the world for recreational and harvest introductions (Wales 1939; MacCrimmon 1971). Chinook from these early shipments did not survive in the rivers of the eastern U.S., but rainbow trout from Baird Station have survived in freshwater habitats on every continent around the word, with the notable exception of Antarctica (Busack and Gall 1980). Between 1900 and 1906, chinook salmon embryos shipped from Baird Station were sent to a hatchery on the Hakataramea River in New Zealand (Quinn et al. 1996). These chinook established self-sustaining runs within 10 years and remain the only known case of successful introduction of anadromous chinook from hatchery stocks outside of their natural range (McDowall 1990). The story of Stone's creation of the first Pacific salmon fish hatchery reads like a chronicle of the philosophy and dedication fish culturalists maintain today with strong roots in the personal bond that exists between human and animal and our need as humans to control or "steward" natural processes (see Lichatowich 1999).

Until recently, the artificial propagation of salmon and trout was considered a developing economy providing significant positive social gain throughout the world. Our dependence on hatcheries to supplement natural production, produce high quality flesh for human consumption, and provide strong economic advantage to producers was never questioned. Lately, however, much consideration has been

given to the fact that hatcheries represent a primary human intervention in aquatic ecosystems, both freshwater and marine. Alarming declines in wild spawning Pacific salmon stocks throughout the Pacific Northwest and British Columbia and numerous federal listings for Pacific salmon under the U.S. Endangered Species Act (ESA) have focused a re-evaluation of hatchery production and the potential impacts hatchery fish may have on natural populations in both freshwater and marine habitats (Nehlsen et al. 1991, Meffe 1992, NRC 1996, Lichatowich 1999).

So many hatcheries, so little time

Over the last 130 years hatchery production across the Pacific Rim has incorporated all seven Pacific salmon species. Hatchery production has increased exponentially since the 1970s (Mahnken et al. 1998, Figure 15.2). Worldwide hatchery-produced salmon introductions into the Pacific Ocean have exceeded 6 billion fish each year for the last 10 years (ENRI 2001).

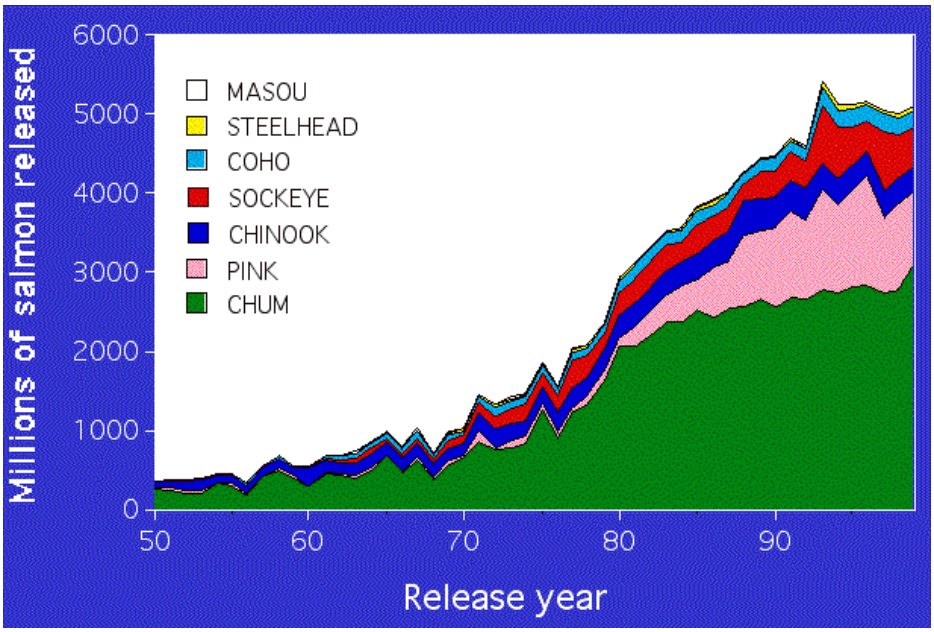

Figure 15.2. Total Pacific Rim hatchery production.

Production centers for hatchery-produced salmon include:

- The **Canadian** Salmonid Enhancement Program, started in 1977 with a goal of doubling the catch of Pacific salmon and steelhead in Canadian waters, accelerated annual stocking programs from 38 federal hatcheries and over 150 public involvement projects including spawning and rearing channels and numerous instream incubation boxes. Approximately 429 million salmon were released from British Columbia hatcheries in 1998 and up to 80% of the coho salmon caught in BC coastal waters were attributed to artificial enhancement (Noakes et al. 2000).
- **Japan** has one of the most extensive ocean-ranching programs in the world with over 300 hatcheries, mostly run by commercial fishermen cooperatives (Hiro 1998). In 1995, Japanese hatcheries released over two billion hatchery-produced salmon into the Pacific Ocean (NPAFC 1995). Hatchery salmon production in Japan has increased to over six billion releases a year in the last eight years (Nagata 2003).
- To counter declining salmon harvests in the mid-1970s **Alaska** started a hatchery salmon enhancement program. Sixteen hatcheries producing over 300 million juvenile salmon, primarily pink and chum, operated throughout the state in the late 1980s. Over 1.4 billion salmon were released from Alaskan hatcheries in 2000, and hatchery produced fish account for roughly 34% of the commercial harvest of Alaska salmon in eastern Pacific waters (McNair 2001, ENRI 2001).

- Hatchery production of salmon in **Oregon, Idaho, Washington** and **California** has a long history. The year 1877 marked the first construction of a chinook salmon hatchery in the Columbia River drainage in an effort to increase production in support of harvest for salmon cannery operations in that drainage. The construction of the Central Hatchery in 1909 near Bonneville in the lower Columbia River created a clearinghouse for the transfer of salmon eggs from and to hatcheries throughout the Pacific Northwest (Lichatowich 1999). By the late 1970s more than 300 million chinook and 200 million coho were released from hatcheries in the Pacific Northwest (Wahle and Smith 1979). In 1995 Washington released over 458 million hatchery produced salmon including chinook, coho, chum, sockeye and steelhead. Releases from Oregon in that same year equaled 80 million, California 67 million, and Idaho 17 million (NPAFC 1995, Mahnken et al. 1998).
- **South Korea** has a small hatchery program that began in 1913 and currently produces 8-16 million chum salmon each year (Seong 1998).
- Hatchery production in the **Russian** Far East started with hatcheries built by the Soviets in the 1920s on the Amur and Kamchatka Rivers. The Japanese also built a number of hatcheries in the 1920s in the northern part of Sakhalin Island and in the Kurile Islands. Following World War II hatchery production in this area increased under Russian control (Radchenko 1998). Currently the Russians operate 17 hatcheries on Sakhalin Island, four on the Amur River and one on a Kamchatka River tributary (ENRI 2001). In recent years, pink and chum salmon production for the Russian Far East has increased significantly with about 500-600 million fry released annually; approximately 52% pink and 48% chum (Khorevin 1998, Ruggerone et al. 2003a). The Russian Far East supports the largest pink salmon runs in the world, all hatchery produced, with an annual abundance of over 162 million adults in Pacific waters in odd-number years and 105 million adults in even years (Ruggerone et al. 2003b).

When tallying the numbers of hatchery-produced salmon released into the Pacific Ocean we cannot ignore the recent development of aquaculture raised Atlantic salmon (*Salmo salar*) in Pacific waters. It is estimated that 992,000 Atlantic salmon have escaped from aquaculture facilities along the eastern Pacific coast in the last 10 years (Nielsen et al. 2003). Based on the above gross estimates of recent hatchery production around the Pacific Rim in an average year over six billion artificially-produced salmon are released from rivers and streams surrounding the North Pacific Ocean.

Using hatcheries to succeed: weighing the advantages and disadvantages

Increased fish production capacity

From the very beginning of Pacific salmon hatchery production at Baird Station on the McCloud River, California, fish managers believed that hatcheries were the means to maintain a lucrative salmon harvest and natural production in the face of overfishing, development and habitat change (Lichatowich and McIntyre 1987, NRC 1996). Shifts in hatchery production varied among the different Pacific salmon species and from place to place based on local needs for harvest, expected escapement, and available resources in support of hatchery management. Increased knowledge of nutritional need, disease prevention, and early life history requirements led to improved survival and increased hatchery production in Canada and the U.S. in the 1950s and 1960s. Sharp declines in salmon stocks in the 1970s and 1980s, however, led to a change in focus for hatchery production, away from harvest management to supplementation and escapement.

Coho salmon (*O. kisutch*), for example, moved from a relatively undeveloped aquaculture species prior to World War II (less than 25 million fish annually) to one of the most successful hatchery produced species in the U.S. and Canada. In coastal Oregon alone a high of 198 million hatchery coho were released into the Pacific Ocean in 1981 (Mahnken et al. 1998). However, the decline in many wild coho salmon stocks throughout the Pacific Northwest and British Columbia has brought the role of hatcheries into question. Coastal coho from southern Oregon and northern California were listed as a threatened species under the

U.S. Endangered Species Act in 1997. In a highly controversial move, the National Marine Fisheries Service is currently re-evaluating their determination of Oregon coho as a threatened species to determine the role hatchery fish may play in their designation of coho salmon Evolutionarily Significant Units (ESUs) in this region. The likely future role of coho hatcheries in British Columbia depends more on whether they benefit wild stocks than on their contribution to a commercial harvest (Perry 1995).

Aquaculture has expanded at a rate of over 10% per year since 1984, primarily driven by a growing demand for fish products (FAO 2000). A large part of this growth is represented by the exponential growth of net-pen aquaculture of salmon. Atlantic salmon grown in marine net habitats for food production has not been without environmental controversy (Anderson 1997). High-density net pens concentrate large amounts of waste and pollutants from unused food, feces, urine and dead fish into the surrounding marine environment (Goldburg et al. 2001). Net-pen aquaculture has significantly increased demand for aquaculture feed derived from fish meal leading to developing concerns about the depletion of forage-fish resources to feed the net-pen culture industry and a net loss in actual fish protein (Pauly and Christensen 1995, Wackernagel and Rees 1995, Naylor et al. 2000; Chapter 14, Rees). Inadvertent escape of domesticated salmon from marine net pens has led to concerns about the spread of disease, interbreeding with wild fish, and invasive competition with wild stocks (Johnsen and Jensen 1994, Todd et al. 1997, Gross 1998, 2001; Kapuscinski and Brister 2001, Nielsen et al. 2003).

Sport fish restoration and enhancement

Hatcheries have played an important role throughout the world in sport fish restoration and enhancement. River, lake and reservoir sport fishing contributes important economic and cultural value throughout the distribution of Pacific salmon, including areas where they have been artificially introduced, such as the Great Lakes where coho salmon were first introduced in 1968 and chinook in 1969 (Lang et al. 1995). Many management activities by state and provincial fisheries authorities still reflect the sport fish priorities of their constituents, i.e. anglers.

As early as 1989, Miller et al. discussed the role of introductions for sport harvest on the extinction of North American fishes over the last 100 years. That study attributed numerous extinctions of native fishes to the introduction of hatchery fish associated with sport fish development. Extinction and decline of native fishes due to introductions of hatchery fish for recreational angling has been well documented (Behnke 1980, Bartley and Gall 1991, Courtenay and Moyle 1996, Jones et al. 1998).

Chinook are the least abundant salmonid in southeast Alaska due to limited freshwater spawning and rearing habitats (Mahnken et al. 1998). The number of hatcheries raising chinook salmon in southeast Alaska grew from one (1971) to 15 in the 1990s. Annual chinook production from southeast Alaskan hatcheries ranged from 25,000 to 112,000 in the period from 1985 to 1992 (Heard et al. 1995). Some of these facilities release hatchery chinook smolts into marine net-pens positioned at remote locations for 4-8 weeks in an effort to create adult returns in rivers some distance from the hatcheries for specific commercial or recreational marine fisheries (Josephson and Kelly 1993). However, variable results from the mariculture and ocean ranching of salmonids around the Pacific Rim suggest caution in supplemental introductions of Pacific salmon for marine harvest. Interactions among and within species in both freshwater and marine habitats, density-dependent survival, and changing marine conditions introduce significant uncertainty in ocean rearing programs at the local and greater ecosystem scales (Peterman 1991, Ruggerone et al. 2003b).

Management needs for endangered species

A new use for salmon hatcheries has developed over the last 50 years – the propagation of captive broodstocks for recovery of threatened or endangered Pacific salmon populations (Ryman and Utter 1987, Griffith et al. 1989, Johnson and Jensen 1991). The development of captive broodstock to protect and expand the natural genetic material in ESA listed endangered species of salmon has been implemented for Snake River sockeye (Lichatowich and McIntyer 1987, Flagg et al. 1995) and Sacramento River winter-run chinook (Hedrick et al. 1995). These aquaculture activities are run with the intent of raising progeny

to augment the natural population, either for direct release into their natural habitats or as a safeguard against total collapse.

Unintentional changes in genetics and adaptation during captive breeding can compromise the success of reintroduction of offspring (Lynch and O'Hely 2001). Genetic concerns over low population size, increased inbreeding and loss of genetic variation resulting in lower long-term fitness are now part of recovery plans for endangered species, including salmon (Ryman and Laikre 1991, Waples and Do 1994, Wang et al. 2002 a, b). Captive populations destined for reintroduction need to be managed to minimize genetic adaptation to captivity (Gilligan and Frankham 2003). Simulation studies by Waples and Do (1994) indicated that the single most important population genetic characteristic in efforts to sustain or increase abundance of ESA species with captive broodstock programs was whether the natural population remained large following termination of introductions. Evidence from this study suggested that the application of fish culture to mitigate fish declines is not sufficient in isolation from fixing the underlying causes for the decline in the first place; i.e., over-harvest, loss of habitat, and population fragmentation (Nehlsen et al. 1991, Meffe 1992).

There are significant concerns and risks associated with conservation breeding programs and only 11% of all serious attempts in vertebrates have led to recovery (Ebenhard 1995). Attempts to use artificial propagation to supplement declining populations of Pacific salmon have yielded variable results (Miller 1990, Cuenco et al. 1993, Flagg et al. 1995). The arguments around this issue seem to migrate between the need to fix the habitat problem that caused the population decline in the first place and a "quick-start" in natural production from the captive program before all is lost (Kapuscinski and Jacobson 1987, Waples 1991, Hard et al. 1992, Kincaid 1993, Waples et al. 1993).

It is clear that there are inescapable risks, trade-offs and uncertainties associated with endangered species management strategies involving artificial propagation (Busack and Currens 1995), and we have been repeatedly warned against application of the "Noah's Ark Paradigm" for endangered species in the wildlife literature (Wiese and Hutchins 1994). A clear analysis of net benefits of such programs (to society, the salmon, and their shared ecosystems) is needed with an accounting of the actual cost of these programs in dollars balanced by potential benefits (Waples 1999).

Another gap in our understanding of conservation hatcheries for declining species is basic research, both in the laboratory and in the field. While some critical genetic issues are well defined theoretically, actual empirical studies of population decline are few and far between. Even our understanding of the theoretical basis for conservation breeding remains incomplete. For example, the long-term cryopreservation of gametes, or gene banking, is in its infancy and still very experimental (Ebenhard 1995), but may serve as a valuable tool for conservation breeding in Pacific salmon. Some idea of the minimum number of effective spawners in declining populations (Waples and Do 1994), and a better understanding of reproductive success and gene flow in small populations (Charlesworth 1997, Nielsen 1999) are needed before intervention with conservation hatchery programs becomes necessary or efficient.

Genetic manipulation

Two new applications of genetic technology are available for fish and fisheries enhancement through hatchery operations: chromosome manipulation to produce sterile fish populations lacking the ability to interbreed with wild stocks (Thorgaard 1992, Ferguson 1995) and the production of transgenic fish (MacLean and Penman 1990, Du et al. 1992, Rodemeyer 2003). These powerful applications of DNA-based technologies can be used to monitor and/or reduce the effects of hatchery releases on wild populations, enhance traits selected for their contribution to superior broodstock, or to confer adaptive advantage in the culture of fish in novel environments.

Sterilization of fish through chromosome manipulation involves the application of temperature, pressure or chemical shocks to fertilized eggs to add extra chromosomes to each egg. The effectiveness of this

approach is highly dependent on the species, methods used, and the quality of the original gametes. The results are frequently a matrix of chromosomal states, both within and among individual fish, and sterilization success rates can vary greatly (10-95%; Maclean and Laight 2000). Kapuscinski (2001) suggested manual pre-screening of all putative tetraploid fish before release into natural environments. However, even with certain sterilization, introduced sterile fish still carry physiological and behavioral characteristics that may introduce competition and interfere with reproductive success and spawning in wild sympatric populations (Kitchell and Hewitt 1987, Cotter et al. 2000).

Growth-enhanced transgenic Atlantic salmon are genetically engineered to contain a DNA construct of the promoter region for cold tolerance (sometimes called an "antifreeze" gene) from the ocean pout (*Macrozoares americanus*). This DNA promoter region regulates the activity of the genes linked to it, keeping them active in cold water habitats, a requirement for successful survival for ocean pout in arctic waters. Unmodified Atlantic salmon produce little growth hormone in cold temperatures, but by putting the salmon's hormone gene under the control of the ocean pout's promoter region these salmon produce growth hormone all year long. These fish convert food more efficiently and reach market size in half the normal time (Fletcher et al. 1999, Cook et al. 2000).

As was the case with Atlantic salmon in Pacific waters, escapes of transgenic fish into wild populations holds the potential for considerable unintended impacts. Accelerated age at sexual maturity has been shown to offer a major advantage on the potential net fitness of transgenic fish in the wild (Rodriguez-Clark and Rodriguez 2001). Transgenic coho salmon and rainbow trout containing novel growth hormone genes have been shown to reach sexual maturity earlier in life than their wild counterparts leading to potential spread of transgenes through wild populations subjected to interbreeding (Devlin et al. 1994, 2001). The so-called "Trojan Gene" hypothesis suggests that even with reduced adult viability in transgenic fish, enhanced mating success could result in a rapid decline of interbreeding wild populations (Muir and Howard 1999; Hedrick 2001).

Hatchery-wild interactions

Inevitably, hatchery salmon released into natural environments – both freshwater and marine - will encounter and interact with wild fish. The implications of these interactions have been reviewed extensively in the literature (Fausch 1988, Campton 1995, White et al. 1995, Waples 1999). Most of these concerns evolve from two concepts:

1) Domestication of hatchery progeny; i.e. hatchery fish with acquired physiological, genetic and behavioral traits that are inappropriate for life in natural habitats (Woodward and Strange 1987, Olla et al. 1991, Ruzzante 1994, Berejikian 1995, Hard et al. 2000, Fleming et al. 2002, Marchetti and Nevitt 2003);

2) Successful hatchery fish; i.e. those that survive in natural habitats, compete with wild fish for limited resources thereby reducing fitness factors in wild stocks (Nickelson et al. 1986, Reisenbichler and McIntyre 1986, Jonsson 1997, Unwin and Glova 1997, Reisenbichler and Rubin 1999, Fleming et al. 2000, Chilcote 2003).

It seems domestication hinders survival of hatchery fish in natural habitats, but in many cases where these fish do survive they have been shown to have detrimental effects on sympatric wild stocks. This conundrum stems from poorly defined culture objectives, products and processes that remain greatly oversimplified, and significant confusion in the public on the roles of fish culture and stocking in resource management (White et al. 1995).

Most hatchery-wild salmon interactions have been studied in freshwater habitats, but several issues of carrying capacity in the ocean have been published (Peterman 1984, Heard 1998, Hobday and Boehlert 2001, Mueter et al. 2002, Ruggerone et al. 2003b). Marine community structure in the North Pacific Ocean has undergone significant change due to well-documented climate regime shifts (Beamish and Bouillion 1993, Mantua et al. 1997, Anderson and Piatt 1999, Figure 15.3). These shifts are thought to

change the prey base available to Pacific salmon in the North Pacific Ocean and can have significant impacts on productivity (Pearcy 1992 and 1996, Pearcy et al. 1999).

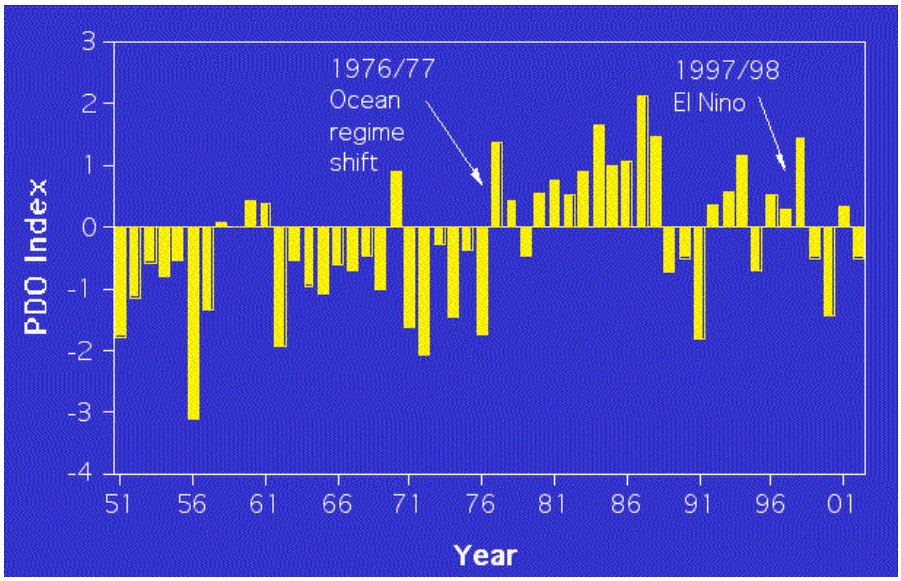

Figure 15.3. Pacific Decadal Oscillation (PDO) and species abundance shift.

Over the last three decades the proportion of hatchery fish, especially pink salmon from Asian hatcheries, which feed in the North Pacific Ocean, has increased significantly (Figure 15.4).

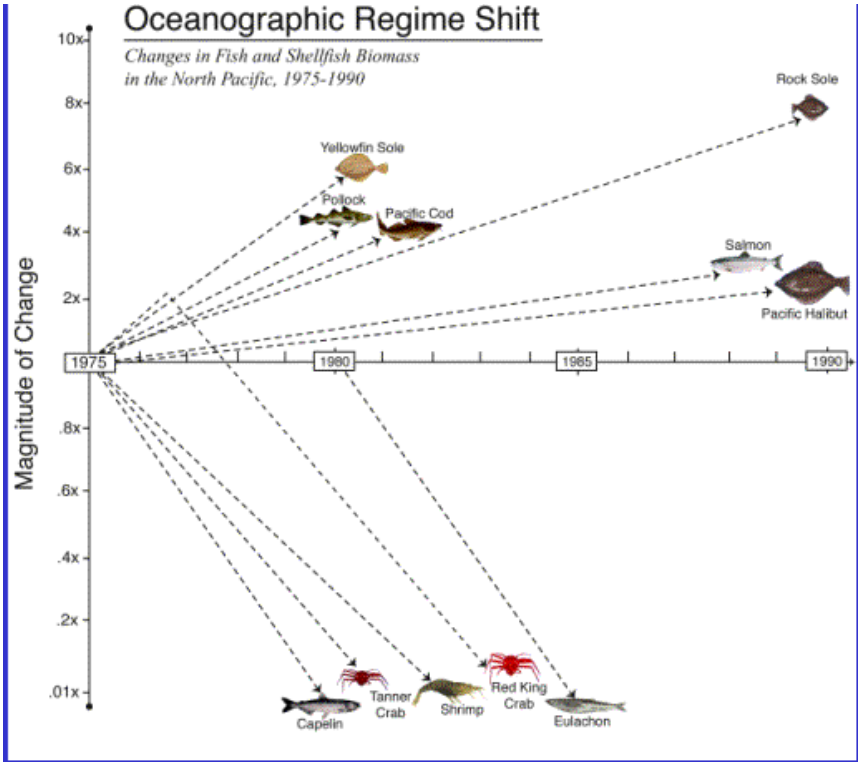

Figure 15.4. Oceanographic regime shifts impact marine populations.

The impacts of hatchery production on ocean carrying capacity for Pacific salmon are not limited to mortality, but also include growth effects. The recent publication by Ruggerone et al. (2003b) suggested

that the overlap in ocean distribution of hatchery pink salmon from Asia and wild Bering Sea sockeye salmon from Alaska (Figure 15.5) has had a significant impact on sockeye salmon growth during their 2nd and 3rd years at sea (Figure 15.6). Based on yearly average landing prices for Alaskan sockeye, the interaction between Asian hatchery pink salmon and wild sockeye would have equaled a loss of over $310 million to the Alaskan commercial salmon industry from 1977-1997 (Ruggerone et al. 2003 b).

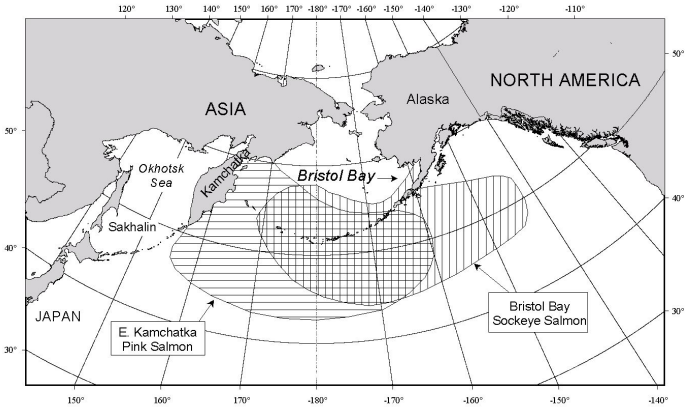

Figure 15.5. Overlap of Asian pink & Bristol Bay sockey salmon: location and diet.

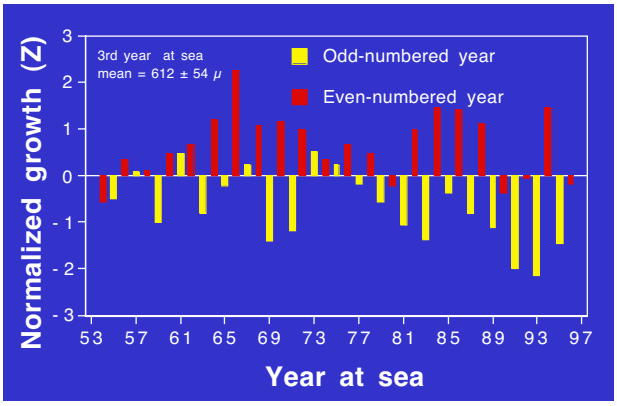

Figure 15.6. Sockeye growth reduced during odd years at sea (2nd & 3rd yrs).

Three implications can be drawn from data suggesting competition in ocean habitats between hatchery and wild Pacific salmon. It is most important that we realize that hatchery production may have unintended impacts on distant wild stocks. We currently have no clear idea where different salmon stocks go in the ocean and what habitat features are critical for their survival. With ocean competition, hatchery production to supplement and enhance declining salmon populations may have unintended impacts on ESA protected salmon species. The potential for ocean carrying capacity and competition between hatchery and wild stock also implies that we need to include the ocean in our dialogue for "ecosystem management" in salmonids.

Hatcheries in the future

Currently there is great discussion within the fisheries management community on the role of hatcheries. Proposals for "rehabilitation", "mitigation", "augmentation" or "supplementation" hatcheries and "adaptive management" in hatchery operations are often discussed as alternatives to production hatcheries. These alternative hatcheries are built around various plans by which resource managers can mitigate hatchery and wild fish interactions and reduce the genetic and ecological impacts of hatchery fish (Kapuscinski 1997). The importance of maintaining genetic and ecological diversity in salmon stocks is the goal of most new hatchery plans, but our ability to meet this goal and the actual costs involved in such production are often not discussed. It is difficult to estimate the actual on-the-ground costs needed to monitor genetic and ecological integrity of wild stocks sympatric with hatchery fish in freshwater, much less marine habitats. But that is exactly what is needed in our dialogue over salmon hatchery production in the future.

We need a clear evaluation of all operational costs, the monetary value of harvested fish (both commercial and sport), and a full accounting in dollars of the social and ecological costs and benefits of hatchery production and monitoring programs (White et al. 1995). If we are really ready to accept "adaptive management" in hatchery production, we should clearly document the social and economic costs involved in shutting a hatchery down, either intermittently or permanently, if the scale of production exceeds reasonable, predetermined ecological or genetic goals for no-impact to wild stocks. The costs of such shutdowns must be built into our initial estimate for the costs of production.

Is sustainability of salmon at the local level really possible through hatchery stocks (NRC 1996, Lichatowich 1999)? Many people think the days of wild salmon are over. The exponential increase in human population and their subsequent demand for resources may be incompatible with wild fish (Chapter 14, Rees). But that really depends on how you define "wild". Are there really any wild salmon left that can respond and adapt to a diversity of natural habitats at a local level outside of Alaska and the Russian Far East? How do we go about defining future relationships we may develop with natural conditions that affect salmon without a clear definition of what we mean by "wild"?

Lichatowich (1999) suggested working toward "building a new salmon culture" and rethinking society's 19th century focus on "conquest over nature" where we turned free flowing rivers into dams and reservoirs and wild salmon into hatchery fish. According to Lichatowich (1999), a new relationship between man and salmon is required for future interactions, "one that is in harmony with the ecosystems". As local communities take interest in urban rivers and begin to value salmon in these ecosystems, grassroots efforts at restoration become part of a new social agenda. Are salmon populations locked into limited urban river ecosystems truly "wild" even if they are self-sustaining? Does that really matter? It all depends on how you define "wild." Social and economic trends can lead society to an acceptance of the consequences of our industrial economy with hatcheries and dams, and move forward with a focus on our obligation to coexist with salmon for future generations (Nielsen and Regier 2003, Chapter 14, Rees). But that relationship, what we as a society really need from salmon, remains to be defined.

That does not mean that hatcheries will not play a role into the future. We have interfered with the salmon's struggle for existence and put up many obstacles to their recovery. The skills of husbandry and propagation learned in the development of today's salmon hatcheries will be needed for many years into the future to support recovery and sustainability of salmon stocks throughout the world. In many parts of the world the difference between hatchery and wild salmon is less contentious than it is in the Pacific Northwest. But the application of our skills as culturists of salmon needs to be focused toward reasonable goals that fit the current social and economic framework for persistence and sustainability of salmon (however we define them) with open dialogue on all the latent and potential problems built into hatchery production (Waples 1999).

It is important to stipulate, however, that hatcheries cannot fix or mitigate the underlying problems of habitat fragmentation and destruction, overfishing, and ocean carrying capacity faced by salmon populations throughout the Pacific Rim (NRC 1996, Lichatowich 1999, Jackson et al. 2001). The National Research Council focused this issue clearly in 1996 by stating "reliance on hatchery production does not change the basic human behaviours leading to fluctuations in salmon abundance" (Anon., 1996). The myth of an agrarian utopia based on hatchery production and the transfer of fish stocks from stream to stream, or ocean to ocean is not working and has lost favour in the public eye.

Enthusiasm for new technologies dedicated to fish and fisheries has become increasingly controversial, especially considering pen-reared salmon and genetically modified fishes. Recent scientific discussions on salmon and their ecosystems have focused resource management away from the "control-of-nature" paradigm to a search for accommodation between nature and human endeavours (Bottom 1997, Nielsen and Regier 2003). Changes in human behaviour in support of a new philosophy of resource management focus our responsibilities for products from the past and forge a new path of integration between culture and salmon. As these trends reach maturation on a global scale they will educate and encourage humans in acts of coexistence with salmon and their ecosystems for generations to come.

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CHAPTER 16

What is limiting our ability to effectively manage salmon?

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Introduction

This paper focuses on British Columbia and one particular policy issue: '*salmon management'*. It really is a microcosm of the experience I have seen in resource management agencies around the world. The question I ask is, "What is it that is really limiting our ability to effectively manage salmon – is it politics, is it habitat loss or is it overfishing?" I want to offer you my most recent view about that, a view which has changed considerably over time. In a number of ways, I will be reiterating some of the points raised by John Fraser in Chapter 1. The view that I will present to you is basically a cynical view.

When I was an undergraduate student I took an introductory economics course and I will never forget what the professor said on the very first day of this course: "Economics is the study of the allocation of scarce resources". In ecology, the study of the ecosystems is basically the same thing – our aim is to understand how scarce biophysical resources are used by a community of organisms to build a food web structure in which creatures become both resources for one another and threats for one another. We are getting very good at building ecosystem models today and understanding at least something about the biophysical basis for production and factors that can influence it. There is *economics* telling us that we are dealing with the allocation of scarce resources and there is also *ecology* telling us that we are dealing with the allocation of scarce resources. My question is, "What resource is it that is preventing us from bringing the ecology and the economics together into some more effective ecosystem management for Pacific salmon?" We know we have to deal with freshwater problems, marine problems and fishing pressures - I question why we are not doing ecosystem-based management. Is it because we cannot plan ahead or is it because we cannot control fishing interests? I do not think either of these is the problem.

The problem: not getting good information

I believe that what is getting us into trouble today is that we cannot manage ecosystems effectively, particularly our salmon resources here in the Northwest, without good information. Good information is critical for allocating management resources in order to sustain salmon and we are simply not getting that information. The scarcest resources we have are human resources and financial resources, both of which are required to gather data.

In British Columbia the public has spent hundreds of millions of dollars in fixing the wrong things while many stocks keep declining. This expenditure has been based on the pretense that freshwater habitat issues are the main causes of salmon declines, and that artificial production schemes can solve these problems. Very large amounts of money are spent on trying to protect and manage salmon in British Columbia. I was shocked to learn, for example, that the public (DFO) expenditures for salmon

management/protection in 2002, per kilogram of salmon captured through fisheries, was approximately 50% of the Florida supermarket price for wild salmon steaks per kilogram.

My basic argument is that we are not allocating the financial and human resources that we have for salmon management in an optimum way (and that is also true for fisheries around the world). The first priority has to be the allocation for gathering information. As a scientist, I regularly field questions as to why the salmon are declining and the survival rates are going down, and what is changing in the ocean? As to the question of whether we, as scientists, are looking at the ocean, the answer is *no*. We are not out there looking at the ocean - we are not getting that information. There is practically nothing being allocated, relative to what is needed, toward the gathering of information needed to answer the kinds of questions that the public is asking us. Without ocean information gathering, we will continue to misallocate human resources. The interface between ecology and economics really is in how the public allocates resources to salmon and marine management and protection, and they will continue to be wrongly allocated.

Declining marine survival rates

In British Columbia the most important single problem for salmon populations is declining marine survival rates (Figure 16.1).

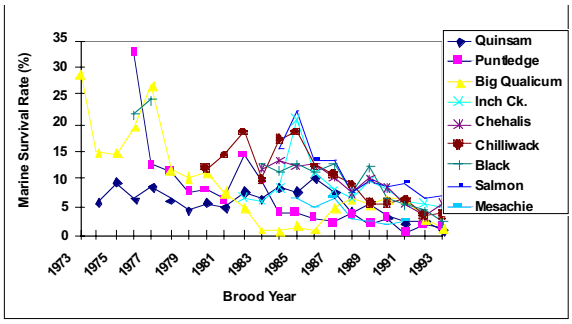

Figure 16.1. Declining marine survival rates in BC coho hatchery salmon from 1973 – 1993.

Every scientist you ask will tell you that the reason there have been major declines in coho salmon, in Rivers Inlet sockeye and pink salmon, Vancouver Island chinook salmon, and a number of other stocks, is not because of freshwater habitat loss or overfishing. Rather, it is because the marine survival rates are going down. The Rivers Inlet sockeye stock collapsed 5-6 years after the fishing was closed completely. We have had virtually complete protection of coho salmon and chinook salmon along the British Columbia coast for the last several years and yet we are not seeing any significant recovery.

Similar to the findings of Jeff Hutchings (Chapter 3), it is clear that shutting down fisheries is not the answer to recovery. Something else is going on that is driving survival variations much larger than the fisheries impacts, and it is not fishing.

Observations of the time trends in marine survival for coho salmon show us that the two kinds of salmon, hatchery fish and wild fish, have exactly the same kind of patterns whether they are protected in their freshwater rearing period through growing in a hatchery or whether they are growing in the wild.

It has been suggested that what happened to the sockeye in Rivers and Smith Inlets had something to do with the obvious impacts of logging on the streams around there and Owikeno Lake. If you have ever been to Owikeno Lake you would know that logging progressed around the lake relatively slowly and, if logging had been the problem, Rivers Inlet sockeye would have declined slowly over time and would not have declined dramatically in one year by 90% as they did in 1994; such a sudden decline suggests a marine survival problem.

The Department of Fisheries and Oceans, other agencies, and NGOs have spent very little money trying to uncover the causes of that problem and to determine whether or not those causes involve something like marine mammals, that we could potentially do something about. Out of the $90 million per year being spent on salmon in British Columbia, only about $300,000 per year is being spent to try and understand what is going on in the ocean. This is virtually nothing in view of the high costs of doing research in the ocean.

Chekamus River coho salmon marine survival experiment
We have recently completed an experiment which examined marine survival rates for coho salmon from the Chekamus River near Squamish B.C. The purpose of this activity was to determine when and where the apparent very high ocean mortality is occurring. We released a small number of coho salmon (15 in total) from the Tenderfoot Hatchery with ultrasonic tags. To carry out the study we borrowed an ultrasonic receiver system from the University of Miami, hydrophones from the Hubbs Marine Lab in California and as another set of receivers from a private company based in Nanaimo, BC.

We probably learned more from these 15 fish than we have about coho salmon in the ocean in a very long time. Results showed that the first four of the 15 coho, as we expected from other studies, were killed within a mile or two of the hatchery, probably by merganser ducks. The remaining 11 coho made it down to near the river mouth and then, within a matter of 3-4 hours, four of those were eaten by seals. Out of the original 15, about 7 survived to reach the middle of Howe Sound a few days later. We critically need information like this to better understand factors determining marine survival in salmonids, and where to do more of the critical but expensive marine research.

Re-allocation of resources
I ask you this question, "Why are we not allocating more of our scarce management resources to building an understanding of what is going on in the place where the problem is?" If we close down just one of the large British Columbia salmon hatcheries whose returns are so poor today because of poor marine survival, that would provide enough money to set up a monitoring network along the British Columbian coast. This would allow us to find out a great deal in a few years about marine mammals, food supplies and other possible agents that could be causing these dramatic changes in salmon.

The largest expenditure for salmon in British Columbia, and certainly by far in the Pacific Northwest, is on habitat management. This is based on the assumption that declining habitat and deteriorating habitat are the main reasons for the disappearance of salmon. British Columbia, for example, has spent hundreds of millions of dollars on habitat restoration programs and the federal government of Canada has spent upwards of $140-150 million over the last few years on habitat. Why do we see so little work being carried out to try to find out, from the population information that we already have on salmon, just exactly what the freshwater habitat impact on those fish has already been? Very few such studies have been attempted, and, in fact, only one that I know of (which examined interior BC coho) showed a serious negative habitat effect. Other studies hint that there may even be positive impacts on habitat change, rather than negative ones. However, the results of these studies have been questioned because the population data are poor, and this is because we are not investing enough in gathering basic population information on salmon. The biggest problem is that there are many whose jobs depend on continuing to pretend that the problem lies in freshwater; when half the employees of an agency are trained for, and their jobs dependent upon, a freshwater management approach, it is not surprising that they resist change, wherever that change might be needed.

BC watersheds study
The following case study demonstrates how tenuous the argument is for spending so much on habitat restoration, anywhere in the Pacific Northwest. A graduate student at the University of British Columbia, Maria Morlin, has recently completed a study which involved sixteen watersheds around Georgia Basin. These watersheds were chosen because it was possible to go back about 25-30 years with aerial photography in these areas and map out habitat changes over time. For each of these watersheds there are reasonable salmon escapement trend data and, for most of them, information on freshwater fry abundances. These watersheds cover the kinds of changes, in terms of habitat, that are observed in the most intensively developed areas in BC; for example, areas along Vancouver Island, such as the east coast where development has been rapid, and the Fraser Valley. These watersheds vary widely in the extent of

disturbance in recent years; some are relatively well-protected (water supply watersheds), some are recovering from old logging damage, and some are experiencing urban and agriculture development. Figure 16.2 shows the locations of these watersheds and Figure 16.3 describes the results of this study. In Figure 16.3 Morlin plotted trend indicators over the set of 16 watersheds, including fry abundance indicators in the top panels of the graph, and escapement trend patterns where higher values mean positive trends in abundance of spawning fish and negative values mean decline in abundance. These are plotted against a variety of habitat changes. Clearly, no correlation was observed between habitat change and coho escapement or fry density. In fact, if anything, there is a very weak positive correlation between salmon abundance and agricultural development in the Fraser Valley where several of the most productive salmon streams are heavily impacted by agriculture. There is certainly no association between old growth forest and any factor except a few indices of coho fry abundance.

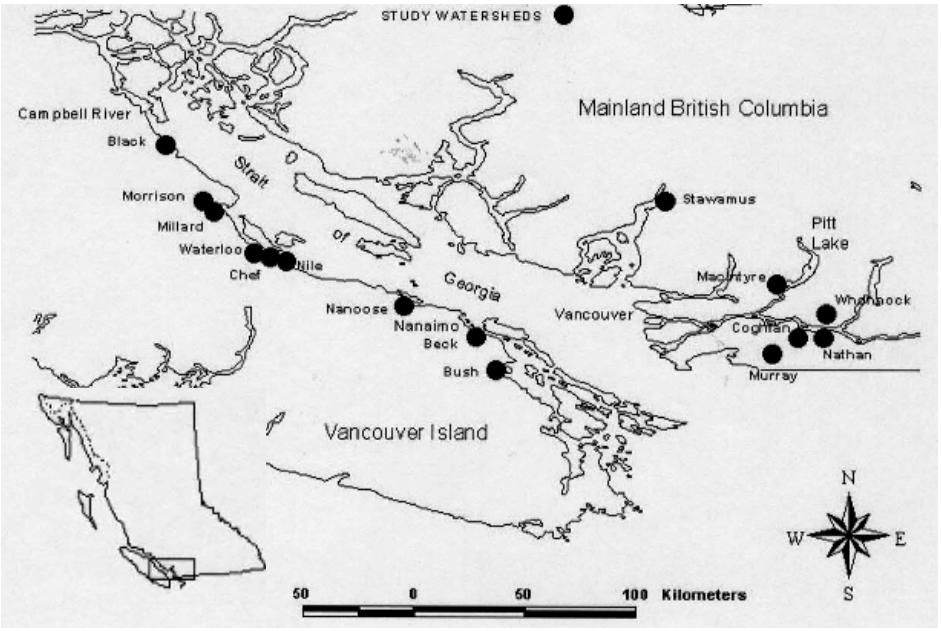

Figure 16.2. Locations of Maria Morlin's study on 16 southern BC watersheds.

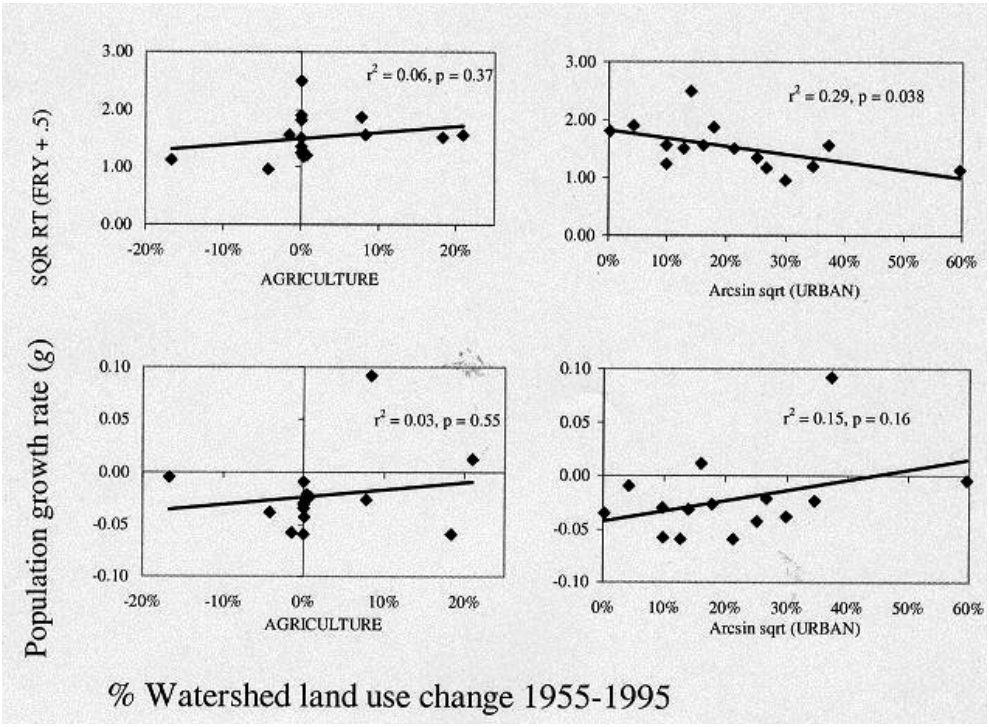

Figure 16.3. Correlation between habitat changes and coho escapement or fry density in the Morlin study.

Data like these tell us that the habitat changes we are observing, that look horrifying to us from an anthropocentric point of view, are not really at the heart of the problem. Rivers in British Columbia are still capable of, and are still, producing large numbers of juvenile salmon, but these fish are not surviving after they leave the rivers. Why is it that a graduate student, rather than those people who are directly concerned in management agencies with monitoring habitat changes, is the one to produce a study like this? Why isn't this kind of analysis of the effectiveness of habitat protection and management being conducted on a routine basis to support decision-making for allocation of scarce management resources?

Hatchery Production and Wild Stock Management

Figure 16.4 provides another hint that things are going seriously wrong. The graph represents time plots of hatchery releases of coho salmon from the hatcheries around Georgia Strait. There was a brief period of very high production in the early 1980s, then things settled back down, and from 1990 to 2002 there has been a gradually increasing trend in hatchery releases. This has occurred during a period of time when we know the marine survival rates of those fish would have been extremely poor and during a time when most of the fisheries for coho and chinook, in the Georgia Strait area at least, have been closed.

We also know that there is a negative correlation between marine survival of wil salmon in Georgia Strait, and hatchery releases - apparently there is competition between hatchery and wild fish in the relatively restricted environment of the Str Why then are we increasing hatchery production at a time when we know we are not going to catch that production, and when we know that it may be causing decreases in survival of wild salmon? Something has gone seriously wrong with the management system when it can make this kind of misallocation of money and resources.

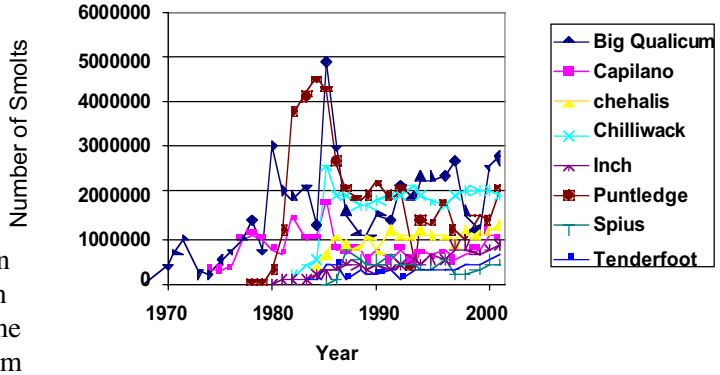

Figure 16.4. Georgia Strait coho releases from 8 hatcheries (1979 – 2000).

Risk management

There has been much interest recently in trying to deal with the biodiversity issue, particularly for species such as coho salmon where there are very large numbers of small stocks. To do this, we must face up to the basic issue that there is no way to manage a Pacific salmon multiple stock complex, whether it is Fraser River sockeye or coho along the coast or chinook salmon, without putting some of these stocks at risk of extinction. From many long-term data sets on fish, we know we will see a pattern like that shown for coho salmon in Figure 16.5. As exploitation rates go up, we expect yield to go up (shown in purple) to some peak, and then to drop down when we overfish. Even near that peak or the maximum sustained yield exploitation rate, 30-40% of the stocks are going to be overfished and at risk of extinction. The only way that the extinction risk can be brought to zero, so as to maintain complete biodiversity, is if we do not fish.

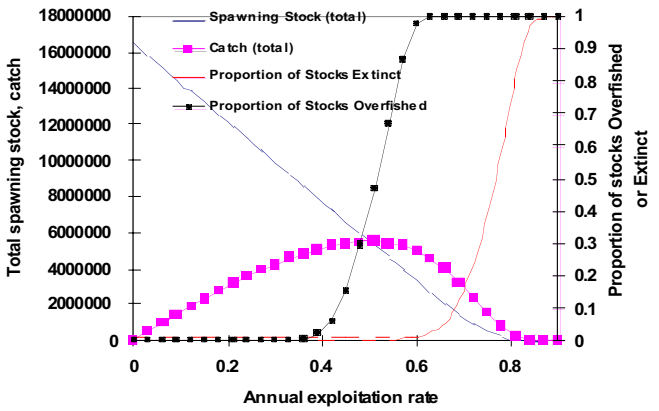

Figure 16.5. Effect of increasing coastwide exploitation rate of BC coho stocks.

We are not facing up to the fact that we cannot have our cake and eat it too – that is, we cannot have biodiversity without a loss in harvest value. I am not arguing that we ought to go out and remove 90% of the salmon stocks and leave only the most productive ones. What I am pointing out is that we are not facing the risk management problem honestly. When we do see improved marine survival rates, we will not have in place any protocols or strategies for dealing with the trade-off issue. What we have been doing instead in the face of that risk management trade-off problem, is to spawn scapegoats and 'quick fix' solutions.

We used to think that we could pump up productivity in a large number of stocks through salmonid enhancement so that the weaker ones could keep up with the ones being harvested at higher rates because they could already sustain them. Then we turned to habitat management. Most recently we have spawned a number of new scapegoats to try to avoid the risk management problem; we can blame aquaculture for the problems, and we will probably get into marine mammal culling before too long. The evidence is growing that mammal predation is at least part of the problem, and mammals are certainly convenient scapegoats in any case. There has been much bureaucratic fiddling under the Endangered Species Act (USA) or Species at Risk Act (Canada) to identify threatened populations and define Ecologically Sustainable Units. Yet none of this activity really addresses the trade-offs in an honest and rigorous way. We are doing everything but getting the information and facing the issues.

In the absence of any clear public policy direction about how to deal with this risk management problem - and if we are to operate along trade-offs where we determine which stocks we will write off in order to be able to harvest the others - we are liable to see arbitrary and capricious solutions. In the past, the solution has been a shifting baseline syndrome, where we have concentrated management on the more productive stocks while praying that the less productive ones would not entirely disappear. In the last few years, we have seen a shift to the opposite extreme where we are shutting down entire fisheries - very valuable fisheries - in order to protect a few relatively small and unproductive stocks. The most recent examples are the closures of fisheries to protect the upper Fraser River and upper Skeena River coho salmon stocks, as if they were major contributors to the fisheries. Now that several sockeye stocks have been listed by COSEWIC as 'at risk of extinction', we may see major restrictions on the most valuable single fishery in British Columbia, the Fraser River sockeye fishery. Perhaps this is wise management, and perhaps it is time to protect biodiversity and stop the shifting baseline, at any expense to the fisheries. What I do not see going on out there, however, is any kind of really honest discourse and debate about whether it is really worth it - whether the positive benefits of risk management in maintaining biodiversity are justified. We are not facing the fact that it is a trade-off, similar to the trade-offs that you have to make when investing in the stock market between risky stocks and safer ones.

Conclusion

There will doubtless be recommendations to increase funding for salmon protection and restoration, which will include statements that we need more information, more habitat, and more of this and more of that. In view of our track record to date and the apparent inability of our management agencies and institutions to respond to knowledge when we do get it, do you really think these are a responsible recommendations? I would rather see my tax money going to support my children's education, the health care system and the other things that many people need and value, than to a fisheries management system that is apparently incapable of using that money wisely.

CHAPTER 17
Dialogue following Potential Threats to Wild Salmon

Are there incentives to change behaviour to be more salmon-friendly?
Randall Peterman asked Bob Lackey for suggestions on how we might create the appropriate incentives for people to change their collective behaviour in the direction that might be more salmon friendly, noting that a set of incentives might be something to overcome the tendency to go around regulations.

Bob Lackey replied that his approach on that is two-fold. Firstly, he is not convinced that the public's behaviour does not reflect their true priorities. The second point is that he believes that we need to be brutally honest with people, from a technical standpoint, and tell them what will or will not work. He noted that all too often, has been in meetings where they have had the daytime discussions where the plans might work, and in the evening they sit around the table and say there is not a prayer that this will work. Somehow, that information does not get out to the public at large.

Are there any recovery strategies underway already that address the four drivers?
Morris Sydor commented: I know that there are a number of salmon recovery strategies in different regions in the US. Is there one that you can point to that actually addresses these four drivers that you referred to?

Bob Lackey replied that there is not.

Are there lessons that can be learned from Japan?
Xanthippe Augerot thanked Bob for his presentation and commented that it contributes a candor that we really need to take to heart. She posed a question to Mitsuhiro Nagata: If we look around the North Pacific, Japan is our future in some ways. Population densities are very high, and there is already a very strong consumer culture that values many other things but not necessarily wild salmon. What recommendations do you have for us in this region as we plan to try to maintain wild salmon populations?

Mitsuhiro Nagata answered that this is a very difficult question to answer. In Japan, there is a very large population and they also have a very unique history for chum salmon enhancement. The commercial fishermen believe that hatchery salmon have a higher survival in the wild because there are no wild chum salmon in Hokkaido. Somehow they have to change these ideas for the commercial fishermen. To do this they will have look at hatchery origin wild fish.

In recent years, some of the commercial fishermen have been worried about water quality conditions around Hokkaido and they know that good water quality is needed to operate the hatchery. Generally, in Hokkaido there is a lot of aquaculture and breeding and the environmental conditions are getting worse. Some of the salmon fishermen are opposed to aquaculture because of its impact on the quality of the water. Now they are thinking about the recovery of a wild fish hatchery. Commercial fishermen are also looking at the enhancement programs sector and are catching more of the chum salmon in the mouths of the river by using weirs. Maybe, in the future, some of the chum salmon will go up the stream for natural spawning. It is possible that they will have a wild conservation program. He noted that it will be very important to have harmony between wild and hatchery salmon to sustain the salmon resources in the future.

Everyone needs to come to the table to discuss the solutions

Randall Lewis commented: It has only been in the 150 years since contact with Cook and Vancouver that we started witnessing impacts within the lands that sustained us (Aboriginal peoples) for thousands of years. We look, for example, at the way of the wild Indians of the United States where, once the buffalo disappeared, they were decimated in terms of their values of life and how they sustained their customs, and the values and spiritualities of the indigenous peoples of their lands. We are looking at the impacts on the fish and the fisheries, in our respective traditional territories, and we are witnessing in our elders and with the society of the day, a lot of different diseases and sicknesses that we have never encountered before. Before it was the epidemics but today we have diabetes and a lot of other different things that are impacting our elders. Our elders, before contact, lived to be 90 and 100 years old.

We have personally witnessed what has happened here with regards to 'contact' on the lands and the fisheries. It is interesting to hear because we are dealing with different governmental jurisdictions, federally and provincially, within our territories and lands. We look at federal and provincial jurisdictions, municipalities and regional districts and we, as First Nations, have to deal with any and all issues that come across our tables. Certainly, we look at the policies and regulations of the day that do not adequately meet the requirements. For example, at a recent community meeting about the 2010 Olympics coming to Vancouver and Whistler we discussed what archaeological impact assessments, and traditional-use land studies there are. We learned that they are very inadequate to meet our needs as First Nations in regard to the potential impact of this event. Since then we have created, along with the Province of BC, an Aboriginal Indigenous Use Study which will look at the impacts on fish and other wildlife of the highway, and new trails and roads being built through our territory. We have to look at how we can participate meaningfully and, hopefully, use the science and technology, which has destroyed our way of life in the past, to help us heal what has been inflicted on the environment within First Nations' territories.

He commented: You talked about how we look at developing harmonization with different governmental jurisdictions that we look at electing to represent our interests as constituents in our municipalities and regional districts and within the larger constituency of BC and Canada. We have to get these people to a table - this workshop is good but, at the end of the day, we walk away wondering about the solutions. We know what some of the solutions are and we have to get these people to the table and but show them some very important facts. The indigenous peoples know the facts and they are very close and near and dear to our hearts and it is important to get these decision-makers to the table after a forum such as this. You are correct, we have to be blatantly up front with them and tell them this is what we need to do and this is how we need to do it and we know how to do it. There are a lot of experts present at this workshop that can begin to develop a plan of attack for the future.

We may have to have a trade-off

Noel Wilkins referred to the problem, raised by Dr. Lackey, of increasing urbanization, and he noted that we have to look through that problem and try and see the challenges that lie behind it. This is taking place worldwide and there will be a balanced demand for increasing wilderness behind that urbanization. People do not come from nowhere - they come from somewhere to live in these large urban areas and the larger the area, the more the necessity, for example, to have impoundments of water to supply the needs of these very large metropolises. That means two things: it means that our continuing research into the basic biology of the organisms that live in freshwater or organisms that can be adapted to artificial impoundments and to reservoirs becomes even more important than it is today. Secondly, we have to perhaps look at the value of our fish resources and say to ourselves, in Dr. Lackey's scenario, the ones that will lose out will be the catadromous and anadromous fishes. We may have to have a trade-off. We may, with our anadromous salmonids, have to face a future in which we deal entirely with sea-ranched populations, where we produce them in hatcheries close to the coast, ranch them to the sea and catch them back at the hatchery after their period in the sea. We may or may not use some of those fish and transport them up to the reservoirs for 'put and take' fisheries. We may have to develop entirely freshwater fisheries in those reservoirs and impoundments. In that scenario for the future, we can have fishery resources but it may well be slightly different fishery resources and not so much the catadromous and anadromous ones but instead the resident marine fishes and the freshwater fishes. He commented that he would not be entirely pessimistic about the future because to be pessimistic about the future is to deny what is going on today.

What about restoration programs for urban salmon threats?

Jeff Marliave referred to a report published by the Pacific Fisheries Resource Conservation Council on citizen group projects, with an emphasis on urban stream projects (www.fish.bc.ca). Referring to the recent abandonment of watershed restoration in British Columbia he noted that by far the vast majority of tax dollars were expended under Forest Renewal BC on critically important restoration projects on Crown Lands. He described some of the side channels built under this program that he observed in the territory of Randall Lewis's people and he noted that they were, literally, invisible to the public. In contrast, a very small proportional amount of money was expended through Fisheries Renewal BC, largely for citizen and community groups working in more suburban areas and a lot of those projects have taken on 'park' access aspects. In light of what Robert Lackey said about public values, he posed the question: Does he not think that the future for 'SeaVan' should involve restoration programs explicitly aimed towards urban salmon streams so that we can have wild salmon surviving in an urban environment or is that impossible?

Robert Lackey replied that he not think that is impossible and that he does not think we will lose all of our wild runs in Southern BC or for the lower United States. He predicts that by 2100 we will have remnant runs along coastal watersheds of Oregon, possibly the north coast of California, and Washington. We could also have what he would define as 'ornamental' runs in a variety of places including urban areas. However, he predicts that retaining the large fishable runs, for wild fish, is a very tough road to hoe, in this part of the world, in 2100.

Would aboriginal rights through Treaties influence policy decisions with respect to preservation and maintenance of wild salmon?

Martin Weinstein commented on the question that Randall Lewis raised and suggested that we look at British Columbia just in terms of the issue of aboriginal rights and the lack of treaties. He noted that we are in a treaty process right now and First Nations have a special set of rights which are largely undefined, but they certainly have to do with salmon. Could the tie of First Nations in

British Columbia to salmon as an aboriginal right influence the policy decisions along the lines of preservation, restoration and maintenance of salmon populations in to 2100?

Robert Lackey replied that in the U.S. there are mostly signed treaties (the 1855 Treaty) which actually guarantee the usual customary places. However, he does not think in the long run, that treaties are the driving factor because the bottom line is that there are no wild fish. Even though you may have treaty rights in the United States, you have to go to court to defend them and most of the tribes, and he was not speaking for the tribes definitively, are supportive of hatchery operations and supplemental stocking because they recognize that the potential for wild fish recovery is not very good. He suspects that the same pressures drive them on every element as with every other outreach group in the US.

We can do more with the resources we have

Otto Langer referred to comments made by John Post (Chapter 11) that we have too many fish populations and too few fish biologists. He hopes that we will manage the remaining fish populations a lot better. He sees the problem being a lack of will to relate to known trends. The literature provides what we have learned over the last 100 years with respect to fish populations and fishing and a lot of that is related to common sense. We just cannot afford to collect all of those data and we cannot wait until we have really good data in our hands. We have to use the 'precautionary principle' to protect our runs and we need some real leadership and due diligence in fish management.

John Post commented that these remarks hit the problem on the head. There is no question that it would be inappropriate to go out and do stock assessments on all of Canada's recreational fisheries and it would be an impossible thing to do. On the other hand, as we see, dealing with provincial governments budget declines and changing priorities, in many places we are doing a poorer job of assessing the systems we do have and in coming up with imaginative management policy in an attempt to stop or reverse declines. He noted that he has also been frustrated by the seeming lack of understanding about the basic relationships between the dynamics of the fish populations and the dynamics of the anglers. It seems that many management agencies do not keep those two systems together and use quantitative models to do assessments and develop policies that can actually manage the predators in the system, such as the anglers, to preserve the fish stocks. He believes that we can do a lot more with the resources we have. However, the resources are declining and we need a re-prioritization of how we use the resources.

Are there examples of decision-making processes in the US that are going in the right direction?

Brian Riddell commented that he has heard this type of scenario described on numerous occasions and he is always left with the challenge of how you would ever make the social decisions and trade-offs that Robert Lackey and others imply are needed. He posed the question: Do you have any examples of decision-making processes in the US that you think might be going in the right direction? Do you have any sense of what we would be able to actually address and make the proper decisions about?

Robert Lackey replied that making the proper decisions presupposes that they are lined up with your priorities. The process, right now, that seems to be working in the US is that the relative priority of wild salmon is being adjudicated. Many people who are on the side of advocates for wild salmon are very unhappy with this - but it seems that democracy, in some sense, is working. As a taxpayer, you may not be happy that we are spending billions of dollars on programs to achieve certain kinds of things and therefore not convinced that governments will come down on the side of wild salmon.

Does limiting access work to preserve fisheries?
Dave Marmorek referred to John Post's presentation and noted that the damage to fish resources from road access in areas, for example where forestry is going on, is probably a lot greater than indirect effects and sedimentation and even angling pressure. Similarly this would apply to hunting pressure. He raised the question: Do you think we can actually put in place regulations to restrict access along roads, built for logging, mining or seismic exploration, in the same way that we now restrict access to recreational experiences, such as limiting numbers of hikers on the Westcoast Trail?

John Post replied that it is his understanding that, at least in some areas, once the logging activities end, there are attempts at reducing access to these areas. Certainly direct access control is something that North Americans are adamantly opposed to. We only have to go to Europe to see a very different management framework for fisheries, or to look at how we manage 'big game' with limited access. Certainly, access provides one tool for preserving fisheries. The question is: How palatable is it and would the public allow those sorts of controls of their 'right' to fish and hunt?

We should also consider the spiritual dimension
Paul Kariya commented that some of the points raised by Robert Lackey made him feel very uneasy and noted that in his day job, working for an NGO, one thinks through what the future of salmon would be. He believes that Robert Lakey has described a challenge where if we do not get to the point of connecting with that spiritual dimension, of how we live, then we are not going to make the changes. He noted that he was saying this out of optimism and not pessimism and he referred to a conference that he attended in the 1970s, when Malcolm Muggeridge gave a presentation on the human condition and was talking about depletion of resources and population. When asked about being terribly pessimistic about the future and if he could ever be optimistic, his response was, "You are right, I cannot be optimistic, but you know what I am…I am '*insanely'* optimistic." If you know the writings of Muggeridge and where he has come from, he was talking about a spiritual dimension. If we are really going to think about salmon and their future, then we need to think about people - and people have to matter. If we are going to get to that point, then we are talking about things like sacrifice, greed and values. If we do not deal with those issues and if they do not underpin what we do, then we will face a pessimistic future.

How to bring the public into the discussion
Jessica Bratty referred to comments made by John Fraser and by Randall Lewis with respect to how we must bring the wider public into the discussion. She noted that she was putting some thought towards what we can do, in a specific way, to improve this connection with wider public values. She referred to John Post's focus on specifically addressing what the management and public response was to his work and suggested that scientists should think about this and ask themselves about how often they actually carry out evaluations of this and actually incorporate this evaluation stage into their study design. As a way of widening the dialogue, she also questioned whether or not improving this, as scientists, would actually improve the way that science is included, in decision-making and wise policy development.

A positive example of public influencing policy
John Gibson cited an example of where scientists did just this. They conducted a study a year ago on the effects of the new Labrador Highway and found that half the culverts on this highway (approximately 200 kilometres) were barriers to fish migration. He noted that this problem is not new – it happens all across Canada and was even described for eastern Russia. In Newfoundland hundreds of small streams have been lost; streams that used to have trout and salmon runs, and

now the salmon runs are down for no other apparent reason. He noted that something that may look trivial, such as culverts, are in fact probably just as important as overfishing and yet they seem to be overlooked. He has been working on this issue for many years in Newfoundland and nothing has happened; there is a very strong Fisheries Act but it is not always enforced. However, the study in Labrador was done in partnership with the Labrador Metis Nation and, as they have a higher profile, the result was that they secured a meeting with DFO which then resulted in the culverts being monitored and remediation planned for next year in Phase 2. If it had not been for the Labrador Metis Nation, nothing would have happened. This illustrates how important it is to have participants involved, as John Post pointed out with the anglers. This is an example that shows the importance of having the public involved in decisions related to policy.

John Fraser commented that the Premier of Newfoundland and Labrador has recently been exhorting other provincial premiers to let him take over the management of the fisheries in Newfoundland and Labrador, as the result of the recent decision by the federal Department of Fisheries and Oceans to finally close the last of the cod fishing in the region. The Premier took the position that this was a terrible thing and it neglected the hopes and aspirations of the people who fish for the cod and therefore that Newfoundland should take over the fisheries from the federal department. Yet, this is the same Premier who, apparently, had to be pushed by a native organization to put decent culverts in the highway. He stressed that premiers and departmental deputy ministers should be at the current workshop instead of getting briefings from somebody else later.

Attitudes may change rapidly

Malcolm Windsor commented on Robert Lackey's presentation. He noted that the same pattern applies in Europe where human population densities are probably greater than in North America. It is quite noticeable that salmon populations are being lost in France, Spain, Southern England, Denmark, and Germany where human populations are greatest. If you go to the Kola Peninsula in Russia or to Iceland, then the salmon are at their highest and the human populations are at their lowest and the pattern is the same. He believes that Robert Lackey made two assumptions. First of all, much was said about attitudes but he noted that attitudes can change faster than we think. For example, two hundred years ago, most people in this room may have supported slavery, and 50 years ago many countries in the world thought the best way to run their economies was by a socialist/communist systems. Thirty years ago, we started to have departments of the environment, and now most governments have those departments in their ministries. Further, the River Thames used to be a sewer and now there are salmon migrating up the river. This means then that attitudes can possibly change quicker than we think and that big human populations could actually put down a lower footprint if they put their minds to it. The second assumption, made by Robert Lackey, is that human populations will continue to grow - he wonders about this statement. Maybe a hundred years from now, there may be some problem with disease or fertility or even, war, which might greatly affect the size of human populations. That is a rather depressing thought but, if you think of it in a good way, the salmon will be happier.

Hatcheries as a reason for the decline of wild salmon

Wayne Harling referred to Dr. Lackey's presentation where he listed hatcheries as a reason for the decline of wild salmon and the general consensus that hatchery salmon are 'bad' and wild salmon are 'good'. If the human population projections are accurate, then it may be that the only choice we may have is hatchery salmon or else no salmon at all, at least in the southern half of BC. Rather than just rail against hatcheries and close them down, he believes that we have to work at ways of making them more effective because we may need them, if we want to have any reasonable scale of salmon fisheries in the future. He suggested that the South Thompson Basin would probably be the best place to start in BC.

Robert Lackey replied that the issue of hatcheries in the U.S. is really a fundamental issue where, currently, on the average, the runs are 80% hatchery. Therefore, these are not large runs, but are substantial runs and that, of course, is pressure to allow fishing. When you allow fishing on those kinds of runs, then that is pressure for the wild runs. He noted that his comment on hatcheries, relative to the US, is more in the context of maintaining relatively large runs, which creates problems for the wild runs. He agreed that if you are going to have runs in the Columbia River, then you are going to have to use hatcheries.

Hatchery production in Russia

Xanthippe Augerot commented in reference to Jennifer Nielsen's presentation, that they are starting to untangle the question of marine-carrying capacity and the influence of hatcheries on some of their wild stocks in other places around the Pacific Rim. These questions come up all the time in her discussions with colleagues around the North Pacific. She noted that the Kamchatka hatcheries rear chum salmon and therefore it must be the Sakhalin hatcheries that were involved in this analysis. Jennifer Nielsen agreed.

What would happen if you factored the impacts of aquaculture and related diseases into the analysis?

Craig Orr referred to Bill Rees' presentation and commented that salmon farms are tremendous sources for concentrating diseases, such as IHN and ISA, and noted that we also know that the parasites themselves on the farms cause losses for the farmers. For example, the average farm in New Brunswick is estimated to lose approximately $350,000 per year because of sea-lice parasitism and the cost of sea-lice, in Scottish fish farms, is estimated at $50-70 million per year. Another line of evidence is the impact of sea-lice outbreaks on wild stocks of fish. This suggests that the footprint may be even higher than was suggested in the analysis provided by Dr. Rees.

Bill Rees agreed that this is very likely. However, he noted that they did not look at those factors because the study was already so exceedingly complicated that it was difficult to manage, and both of these factors are rather unpredictable. Their intent here was to be conservative and if they were to add these kinds of factors, and there are others that people have raised, it simply makes the picture look worse than the one that they came up with. In other words, once you start getting into the 'ifs' and 'maybes' and 'what ifs', then you begin to get into a domain that softens the immediate credibility of the argument. They believe that they can stand absolutely on the ground with these data and these kinds of amendments make it actually worse than the situation they have described.

How much live food is consumed by wild salmon?

Jeff Marliave commented on the model presented by Bill Rees and noted that he completely agrees with putting humans squarely inside of nature. However, it seems in the model that the salmon farming box is squarely inside nature's ecosphere, whereas the wild fishery box is somehow outside the ecosphere. He asked: Do you have an estimate of the number of kilograms of live food that the wild salmon has to consume in the high seas to put on a kilogram of weight?

Bill Rees replied that the ecological footprint of the wild fish fishery includes a contribution of the average productivity of ocean required to sustain the feed stock for the wild salmon. The comparative analyses are absolute parallels.

Are we moving forward in a way that is sustainable?

Frank Heinzelmann questioned whether, in fact, the rise of the salmon farm industry really had anything to do with the decline in wild salmon abundance because in the 1980s and 1990s there

were record yields of wild salmon from Alaska and hatchery salmon from Japan. He speculated that it was just more economic opportunity rather than the decline of wild salmon yields.

Bill Rees noted that they were not trying to say that, in particular, the BC hatchery industry arose because of declining wild salmon, or that aquaculture, generally, is a defense against the vagaries of nature. Their point in undertaking this comparative analysis was to ask a simple question, "Are we moving forward in a way that is more or less sustainable given future population demands, energy requirements and so on?" This analysis was simply to say, given that we need, globally, to reduce our total ecological footprint, is this kind of intensive aquaculture moving us in the right direction and the answer is, "no, it is not".

How do aquacultural and agricultural practices compare in terms of sustainability?
Sandy Fraser commented that although the argument was interesting he could not help but think that several thousand years ago, perhaps an analyst back in Neolithic times looked at terrestrial agriculture and said, "Well, you know, that is not sustainable at all." He asked the question: How do you square your conclusion that aquaculture is unsustainable with the fact that terrestrial agriculture and, specifically, the raising of herbivorous animals for consumption by humans, appears to have survived and appears to have thrived over several thousand years?

Bill Rees commented that there are a number of differences. First, between trying to manage marine species and terrestrial ones, we need to go back to the basic question of terrestrial agriculture. For example, in a recent edition of the newspaper the Globe and Mail, it says that in North America we have run out of readily accessible natural gas. The United States' reserves have been in decline since 1967 and Canada since 1984. The Canadian gas production, this year, will decline by about 5% and our exports to the United States will actually decline for the first time in 20 years of continuous increase, particularly since the implementation of NAFTA. Why is this relevant? Because we are constructing an agricultural system increasingly dependent to sustain around 6-9 billion people on the continued abundance of natural gas as a feedstock for fertilizers. People are not generally aware that, at the same time as the fish catches began to decline, in adjusted terms (using the calculations of Daniel Pauly) around 1985, green production, per capita, peaked and has also been in decline for about 15 years. We do not notice these things in North America or Europe because, whatever the situation, we have the wealth to maintain our supplies. However, if we go back to the 1987 and 1988 crop years, those were the first years in the history of North America that we did not grow enough food to sustain ourselves. Again, we did not notice this in the market place because we had about 250 days of grain stores in lockup and we were able to supply, not only our basic needs, but also our export markets. We have never recovered from that slump and we are down to less than 40-45 days of grain stores in the world today, at the same time as the fossil fuel basis, for much of that production, seems to be coming into jeopardy, certainly in the North American context.

It may be true that we have had agriculture for a very long time but it is implicated in the collapse of many prior civilizations as irrigation and whatever technology was brought to bear to increase production in those days, ran its course through water-logged soil destruction and other forms of landscape deterioration. There are a number of ways of answering the question and, first of all, it is clearly demonstrable that many civilizations have collapsed because of the collapse of agriculture, historically. We now have a global culture and if you plot the expansion and explosive growth of the human population against the use of fossil fuel, the line increases begin around 1850. As fossil fuel has become the dominant means of producing food and therefore human population and enterprise generally, it may well be that the fossil fuel crunch, which will happen in this century, will see a more global phenomenon of failure in agriculture as well as aquaculture. He stressed that we seem to be repeating historical trends, on a much broader scale,

than has occurred in the past. It is demonstrable that agriculture has failed repeatedly and brought whole civilizations down.

Where do we go from here?
Jessica Bratty commented on Bill Rees' presentation. She referred to the Peruvian decree. Has that decree been implemented and, if it has, what will be the impact on the fish feed industry? She also asked: Let us assume for a moment that we are in an alter reality and we have adopted your final suggestion that we need to, as you put it, "acknowledge our genetic predisposition". Once we have done that, what is next? Where does it go from there?

Bill Rees replied that he believed that (in October of 2002) Peru proclaimed that they were going to stop this export of these fish but he is not certain as to whether it has actually been implemented.

With respect to the second question, he stressed that we are in a state, as has been said over and over again, of denial. We treat symptoms and do not look at the fundamental problems. If we are going to pull this off, there has to be a raising to consciousness of the authentic origins, at a global level, of the dynamic forces that are pushing global culture ever closer to the resource brinks that we have been talking about here. He cited the example which occurred in the previous week where Paul Wolfowitz, the US Under Secretary of Defense, admitted that the recent war in Iraq was about fossil fuel. That is an astonishing admission given what has been going on before. He cited the book, "*The Resource Wars"* written by Michael Klare where he predicts that, as populations rise and the competition for energy and other resources intensifies, we are going to see increasing actions, such as the United States took, in a unilateral way, to secure its own future.

The bottom line is that the human brain has evolved in great leaps and bounds but we have a primitive limbic system, where our emotions and our response to certain social circumstances, and our need for prestige and political power and dominance, reside. In the last 100,000 years or so, we evolved the so-called cerebral cortex, where the response to logic, analysis and rational capacities have evolved. A neurologist referred to this as a layering and the way human beings behave is a delicate balance between our limbic emotional senses and our need for dominance, our need for social security, for prestige, and for all of these kinds of emotive things, in balance with our capacity to reason things through and do the right thing. The argument seems to be that, when 'push comes to shove', the evolutionary older part of our behavioural dynamic, in our neural-system, prevails. We will be aggressive in defense of our own needs, regardless of what more we might achieve, were we to come together in ways that recognize we are facing a fundamental, common problem of the global commons being destroyed. He believes that the actions of the United States, recently, represents the coming to the fore of the limbic response - we will go it alone, we will take what we need for our purposes and we will abrogate many international treaties that would otherwise hamper us in ensuring our survival. He argues that this is an example of how humans will behave as the resource situations become more difficult. Conceivably, if we can come together and acknowledge that that kind of behaviour is totally destructive, not only of our fish stocks but for all other resources and ultimately ourselves, then we may be able to develop a form of coercion mutually agreed upon and recognize that we need to create international institutions to regulate our behaviour and to reduce the demand on nature. Our innate response, because of our need to expand, has always been on the supply side. For example, we cannot face that there may not be enough fish, so we build fisheries. We have to begin to work within the limits of nature, which means working more to control demand rather than always trying to increase supply.

The supply increase end of things is not going to wash, in the long run, for 9 billion people and the question is, "What kind of institutional arrangements can we make, at the international level, so that we can adequately share the world's economic and ecological output in ways that there is sufficiency and, therefore, a means to reduce the propensity for international conflict and the solution of these resource scarcity problems?" There would be plenty to go around if we were more conservative in the use of the resources but if we do not take this kind of step, then we are going to see the emergence of increasing international strife as we squabble over the declining resource base. This is why he has now appealed to the Fisheries Minister in Canada and, perhaps, this conference could endorse this, that Canada call a political meeting, among the world's fishing nations, to erect precisely this kind of regime to preserve and enhance the world's fisheries by reducing fisheries' demand and by creating 'no fish' zones needed, over the very long run, to rehabilitate those stocks (see Appendix III).

In his opinion, Canada is partially responsible for the mess we are in and we have a moral obligation, to future generations, to try to solve it. Let us take some leadership and see if we cannot create an international regime to control demand on the fishery, instead of always trying to do things to increase people's supply, when the production simply is not there to sustain it even if it is enhanced by fish farms and hatcheries. In his view, the general problems we are now discussing, will be the major issues facing us all in the 21st century, not just in the fisheries area, and if we do not pull it off with an international regime level, then we are not going to pull it off.

What have we done right in salmon management?
Fred Whoriskey asked: Did we do anything right?

Carl Walters replied that in his opinion we have been pretty good at dealing with the problems with salmon, that we know about; that is, harvest regulation in the face of declines whether they are caused by overfishing or marine survival changes. We have responded by cutting off fishing mortality and cutting it way back in most of the cases. He referred to the rather sad case presented by Brian Riddell with respect to chinook salmon in Georgia Strait where the regulatory system was not effective at reducing mortality and as the stock shrunk, the remaining fishery shrunk with them but they maintained about as high a mortality rate as always.

Stating clear management objectives and the need for audits
Randall Peterman noted that Dr. Walters did not actually use the words 'clarifying management objectives'. He suggested that what we need to do, is learn about how one would actually do this - that is, someone would lead the dialogue that would get people to clarify what kinds of trade-offs they would be willing to live with. He noted that this would give clear direction to the management agencies and suggested that until that happens, it will not be there.

Carl Walters commented that it appears that what we have now is a lot of clarification of objectives of the very trivial kind – such as, we want more fish - and this is very much the kind of situation that was faced by scientists in the early 1970s in the early development of adaptive management. Then they were trying to say, "Stop this nonsense" when talking about objectives. He suggested that every one of us could agree on what those are in broad terms, but what we really need is to face up to the nasty trade-offs among those objectives. That is what we are not doing – we are not quantifying those trade-offs, partly because of the lack of information and partly because nobody wants to look at them, and we are not forcing a clear public debate on the trade-offs. Also, we are not holding the public agencies accountable for where they allocate resources to issues and problems. For example, no one is asking the Department of Fisheries and Oceans, "Why are you fixing streams that don't need fixing?" There is a serious lack of auditing.

Is the problem freshwater habitat?
Wayne Harling noted that while logging practices may create a temporary impact, the impact of paving over a stream is permanent. He noted that hundreds of small coastal coho streams have been completely destroyed and even if the ocean survival comes back to the 10-15% range, those streams are still lost. In his opinion is it not entirely correct to say that freshwater habitat is not the problem.

Carl Walters replied that with respect to the loss of coho streams, it is not hundreds, but rather about one hundred streams that are lost and most of these small streams were lost a long time ago and they are not going to be restored because they are in urban areas. Relative to this the recent habitat loss is miniscule and that is out of thousands of streams. Therefore, measured over British Columbia as a whole, habitat loss is a trivial component. When we back-calculate freshwater production of coho to the ocean, that is, the number needed to explain the catches and escapements what we see is that the total wild smolt production by the freshwater systems surrounding the Georgia Strait has actually gone up a small amount, not down.

Are hatcheries the problem?
Wayne Harling also posed the question: If we eliminate hatchery production, would not the impact of predation on wild stocks increase and put them at greater risk?

Carl Walters explained that they have been doing reconstructions of the history of the Georgia Strait by taking many time series of fish data and mammallan data and asking, with an ecosystem model, what it takes to explain the patterns of change that they observe. It looks like there are two major factors involved in that pattern; one is a declining primary productivity over the last decade and the other is they find they cannot leave out of the models and still fit the data, is the massive growth in marine mammal abundance in southwestern BC. If either of those things are taken out, then the models do not fit.

Therefore, the fish are becoming caught in a squeeze between declining food availability on the one side and big increases in predation on the other side. What happens when you put a hatchery into that squeeze is that it makes things worse in two ways; one is it increases the squeeze on the food resources available, and the other is it is a training ground for marine mammals - seals and other creatures are learning how to catch little salmon by having readily available concentrations and naïve fish. The numbers of fish going out are never enough to really satiate the predators, which you have to have to get that protection function - they are coming out over too expanded a period of time. They might be right in the middle of the densest runs out of a few of the rivers where there are tens or hundreds of thousands of fish coming up per day, and there would be a buffering effect with respect to the local mammals. However, that goes away as they spread out and, as you move toward the front or back end of the run, so that the fish are protected in the middle, but it is not helpful.

If a large amount of money was available for research on the oceans, what would you spend it on?
David Einarson commented: I have heard you say before that one of the dangerous things is to have a whole lot of money suddenly available for research. If a lot of money suddenly did become available for research on the oceans, what would you spend it on?

Carl Walters replied that he would put the first $2 million into a coast-wide intelligence gathering program. He noted that when we see a collapse, such as suddenly occurred with Rivers Inlet sockeye, it is basically ecological detective work to try to figure out what was going on. As soon as we try to do that detective work, what we find is that there is no information at all about what

has been happening to plankton abundance in the coastal areas where the juvenile fish are coming out, there is no information on marine mammals, there is no information on birds, and there is no information on the agents of mortality or the capability of the systems to support fish. That is, there is no basic monitoring program. The first $2 million could be productively used to put together a coastal ecosystem-monitoring program. The next priority would be to put funding into direct monitoring of distributions and mortality of salmon in the ocean through the new high-technology tagging systems. We need to find out where and when the fish are dying before we can figure out what the causes are and if we initiate experimental programs to try to reduce mortalities, such as seal culling, we have to have monitoring programs in place that can accurately identify where and when the mortalities are occurring. For this we have to have things such as acoustic tags which are very expensive. He concluded that for $2 million we could put together a good coastal surveillance program for the things that we know to be the major resource factors such as food supplies and predation risk factors for salmon along the coast.

The relationship between habitat loss and marine survival

Jan Konigsberg asked: For the studies of habitat degradation in relationship to salmon production, was there any relationship between the habitat loss or degradation in the stored energy reserves of the smolts, body size, and ability to survive? And, What is the relationship between habitat, fish, smolts and relative health in marine survival?

Carl Walters replied that his presentation showed that we really do not know the answer to this question. He noted that one of the scariest hypotheses, which has been put forward for the progressive pattern of the decline that occurred in coho salmon, is that its origin was actually freshwater. However, the fact that it hits hatchery fish in the same way as wild fish implies that it is not something to do with the food supply in freshwater. Exactly the same pattern of decline occurred in Atlantic salmon, over the same years, on the east coast of Canada and in some of the European systems. What factor gets shared at that scale? Nothing that we know of in the coastal oceans. The only shared factor we know of is ultraviolet (UV) radiation which has increased over that period. It is possible that what we are seeing as increased ocean mortality is actually declining availability of fish in freshwater due to chromosomal damage that is not being repaired because the enzymes aren't being used until they get to the ocean and that the ocean mortality is a symptom of *that* going on in freshwater. The only thing that we know of, that would operate on such a large scale as across the continent and in a particular latitude band where the mortalities are similar, is UV radiation. It is clearly not water flows or any of the other obvious things.

Ocean productivity cycles and the need to protect freshwater habitat

Guido Rahr noted that ocean productivity has fluctuated over thousands of years and so have salmon populations. However, if you assume that there is a relationship between healthy habitat and the health of the salmon populations and the number of smolts that are delivered to the ocean, then would not the fact that ocean productivity fluctuates be the best argument for protecting healthy habitat in that it would carry the stocks through periods of higher mortality in the ocean?

Carl Walters replied that he contends, based on his examination of a lot of actual population performance data, that the problem with this argument is whether or not habitat is unhealthy in the first place. If we could demonstrate that we really do have severe survival problems in freshwater then he would agree that we should fix part of the system that we can fix. However, we cannot even demonstrate that the problems are that severe in the first place - certainly not in situations like Rivers Inlet where we see the stock declining by 90% in one year and there is no freshwater habitat associated incident that happened prior to that. You can fix all the freshwater habitat you want but with current marine survival conditions, we are still going to be losing stocks. Moreover, with the regularity with which these big marine survival changes have been

occurring across species and over time, we can expect to see more of them - and we are going to be looking for more scapegoats and we are going to be trying to apply more bandaids in the wrong part of the ecosystem or the wrong part of the lifecycle of the fish. In his opinion, we are spending money in the wrong places.

Overall effects of fishing on the northwest Atlantic ecosystem and competition-predator interactions

John Gibson commented: The closure of the Atlantic salmon fisheries in 1992 resulted in an increase in returns to the rivers. This may not have resulted in more smolts and, in fact, for one river there was no increase in smolt output so there probably was already carrying capacity - but there has been a dramatic decline in ocean survival. You made the point that fishing was not the problem. However, I would suggest that fishing probably *has* been the problem because it has completely messed up the northwest Atlantic ecosystem. The data are not there and the work (which I have previously criticized with DFO) is mainly put into assessment and counting fences rather than what is actually going on. Jeff Hutchings pointed out in his presentation that some of these pelagic fish have recovered and there may be interactions that involve competition with the smolts. Another point is: You did mention lowered productivity in the Pacific coast, and it may be more resilient, but in the Atlantic, is it possible that reduction, generally, has decreased because the general efficiency in the food chain has decreased?

Carl Walters replied with respect to the latter point, that this is referred to as the jellyfish argument; that is, has the food chain efficiency gone down because of other things? The answer to that is 'no'; in fact, all the calculations indicate the opposite - that the food chain, as an energy transfer unit out in the ocean, is becoming more efficient.

With respect to the first point, in the case of both Atlantic salmon and coho salmon, there are a lot of data on smolt outputs *vs* egg deposition. On the Pacific coast with regard to coho, there are only three observations that show any effect on egg deposition on the smolt numbers, so almost all the coho streams are saturated. There is one place where virtually no fish returned – that was Snow Creek near Port Angeles, WA, and there was smolt failure after that. There is one year in the history of the Carnation Creek (Vancouver Island) long-term study when there was a low enough spawning run that there was a recruitment decline and one year on Black Creek (Vancouver Island). The other 100 or more observations are exactly the same as Dr. Gibson described.

He noted that in the last six or seven years, they have been building ecosystem models of virtually every large marine area in the world and trying to fit them to historical data as a way of seeing if their structure is a reasonable explanation for what they are seeing. One of the things that has come out of these models is something referred to by Jeff Hutchings; that is, what we call a 'cultivation depensation effect'. If you take a big dominant creature, such as a cod or Pacific salmon or the elephant tunas of the equatorial Pacific, and if you fish it down really far and then look at what it does, the models all predict that it will recover much more slowly than thought from the productivity when it was being knocked down, and that is what Jeff described. What the models indicate cause us to pose the question, "Why is the elephant tuna, or salmon, or cod the dominant species out there?" The argument is that they are dominant because they cultivate their ecosystems. As the cod population builds up, it knocked down a lot of potential competitors and predators, as well as juveniles. When it goes down, that protection or cultivation effect on its own reproductive success, goes away. It then becomes very much more vulnerable to impacts of intense specific competition. One of the great unexplained declines combined with the failure to recover in the area around Vancouver, of the type described by Jeff Hutchings, is chinook salmon. In the mid-1970s it was possible to catch 500,000 - 700,000 chinook salmon a year out of

Georgia Strait. Currently, we would be lucky to catch 30,000. There has been a massive decline and we cannot show that there is anything obviously wrong with the food supply out there. There are a lot of herring and a lot of prey - yet these stocks are not only *not* recovering, but they are continuing on down slowly just as the cod did. That has to be an ecological interaction of some kind and it has to be a competition–predation interaction. It is not ocean temperature. Something has gone wrong in the trophic interaction structure of that system.

How the different users regard the risk evaluation and the trade-offs

Noel Wilkins noted that with respect to the decline being observed in the hatchery-reared salmon as well as the wild salmon, he has for a number of years been ranching Atlantic salmon in Ireland, and the decline in the ranch stock mirrors the decline in the wild fish - so it is obviously something in the sea.

With respect to how the tax dollar is being spent, is there a mixed message here? You talk about allocating money to the problems we have - it seems that there is an implication there that all the different users will regard the risk evaluation and the trade-offs in the same way. He believes that is not true. For example, the commercial fisherman will want to maximize the catch he makes at sea whereas that may be in direct conflict with the anglers. The requirement of the conservationist, who wants to maintain the birds and the mammals, will also have a different trade-off.

Carl Walters replied that there are a number of issues here. One of them is: How do we obtain a clear public policy regarding tolerable risk when most consumptive users are willing to take a lot higher risks than are people with conservation interests? That is a matter for public debate and discourse - getting the trade-off out on the table for discussion. It is a very different matter to discuss how DFO uses the public's tax dollar. When DFO goes out and tells the public that habitat management is the most important thing to be doing with tax dollars, I consider that is not so and it does not have anything to do with risk management or anything to do with trade-offs. Rather, it has to do with the lack of analyses and a bunch of people wanting to attack the 'easy' problem rather than the 'real' problem. He commented, "I do not mind my money being spent on public discourse and democratic debate but what I do object to is my money being spent with public approval when the public is being misinformed about what the problem really is".

The need for re-profiling the existing resources and for more resources

Maurice Coulter-Boisvert commented: Although most people probably accept your premise that more investment should be made in the marine environment, I think it is largely irresponsible for you, and not aimed at solution seeking, to suggest that this should be done at the expense of habitat protection or habitat restoration when your main beef is with fish restoration policies of the major facilities' departments. The bottom line is that there is a greater need for re-profiling of the existing resources and possibly the realization that more resources are needed to study the sorts of things that you need to study.

An example of the importance of habitat restoration

Stefan Ochman commented: I work with the Huu-ay-aht First Nation (on west coast Vancouver Island) and Carnation Creek is in Huu-ay-aht First Nation Territory. There are some effects that were not presented that have been observed for some of the streams on the west coast of Vancouver Island. For example, during the summer period, the Sarita River flow goes from an average of 400 cubic metres per second to less than 1 cubic meter per second - where there is a trickle of water flowing under a few feet of gravel and there is no fish habitat. The result is the coho are stuck in a few pools and the water temperature increases and some of them die. There is definitely a need to continue some habitat restoration. From the Sarita River, they have found that

90% of the coded wire tagged fish that returned were from the efforts of the hatchery – that is, if not for the hatchery efforts, there would probably be very few, or no, fish coming back.

Carl Walters replied: You might want to ask yourself what the wild fish would do if you shut down the hatchery in some sort of experimental way. He commented that it is hard to say whether the hatchery fish have impacted the wild survival. One thing you never want to do is assume that you, as a person, are a good judge of what fish need. They have had streams where they put in smolt fences and counted the smolts where during the previous summer the streams went dry and they still produced smolts, meaning that juvenile coho, at least, are either moving down into the estuary part of the time to deal with some of that habitat variability which is there naturally, as well as due to other effects, or else they are managing to stay alive in habitats that we do not understand yet, such as in the interstitial gravel which is where a lot of the fish probably go during those harsh times. If there is any lesson from Carnation Creek, it is that, you should not assume that you know what the fish need. In some ways coho are 'tough as nails' and in other ways they are amazingly vulnerable; for example, the situation where half of each coho smolt run was wiped out probably mostly by birds during the first mile or two of downstream migration, and the fact that we do not understand why they are so vulnerable for a short time in healthy or unhealthy environments. We are not getting that basic knowledge anymore and our monitoring programs and the research programs that would allow us to get this information are being shut down.

Habitat restoration effects for the ecosystem of the Squamish valley rivers

Randall Lewis commented that he agreed with Dr. Walters with regard to the interceptive fishery and the ocean mortality. However, with respect to the work that the Squamish First Nation have carried out with chinook, coho and chum enumeration over the last seven years, the increases they have observed can be attributed to the habitat restoration that they have carried out in the past on the Chekamus River side channels. In the case of the Mamquam River and the Stawamus River, Squamish First Nation elders remember playing on the rail cars in Valleycliffe where they used to do the heavy logging. Then Valleycliffe used to be the largest producing salmon tributaries in the watershed. Now all the tributaries have been built over. As a result of doing a lot of restoration work on the Upper Squamish, there are increased salmon returns - in the seven years from when they first started they have gone from 2,000 - 3,000 coho, to two years ago approximately 14,400 coho, and last year there were 23,000 to 24,000. That is observed in the mouth of the Cheakamus River, where it comes out as a tributary of the Squamish River. This area was known as the 'eagle capital' of Canada - there were 4,000 or more eagles in one area. The reason they were there was because of traditional salmon spawning grounds - there aren't any fish there now and they are saying the eagles are disappearing because of this. This is not true however, they are just moving up to the areas where the restoration work has been carried out and to the spawning grounds in these different watersheds. The eagles are dispersing and going to where the fish are spawning again in the historic channels where the groundwater channels exist now. You can also see that the forests are becoming healthier in and around that area where the fish are frequenting these waters again because the bears are also coming down and removing those fish and taking them into the forest and the eagles are taking them up into the trees again. There is evidence of return, directly related to the habitat restoration that has been conducted in this area and, the Squamish First Nation considers that there is a lot more of this work that needs to be done in the future. If you have more fish reaching the headwaters, then there will be a lot more returning back to the ocean. He commented: You are right when you point out the ocean mortality and we need to understand what that is but I would not discount the importance of habitat restoration.

Carl Walters replied that only time will tell as to whether or not any of that restoration activity can overcome the effects of the marine mortality. In his opinion, they need to be prepared with policy formulation on analyses for dealing with this very large issue of a whole new competitor for the fish out there. The First Nation traditions involve helping to get rid of that competitors, such as the marine mammals. The best candidate we have for why those ocean survivals have not turned around a lot more than they have, especially considering some of the changes in ocean conditions in the last few years, is because of this persistent ecological variable.

SECTION IV

Photo by Anatoly Semenchenko, Wild Salmon Center

CHAPTER 18

First Nations and wild salmon

Arnie Narcisse, Chair, BC Aboriginal Fisheries Commission, North Vancouver, BC, Canada

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In this chapter I will refer to how we can work in cooperation with each other and how, as First Nations, we can help to instill some of the values that we have for these salmon that have kept us alive all of these years.

Historical relationship of British Columbia First Nations and salmon

British Columbia's First Nations have a special relationship with the wild Pacific salmon, a relationship forged over nearly 10,000 years. Salmon are an important source of food and commerce for many of British Columbia's 202 First Nations. Our cultures, languages and values are intimately linked to the continued existence of salmon and other marine resources. The recent decline in salmon numbers, and increasing pressures on salmon stocks and habitats, was referred to in a number of the previous chapters. We have more humans and the salmon resources have never been under greater pressure - that is a fact that we all recognize. First Nations have responded to the threats facing wild salmon by increasing their involvement in habitat protection and restoration and salmon enhancement activities, in addition to co-management efforts.

We also know that it is vital that we incorporate our traditional knowledge into how we treat salmon. It was my Great Grandfather, not my Grandfather, who was among the first to decry the hatchery techno-fix first introduced around the turn of the century - a warning that was ignored by many and that is more important than ever today. He made this statement in the 1911 Stlatlimx Declaration that talked about the impact of more people coming into his territory, the impacts of the gold-mining activity upstream and the impact of the commercial fishery that had opened up in 1888. In 23 short years, the populations of fish and salmon that he had relied upon to feed his family had been decimated to such a degree that a hatchery and spawning channel was being constructed in his territory. The Stlatlimx Declaration basically stated that all First Nations want is the same as yesterday. That is it, nothing more, nothing less. Specifically, he was concerned with the construction of a hatchery in his territory together with the effects of gold-mining and commercial fishery. I do not know whether or not he understood the magnitude of the problem that he was facing back then and that the cycle had indeed been broken.

This relates also to the discussion about augmenting the food web requirements. The nutrients that were delivered to the watershed, by the salmon, were diminishing. Those naturally occurring nutrient loads come from decomposing salmon and that vital link to the cycle was being broken as early as 1911- this long cycle that had been carried on for eons.

New problems with salmon faced by First Nations today
Now we fast forward to 2003 where we are seeing the impacts of these activities. Overfishing and minimal habitat destruction were the only problems back then in the early part of the last century. If my Grandfather were to see what I am facing now, he would say that I have a lot more problems to deal with than he ever had. Now we have other problems and issues including the impacts of urbanization. As well. the intensive agriculture that we see in the Fraser Valley and in the Yakima Valley and other places, remind us of the values that we need to wrestle with in terms of what has more value. For example, does water have more value in growing crops or growing fish? And in addition we now have salmon aquaculture and loss of biodiversity to deal with.

The role of First Nations in the development of species and habitat recovery plans
These impacts have led to the recent designation of three Pacific salmon populations as *endangered* wildlife species by COSEWIC: Cultus Lake sockeye, Sakinaw Lake sockeye and, in the interior Fraser, the Thompson coho. The Soowahlie people from the Sto:lo Nation have relied upon the Cultus sockeye, the Sechelt people have relied upon the Sakinaw sockeye and the many Interior First Nations, have relied upon the Interior Fraser coho stocks. Despite this fact, none of these tribes are involved in the Species at Risk Act (SARA) process or the required recovery planning processes. There is something wrong here since the value of these salmon is the greatest to these affected tribes and, therefore, we consider that they should be participants in these discussions. The listing process, used by COSEWIC, is based on a whole set of different values, mainly economic. If the species has some economic value then it is more likely to be listed and given attention in the form of these recovery plans. If they do not have a lot of economic value, then the attitude is that they will be dealt with later.

We are currently engaged in discussions with Environment Canada and other ministries, including the Department of Fisheries and Oceans, which are examining ways and means to incorporate the capacity of First Nations in the development of species and habitat recovery plans for the endangered salmon species described above. There are many First Nations' tribes that have developed a high level of stewardship capacity over the past ten years under the Aboriginal Fisheries Strategy. Note that I emphasize stewardship capacity and not management capacity. Management is a foreign concept to us as First Nations' people. We do not manage the resource; we try to work in a husbandry or stewardship mode. That is the capacity that we have developed over the past ten years under the Aboriginal Fisheries Strategy. The tribes that are involved in stock restoration efforts are complimented by a broad range of habitat restoration, protection and enhancement work, as well as a full sweep of stock assessment programs, from helicopter overflights to carcus dead pitch assessments.

The Nicola Watershed Stewardship and Fisheries Authority, a program that I previously managed, built the first permanent coho enumeration fence in the BC interior town of Merritt and in the middle of City Park. The reason I make mention of this is because this project has been instrumental in helping to increase the value of the local coho and chinook salmon populations to the local people. Prior to the construction of the fence, people were mistreating the salmon. Basically, this was because they had no sense of community with the salmon and no connection to them. With the building of the facility, they now have that connection, and busloads of school children are coming to the fence to witness, first hand, the benefits of some of their schoolroom enhancement programs. The children have helped to instill new values in their parents and new respect for the fish so that there is no longer mistreatment of these special animals.

The good thing about this story is that it brought together four levels of government to achieve one common vision. This was instigated in 1998 when David Anderson was the Minister of Fisheries and Oceans and we were going through the throws of the coho conservation requirements and the 'red' listing. I recognized the significance of the coho conservation concerns and went to the Department of Fisheries

and Oceans and advised them that we wanted to construct a coho enumeration fence that could withstand the vigour of a cold-water system. This is a volatile system that has no lake to hold it back so that when it comes down, it needs a substantial fence to stand up to it. We were able to convince the Department of Fisheries and Oceans to fund the project. When I talk about four levels of government, I am also talking about the First Nations as we consider ourselves a level of government. At that time the provincial government agency, Fisheries Renewal BC, was in operation. They provided the $137,500 required to operate this facility for the first year. The fourth level of government was the municipality of the town of Merritt itself and the Mayor gave us her blessing to build the coho enumeration fence in the middle of City Park. The moral of this story is that you can bring four levels of government and the community together under a common vision to carry out a common goal. That is one of the things that we are doing as First Nations' people in terms of trying to broaden the value-base that we have for wild salmon stocks.

Instilling new values

We also need to think about the young people and instilling new values into their parents. These are values that go beyond simple economics. They are values that are incorporated into an ecological perspective and the need to reconstruct the broken cycle. This cycle begins in many of our traditional territories. The Carrier Sekani Nation, at the headwaters of the Fraser River, are working to reconstruct a broken cycle by developing conservation management and harvest plans that are especially mindful, not only of their food needs, but of those of the animals they share the salmon with. They are hopeful that, by doing this, they will be able to restore the productivity that once sustained their people, the land and the animals and, thus to repair the broken cycle.

Salmon farming issues

Salmon aquaculture is the most recent techno-fix that has come our way. My Great-Grandfather was faced with hatcheries and spawning grounds; I am faced with salmon aquaculture and other types of finfish aquaculture that we as First Nations people are very concerned about. Someone appears to have determined that farmed salmon may have more value than wild salmon. Someone has determined that it is acceptable to take food out of the mouths of poor, developing nations to make fishmeal for farmed fish so that we, in the developed nations in the northern hemisphere can eat them. I have been told that it takes four times the amount of feed to create the fishmeal that produces one pound of Atlantic salmon. There is something extremely wrong with that equation.

Moreover, there are too many unanswered questions surrounding this industry that precludes our embracing it as a sustainable one - problems such as escapes, diseases including sea-lice, habitat degradation and so on. Yet, it appears that in the eyes of government, farmed salmon have more value than the wild salmon. This is evidenced by the fact that there is a federal Salmon Aquaculture Commission in place in Ottawa within the Department of Fisheries and Oceans Canada. Their job it is to promote salmon aquaculture; however, there is still no wild salmon policy that will, once and for all, give the wild salmon the protection that they need in order to flourish.

Wild salmon policy

In the draft copy of the Fraser Review of the 2002 Fraser Sockeye fishery the first recommendation is the establishment of a wild salmon policy.

> *It is recommended that the Department conduct consultations on a wild salmon policy and associated guidelines with First Nations' harvesters and other interest groups, including conservation organizations and the policy should be finalized by December 31, 2003. This policy will provide a framework for defining conservation objectives for naturally spawning salmon and will include direction for resource management, conservation units and reference points, habitat protection enhancement and aquaculture.*

The current draft wild salmon policy has the blessing of the majority of BC's First Nations and needs to be ratified soon so that we are no longer subjected to the schizophrenic responses received from the Department of Fisheries and Oceans and the Province of British Columbia with respect to the priority of conservation of wild salmon over farmed salmon. We urgently need that policy.

I would like to comment briefly on a statement from Bill Rees (See Chapter 14) "*Farming salmon is an inherently unsustainable economic substitute for a service that nature once provided free*." Those are wise words. Similarly, Brian Riddell points out, "*… the first hundred years of managing Pacific salmon focused on their economic importance. Recently, conservation issues have led to substantial allocation debates, and now the focus is clearly on the conservation of "wild" salmon, their diversity and their ecosystems*." (See Chapter 7). The maintenance of the biodiversity of wild salmon and their attendant ecosystems have always been the core value of the First Nations of BC. The loss of the salmon that we depend upon, would be catastrophic to all aspects of our being as First Nations' people and it is a loss that we are not prepared to allow.

Conclusion

Our job, as First Nations' people is to instill those other values, that go beyond simple economics, into the psyche of the general public, and to make people aware of the broader ecosystem requirements that will benefit the wild salmon. In 1911, my Great-Grandfather attempted to point out these values to the Honourable Frank Oliver, in the Stlatimx Declaration that he was signatory to. Today I write letters to the Minister of Fisheries and Oceans Canada to do the same thing. It is critical to instill a set of values that will ensure the long-term sustainability of the Pacific wild salmon.

CHAPTER 19

Valuing wild salmon: the economic approach

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Introduction

The topic this chapter addresses is the issue of valuing wild salmon. First this paper complements Bill Rees's presentation (Chapter 14), which focused on the full costs associated with activities such as farm raised salmon, and measured those costs in terms of ecological, energetic or land equivalent costs. My perspective is on the other side of the coin; the benefit side of wild salmon. You will likely find that my interpretation of an economic perspective might be quite different from yours. I am not a fisheries economist. I do not study the fisheries industry and I do not count jobs and spending. I am an ecological economist and my perspective is to look at natural systems and what we can call natural capital stocks, such as stocks of fisheries, and begin to think about what the services are from those stocks and what the values are associated with those services. Being trained as an economist, my way of translating those values is to put natural service values into economic terms.

This chapter will illustrate ways to convert things that you may not have thought of converting before into economic or monetary valuations. I have to be very clear about what this is and what this is not. This is an attempt to look at natural systems and their services, and to illustrate the monetary valuation of those services. There are many aspects of natural systems that it would be foolish or trivial to value monetarily. For example, the cultural values, separate from the employment and food supplies, of First Nations are so moral and ethical based and so existence based that they lie on a moral and ethical plain that is above any attempt to trivialize them through monetization. I have no intention to address these broader cultural values nor to assess ecological values as ecologists think about them.

What does the public typically mean by value?

If we were to talk to people on the street or on the bus somewhere and ask them something about the value of some activity, they would refer to total spending, jobs, incomes and taxes. In the case of wild salmon they might think about how much money is spent on the recreational and commercial activities associated with wild salmon; and how many jobs and how much income is generated; or how much tax is generated. That is what the public interprets as value.

What do economists typically mean by value?

I am an economist and I think, translating fairly on their behalf, when economists are talking about a value they are referring to the contribution of something to human well being, or what we could call "welfare." In other words, how much better off are we because of something? In the context of the

salmon issue, how much better off are we with wild salmon than without it? That is the first definitional concept; value equals welfare enhancement. Secondly, however, economists try to go a step further and measure this welfare enhancement, mostly through monetization. We try to establish some monetary measures partly because of convenience. In many instances there are markets that give us this information. But at a deeper level, our traditional economic choices enable us to express, through our purchases, the relative values we place on various items. So the monetary values do reflect relative valuations of items, and people are familiar with the monetary metric.

Economists have put great effort into developing these monetary measures of value. These measures come in two basic forms: how much would people be willing to pay to have something, such as wild salmon, and how much would they be willing to accept in compensation for its loss? These are two very different kinds of measures, one is associated with a gain and one is associated with a loss, but all seek to put a value into a common monetary metric.

Impact *versus* value

I have organized this chapter around the issue of impact *versus* value. There is substantial difference between the two. Impact is a measure of the gross significance of something to the economic "scene." For example, we observe there are many jobs and incomes associated with the salmon fishing industry. But value is a measure of the "difference" something makes to the public welfare. For example, how many *more* jobs and incomes are available with the salmon industry than without it. Impact and value may be vastly different. While there may be 10,000 people employed in the salmon fishing industry, closing the industry down may result in only a loss of a small portion of those jobs, as people seek employment elsewhere. Of course, this is not always the case; an economically isolated community may have a net loss of all its salmon related jobs, so that impact and value are the same.

Politics *versus* policy

Political interests tend to focus on impacts and they focus on impacts because it is a metric and it is an image that is understandable and the stakeholders themselves can identify with impacts. How many jobs are at risk in the salmon industry? How much income is at risk in the wild salmon industry? These are images that are useful in a political context. What I am interested in is more the policy analysis measures that will help us in determining whether or not something is worth doing. Is it worth saving wild salmon? Is it worth having farm-raised salmon? The policy answers to these questions are: what is gained, what is lost and what is the net? These should be the basis of policy decisions. How one goes about measuring what is gained, what is lost and what is the net, is another thing altogether. Economists are critiqued for cost-benefit analyses because they try to squeeze everything into a dollar metric. Many of the benefits or losses are not appropriately measured. The policy issue is whether something is worth doing and always boils down to the question of what is gained and what is lost and what is the net.

Gross *versus* net values

What do we mean by gross *versus* net values? Net value is the difference between a gross value and a cost. Suppose that there is a chinook salmon and you are willing to pay $60 for it; that is a measure of its value to you in the sense of what you are willing to sacrifice in order to obtain it. Let us suppose that it costs you $40 to obtain that chinook salmon. The net value is the difference between the gross and the cost, that is, $20. When we look at salmon from a policy perspective and ask, "What is the measure of our loss by not having this kind of option available?", the answer is $20. It is always difficult to explain this to the public as they focus on the $60 and see the loss of $60 worth of salmon. But they have also saved $40 because they have not been able to buy the salmon, so they have $40 left in their pocket.

Sources of value

I now want to address further the various types of values and sources of values. Bill Rees went through an analysis of the full cost associated with an activity (Chapter 14). I want to take the other side of the

picture and consider the full benefits of natural services that are generated from this type of natural capital stock – the wild salmon. This is really a traditional economic analysis and divides the sources of value into two types: user values and non-user values. The user values include what probably much of the public discussion is associated with such as commodity values and recreational values. A number of the previous papers focused on some of the other values such as biodiversity values and ecological values that are much more difficult to place than economic evaluations. However, it is unfortunate that in public policy issues associated with natural capital stocks, whether it be forests or fisheries, the focus of attention is predominately on commodity and recreational values. This is partially because they are important, but also because they are more measurable than other values. The measurable items crowd out the immeasurable items even though they may be less important. Non-user values include two types: potential use values, or what we will call option values, and knowledge or existence values. Non-user values would include some desire for natural state conditions or the cultural values associated with First Nations' interests.

User values

When considering user values, economists have spent a lot of time developing ideas like the 'demand for things' and, when we are thinking about the user value of something to people, we can represent that user value based on what people would be willing to pay for these items. For example, Figure 19.1 illustrates the case of fish, where the demand for fish for commodity purposes is represented by the red line in the graph. That demand represents what people would be willing to pay for these fish. If there were a small number of fish, they would pay a higher value per fish and if there were a large number of fish and they were more abundant, then they would pay a smaller value. However, the area that is represented by 'A' in the graph is the gross user value of the supply of fish. Let us say that the user value here is consumption. However, the net value is this gross minus what people have to incur in costs to obtain these fish. For example, there is a cost to land a fish, a processing cost, a retail markup cost, and finally a retail price per fish. Given that retail price and people's demand for this commodity, 'B' in Figure 19.2 represents the net value of fish to consumers. If they are not provided with the opportunity to engage in this market as it is pictured here, then 'B' disappears and 'B' is a measure of their loss.

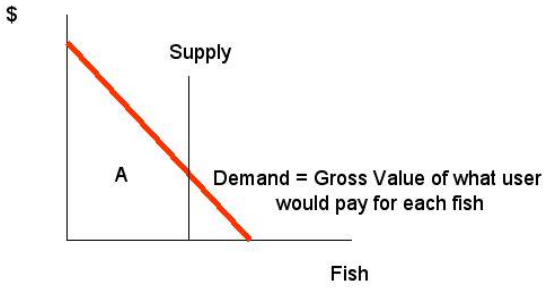

Figure 19.1. User value.

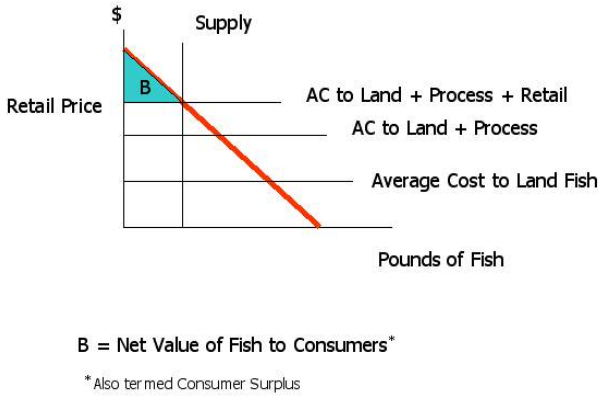

Figure 19.2. Commodity value of salmon.

An actual example is provided by a Vancouver economist (Gislason, 2001) who studied the values of British Columbian chinook salmon fisheries. In 1994, 7.15 million pounds of fish were bought and sold on markets and most of that was exported at a price of $3.90 per pound. Using basic geometry, we can determine the area under the demand curve up to 7.15 million pounds; roughly $35 million. The retail cost was $28 million, yielding a net value of $7 million for area 'B' (Figure 19.3).

The interpretation of this picture is that the $7 million would be the measure of the consumers' loss per year, if all of the BC chinook salmon were to suddenly disappear. That is the net consumer valuation

associated with this British Columbia chinook salmon. An interesting point is that if chinook salmon were not very distinctive in consumers' minds then the demand curve would be more horizontal and, as you can see, that would squeeze area 'B'. In fact, if there were perfect substitutes for British Columbia chinook salmon in consumption, for example chinook farm-raised salmon, then area B would almost disappear completely. That would mean, from a consumer perspective, the loss of wild salmon would be trivial to consumers if farm-raised salmon were a perfect substitute. I am not saying it is, but that is the answer to the question, "How much difference will something make to our well-being?"

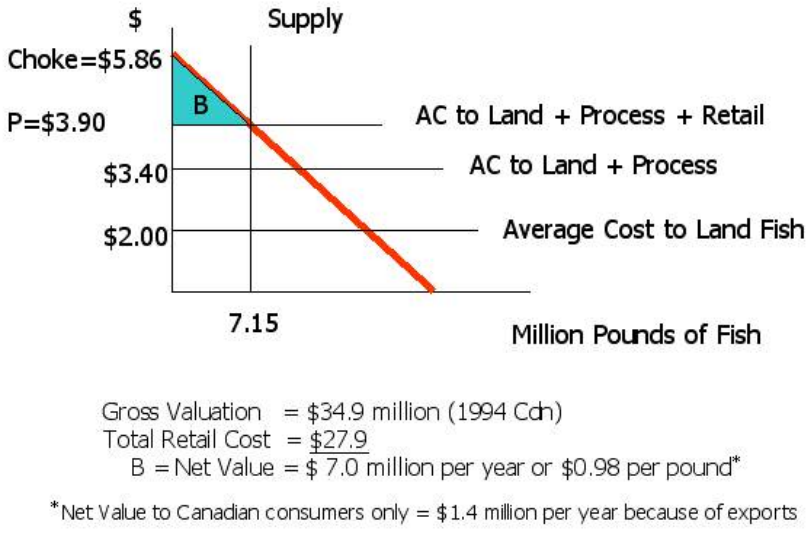

Figure 19.3. BC chinook salmon. (Source: Gislason 2001).

Producer value

The other side of the value picture is associated with the producer values. The net values to producers are revenues minus costs both to the firms and to the workers. In the chinook example above, Gislason (2001) noted that while firm revenues were roughly $28 million, they had costs of $25.5 million; the net value to firms per year of this BC chinook salmon fishery was $2.4 million per year. He also found that workers received increased wages over what their alternatives would have been, and this increased income was roughly $3.8 million per year. These are the net values to producers, both firms and workers.

Net commodity value for 1994 BC chinook harvest

The net commodity value of this chinook harvest, would be the sum of consumer, firm and worker values, or a net commodity value of $13.2 million in 1994 dollars Canadian, or $1.85 (Cdn) per pound. What is the usefulness of this kind of information? If this chinook fishery were closed for one year in 1994, this would be a measure of the net economic value of the consumption-based social loss in that year. In other words, society would be worse off by $13.2 million. If this fishery became extinct and these valuations were to have prevailed over time, then this annual loss would have to be converted to a present value. This present value would be $440 using a 3% discount rate. You can take this $13.2 million and it can become helpful to you in policy because it says, just considering this value alone - and I am not talking about the other values I will be getting into below – it would be worth at most $13.2 million per year to save this fishery for commercial use.

We can use the information in Figure 19.4 to establish the value of augmenting a salmon run. Suppose we were to add 5 million pounds per year to the run and one-fifth (20%) of that would be caught for commercial use each year, increasing annual supply from 7.15 to 8.15 million pounds. The retail price of

salmon would fall from $3.90 to $3.63 per pound. Areas 'C'+'D' in Figure 19.4 represents the net increase in value of chinook salmon, which is over $2 million per year. If this increased run prevailed into the future, then the present value, using 3% as a discount rate, would be $66.7 million. That is, it would be worth $66.7 million to enhance the run by this magnitude.

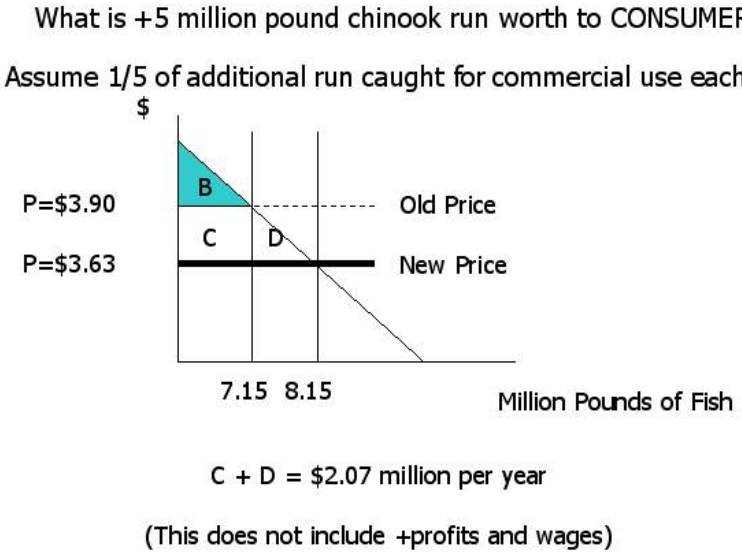

Figure 19.4. Commodity valuation and policy.

Recreational values

An earlier paper discussed how much spending there was in freshwater recreational fisheries (Chapter 11, Post). This spending represents the impact of fisheries and not its value in the terms that I am using. A study of the Copper River fishery in Alaska (Henderson et al. 2000) used a technique that economists refer to as a travel cost evaluation method, where we assess what people would be willing to pay to access a fishery and estimate the actual costs of access, including time and travel expenses. The difference between these two is the net value to a user. This study estimated that the net value to a typical household using the Copper River fishery for recreational purposes was $57 per household per trip. Some 6,000 households were using the fishery as a recreational fishery and they made 1.5 trips per year; therefore, the total net value was roughly $513,000 per year. This is a very different kind of value from the total recreational spending in the Copper River fishery.

A similar travel cost study of recreational chinook fishing on the Gulkana River, Alaska, estimated that the value of fishing under existing catch conditions was $61 per person per day (Layman et al. 1996). The study also determined that the value of fishing under a doubling of catch would have been $82 per person per day. Therefore, doubling the catch was worth an estimated $21 per person per day.

Biodiversity value

There are different concepts of biodiversity such as species, population and genes. Over 19,000 different Pacific salmon stocks have been documented. How does an economist go about thinking about the biodiversity value of these multiple populations or stocks? By protecting against single events, such as disease and climate, biodiversity provides some sort of insurance against the extirpation of large shares of salmon populations and stocks. Economists have not been able, that I have seen, to make economic valuation estimates of fishery biodiversity. Basically, we are talking about increasing genetic variability reducing the probability of extirpation and the saving of all of the natural service values associated with those populations and stocks. For example, suppose that having 100 stocks *versus* 40 stocks reduced the

probability of massive fishery extinctions from disease by 10%. If the annual value of these fisheries is $100 million, then the biodiversity value of an additional 60 stocks is an expected, probabilistic value of $10 million per year. Another way to consider biodiversity value is the effect on biomass productivity from extensive habitation and niche exploitation. The greater the genetic variety, the more niches salmon can inhabit and that increases biomass productivity– you can actually measure that economically on a per pound basis.

Ecological values

One role of wild salmon in the ecosystem is as a nutrient source for other species. Bears are dependent on salmon, and bears have value to us for recreational purposes. By implication, the salmon have value. Also, bears carry fish carcasses and fertilize the landscape. This activity does have an economic equivalency and we could actually go back into the ecosystem and try to measure the value of wild salmon as they enhance the fertilization of forested landscapes and, therefore, either save us money or increase biomass growth. The economic value could be measured either of those ways.

Non-user values

Option values are what a person would pay to preserve the opportunity to use a resource in the future, although they currently do not use it. Existence values stem from peoples' knowledge of the mere existence of gifts of nature and they would be willing to pay something to know that those gifts remain intact. Cultural values are a type of existence value; they may represent an ethical value that we cannot really monetize or that the culture would not tolerate being monetized.

There is an example of non-user values for salmon runs. A study in Oregon and Washington asked households what they would pay to double the size of the Columbia River Basin salmon and steelhead runs or what they would accept to forego the doubling of the runs (Olsen et al 1991). Option values and willingness to pay were roughly $5 per household per month for over 300,000 households, giving a total willingness to pay of roughly $20 million per year just to preserve the option of using this increased run. Given the size of the run, this would have represented $7 per fish each year. These valuation responses were from people who had no immediate intention of using the run. The same study evaluated existence values by asking persons who had absolutely no foreseeable intention of salmon fishing. While their willingness to pay for a doubling of the runs was only roughly $2 per household per month, there were nearly 1.6 million households who would never conceivably use the fisheries. This constituted an annual existence value of over $42 million per year. In contrast, current recreational users of the steelhead fisheries were willing to pay over $6 per month per household for a doubling of runs; this is a user value. This represented an annual value of nearly $111 million per year. As we might expect the valuation per household is the lowest for existence values and the highest for recreational use values.

The total value of doubling the steelhead run would include the recreational use value in addition to the option and existence values. In this example, the total value was over $171 million per year (1991 US$). This would represent roughly $68 per fish for the 2.5 million additional fish constituting the double run. If this doubling were to prevail into the future, then the present value of this doubling using a 3% discount rate would be $5.7 billion.

Impacts *versus* valuation

As noted above, Gislason (2001) looked at the harvest, landed values, processor margin and total market value of British Columbia chinook salmon. The total commercial market value in 1994 was $28 million for chinook. Recreational angler spending in 1994 was $285. Therefore, the total spending impact was $313 million for chinook salmon.

How do these impact measures compare to values, as I am using the term? While commercial impacts were $27.8 million, only $13.2 million of that represents increased incomes and consumer net gains. The

recreational spending impact was $285 million. However, the Gislason study showed that there was a recreational value in terms of willingness to pay, of only $60 million. There is a huge gap between what I call impacts and the value of the difference something makes in people's lives.

Conclusion

It is very important when talking about economic valuation of things, to make sure we understand whether we are referring to value, which I would say is the metric we would want to use in public policy decisions, or impact. Value reflects what difference something will make to us and is the proper measure to compare with whatever costs may be incurred to achieve it. Political systems may focus on impacts but values are the key to rational policy decisions. Many values may be monetized, especially if they reflect the relative valuations of economic goods or services. Of course, we cannot measure all values. Cultural values may be the most difficult to measure, and it may not be reasonable to even consider any type of monetization of these values.

Natural systems provide a huge array of values stemming from the services of these systems. Salmon are just one of many natural system services that we can value for diverse reasons. Traditional commodity and recreational values are understandable and meaningfully valued and monetized. However, other services, such as biodiversity and ecological values, may not be as easily measured or monetized, but may well exceed the values of those that can. It is also important to recognize that non-user types of values may be very important, especially cultural values. Salmon fisheries represent the complete range of issues associated with valuation.

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CHAPTER 20

Perspective of the commercial salmon fishery

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I would like to achieve four things with this paper: first, to describe the importance of the Skeena River commercial sockeye salmon fishery to the thousands of fishermen, shoreworkers and trade people who live and work in native and non-native communities up and down the BC coast; second, to describe the inherent complexity involved in planning and conducting a commercial fishery targeting Skeena River sockeye; third, to illustrate how the industry has participated in building a sustainable fishery; and, finally, and maybe most importantly, to point out how academics, NGO's and fisheries bureaucrats, are avoiding or ignoring the harder decisions and trade-offs that surround altering or eliminating commercial fisheries.

Commercial Skeena River sockeye fisheries

Upon their return to their natal streams Skeena River sockeye pass through commercial fisheries in Alaska, and in BC marine waters around Prince Rupert. They then encounter Aboriginal Food, Social and Ceremonial (FSC) fisheries and Aboriginal Commercial Excess Salmon to Spawning Requirements (ESSR) fisheries as they make their way up the Skeena River past Terrace and then Hazelton. The vast majority (>90 %) end up in Babine Lake. The balance find their way into a myriad of smaller tributaries along the way (Figure 20.1).

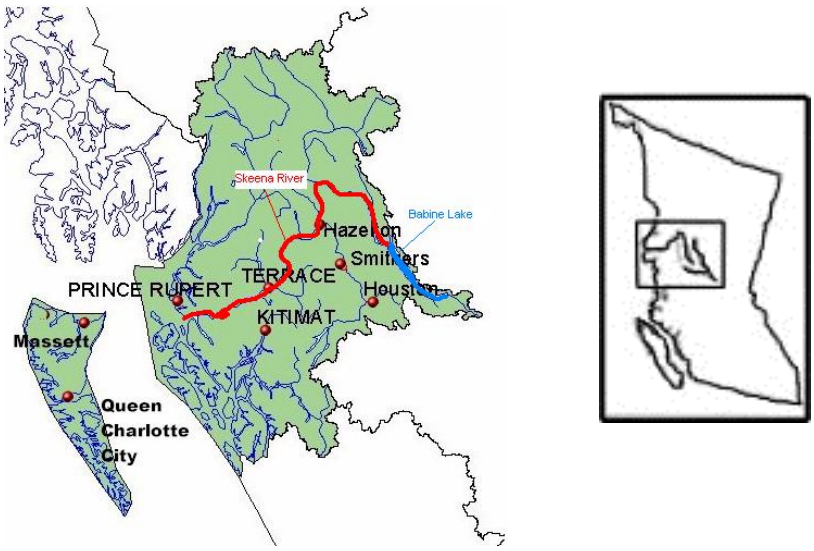

Figure 20.1. Map of Skeena River and Babine Lake.

There are five major First Nations in this area: Tsimshian on the Coast, Gitxsan around the Gitwangak - Hazelton area, the Wet'suwet'en around Moricetown and Smithers, the Gitanyow just north of the Gitxsan, and the Lake Babine people who live in several villages around Babine Lake and near Burns Lake. Archeological records going back 10,000 years make it clear that salmon grew to become an essential element in the First Nations culture, society and diet in this area. Today, First Nations have a constitutional right to harvest salmon for food, social and ceremonial (FSC) purposes. However, they are not allowed to use their FSC harvest for commercial purposes, although this will likely change with the advent of Treaties. First Nations have also had, on the north coast, commercial access to salmon through the commercial salmon fishery. First Nations people owned or operated a large proportion of the fishing fleet in the north of BC and as well they worked in the local processing sector. First Nations employment in both these sectors has declined in the 1990s and 2000s as the result of reduced access to sockeye, poor markets, and fleet and processing rationalization. During the 1990s an in-river Excess Salmon to Spawning Requirements fishery began in which some First Nations were able to participate. There were years in which a significant proportion of the Total Allowable Catch (TAC) was taken in ESSR fisheries and these fisheries provided a significant injection to many local First Nations communities.

Total annual average returns of Skeena sockeye have grown from around 1.7 million for the years 1950 to 1959 to 2.7 million for the years 1990 to 1999. Much of this growth is due to the introduction of large spawning channels in Fulton River and Pinkut Creek on Babine Lake. It is estimated that enhanced sockeye which make up over 90% of returning sockeye could withstand harvest rates of around 80% whereas unenhanced sockeye might only be able to withstand harvest rates of between 50-65%. Managers have tried to balance economic and community interests with resource interests by limiting harvest rates to where some of the potential catch of enhanced Babine fish is foregone but above that would maintain all unenhanced stocks at Maximum Sustainable Yield (MSY). The result has been some significant over-escapements in recent years, the creation of ESSR fisheries and a reduction in the number of sockeye returning to unenhanced streams. Currently none of the unenhanced sockeye stocks have been listed by COSEWIC.

The Skeena River is second only to the Fraser River in sockeye production and it is the key to the northern salmon fishery. It is the life-blood of the industry, and without sockeye there would be no modern commercial fishery. Maintenance of the modern northern salmon fishery requires balancing scientific, management, economic and social objectives.

Policy underlying the development of the modern commercial fishery

This balance was articulated in the 1988 Salmon Stock Management Policy (SSMP). This policy's stated objective was to conserve the resource and provide the highest sustainable contribution to the economic and social development of the people of Canada. It was also explicit in regard to trade-offs, which were to divide stocks into actively managed stocks and passively managed stocks. Actively managed stocks were those that would be targeted by commercial fisheries whereas passively managed stocks were those that would necessarily be impacted by commercial fishing. The objective for passively managed stocks was to not allow them to go extinct but for them to cycle at some lower level of abundance. Fishermen, communities, and processors based their investment decisions on this policy and the explicit trade-offs it articulated.

The benefits of this fishery, particularly to the north coast (a region with a low population base and very dependent upon natural resources) are far reaching. The industry employs 700 gill-net boats, many of which come from the First Nations and coastal communities, 100 seine boats, many of which come from the area, and 2,000 shore workers, 60% of which come from local communities and First Nations. Major in-river ESSR fisheries that have developed along the Skeena River employ large numbers of natives who would not ordinarily have any work and thus provide for significant cash injections into many of their communities. Six major processing plants as well as many smaller ones are located on the north coast.

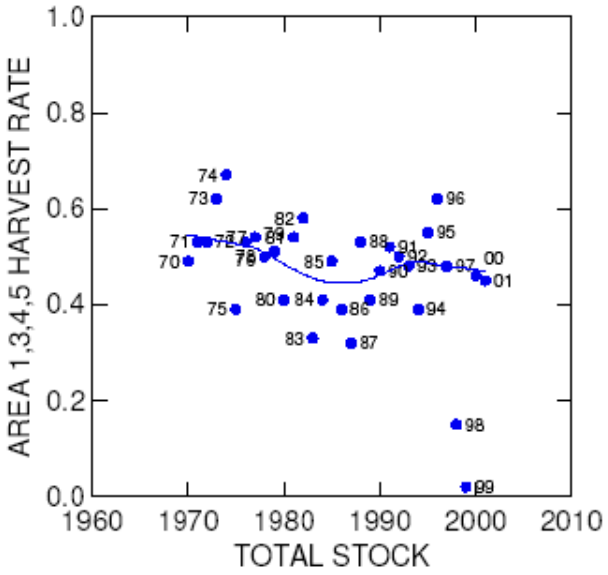

Figure 20.2. Commercial harvest rates from 1960-2000.

Table 20.1. Commercial salmon harvest rates.

Period (years)	Harvest Rate (%)
50-59	0.45
60-69	0.44
70-79	0.54
80-89	0.45
90-00	0.43
2000	0.46
2001	0.45
2002	0.47

The perception is that when enhancement channels were introduced there was a significant increase in marine harvest rates with a concurrent increase in fishing pressure. This is not the case. Figure 20.2 and Table 20.1 shows that in the 1950s the harvest rates averaged around 45% and in 2002, they were approximately 47%. There did seem to be a peak from 1970 – 1979 following the establishment of the enhancement facilities but everybody realized at that time that the increase was not sustainable. Since that time marine harvest rates have been reduced to pre-enhancement levels honouring the trade-offs made explicit in the SSMP.

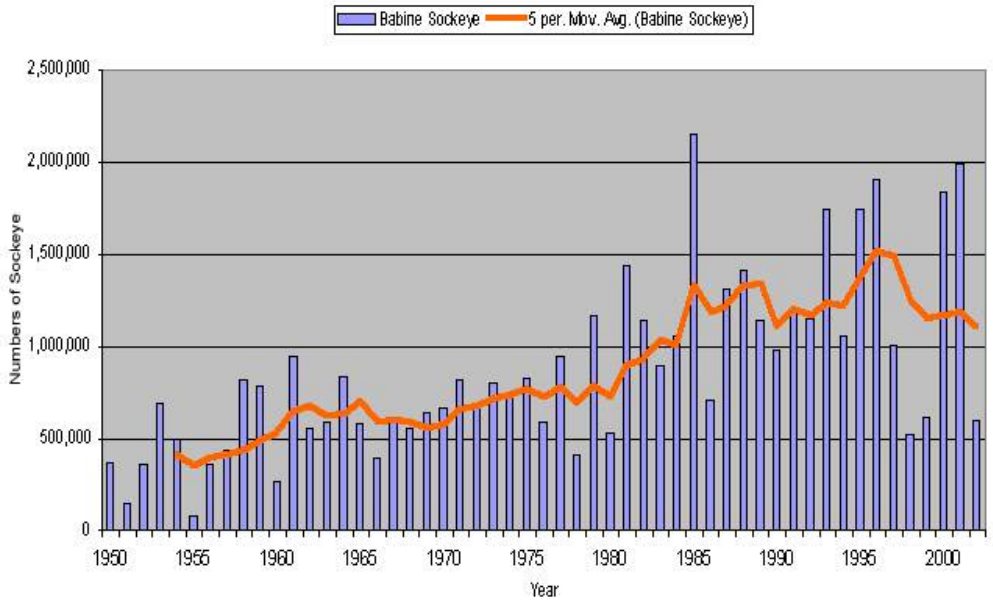

Figure 20.3. Escapement of Lake Babine Sockeye: 1950-2002.

After the development of the Babine enhancement facilities in 1967 the total return of Skeena sockeye increased markedly (Figure 20.3). Escapement targets remained at 1,050,000. With marine harvest rates remaining stable major surpluses of Babine fish occurred, creating massive over-escapements to the spawning facilities. This led to the introduction of ESSR fisheries which became, until recent management changes were implemented, very important to First Nations communities along the main stem of the Skeena and into Lake Babine. Also, even though marine harvest rates remained stable, the increased amount of sockeye available meant larger catches for the commercial industry operating in the marine environment.

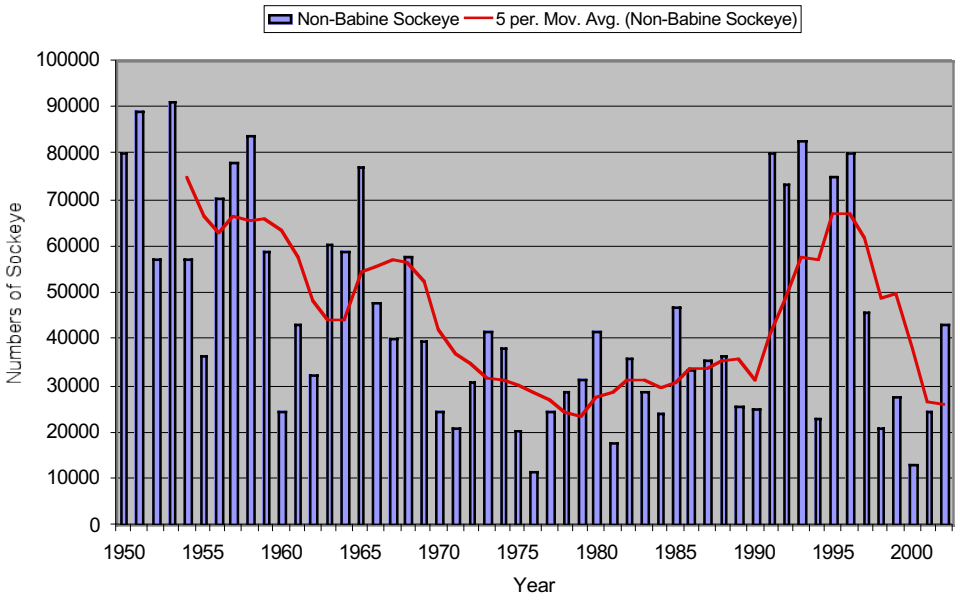

Figure 20.4. Escapement of non-Babine sockeye 1950-2002.

There has been an impact on unenhanced Skeena sockeye stocks. Escapements declined after the introduction of the enhancement facilities in the 1960s. This downward trend stabilized in the 1980s and in recent years there seems to be some growth in aggregate escapements of unenhanced sockeye (Figure 20.4).

The commercial industry, working through the advisory process of the Department of Fisheries and Oceans, has met the objectives set down in the SSMP. Catches have increased, new fisheries have been created and all stocks, including unenhanced sockeye stocks, continue to persist. However, they are cycling at lower levels than what they would be without the fishery.

There are approximately 28 unenhanced sockeye stocks on the Skeena ranging from a few dozen adults to many thousands. Commercial fishermen are frustrated because the non-Babine stocks are a tiny proportion of the overall stocks in the Skeena River. They have met the objectives of the SSMP but now people are demanding that all stocks be maintained at MSY or higher levels. If the policy of DFO were to change to reflect this there could not be a viable commercial fishery and people's and communities livelihoods and investments would disappear.

Fishermen are also frustrated in that there seems to be little or no relationship between commercial harvest rates and escapement of unenhanced sockeye stocks. While there is no question that the stocks are lower than they would be without a commercial fishery, they seem to be stable.

An agreement to rebuild the Morice sockeye

One of the problematic stocks is the Nanika/Morice which branches off the Skeena River at around Hazleton and travels up the Bulkley/Morice to Morice Lake. Figure 20.5 illustrates that there is little relationship between weekly harvest rates and the escapement of Morice Sockeye. Morice Sockeye is a very unproductive stock and it seems to be persisting at a lower level than it would do in the absence of a commercial fishery.

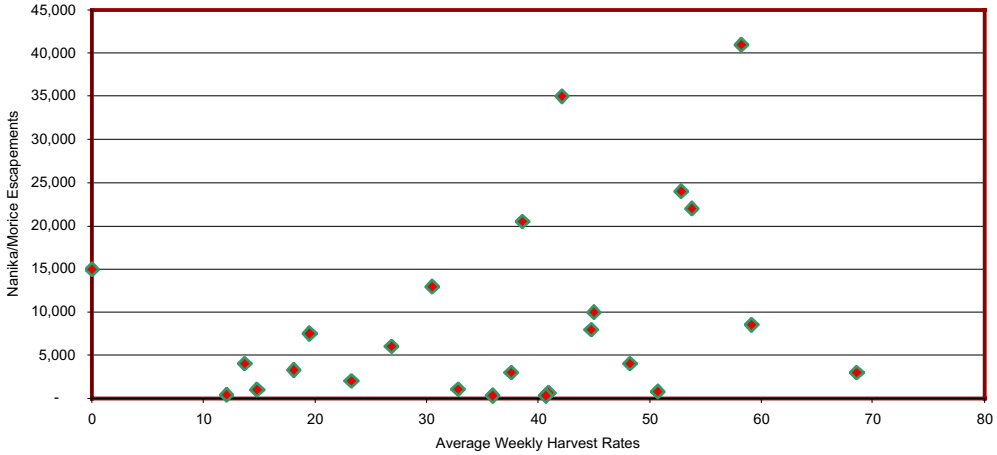

Figure 20.5. Relationship between Nanika/Morice escapements and average weekly havest rates for weeks 7-1 to 7-3.

The Wet'suwet'en people are very concerned by this and they would like to rebuild the stock. In an agreement initiated by some members of the Native Brotherhood, the commercial industry worked with the Wet'suwet'en Chiefs and have implemented a bi-lateral agreement, which has seen, in 2002 and 2003, significant increases in sockeye escapement to the Nanika/Morice.

Status of Non-Babine Stocks

The status of unenhanced stocks varies quite a bit (Figure 20.6). Most of them are below either their productive capacity or MSY targets and most seem to be cycling somewhere in between what scientists are now calling the Prudent Reference Point and MSY. The Prudent Reference Point (PRP) is defined as the point at which the stock would rebound within three years without fishing pressure. There are only one or two stocks that could currently be classified as being below their PRP limit and the status of these stocks must be addressed. The balance of the 28 stocks is persisting around some level of abundance lower than MSY but higher than their PRP. Again, this meets the objectives established by the SSMP.

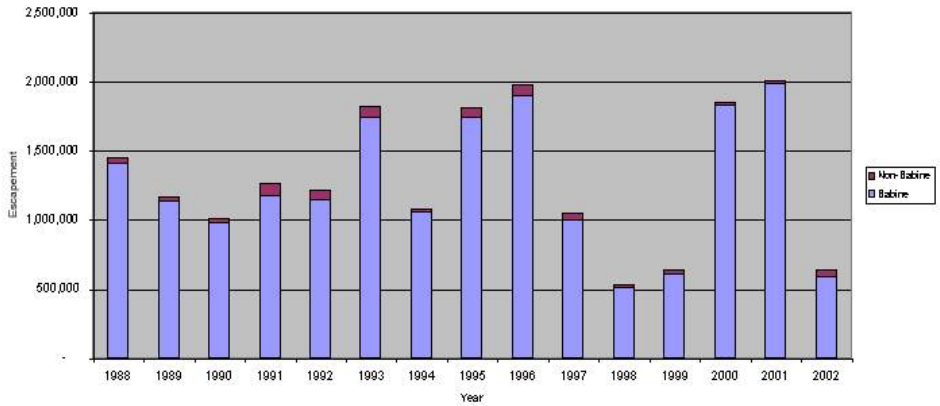

Figure 20.6. Relative size of escapements of Babine (largely enhanced) and non-Babine (unenhanced) sockeye.

Industry has responded to conservation challenges

Often the fishing industry is portrayed by bureaucrats, academics and NGOs as a rapacious monolith. The reality is that the industry is comprised of thousands of people working very hard to make a marginal living in areas with little alternative employment opportunities. These people, I am proud to say, have worked hard over the last decade-and-a-half to create a sustainable fishery, embracing significant improvements in the way they do things. They have:

1. reduced harvest rates from the peak in the 1970s,
2. introduced the revival boxes in the 1980s which are now on every fishing boat on the coast,
3. developed the first selective seine fishery in the world in the early 1990s,
4. participated in the Skeena Watershed Committee process which revolutionized how fisheries were managed on the Skeena River,
5. worked with the First Nations to introduce some of the first in-river and in-lake commercial fisheries in BC in modern times,
6. cooperated with DFO during the 1998 coho salmon crisis to rebuild coho returns (which we see happening in the north coast faster than anywhere else),
7. designed a series of studies that led to the introduction of selective seining coast-wide,
8. designed and organized a series of studies that led to the introduction of more selective gill-nets in terms of drop weed lines (to allow steelhead, which tend to swim at the top of the water column, to pass through the nets) and mesh sizes in order avoid or release certain species of fish,
9. developed the first selective gill net fishery in 2000 with a combination of short-sets and different mesh size, which was scientifically proven to be extremely successful at ensuring the survival of different stocks,
10. negotiated an historic bilateral agreement with First Nations to increase escapements to a specific stock, and
11. worked with the First Nations and DFO to reduce harvest rates in the Gitwangak sockeye in 2002.

The industry is proud of these achievements. They have also proven their ability to take on and solve specific issues such as an action plan if one or two stocks is below its PRP. Industry cannot persist in an environment which eliminates the trade-offs in the SSMP in favour of a policy which demands that all stocks be at or very near to their MSY or productive capacity.

Problems with management approaches

Many DFO bureaucrats, NGOs and people from academia are prescribing a no-risk doctrinaire regime that argues for a new set of objectives so that "each salmon species, whether mixed stock fishery, must be managed in accordance with the strength of its weakest genetically defined stock component and that all genetically defined stocks in each species group should be maintained at MSY or higher levels and that these objectives should take precedence over all other socio-economic objectives." That is a pretty hard pill to swallow for the commercial industry people who are trying to make a living. Fisheries management used to be a dynamic, flexible and pluralistic process set within the context of the trade-offs laid down within the SSMP. Fisheries management, under pressure from within and without, is evolving into a top down doctrinaire approach that tolerates no risk. There used to be consideration for people, communities and economy when risk was calculated. A calculation of risk involved more than the relative abundance of a stock of fish; it involved the impacts upon people, communities and economies. It promoted a collaborative approach between the stakeholders, managers and scientists such as we saw in the Skeena Watershed Committee (SWC) process.

Another frustration is that DFO employs simplistic, linear models to evaluate risks and possible solutions. They have not incorporated the local, historical knowledge that fishermen can bring to the subject. I will give you a quick example with respect to steelhead. Fishermen knew where a large proportion of

steelhead were intercepted. They knew this because they had learned from their fathers, grandfathers and great-grandfathers who fished the same drifts. This information was brought to DFO but they said that their models could not absorb this level of detail and so could not ascertain or measure its impact.

The models also have difficulty assessing real world solutions and compromises. The Kitwanga (which has an unproductive unenhanced sockeye stock) is a volatile river. A large back eddy guards its mouth where it enters the Skeena River. The sockeye hold in this back eddy waiting for the Kitwanga to rise. There are six or seven families who take their food fishery in the immediate area and just below the back eddy there was a major ESSR fishery. Working with these First Nations has led to them adjusting their food fishery so as to reduce the impact on Kitwanga sockeye. The result was an increase in sockeye escapement to the Kitwanga in 2002 and 2003. Again, we were told that this type of solution cannot be incorporated into the management model.

The only factor that can be measured by the current management model is marine harvest rates so all solutions must incorporate measurable changes in harvest rates. Innovative solutions that benefit all users cannot be incorporated so the benefits cannot be measured. The simplistic construction of this approach, focusing exclusively on the manipulation of marine harvest rates, assumes that scientists are capable of making the necessary value judgments. It assumes that managers cannot be trusted to manage the fishery and cannot be trusted to work with the fishermen to ensure a sustainable fishery. It assumes that fishermen cannot contribute useful knowledge and have little interest in building a sustainable fishery.

It also ignores other options that we feel are in the toolbox such as: moderate lowering of harvest rates, modified fishing times and locations, targeted enhancement, in season adjustments in response to specific challenges, the Nanika (see below) type of arrangements between stakeholders, local adjustments to increased escapements, such as the Kitwanga example, and increased funding for First Nations' fisheries research.

Critical scientific economic and political questions left unanswered

There are critical scientific and economic questions that have been left unanswered. For instance, how should a salmon stock be defined, as a reasonable stock grouping or as an independent conservation unit? What is a reasonable rebuilding target for a stock: limit reference point; prudent reference point; MSY; maximize escapement or productive capacity? What is a reasonable rebuilding trajectory for a stock and how quickly do we to get there and how risk-tolerant are we prepared to be? The answers to these questions have very different ramifications for the commercial industry. If any of these answers lead to management objectives substantially different than what is outlined in the SSMP the very existence of the commercial fishery will be jeopardized.

Risk intolerant approach

The proposed risk intolerant approach supported by many in the science community would cut the commercial and ESSR sockeye harvest on the Skeena by over 50%. This would collapse the industry as we know it and would also preclude any but the most terminal ESSR fisheries.

Modeling the impact of a risk intolerant management approach indicates that it would produce a major decrease in commercial catch compared to the 1988 to 2002 commercial catch. Fishermen would be catching less than half the sockeye. The average fishermen's gross income would be cut by approximately 50% (see Figure 20.7) which would eliminate any net income as all the remaining income would go to paying fishing expenses. It would be like going home to your spouse and saying, "Guess what, the good news is, I am going to be able to go to work tomorrow but the bad news is they are not going to pay me." That is the scenario that the fishermen are facing. This would no longer be an economically viable fishery. And what benefits would accrue? Some of the unenhanced sockeye stocks would be larger than

they currently are. This is the trade-off many in the scientific, NGO and academic communities are calling for.

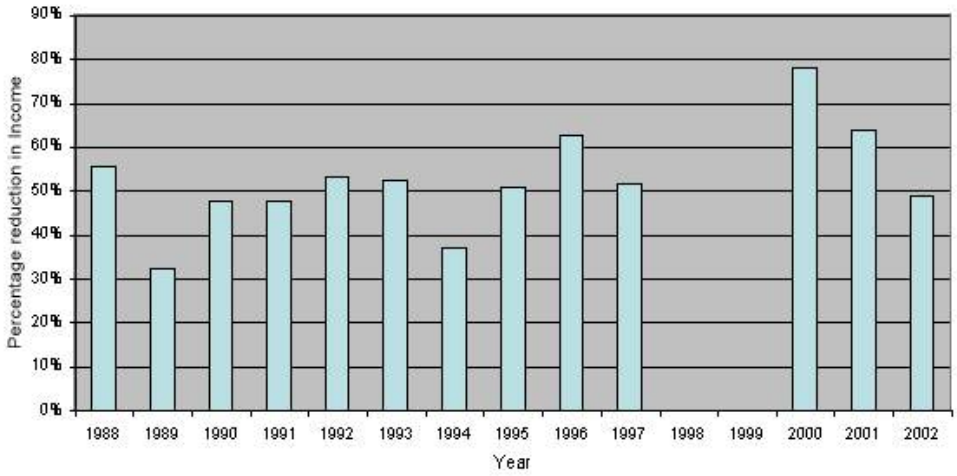

Figure 20.7. Percent reduction in average gillnetter's income from Skeena River sockeye for the years 1988-2002 if weak management had been in place.

Additional consequences of new approaches

We have heard some of the platitudes about people wanting to see a commercial fishery while at the same time moving unenhanced sockeye stocks closer to their productive capacities. This is either foolish or mean-spirited. There would be no commercial fishery under those kinds of scenarios. In-river fisheries for the First Nations, as I have described, would also be finished.

The social contract between DFO and the stakeholders is being seriously eroded and we are seeing big problems including large-scale poaching, people not working with the enforcement people, fishermen no longer willing to work with managers, and a real collapse of trust between fishermen, other stakeholders and DFO. The real question in their minds is why should they work to defend the resource? For the first time, at a North Coast Advisory Board meeting, I heard a commercial fisherman say, "Listen, if this fishery goes, we will need fish farms because we need to have jobs." I could not believe my ears because at the same time as we are fighting expansion of fish farms to the north coast, we have a commercial fisherman considering this option because he does not know what else can be done.

Moving away from the trade-offs articulated in the SSMP to a new no-risk approach that seeks to maximize the productive capacity of unenhanced sockeye stocks on the Skeena will also eliminate the incentive to work with DFO and others on innovative and cooperative projects and processes such as the Skeena Watershed Committee process, Nanika Agreement and Pallant Creek. Clearly the current commercial fishery is not viable in the proposed regime. There will be staggering personal, social and economic transition costs if we go down this road.

Industry's position is that we made decisions and investments based on DFO's 1988 policy and we received re-commitments of this policy from two recent ministers. Industry was guaranteed that the future of the industry would be conservation, partnership and economic viability. We would like to work with the DFO managers and stakeholders to maintain an economically and ecologically viable fishery. However, if DFO decides to introduce this new regime, in the face of these previous commitments, then government has an obligation to compensate industry.

In light of many of a number of previous papers, it is irresponsible for me to not include some discussion of the consequences of the proposed changes to salmon management. There will be real life consequences

to people. We believe that the dramatic changes in policy demand social accountability: How should the compensation be paid to fishermen; who should be compensated; how will communities adjust; what are the social costs of lost livelihoods and businesses as people lose everything; what role should government play in helping the fish processing business and the 2,000 shore workers adapt to changes? All of these questions have to be addressed. Failure to demand changes without consideration of the consequences is why industry argues that science and scientists are not the people who should be making value judgments. And these *are* value judgments. If the salmon stock's Limited Reference Point (LRP) is 100 and a scientist says that the stock should have an LRP of 1,000, then the difference between 100 and 1,000 involves political, social and economic value judgements.

Change the course

I would argue that there is a way to manage salmon resources that will allow us maintain a sustainable resource and fishery. To get there we will have to entrench a policy commitment that clearly states that there is an environmentally and economically sustainable fishery in our future. There has to be some kind of balanced approach. It might be quite different from what we saw in 1988, but without some kind of balance that states that we can have an economically viable fishery, we have to return to the question of what happens to the people. I think that new partnerships between industry and DFO, with respect to the salmon fishery, can be one of the solutions that will take us to where we want to go. We saw an example of this in Barkley Sound in 2002 where seiners went to a pool fishery. We have also developed several Individual Quota (IQ) fisheries that have allowed for both a bountiful resource and a viable fishery and we have gone to non-competitive fisheries to reduce fishing pressure. These examples illustrate our willingness to build new partnerships that would get us to where we have to be for a sustainable fishery.

But we must have access to sockeye or else it becomes just an academic exercise. Industry does have the skills - we are willing to change and to adapt. I recall all the changes that we experienced over the years on the Skeena where people were willing to adapt to preserve their fishery and to ensure that they have a fishery for the future. Interest-based negotiations are a part of it as well as accommodation and compromise. We, as a fishing community, have to move toward some sort of forum where we can discuss and hammer out some of these concepts, where we can all take our interests, put them on the table and try to negotiate something that would allow us to have a fishery that meets the objective of conservation and still meets the goals and aspirations of people in the commercial fishery.

I believe it is possible but it will take compromise and a willingness to accept that not all of these stocks are going to be at their productive capacity. An example of a process we could use to do this, is the Skeena Watershed Committee process which ending in 1996. Although it was somewhat flawed, it did get people together and significant compromises were made all around. We preserved the fishery – a very different fishery – but it was a sustainable fishery that everybody agreed to and everybody could buy into. The Nanika Agreement is another example. In this case, a bi-lateral agreement was reached between industry and First Nations and it was successful in increasing escapements to a specific stock. Pallant Creek is another example; here industry worked with First Nations on the Queen Charlotte Islands to create, for the first time, a commercial fishery that helped to pay for a hatchery owned by the Haida Nation. All of these things are possible and we can create these kinds of institutions that will create a fishery for the future but it is predicated on industry having access to enough sockeye to maintain an economically viable fishery.

CHAPTER 21

Valuing wild salmon: who gets to decide?

Jan Konigsberg, Director, Alaska Field Office, Trout Unlimited, Anchorage, Alaska, USA

Introduction

Different life-paths bring us together to plot a route to the summit of salmon sustainability. Undoubtedly we see different routes to the top and probably disagree about which peak is the true summit of Mt. Sustainability.

I do not believe that any salmon fishery management regime has attained the summit. 'Team-Alaska' reached a false summit, because the way in which Alaska fundamentally values salmon follows the same path that led Oregon and other Northwest states up and off the cliff of the Endangered Species Act. Those who follow this trail adhere to the tenet that the fishery management authority can fulfill its duty to steward the resource principally by managing the fisheries. Yet, no matter how well-intended the managers are, they are bound to fail because they have not been given either the authority or the responsibility to manage the ecosystems upon which salmon depend.

Fishery-sustainability certification programs

Thus, fishery-sustainability certification programs that do not evaluate management's capacity and ability to address the root causes of the decline and extirpation of salmon populations, of which overfishing is only one, are of limited value and may result in incomplete and misleading evaluation.

This path equates sustainable fishing with sustaining the fish. This equivalency renders the definition of sustainability far too problematic. This definition makes it possible to argue 1) that a fishery is sustainable even as it is being overfished so long as there are appropriate management tools available for rebuilding; and moreover, 2) that a fishery that has been managed unsustainably for decades, but is now in the process of rebuilding, can be judged sustainable. There is the further problem of what is meant by the term *rebuilt*. Some American fisheries are reported as fully rebuilt - but, rebuilt to what level? In most cases, it means the *rebuilt* fishery has been restored only to the abundance level of a decade ago, which in reality is a mere 10 percent of the pre-industrial fishery abundance for that species. In the last 100 years, wild salmon abundance in the Pacific Northwest and California has declined 90 percent. Of 192 anadromous salmonid stocks historically known from the Columbia River Basin, 67 (35%) are extinct, 36 (19%) are at high risk of extinction, 14 (7%) are at moderate risk of extinction, 26 (13%) are of special concern, and 49 (26%) are considered to be secure. On the Pacific coast of the United States

alone, salmon have been lost from 40 percent of their one-time range, and stocks are threatened or endangered in another 27 percent.

What is the public to think? Are they to believe that fisheries that have been severely depleted are now rebuilding according to some recovery plan ordered either by the court or the management agency? Are they to be considered sustainable and a testament to current good management? Apparently so.

Nonetheless, the problematic definition of sustainability is a very convenient one for the commercial fisheries. When Marine Stewardship Council (MSC) certification of the Alaska salmon fishery was first proposed, the industry balked. Now, however, the industry believes "sustainability" sells – at least it seems to help sales in niche markets. As the eco-label is perceived to provide a competitive advantage, many fisheries want certification.

While the primary impetus for establishing the MSC was the belief that certification would force improvements in fisheries management through market mechanisms – a sensible rationale – what does seem to have "improved" is the marketing hype. The following quotation demonstrates this point.

> *I can't comment about fisheries in other parts of the world, but I think governments, conservationists and even other nations' fishermen could learn a lot from what we've done here in California to sustain our fisheries. Our fishing men and women have taken the lead in restoring fish habitat and making sure our fishing is well-managed – Larry Collins, a San Franscisco fisherman and Chairman of the California Salmon Council 2003.*

Mr. Collins would have been on safer grounds to have instead made the point that unsustainable fisheries are more readily discerned than sustainable ones, and that the best that can be said for most California fisheries is that they reside in purgatory, not yet having gone completely to Hell. In other words, the essential, if somewhat imprecise, concept of sustainability functions more powerfully as a lens to detect the unsustainable than it does as a compass to navigate toward sustainability.

Fisheries management in Alaska

As one of its first acts, the Alaska Legislature established an Alaska Department of Fish and Game (ADF&G) in order to ensure an abundant supply of salmon for the commercial fishery.

The Alaska Department of Fish and Game was established with the statutory requirement that,

> *The commissioner shall manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state… through rehabilitation, enhancement, and development programs, [ADF&G must] do all things necessary to insure perpetual and increasing production and use of the food resources of state waters and continental shelf areas.*

In terms of Alaska's salmon abundance, management tends to take more credit than it deserves. Yes, Alaska has plenty of fish, but the reason it still has plenty of fish is because it has plenty of productive salmon habitat. As much as government would like to take credit for maintaining habitat it is a fact that, where there is settlement and development in Alaska, there is degraded habitat — the same as everywhere else. In Southeast Alaska, for instance, nearly 70% of the

culverts in the Tongass National Forest impede fish passage. Nonetheless, Alaska fishery managers and the industry flaunt abundant harvests as evidence of sustainable fishing, but that is not necessarily the case.

Given that the goal of Alaska's salmon managers is to provide maximum sustained yield of commercially important salmon stocks, the major precepts of management are shown in Table 21.1.

Table 21.1. Principles of salmon management and associated problems.

Principle	Critique
• In order to provide the greatest opportunity to harvest surplus production, fisheries of many commercially important stocks are usually prosecuted on mixed stocks	Over-exploitation of the non-target species is difficult to control.
• Escapement targets are predicated on the assumption that allowing too many salmon onto the spawning grounds (over-escapement) has an adverse impact on salmon production	Over the long term, however, manipulating escapement to prevent over-escapement is likely to decrease salmon biodiversity and ecosystem productivity.
• Due to natural fluctuations in abundance of wild salmon, aquaculture-based fishery supplementation (salmon-ranching) is sanctioned and practiced	Despite the potential for genetic and ecological impacts on wild salmon populations.
• Abundance based management	Using abundance as a proxy or even an index of sustainability of salmon stocks is quite problematic and can even be misleading.

Abundance-based management

Managing commercial fisheries based on biological escapements determined to produce the greatest sustained yield does not ensure that the temporal and spatial segments of the run (and, hence, the biodiversity of the targeted salmon stocks) will be protected over time. Indeed, even if certain spatial or temporal segments of the run are depleted or even extirpated, which all other factors being equal would result in less "surplus" production to harvest, effective management of the fishery would merely require recalculating maximum sustained yield and biological escapement downward. Therefore, given only abundance-based criteria and analyzing only abundance-based data, management could be deemed successful even as biodiversity declines. The abundance of the return is not a sufficient determinant of whether or not a salmon stock is being exploited sustainably.

In fact, abundance of the catch is not in itself a measure of the health of individual stocks or of freshwater habitat conditions. Abundance of returning salmon can fluctuate dramatically because many factors affect salmon productivity and mortality. Therefore, high returns may or may not be indicative of good management (during periods of high marine productivity, significant management mistakes would be hard to discern); conversely, low returns are not necessarily indicative of poor management. Moreover, there is evidence that a relatively small part of the breeding population is the most productive and that this productive segment is both changing and unpredictable. Thus, population dynamics models that only incorporate abundance will fail to predict decreases in stock productivity as a consequence of actions that maintain abundance in the short term, but decreases genetic variability in the longer term.

The goal of abundance-based management is to maximize the catch, not to conserve biodiversity. Managing for abundance, particularly when hatchery production masks wild population dynamics, does not depend upon protecting the full spectrum of genetic and life history diversity of salmon populations nor the full spectrum of salmon habitats. Moreover, evaluating the success of salmon management based on abundance has the unfortunate, if unintended, blow-back of justifying development projects that might harm local salmon populations according to the rationale that, because there are so many salmon, the loss of a few salmon is not significant.

The Alaska Salmonid Biodiversity Program

Trout Unlimited (TU) established the Alaska Salmonid Biodiversity Program in 2000 to advocate principally for conservation of the extant demographic, genetic, life-history and ecological diversity among and within Alaska's five species of Pacific salmon. Alaska has the greatest reservoir of salmon biodiversity remaining in the world. Sustaining this biodiversity will require fundamental change in salmon management.

In 2000, the same year that TU established its Alaska office, MSC certified the Alaska salmon fishery. With the certification under its belt, the State of Alaska, along with the Alaskan salmon industry and the emerging green campaign against salmon farming, were quick to juxtapose Alaska salmon management to that of the Pacific Northwest and to the growing but unsustainable and environmentally unfriendly farmed-salmon industry.

Table 21.2. Percentage hatchery salmon of 2000 catch.

Region	% of hatchery salmon in 2000	
	Species	% of catch
Southeast	Chinook	29.7
	Sockeye	16.0
	Pink	1.0
	Coho	20.1
	Chum	72.7
	Total:	**26.5**
Prince William Sound		
	Chinook	0
	Sockeye	24
	Pink	82
	Coho	65
	Chum	88
	Total:	**80**
Statewide	Chinook	18.6
	Sockeye	4.0
	Pink	42.0
	Coho	24.0
	Chum	64.1
	Total:	**34.0**

TU, however, was not nearly so sanguine about Alaska salmon fishery management. They believed that the Sustainable Salmon Fisheries Policy (SSFP) adopted by the Board of Fish (BOF) in 2000 acknowledged the need for substantial reform in salmon fishery management and hoped that the policy would provide a favourable environment for TU's salmon biodiversity advocacy. Unfortunately, the environment has proved less than favourable.

In October 2001, TU released the report – *Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issue*s (accompanied by TU's recommendations for reforming the hatchery program). In this report TU raised the issue about how Alaska's salmon fishery can be called sustainable when about one-third of the statewide annual harvest is comprised of hatchery-produced fish, with hatchery fish comprising 2/3 or more of the annual harvest of some fisheries (See Table 21.2).

The state and industry take offense that TU would dare to question whether the salmon fisheries are sustainable, especially when farmed salmon were displacing Alaskan salmon in the world's markets. Apparently, TU should have known better than to be asking the wrong questions at the wrong time.

> *The industry is "in no mood to listen to theory about how Alaska hatcheries that help them survive might, conceivably, be overgrazing the ocean's pastures or genetically weakening wild salmon."*
> Brad Warren, Editor, Pacific Fishing Magazine, January 2002.

These questions were being raised at the time the industry and state seized on the opportunity to differentiate Alaska salmon from farmed salmon in the marketplace. The strategy to compete with farmed salmon and gain the support of the "greenies" depended, however, upon the fiction that all Alaska salmon were naturally wild and that farmed salmon are the major threat to Alaska salmon. While there is no question that farmed salmon are the major threat to the economic value of the Alaska salmon industry, they are hardly a threat to wild salmon biodiversity when compared to the release of about 1.5 billion juveniles annually into Alaska's natural waters from 27 industrial-strength hatcheries. Figures 21.1 and 21.2 show the extent of these hatcheries throughout the state.

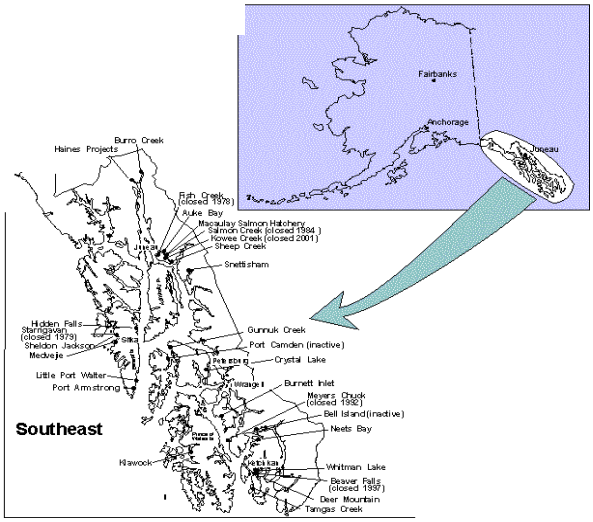

Figure 21.1. Locations of Hatcheries in Southeast Alaska.

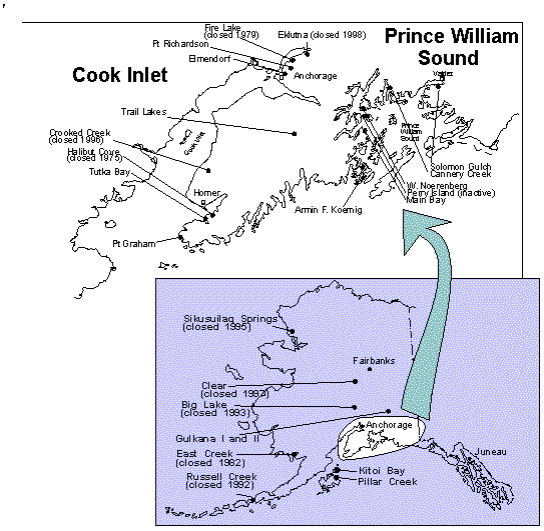

Figure 21.2. Locations of Hatcheries in Prince William Sound, Interior and Southcentral Alaska.

Impacts of salmon ranching

Since its inception in the mid-1970s, Alaska's salmon-ranching program has been dogged by worries about the potentially harmful interaction between hatchery and wild fish. For example, the American Fisheries Society published a paper, co-authored by the Alaska Department of Fish and Game's chief research scientist, which concluded that hatchery pink salmon are replacing wild pink salmon in western Prince William Sound. Nonetheless, ADF&G insists that hatchery and fishery management protocols safeguard Alaska's wild salmon from adverse impacts of salmon ranching.

In fact, the commissioner of Fish and Game informed TU that he had no confidence in his chief research scientist's findings regarding Prince William Sound pink salmon hatcheries and further, that he saw no inherent conflict between salmon ranching and the recently adopted Sustainable Salmon Fisheries Policy's precautionary principle. Such a cavalier attitude toward salmon ranching, which is after all the other side of the salmon aquaculture coin, contrasts with the Department of Fish and Game's paranoia about salmon farming, which the legislature banned. TU's recommendation that hatchery fish be distinguished from wild fish is based on the same reasoning the State uses to distinguish wild from farmed salmon. The department explains that Alaska outlawed the "*farming of salmon to protect strong native stocks from hybridization, disease, pollution, and competition for food*." These are precisely the same concerns that apply to ranched salmon. The industry would have us believe that salmon farming was banned because of environmental concerns. This concern may have been a factor, but not the driving one, which was to prevent economic competition from aquaculture.

Just as banning of salmon farming was driven by the self-interest of the commercial fishery so is the misleading and deceptive marketing of Alaska's salmon as wild and sustainable. Hatchery-dependent fisheries, by definition, are neither wild nor self-sustaining. Therefore, encouraging consumers to avoid farmed salmon and opt instead for Alaska salmon materially supports Alaska's salmon-ranching program, which poses a far greater threat to Alaska's salmon biodiversity than does salmon farming.

MSC disputes that salmon ranching is a significant problem and they have refused to respond to the concerns raised by Trout Unlimited. TU's entreaties to the State of Alaska have also been rejected: The director of Alaska Seafood Marketing Institute told TU *My concern is that the farmed salmon producers might pick up your message and run with it*. The Commissioner of Fish and Game explained to TU that *We believe the generic marketing of Alaska salmon, including hatchery salmon as wild salmon, is appropriate*. The Director of the Commercial Fisheries further affirmed that the department believes there is practically no difference between a wild salmon and a hatchery salmon — a claim squarely at odds with basic biology, not to mention Alaska statute. As if to put an end to the debate, an Alaskan senator stepped up to the plate last year with federal legislation that declares hatchery salmon are to be labeled as 'wild'.

Prospects of Alaska's hatchery program

The hatchery program has subverted the dependent community's relationship with the natural world, which used to be the sole source of salmon. As dependency upon hatchery-produced fish escalates, more attention is focused on maintaining and expanding hatchery production and there is less concern for wild salmon and their ecosystems. The high proportion of Southeast salmon produced in hatcheries, especially chum salmon, conveniently obscures the decline in the abundance of wild salmon. In fact, for the last several years, millions of dollars of federal funds designated for wild salmon and their habitats were spent on hatchery production and operations in Southeast Alaska.

Clearly, the hatchery program is not simply science, technology, and economics of fish culture, but also is a social-cultural force affecting the attitudes and belief about fishery management in the communities and regions in which hatcheries exist. In the end, these communities and fisheries have become more dependent on hatcheries and less reliant on wild fish, much the same situation that results from salmon farming.

Just as the Pacific Northwest willingly traded salmon habitat for hatcheries, so does Alaska. Hatcheries, rather than habitat, now produce most of the pink, coho, and chum salmon caught in Prince William Sound and most of the chum in Southeast Alaska. Consequently, when public

funds have become available for wild salmon programs, the Southeast Alaska salmon fisheries would rather subsidize hatchery operations than fund habitat protection and restoration programs (and thus, support elected and appointed officials who, while paying lip service to the importance of habitat, place higher priority on salmon-ranching).

Alaska's salmon fishery management system has become wedded to hatchery production. The salmon-ranching program exemplifies the degree to which economics trumps ecology and commercial considerations trump biological ones. When confronted with the biological certainty that a hatchery fish is not a wild fish, fishery managers are compliant to and complicit with business interests. There could not be stronger evidence that Alaska's salmon fishery management is on same path to salmon purgatory as the rest of the Pacific Northwest.

Most troubling, however, is that salmon fishery managers in Alaska display the same hubris as did the managers in Oregon, Washington, and California. The net effect of MSC certification of the Alaska salmon fishery has been to buoy the state's self-assurance and complacency, rather than to improve salmon fishery management to any significant degree.

The Alaska Department of Fish and Game insists that everything is under control – just as their Northwest counterparts did, even as salmon populations there were being extirpated. This self-assurance dulls the scientific inquisitiveness and subverts the objectivity essential to adaptive management. It also creates a false sense of security among the public and elected officials, who, even when confronted with evidence that wild salmon and especially salmon habitat may be threatened by development, insist that all is fine and that those who say otherwise are simply obstructionists.

Recent changes in Alaska salmon management

Lest there be any doubt that this mind-set is deleterious to long-term sustainability of salmon and their ecosystems, in April 2003, Governor Murkowski transferred the fish habitat permitting and related habitat protection duties from the Department of Fish and Game to the Department of Natural Resources (DNR), eliminating the Habitat and Restoration Division within the Department of Fish and Game. In addition, other bills have passed that will expedite development projects by diminishing regulatory review of habitat impacts by curtailing and chilling the public process and by consolidating project review and permitting functions in DNR. The Alaska Coastal Management Program will be consolidated within DNR, eliminating local involvement in coastal habitat development and conservation.

In fact, the current administration justifies consolidation of permitting and oversight in DNR as following Oregon's "successful" example. What is more is that this consolidation is supported by Alaska's dominant commercial and sport fishing organizations.

Is management capable of sustaining salmon and their ecosystems?

This brings us back to how one is to truly evaluate whether or not management is capable of sustaining the fish and their ecosystems and not simply sustaining a fishery even as the productivity declines due to habitat loss and loss of biodiversity. In practical terms, an effective salmon management system would maintain the ecological and biological conditions for salmon survival and production and ensure that they are not impaired by human activities, whether fishing, timbering or others. While salmon fishery managers have authority and power to control fishing effort, they do not have commensurate authority and responsibility to control salmon habitat. Thus, while adjusting sustainability principally in terms of salmon fishery management's capability to prevent overfishing is understandable, it is ultimately an inauthentic approach.

Evaluating the success of management in sustaining salmon populations and maximizing production depends in large measure upon management's ability and capacity to ensure the conservation of biodiversity – conserving genetically unique and locally adapted populations. A critical biological variable affecting salmon production is biodiversity and a critical ecological variable is habitat. The two variables are interdependent, the more productive habitat, the more potential production and the more biodiversity, the more habitat that can be potentially used.

I believe that Alaska's salmon fishery management claim to sustainability is overblown, because:

- It refuses to acknowledge the inherent limitations of traditional fishery management and thus the need for significant change if salmon and their ecosystems are to be sustained; as if such an acknowledgement would be tantamount to admitting failure. Ironically, it is this refusal to admit to the inherent limitations of traditional salmon fishery management that is the failing.

- To the extent that fishery managers seek to maximize available surplus of commercially-important stocks by placing salmon biodiversity at the risk in mixed stock fisheries and hatchery supplementation.

- Even if sustainability is to be evaluated strictly in terms of traditional fishery management, management's performance should be measured according to the degree to which managers hew to the statutes, regulations, and policies that provide protection to wild salmon.

The performance indicators that are the most critical for assessing the sustainability of Alaska's salmon fisheries are those that provide evidence for the transformation from 'salmon fishery' management to 'salmon' management. Unfortunately, current indicators suggest just the opposite. Given the failed fishery management regimes throughout the Pacific Rim, coupled with increasing knowledge about the factors that affect salmon productivity, it is no longer sufficient to manage "just" the fishery; rather the salmon fisheries must be managed in the context of preserving both salmon biodiversity and whole ecosystems. This is a tall order, since it requires a degree of intergovernmental and interagency planning, coordination, and cooperation to achieve an integrative transformation in the exercise of authority, currently fragmented among agencies and jurisdictions, in order to manage for the major factors that affect salmon and their ecosystems. Without such a transformation in the institutional function and structure of Alaska's fishery management system, it will continue pell-mell along the same path as other once abundant salmon-producing regimes.

As long as the salmon business, which of course is embedded in the larger world of business, drives fisheries management, there will be little impetus for change. We have a choice to make about how we value salmon.

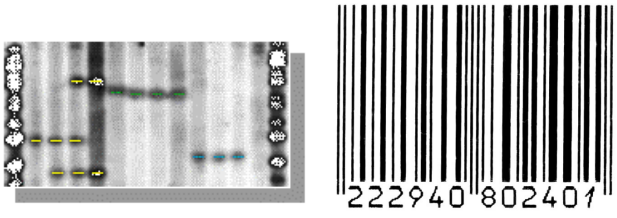

Figure 21.3. Coho genetic code and Coho bar code.

As long as we reduce the bar code on the left to the bar code on the right in Figure 21.3, the less likely we will manage for salmon biodiversity and the more likely all salmon will be conceived in a bucket.

CHAPTER 22

Wild salmon strategy

Terry Glavin, Marine Conservation Advisor,
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Introduction

Three years ago, Gordon Hartman, Cornelius Groot and the Thomas Northcote wrote a marvelous chapter in a book about sustainability in salmon fisheries, entitled *Science and Management in Sustainable Fisheries: The Ball is Not in Our Court* (2000). Taking a bit of a liberty with the point that these three argued was that fisheries scientists, fisheries managers, geneticists, ecologists and other such specialists have practically no influence at all in determining the future of wild salmon anywhere in North America's northwestern quarter.

The ball is simply not in our court, they said. The future of salmon, they argued, lies with the much broader social, cultural and economic forces of the very kind that have formed and shaped the North American landscape over the past five centuries, and which have so utterly obliterated so many of the wild landscapes and the wild rivers that supported salmon in great abundance for ages.

The way they put it was this: "If there is to be a repreive for Pacific Northwest salmonids, it must come in the form of initiatives that reach into areas of society beyond fisheries science and management."

I agree with this idea; however, I am not so pessimistic as Groot, Hartman and Northcote. They saw a continuation of the most dreary sorts of trends which have put wild salmon at death's door throughout most of the U.S. Pacific northwest states. Instead, I see something completely different, or at least a wholly different possibility, and it involves the profound cultural changes that have taken such deep root in the public consciousness in recent years, especially in British Columbia and the U.S. Northwest. It is something that has come to be called the totemic and iconic role that salmon have taken on in the settler cultures in this part of North America.

The iconic role of salmon

This is an historic development, and we tend to completely underestimate its significance. The salmon that once swam at the vortex of aboriginal cosmologies have come to occupy a totemic place within settler cultures, throughout the traditional range of Pacific salmon.

In British Columbia, environmental values are deeply entrenched. These values are given expression in the most pronounced ways when it comes to salmon. Recent public opinion polls show an overwhelming majority of British Columbians understand that salmon are worth far more to society, to local landscapes, and to ecological functioning, than their mere commercial value. Salmon are now recognized as a vital

component of the British Columbian landscape itself, and salmon are accepted as the most significant "keystone species" in terrestrial ecosystems west of the Rocky Mountains. Salmon have come to play an irreplaceable role in British Columbia's identity and heritage, and in British Columbians' collective pride of place.

In attempting to answer the question: “How do we value wild salmon?”, British Columbians have answers, and they are important and very instructive answers. Every weekend, thousands of British Columbians routinely involve themselves in a variety of salmon-conservation initiatives. The various “non-extractive” values associated with salmon are now being afforded higher public priority than the conventional commercial and extractive values of salmon.

The changed relationship between salmon and people in British Columbia has occurred even though salmon are no longer of any consequence to the provincial wage economy. By 1997, the economic significance of B.C.’s salmon fisheries - commercial fisheries, recreational fisheries, fish processing, and aquaculture – accounted for less than one half of one per cent of British Columbia’s gross domestic product. Recreational fishing, and the tourism it attracts, accounts for about a quarter of a billion dollars in value added to the provincial economy. While recreational fishing makes the largest contribution of any of the various sectors within B.C.’s fishing industry, the recreational fishery’s contribution represents only about five per cent of the overall contribution the provincial tourism industry makes to B.C.’s economy.

British Columbians appear to have come to value salmon more, not less, as the direct “extractive” value of salmon declines in significance. An exhaustive public opinion survey conducted in April, 2000 by the Department of Fisheries and Oceans’ Habitat Conservation and Stewardship Program shows just how deeply British Columbians have come to identify with salmon.

The survey showed:

- A majority of British Columbians say salmon runs should be protected, and salmon habitat should be conserved, even if it means a slowdown in the rate of economic development, or paying higher taxes.
- Support for conserving salmon habitat, even at the expense of economic development, ranged from 61 percent in north coastal B.C., where the economic aspects of salmon-fishing are most important, to 72 percent in the Lower Mainland, where the economic value of salmon is least significant.
- Support for the idea of paying higher taxes if necessary to protect fish and wildlife habitat ranged from 58 percent of respondents in the southern interior to 69 percent in B.C.’s south coast areas.

Most British Columbians rank the commercial value of salmon behind a range of other values. These include the contributions salmon make to ecological health, to the “beauty of the region,” to tourism, recreation, and the enhancement of “community involvement.” So that is how British Columbians value salmon, quite clearly. And I think the people are right.

But to what extent does the public interest in the conservation of salmon and the public will to conserve salmon influence public policy and restrain those forces that weigh against the diversity and abundance of salmon? Not much.

Government policy is out of step with changing conditions

At the outset of this volume (Chapter 1), the Honorable John Fraser made a very important point about the need to answer the more important questions about threats to salmon in clear and plain language, especially language of the kind that politicians can understand. Here is how I would answer the question

about the single greatest challenge in the relationship between people and salmon at the beginning of the 21st century.

I would say it is in the persistence of outmoded government policies that do not accord with the changing conditions that salmon are encountering in the post-industrial era. Neither does government policy accord with the scientific understanding of the necessary elements of salmon conservation. Most importantly, government policy is completely out of step with the cultural changes underway in human communities throughout the range of salmon.

While profound cultural changes are sweeping British Columbian society, institutional cultures within government simply have not kept pace. The various levels of government with jurisdictions that affect the health of salmon runs – particularly Canada's federal government – take an approach to the challenge of salmon conservation that remains deeply entrenched in an era in which the maximum sustainable yield of the great biomass of the most valuable salmon species was all that mattered. It is an approach still largely driven by antiquated economic measurements and outdated fisheries-management objectives.

It is so deliciously easy to heap calumny upon the Department of Fisheries and Oceans. If the department did not exist, I would say it would be necessary to invent it, if only for the purpose of attributing all that ails us to what we so affectionately call DFO mismanagement. I think this is actually somewhat less than fair. The department is not to blame - we all are. City people, farmers, loggers, fishermen, fisheries managers, even environmentalists – none of us are without virtue, and none are without blame.

We heard a most compelling and disquieting presentation by Jeff Hutchings (Chapter 3), about the fate that befell the marine ecosystems of Newfoundland, and the thorough destruction of the great North Atlantic cod stocks. Yes, we should quite properly lay blame at the feet of the individuals responsible for this within government and industry. But where was the environmental movement while this was all happening? Some answer that question by noting that environmentalists were too busy having their photos snapped with Bridgitte Bardot on the ice floes off Gaspé in the Province of Quebec, and were otherwise trotting around Europe convincing rich people not to buy furs from trappers in Canada's far north. Certainly there were some environmentalists who were trying to raise alarms about the overfishing of cod. But clearly, many were not.

North Pacific groundfish

And now, in the first decade of the 21st century, environmentalists are finding themselves obliged to turn their attentions to the seaward, Canada's west coast. When we look out to sea, what we soon find is that the North Pacific is now giving up fully one quarter of all the marine fish harvested from the planet's oceans. To the north of us, the Bering Sea is undergoing major ecological transformation in response to large-scale trawling. Severe ecological disruption, foreshadowed by the collapse of seabird and marine mammal populations, appears to be spreading to the waters of Southeast Alaska.

To the south of us, roughly two-thirds of the offshore fishing grounds between the Mexican coast and the Canada-U.S. border were placed off-limits to trawlers in two major decisions, in 2001 and 2002. From Point Reyes in California to Cape Flattery at the tip of Washington state's Olympic Peninsula, "groundfish" fisheries were closed following a rapid series of catastrophes. The closure paralleled what was previously the worst fisheries disaster in American history – the collapse of the cod, haddock and herring fisheries of Georges Bank, on the U.S. East coast, in the early 1990s.

Here on Canada's west coast, under the management authority of the same federal Fisheries and Oceans bureaucracy that oversaw the collapse of the East coast's great cod fishery, several thousand fishing vessels are now removing an amount of fish from British Columbia's waters, every year, that has grown to exceed the weight of British Columbia's human population. By 1997, B.C.'s groundfish catch had

grown to exceed the groundfish catch from California, Oregon and Washington combined. Three years later – before the U.S. trawl fleet was almost completely shut down – B.C.'s trawlers were catching three times as much groundfish as the U.S. fleets.

British Columbia's total fisheries catch has now reached a phenomenal 225,000 tonnes, enough fish to fill a convoy of pick-up trucks, bumper to bumper, between Vancouver and San Francisco. Long-lived and slow-growing rockfish species are the primary catch of B.C.'s groundfish fleets, which now catch more than half the fish, by species and volume, on Canada's west coast. Among the rockfish being harvested by B.C.'s trawlers, long-line and cod-trap vessels are catching *boccaccio* and yelloweye rockfish from the same troubled stocks that U.S. fisheries authorities intended to protect two years ago when most of the U.S. groundfish trawl fleet was idled.

The U.S. National Marine Fisheries Service anticipates that it will take between 24 and 106 years, depending on ocean conditions, for the troubled U.S. rockfish stocks – including dark-blotched rockfish, widow rockfish, canary rockfish and cowcod – to recover. Since the U.S. closures, three-quarters of California's supply of groundfish – rockfish, "red snapper", Pacific Ocean perch, Pacific cod, and so on – is coming straight from British Columbia's groundfish fishery.

Pacific hake, a cousin of Atlantic cod, is one of the most ecologically important fish species on North America's west coast. As recently as the late 1980s, the great hake stock ranged from California to British Columbia's northern waters in a biomass exceeding six million tonnes. This is an amount of fish that is more than three times the biomass of Newfoundland's northern cod stocks, which Jeff Hutchings described (Chapter 3), before the chronic overfishing that led to the cod stock's rapid collapse. A quiet but debilitating "hake war" between Canada and the United States began in the early 1990s, when the two countries could not agree on a catch-share formula. Last year, the hake stock had fallen to its lowest observed levels in 30 years – about 710,000 tonnes. The Canada-U.S. dispute, coupled with decisions by politicians on both sides of the border to ignore the recommnedations of a joint panel of Canadian and American hake scientists, is not unrelated to this tragic decline. In the summer of 2003, for the second year in a row, the Minister of Fisheries and Oceans Canada and his American counterparts have authorized fisheries that put the combined Canada-U.S. allowed catch this year at 180,000 tonnes.

The closer you look at B.C.s groundfish fisheries, the more absurd the picture becomes. To begin with, Canada's fisheries managers cannot say with any certainty, from year to year, just how many fishing vessels are engaged in fisheries that impact upon groundfish stocks, either directly or indirectly. There are 142 "big boat" trawl licences on B.C.'s coast, along with 410 halibut licences, 191 "outside" rockfish hook-and-line licences, 47 sablefish (black cod) licences and at least 534 active permits for dogfish, sharks and skates, and lingcod. However, many of the larger vessels carry several of the more valuable licences, as is the case with halibut licences and trawl licences. Also, permits to harvest lingcod, dogfish, sharks, skates and other "bottomfish" species are available to salmon-licenced vessels, crab licenced vessels, and so on – potentially, 4,000 other vessels. More importantly, most of the fish species harvested by B.C.'s groundfish vessels are not protected by any catch limits, whatsoever.

Major reforms have been recently imposed on B.C.'s offshore trawlers, such as 100 percent on-board observer coverage, and a system of transferable quotas that tends to keep the trawlers within the quotas they are assigned for "managed" species. But only two dozen of the 75 finfish species B.C.'s trawlers catch are protected by annual quotas. And even for those two dozen "managed" species, the fish that are "dumped" annually are not deducted from the quotas that are supposed to ensure they are properly conserved. For those species not "managed" by quotas at all, it's a free-for-all. Without adequate stock assessment resources, fisheries scientists remain incapable of assigning quotas for about 50 of the species that routinely come up in trawlers' nets. In the absence of quotas for these "unmanaged" species, there are simply no catch limits at all.

One of the worst examples of this free-for-all involves Pacific turbot, also known as arrowtooth flounder. The Pacific turbot is a distant flatfish cousin of the Atlantic turbot, also known as Greenland halibut, and Pacific turbot has been rising in value in recent years. Over the past nine months, BC's trawlers caught more than 14 million pounds of turbot – an amount of fish that equals the weight of about half the population of the City of Vancouver - with no catch controls in the fishery whatsoever.

For me, the most disturbing aspect of this free-for-all is the fact that only a dozen offshore rockfish species are nominally protected by quotas that govern the trawl fleet's catch, which means another twelve rockfish species remain unprotected by any catch limits at all. These are sharpchin, longjaw, redbanded and darkblotched rockfish. They are greenstripe, splitnose, rosethorn and harlequin rockfish. They are dusky, chillipepper, aurora and vermilion rockfish. They are beautiful, mysterious creatures, and they are being mined from the sea, along with millions of pounds of soupfin sharks and cat sharks and thresher sharks, scorpionfish and grenadiers, slender soles, flathead soles and deep sea soles, ragfish and shad, poachers, and prowfish, and on and on it goes.

This narrative is not intended to demonize the fishing industry, and it would be wrong not to mention that there are many progressive fishing industry leaders and government scientists who are every bit as concerned about these things as the environmental community of BC is. But this sort of thing clearly cannot last. This is conduct that simply cannot withstand public scrutiny. It is a scandalous state of affairs, and we cannot afford to resign ourselves to cynicism, which is always the easy way out. These things happens not simply as a result of humanity's inherently rapacious nature. These events are not inevitable, especially with the benefit of hindsight, and we are now amply equipped with that hindsight.

Fisheries management and salmon conservation objectives

I should mention that this slight digression was not wholly unrelated to the subject I am addressing. The point that needs to be taken from all this is that these circumstances are precisely the fisheries-management context within which efforts to conserve salmon are expected to be effective.

I will digress a moment, however, to say how astonished I was with the lucidity and the clear perception of Bob Lackey's paper (Chapter 13). Dr. Lackey touched on what I obviously regard as the very heart of the challenge itself – but I remain a bit suspicious of assumptions about the degree to which what he called, our collective actions, accurately reflect our collective will as citizens. It is a profoundly important question. It gets us into the strangest corners of metaphysics. Dr. Lackey's observations raise the most important questions about the extent to which humanity might determine its own destiny. But I am not a metaphysicist. I claim no special competence here. What I can say is that the tragedies that befall fisheries abundance are the result of identifiable decisions, made by identifiable people, on our behalf, as citizens, the ultimate owners of Canada's marine resources.

So it seems to me that we need to set some some rather bold objectives for ourselves to ensure that what has happened to the marine ecosystems elsewhere in the world is not visited upon ourselves here. And these objectives must not be unduly constrained by how difficult and complicated they might make the work of fisheries managers or fishermen.

The conservation objectives that the Sierra Club of BC has identified as necessary for the management of fisheries on Canada's west coast, which we believe are entirely consistent with the public interest and with widely held public expectations, can be expressed in three simple sentences, which the Honorable John Fraser might be happy to know can be written in the language of common speech:

- *Not one fish should be taken from Canada's Pacific waters unless it comes from an identifiable, harvestable surplus of a stock of known abundance, distribution and productivity.*

- *Not one fish should be caught that is not accounted for by scientifically defensible catch-monitoring methods.*

- *No fishery whatsoever should be permitted in Canada's Pacific waters unless its consequences, both for the fish species and for the ecosystems they inhabit, are fully anticipated and accommodated.*

We realize this is asking a lot. We realize that almost all fisheries entail a certain degree of risk, we must be prepared to accept risk and uncertainty and accommodate these things into fisheries management. We also realize that such objectives will oblige fisheries managers to adopt a posture of wholly uncharacteristic humility. We further believe that such standards are necessary, and achievable, and are consistent with the basic expectations of ordinary Canadians. We also fully realize that, in the context of current fisheries management practices, we are a formidable distance from achieving these ends.

Returning to the matter of the conservation of salmon, I would similarly remind everyone that the moral responsibility for conserving salmon falls on all our shoulders, as citizens. But the constitutional and political responsibility for the conservation of salmon rests with the federal government, and with its fisheries department. As citizens, we express our collective will through our governments, and the overwhelming will to conserve and restore salmon in abundance and diversity, it logically follows, must be reflected in the policies, practices, purposes and objectives to which the federal government, through DFO, commits itself.

What do we intend to conserve?

But here is a strange thing. Everybody claims to be in favour of conserving salmon, but to the obvious question, "What do we intend to conserve?" the federal fisheries department has no clear answer. And it is the most important public policy question. Its answer will determine everything that our government agencies do with respect to the objective of salmon conservation.

Conventionally, the federal government has answered this question by identifying salmon as merely a renewable resource that should be managed for raw commodities in ways that provide for the greatest annual economic yield. As the economic significance of wild salmon has declined, there has been a general retreat by the federal government in the exercise of its duty to conserve salmon. To the extent that the primary legal and political responsibility for salmon conservation still rests with the federal government, DFO still sees its duty to conserve mainly through an outmoded and increasingly irrelevant economic-yield prism.

Clearly, government institutions, particularly the Department of Fisheries and Oceans, must break through barriers of their own making in order to conform with the public's reasonable expectations that B.C.'s salmon runs will be protected and conserved, in all their diversity, variety and abundance, for future generations. But this means a wholly new vision must guide government decision-making with respect to salmon conservation. It means that the importance of salmon in British Columbia's cultural consciousness, and the importance of salmon as a keystone species upon which British Columbia's environmental health so deeply depends, must come before any and all other "production" objectives with respect to Pacific salmon.

Scientists, particularly geneticists and conservation biologists, have made tremendous contributions to the public's understanding about the necessary conditions for the long-term survival of salmon. Science must

be credited with developing a broad public awareness that salmon must be protected and conserved in greatest possible natural diversity, over the greatest possible range, if they are to be part of our common future. Similarly, economists have contributed greatly to an emerging realization that the indirect, long-term values associated with healthy salmon runs and a healthy environment far outweigh the direct, short-term extractive values associated with salmon and a healthy environment.

But when it comes to British Columbians and salmon, there is far more at stake than science or economics. Ultimately, although salmon are involved in ancient and specific relationships with aboriginal communities – and salmon are rightly subject to the legally-enforceable fishing rights of B.C.'s First Nations – salmon remain a Crown-owned resource. Salmon are a public resource. They do not "belong" to the government, or to industry. They belong to all Canadians, and all British Columbians, to generations long dead and generations unborn. British Columbians should not be obliged to defend or justify their will to conserve salmon to anyone. British Columbians should not be required to resort to the terminologies of the sciences or economics to defend their desire to persist in their relationships with salmon.

Salmon do not exist simply to be "managed." Salmon exist because they exist, uniquely and distinctly, wherever they occur, and we are all the richer for it. British Columbians have always been enriched by their presence. British Columbia continues to be enriched by their presence, and British Columbians should not have to make excuses for their desire to see salmon protected and conserved for generations to come. Even the smallest salmon streams, regardless of their economic, genetic or ecological significance, are worthy of protection. The vast majority of British Columbians understand this, and it does not matter that conserving salmon at such local and difficult-to-manage scales presents challenges to fisheries managers. Salmon conservation at the small-stream level also presents enormous challenges to city dwellers, loggers, and farmers. But these are challenges that British Columbians are showing an increasing willingness to face.

The evidence of that willingness can be found in the dedication of thousands of British Columbians organized in "creek watch" committees, streamkeeper groups and watershed stewardship groups all over the province. These people include commercial fishermen, anglers, and members of British Columbia's Indian bands. They also include people with no vested interest at all in the harvest of salmon.

What do we intend to conserve?

How the Sierra Club of British Columbia answers that question is this:

To give the public will to conserve salmon its full expression in government policy, the federal authority over salmon and salmon habitat must be exercised in a way that is consistent with the following principles:

i) The conservation of British Columbia's salmon populations must take precendence over all other objectives with respect to salmon production, and salmon populations must be conserved, in the greatest biological and genetic diversity and abundance, for their intrinstic values. These values are not exclusively and directly economic in nature. In keeping with the purposes of the U.N. Convention on Biological Diversity, the diversity and abundance of British Columbia's salmon populations must be maintained for economic, ecological, genetic, social, scientific, educational, cultural, recreational and aesthetic values.

ii) The federal government, through the Department of Fisheries and Oceans, must commit itself to protecting and maintaining salmon habitat on an ecosystem basis. Both the federal and provincial

governments should assume joint responsibility for protecting the health of the ecosystems upon which salmon depend.

iii) Federal fisheries managers must take into account the role salmon play in ecosystem functioning, and the contributions salmon make to terrestrial ecosystems. Salmon must be conserved from the premise that the diversity and abundance of myriad terrestrial species depends upon the diversity and abundance of salmon across the broadest possible range.

iv) The federal government must commit itself to a precautionary approach in its decision-making, and must always make efforts to regulate fisheries and protect salmon habitat in a risk-averse manner. This will mean ensuring that, at a minimum, fisheries are managed so that their impacts upon salmon runs are predictable and sustainable and the genetic integrity of salmon populations is protected. It will also mean that, at a minimum, habitat is protected in ways that allow "gene flow" between fragmented populations, and safeguards are established to ensure that hatcheries and other "enhancement" initiatives pose no threat of adverse genetic impact upon unenhanced salmon populations.

These four principles merely reiterate, in summary fashion, what salmon scientists and conservation biologists have long considered to be the necessary conditions for the survival of salmon over the long term. As such, there is nothing necessarily "new" in their articulation. What is new is that the establishment of these necessary conditions for the long-term survival of salmon has at long last become politically achievable in British Columbia

Effective decision-making

I want to return to the importance of effective decision-making processes, which has been the subject of some lively debate. In keeping with the view that public policy must reflect public values, it has long been the view of the Sierra Club that all decision-making with respect to fisheries conservation and conserving marine ecosystems and the diversity and abundance of salmon must be made openly and transparently, and that decision-makers must include many more interests than the conventional stakeholder interests.

If we return to the Convention on Bioloigical Diversity, we find that Canada's commitment to implement and enforce the principles of this important international instrument oblige us to conserve salmon for a variety of values: for their economic, ecological, genetic, social, scientific, educational, cultural, recreational and aesthetic values. So it seems to me that quite clearly,

> *... these values must be directly represented in all decision-making with respect to salmon conservation. At the very least, it will mean affording full stakeholder status, along with First Nations, commercial and recreational interests, to include the full public interest in salmon conservation. At a minimum, this will mean providing formal room at the table for the conservation sector, which includes environmental organizations and the streamkeeper/stewardship constituency.*

And I am happy to report that the Fisheries Minister recently agreed to historic reforms in fisheries decision-making on Canada's west coast that do just that.

Ken Wilson (Chapter 10) described the daunting challenges facing fisheries managers in conserving the diversity of the Fraser River's sockeye populations in the context of what are almost exclusively mixed stock fisheries. We know about the rumpus-making that occurred in 2002 after DFO's fisheries managers actually had the audacity to conduct themselves, for the most part, as though small salmon runs actually mattered, and how they erred on the side of caution, which, by its very definition, means a code of conduct in which one will occasionally err. As a result of all the carry-on during the 2002 salmon fishery,

the minister assembled an unprecedented cross-section of interests in a review committee, whose many recommendations, I am further happy to report, were uneqivocally and completely and quite publicly accepted by the minister, who promised to implement each and every one of them.

A key recommendation of the review committee calls for the federal government to develop a scientifically defensible policy that defines conservation objectives for Pacific salmon and addresses concerns about overfishing, habitat loss, aquaculture, and hatcheries. That is the wild salmon policy (Chapter 33), and it is in the business of answering that most important of all policy questions –what is it we are trying to conserve?

Secondly, the Minister announced his concurrence with the recommendation for a new, coast-wide policy committee, involving the B.C. government, conservationists and community organizations along with First Nations, commercial and recreational representatives. The federal government will retain constitutional authority over fisheries management, but the coast-wide committee will provide Ottawa with direction to guide fisheries management and conservation for all fisheries resources—not just salmon—on the coast.

Also, conservationists will participate in two new fisheries-planning bodies to be established, one for the north coast and one for the south coast, which will have direct input into the development of annual salmon fishing plans. The two new committees are expected to ensure that all proposed fisheries are consistent with conservation objectives and Canada's international commitments, including the United Nations' Code of Conduct for Responsible Fishing and Convention on Biological Diversity.

I regret to say that already the DFO bureaucracy is conducting itself as though the minister made no such commitments. But we remain hopeful. We're used to walking three steps forward, then two steps back. Although awkward, this is still forward movement. What we can see in this is an emerging regime in which conservation groups will co-author fisheries management regimes, assuming a new and rather more daunting role in ensuring the conservation of broad-scale ecosystems.

The ball is not at all "in our court." But the court is widening, allowing for many more players. Things will be more complicated. Life is complicated. But this, in our view, is the right direction to take in order to ensure the persistence of salmon in the landscape through the 21st century.

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CHAPTER 23

An overview of the precautionary approach in fisheries and some suggested extensions

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Introduction

Uncertainties in fisheries systems are pervasive and they have important consequences. These uncertainties result from natural variation and our imperfect knowledge of how these systems work, among other factors. Uncertainties are significant because they create risks: biological risks to fish populations, economic risks to those in the fishing industry, and social risks for people in coastal communities who depend on productive aquatic systems. Risks include not just the worst possible event that could happen (e.g. loss of all fish in a stock, loss of all fishing industry jobs), but also less severe events. Estimates of risk consider each of these possible events, taking into account the chance that each of them will occur. Over the past five decades, scientific research on fisheries problems has reduced uncertainty and its affiliated risks but there is still a considerable amount of uncertainty remaining. We must therefore deal with it effectively in our scientific advice and in our management.

Responses by harvesters and managers to uncertainties and risks

The standard responses by harvesters and managers to uncertainties and risks fall into one of three categories. First, people may make an optimistic assumption about how the ecological system might respond to human disturbances; this usually leads to aggressive actions such as high harvest rates or the introduction of non-native species. Second is the often-noted response that, "We know so little about what to do that we should just leave things alone." This view means that, for example, a decrease in productivity of some stock should not be attributed to fishing until all other alternative explanations such as environmental changes are ruled out. This approach uses uncertainties to maintain the status quo. Another alternative is to make a more pessimistic assumption about the ability of the ecological system to respond to human disturbance, cautiously alter the system, and monitor its response. This third response to uncertainties reflects the view that, with appropriately cautious harvesting and management actions, we might not be able to reduce uncertainties further but we might be able to reduce the resulting risks.

Historical perspective

Techniques for incorporating uncertainty into fisheries management have evolved over the last 50 years. In the 1950s, management quantities such as maximum sustainable yield and optimal escapement were calculated using best-fit estimates from stock assessment models. Later, scientists and managers responded to the recognition of uncertainties in data by adjusting the

management goal in an ad hoc way (e.g. MSY spawning abundance plus 20%). In the 1980s and 1990s, scientists became proficient at building stochastic models to calculate probabilistic indicators of consequences of management actions (e.g. the probability of having spawner abundance less than some target level). Methods for calculating target reference points (which are goals towards which we should head) and limit reference points (conditions that we should avoid) also emerged. Harvest decision rules have been used broadly in the past to help avoid crossing those limit reference points. Unfortunately, reference points are difficult to estimate reliably in practice, given the uncertainties in stock assessment data. It is also difficult to determine reliably the status of a stock relative to those reference points. Furthermore, we have often found that in practice, decision rules are not as successful as anticipated for avoiding limit reference points.

This process of becoming more conscious of uncertainties and increasingly accounting for them in analyses and management recommendations eventually evolved into a comprehensive framework that was codified in a 1995 document, published by the Food and Agriculture Organization of the United Nations (FAO), called the "Precautionary Approach to Fisheries Part 1, Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions" (FAO 1995a). This document reflects lessons learned about dealing with uncertainties over the previous five decades in fisheries science and management. It encapsulates these lessons into a framework that can help other agencies implement a precautionary approach, both for managing capture fisheries, and for avoiding problems with species introductions. In particular, the FAO (1995a) guidelines provide specific steps that can be taken to meet the goal of taking a more precautionary approach. This document is only one of the latest steps in the natural evolution of thinking and procedures for dealing with uncertainties in fisheries systems. Changes continue to be made in these procedures.

Precautionary *Principle*

Before discussing the FAO (1995a) precautionary approach document in more detail, it is important to clarify the difference between the precautionary *principle* and the precautionary *approach*. Consider a spectrum of restrictions imposed on human activities, ranging from very severe restrictions to none (Figure 23.1). The precautionary *principle* applies to the extreme end of the spectrum where one assumes that there will be a very damaging response of the ecological system to human activities and where very severe measures are therefore taken to restrict those activities. The first example that led to the application of this precautionary *principle* was the banning of dumping of wastes into the North Sea. In this case, scientists had assumed the chemicals being dumped were inert, when in fact they were toxic and damaged marine ecosystems. The number of these "Type II errors" had risen to the point where it was decided to totally ban the dumping of wastes because there had been too many deleterious surprises. Other examples of applying the precautionary *principle* include the banning of ozone-depleting substances and the banning of commercial fishing on interior British Columbia coho salmon in 1998.

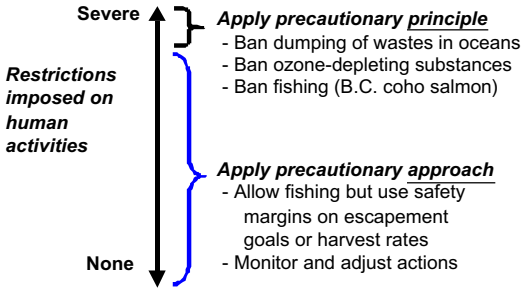

Figure 23.1 Schematic illustration of how applying a precautionary *principle* differs from applying a precautionary *approach*, in terms of the degree of restriction on human activities. Examples are provided.

Precautionary *Approach*

However, fisheries scientists and managers noted that such extreme restrictions were not necessarily appropriate in all cases. For instance, wild fish populations usually exhibit density-dependent growth, reproduction, and/or mortality such that they can rebound from depletions as long as they are not too severe. The precautionary *approach* reflects this knowledge and can refer to any part of the range of restrictions on human activities, between none and severe, but it does not refer specifically to one point on the range (Figure 23.1). For example, to take a precautionary *approach* in a fishery, fishing could be allowed but reduced by "safety margins" on the escapement goals or harvest rates, which would result in harvesting fewer fish than normal. The precautionary *approach* also includes carefully monitoring the responses to our actions, and adjusting actions appropriately. The precautionary *approach* to fisheries management is thus more flexible than simply applying the precautionary *principle* in the presence of major uncertainties. This frequently overlooked distinction is important because it can make the difference between clear communication and misunderstanding among scientists, managers, and stakeholders.

The FAO (1995a) Precautionary Approach document

This section briefly reviews some key parts of the FAO (1995a) document, which describes detailed guidelines for implementing the precautionary approach. Even though this source document for the precautionary approach concept has been available for several years, my informal polling of groups of fisheries scientists and managers indicates that very few people have actually read it. This is unfortunate because most fisheries people use this term widely and sometimes incorrectly, which creates confusion. The brief overview below of this source document should be treated merely as an introduction – I strongly encourage readers to read the full document.

First, the FAO (1995a) document states that we can use fish resources, even in the presence of uncertainties, but only when uncertainties and risks are taken into account explicitly during the scientific analyses and management decisions. Industry's investments should also consider those uncertainties – the fishing industry takes risks when it makes investments. Managers and those in the fishing industry should apply prudent foresight when evaluating current possible actions in terms of not only short-term effects but also effects on future human generations. As well, the chance of making irreversible changes in the system should obviously be reduced.

A key point in the precautionary approach document is that, if faced with considerable uncertainty and risks, and if it is not clear which action to choose, actions should be chosen to give priority to conserving the biological productivity over the long term rather than satisfying short-term economic or social demands. It is most important to keep the aquatic system productive; only then will economic and social benefits be maintained over the long term. The FAO (1995a) document also discusses considering the effects of fishing on other species. There are also specific implementation guidelines for four different categories of fisheries: new or developing fisheries (which are rare for salmon on the west coast of Canada but occur for other species elsewhere), traditional or artisanal fisheries, fully utilized fisheries, and over-utilized fisheries.

To illustrate the FAO (1995a) implementation guidelines, I give below an example of one of these categories of particular relevance to salmon, over-utilized fisheries. The first step is to develop a recovery plan. Recovery will allow for biological and economic benefits from a more productive fishery. This is already part of the process for the Endangered Species Act in the USA and the Species-At-Risk Act in Canada. Obviously, for over-utilized fisheries, we need to reduce

fishing capacity and harvest rates and to give priority to using subsequent large recruitments (abundances of mature adults) to rebuild the spawning stock rather than to reopen the fishery to satisfy pressures from the fishing industry. The document also suggests that we should *not* use artificial propagation as a substitute for these precautionary measures.

The FAO guidelines also suggest removing subsidies for the fishing industry because subsidies change the perception as well as the reality of risks. If the industry assumes that the government will "bail it out" financially if low harvests occur over a long period, then the industry's response to an uncertain abundance of a stock, for instance, is going to be quite different from the response if there were no subsidies. Industry may take a more precautionary approach in the absence of subsidies. Defining reference points to identify recovery goals is another obvious step in the FAO guidelines for the implementation of the precautionary approach for over-utilized fisheries.
It is worth emphasizing that this precautionary approach is applicable to everyone involved in fisheries systems; it does *not* just apply to management agencies. It also applies to harvesters and those involved in altering habitat and carrying out enhancement – however well intentioned their actions might be. For instance, there are many examples of hatcheries not producing the intended beneficial effect; this is also true for habitat restoration activities. Salmon aquaculture should also be considered in the context of the precautionary approach. Stock assessment scientists also need to consider uncertainties and risks explicitly; this does not mean applying a conservative assumption at each step of an analysis, which would result in managers being unclear about the degree of bias, if any, in the scientific advice. Instead, scientists should evaluate each management option for a wide range of hypotheses about parameter values, structural forms of models, and other uncertainties to provide managers with the full range of possible outcomes for each action. Finally, the decision-making step can take a precautionary approach by considering these potential outcomes and uncertainties when ranking actions with clear management objectives.

The precautionary approach is now widely used in fisheries management (Garcia 2000). Several fisheries organizations have applied the approach and adapted it to their own purposes. For instance, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), which used precaution before the term 'precautionary approach' even emerged, has further applied this approach in recent years. The precautionary approach has also been used in other FAO documents. For example, the FAO "Code of Conduct for Responsible Fisheries" (FAO 1995b) applies the precautionary approach to industry, in addition to management agencies, but there is considerable overlap between this and the other FAO (1995a) document. As well, in December 1995, the United Nations "Agreement on Highly Migratory and Straddling Fish Stocks" incorporated many of the recommendations of the earlier FAO (1995a) document on the precautionary approach.

In addition, the FAO (1995a) document has been used as a framework for developing area-specific and species-specific procedures by the International Council for the Exploration of the Sea, the North Atlantic Salmon Conservation Organization, the International Baltic Sea Fishery Commission, the North Atlantic Fisheries Organization, the U.S. National Marine Fisheries Service, and the Canada Department of Fisheries and Oceans. These organizations are at various stages in incorporating concepts of the precautionary approach into their management and assessment procedures.

One question that often arises is how to choose an appropriate level of precaution in a particular situation. We could arbitrarily choose the best action in an *ad hoc* manner, which has often been the case for management targets such as $F_{0.1}$ and F_{med} used in non-salmonid fisheries. In contrast, quantitative risk analyses can help choose the most appropriate action in a consistent, rigorous

manner. Such analyses describe a range of alternative hypotheses about how the natural system and the physical system interact. This range of hypotheses includes different structural forms of the underlying models, rather than simply assuming the best-fit model is true. This approach is important because at least parts of the range of alternative models have the potential to create different feedbacks within the system and therefore quite different outcomes from the best-fit model. Risk analysis includes extensive sensitivity analyses to understand how these different assumptions affect the recommended actions (Peterman and Anderson 1999). Despite such analyses, uncertainties will always remain. We therefore want risk analyses and decision analyses to identify actions that are robust (i.e. perform well) across a wide range of assumptions about the uncertain components of an analysis.

Future Extensions to the Precautionary Approach

Although the precautionary approach framework has proven very useful, it is clear that further extensions and adaptations are required. I will discuss only five main extensions here.

Extension 1: Take implementation error into account

In salmon fisheries, implementation error is simply defined as the deviation between the desired (target) and the actual spawner abundances (similarly for harvest rate). The difference between target and actual spawner abundances can be quite large. It is not uncommon to end a fishing season with only half the target abundance of salmon spawners or with more than two or three times the target. Alternatively, in some years, the difference is less than a few percent of the target, which indicates very little implementation error. An important feature of frequency distributions of annual implementation errors over several decades for a given stock is that they are often asymmetric with a long tail at high abundances of salmon (i.e. there are occasional years of large implementation error). Therefore, salmon models should not simply use a random normally distributed variate to represent implementation error. Furthermore, models should reflect whatever structure is in the implementation error. An example for the Kvichak River sockeye salmon stock in Alaska exhibits such structure (Figure 23.2). When the ratio of actual to target abundance of spawners (Y axis of Figure 23.2.) is 1.0, the target is achieved perfectly. Below that value, there are too few spawners; extremely low abundance might create conservation concerns. When the forecasted recruitment of the Kvichak sockeye in different years (data points in Figure 23.2) was larger than the actual recruitment (values > 1.0 on the X axis of Figure 23.2), this usually resulted in too few spawners. This structural form to the implementation error in Figure 23.2 results from an interaction between in-season abundance estimation and management regulations. For instance, by the time the in-season estimates documented that the pre-season forecast was too high, in most years it was too late to achieve the target number of spawners, even if all fishing was shut down. Also, note that in general, underestimated forecasts may be represented more frequently than overestimates, or vice versa, creating a skewed probability distribution of implementation errors.

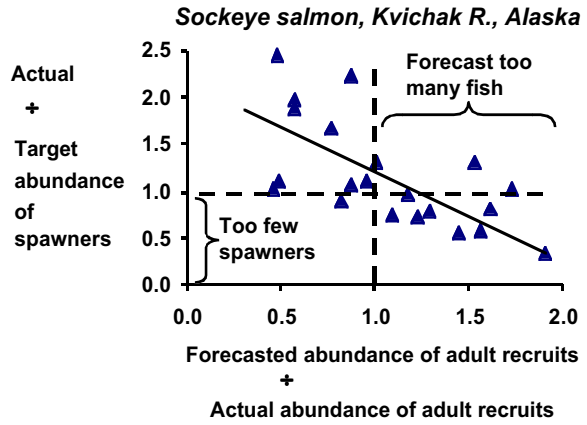

Figure 23.2. Example of implementation error for Kvichak River sockeye salmon, Alaska (each point represents a different year). The X axis is the ratio of the pre-season forecast of abundance of adult recruits of this stock to the actual post-season estimate of abundance of recruits (vertical dashed line represents a perfect forecast). The Y axis is the ratio of actual spawner abundance at the end of the season to the management agency's target abundance of spawners (horizontal dashed line represents a perfect achievement of that target).

Thus, there is asymmetry in the distribution of implementation errors, and they also have a structure, which can be taken into account when including implementation error in stock assessments. However, very few stock assessments for any fisheries, let alone salmon, explicitly consider implementation error. Nevertheless, just like variation in natural mortality or environmental conditions, implementation error is a source of uncertainty that has important management implications.

To better represent implementation error in stock assessment models, the dynamics of human harvesters could be included by considering humans as predators and drawing upon the rich empirical as well theoretical literature about how predators behave. Hilborn (1985) examined the dynamics of salmon harvesters in this context, and many other researchers have done so subsequently. Nevertheless, movement dynamics and in-season, state-dependent changes in harvesting efficiency are still rarely incorporated into stock assessments for salmon.

Extension 2: Reduce implementation error

The second extension to the precautionary approach is to reduce implementation error in the field, not just recognize its existence in stock assessment models. This can be achieved through improving in-season and pre-season estimates of abundance and by communicating the consequences of implementation error more effectively to the fishing industry, so that they understand long-term as well as short-term consequences. Reducing non-compliance of industry with regulations is a difficult challenge; we need to develop the right incentives for harvesters to reduce non-compliance. This might result from certification of fisheries (Peterman 2002), a process by which it will be in the interests of both management agencies and industry to maintain productive stocks over the long term.

Extension 3: Improve communication

The third extension is to develop better communication methods for scientists to discuss risks with both stakeholders and fisheries decision-makers. Although most natural scientists have similar understandings of various concepts related to uncertainties and risks, most managers and stakeholders do not generally have that knowledge because they do not have a quantitative background. Fisheries scientists should therefore learn from the extensive research in cognitive psychology on the topic of how to communicate about uncertainties and risks. One simple example of the need for examining that work in cognitive psychology is that there are six different interpretations of the word "probability" (Tiegen 1994). For instance, it could mean the chance of some event happening, or it could mean the plausibility of somebody's model that calculated that chance, or it could mean a degree of confidence in some statement based on the person's knowledge about the subject. Anderson (1998) discusses applications to resource management of several such findings of cognitive psychologists.

Extension 4: Clear management objectives
The fourth extension to the current precautionary approach is to encourage development of clear, unambiguous management objectives. This includes defining how trade-offs will be made among different components, such as maintaining both rare and endangered stocks and economically viable fishing industries. One technique that has recently emerged in the social science literature, "decision-choice modeling", removes some of the restrictive assumptions of the more commonly used multi-attribute utility analysis. Decision choice modeling is a way of documenting how people quantitatively trade off different indicators when making complex decisions. It has been applied to a few fisheries situations (e.g., Aas et al. 2000). This approach holds considerable promise and should be explored further.

Extension 5: Revise institutional structure
The fifth extension to the precautionary approach deals with institutional structure. In order to make the various elements of a precautionary approach work together successfully, an appropriate set of conditions and enforceable regulations must be present. These are described in detail in Chapters 5 and 6 of a report written for the Royal Society of Canada on marine fisheries (de Young et al. 1999). One recommendation was to improve economic incentives for those in the industry and to clarify property rights and access rights to fisheries in order to reduce the impact of uncertainties on fish stocks in the long term. This included promoting stewardship by helping to align individual interests with long-term goals of sustainability, and providing a positive feedback or incentive among members of the fishing industry to maintain stocks over the long term. Finally, managers and industry should identify some pre-agreed-upon decision guidelines to help reduce the number of delays in taking action caused by consultations that occur in-season in salmon fisheries. These guidelines would identify a range of management actions that would be taken for a given estimated status of a stock. This procedure has been used elsewhere in the world with promising results (e.g. Cochrane et al. 1998); we need to incorporate this method into salmon fisheries management.

Conclusions
Three concluding points will suffice. First, uncertainties are pervasive in salmon systems; they are large and some will always be present despite future research. These uncertainties are important because they create risks – economic, biological, and social risks. Scientific researchers have been reasonably successful over the past four or five decades at improving our understanding about how these aquatic systems work, but uncertainties are still large and the associated risks remain.

Second, there is a significant difference between the precautionary principle (which is generally analogous to complete closures of fisheries or stopping of human activities) and the precautionary approach (which allows some human activities but on a very cautious, limited scale to reduce risks). This difference is not just a trivial issue of semantics. It is important because, for example, people in the fishing industry might assume that managers are talking about completely shutting down a fishery when they hear the term "precautionary approach", when in fact managers mean only restricting its activity to some extent (or *vice versa*). Such miscommunications lead to dysfunctional discussions, but this specific problem can be avoided simply by using the terms as they are used elsewhere in fisheries (e.g., Europe, where the concepts emerged). Also, note that this precautionary approach does not just apply to fisheries management agencies; it applies to everybody involved in manipulating fishery systems, directly or indirectly.

Finally, we need to extend the current precautionary approach, at least as outlined in the FAO (1995a) document, to improve some deficiencies. Specifically, scientists need to take account of implementation error regularly, and managers need to create incentives for the fishing industry to reduce non-compliance with regulations and also implementation error. As well, scientists need to

improve communications with stakeholders and decision-makers about uncertainties and risks. Finally, managers must further clarify objectives and the trade-offs among the biological, economic, and social components of complex objectives.

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CHAPTER 24

Application of the precautionary approach to the conservation of wild Atlantic salmon stocks

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Introduction to the Precautionary Approach

Why are most fisheries management organizations, international and national, now attempting to introduce the concepts of the Precautionary Approach to their work? Most fisheries management has failed. The evidence is all around us. One of the reasons for the failure has been a tendency by politicians and others to ignore advice that they do not like but to try to make this seem rational by calling for more research. Thus the demands for more research become something of a smoke screen to obscure the fact that unpleasant decisions needed to be taken, but were not. One of the central tenets of the Precautionary Approach is, therefore, that lack of scientific evidence shall not be used as an excuse for inaction. This does not mean a recipe for stopping everything and it does not lessen the need for scientific advice and research. It does mean that where there are reasonable grounds to conclude, for example, that a stock is declining or that sea lice are causing losses in wild stocks or that habitat is being lost, remedial action must be taken. The excuse "there is no evidence that…" is not allowed under the Precautionary Approach if there are reasonable grounds to believe that conservation measures are required. But it has to be reasonable. One could hardly halt all dam building in Spain because of a decline in Russian salmon stocks.

First, I should make it clear that I will discuss North Atlantic Salmon. The North Atlantic Salmon Conservation Organization (NASCO) is not involved at all with Pacific salmon, although we are trying to work much more closely with our colleagues here. For those of you who are not familiar with the international aspects of salmon management in the Atlantic, NASCO is an inter-government treaty organization established in 1984. Members are Canada, Denmark (in respect of the Faroe Islands and Greenland), the European Union, Iceland, Norway, Russia and the USA. We also have about 30 Non-Government Organizations who bring much experience to our work.

I will not discuss the concerns about the state of the stocks discussed by Kjetil Hindar and Fred Whoriskey, Chapters 5 and 6. In spite of the restrictions on harvest introduced all around the North Atlantic, abundance has not improved. It is widely believed that the factors responsible for the decline in abundance relate to the marine phase of the life-cycle; evidence from a number of monitored rivers indicates that marine mortality has doubled since the 1970s. Focusing only on the fisheries is simply not enough. A broader, more holistic approach is needed if we are to fulfill our objectives of conserving, restoring and enhancing Atlantic salmon. We need new principles to help us to achieve these objectives.

It is for this reason that NASCO and its Contracting Parties have adopted and are now applying the Precautionary Approach to a wide range of activities.

The first hurdle when introducing the Precautionary Approach is to agree on a definition. NASCO adopted the basic philosophy that we should be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.

Implementation of the Precautionary Approach

It was further agreed that implementation of the Precautionary Approach requires:

a) consideration of the needs of future generations and avoidance of irreversible changes;
b) prior identification of undesirable outcomes and of measures that will avoid them or correct them;
c) initiation of corrective measures without delay;
d) priority to be given to conserving the productive capacity of the resource;
e) appropriate placement of the burden of proof.

These principles draw heavily on those developed by the FAO. We now have a new 'lens' through which to re-examine our management measures. You will see that the lens has a number of faces but perhaps the most important is that irreversible change must be avoided because future generations have rights to the resource. To tell you the truth, it is not too difficult to agree on definitions, they all sound very reasonable and sensible. It is a little more difficult to turn these definitions into agreements. Nevertheless we have made progress which I will outline now. We have so far examined eight elements:

- scientific advice;
- management of salmon fisheries;
- habitat protection and restoration;
- aquaculture, introductions and transfers, and transgenics;
- stock rebuilding programmes;
- socio-economic issues;
- unreported catches; and
- by-catch.

There is one element that we have not yet looked at in detail and that is predation. Furthermore, in the light of the previous papers and dialogue (Chapters Lackey 13, Rees 14, and Dialogue 17) we might also need to consider major issues including population control and human attitudes to the environment if we are going to conserve Atlantic salmon for future generations. NASCO does not have such a wide remit but there is no doubt that developments in these fields constitute huge uncertainties.

A major and obvious problem is that many of the adverse impacts on wild salmon stocks come not from management of the fisheries but from external factors. Over some of these external factors such as climate and ocean temperature we have no influence and for others such as pollution, hydroelectric schemes, aquaculture practices, forestry practices, the influence is often beyond the direct hand of the fishery manager. In our view the Precautionary Approach must be seen as a holistic concept. For this reason we have assembled in our Action Plan all the elements that go to make up this whole. They are presented in Figure 24.1, but as you will notice the whole sphere of precautionary actions is floating upon a sea of uncertainty.

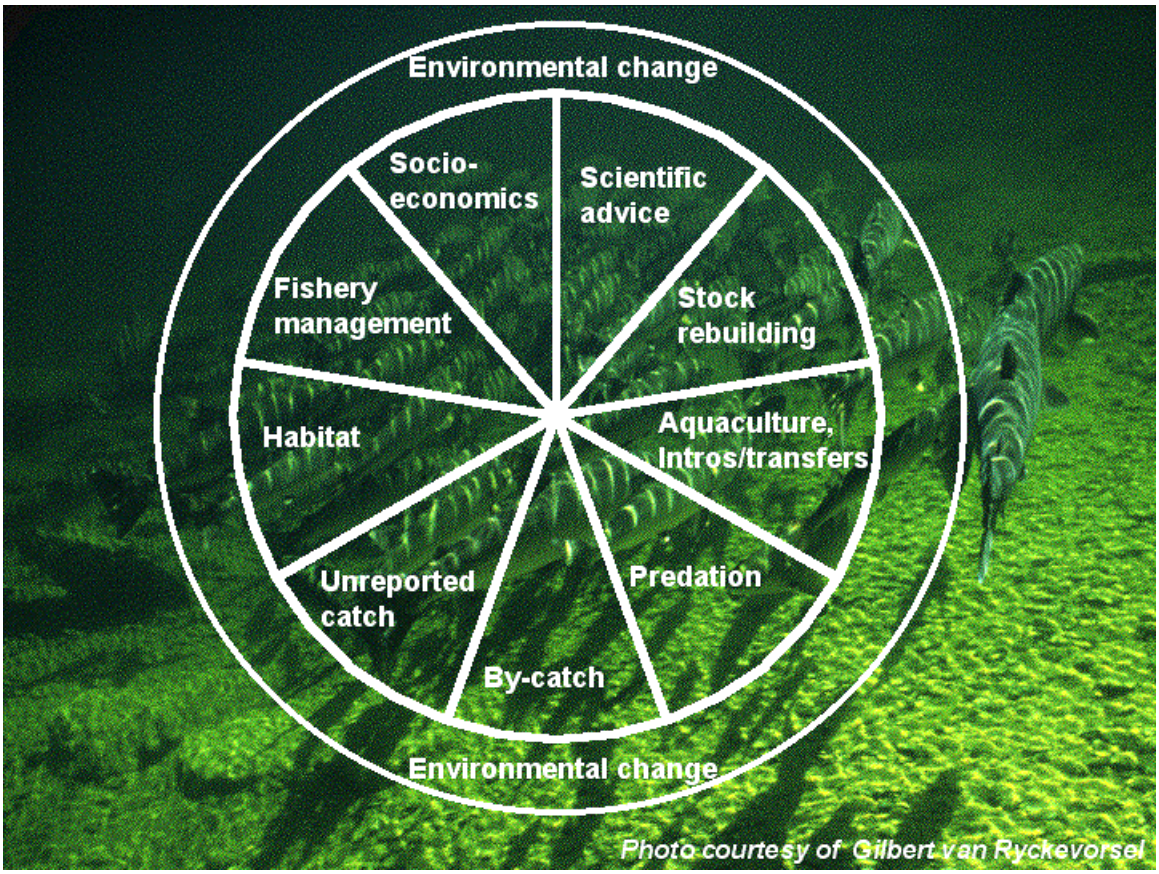

Figure 24.1. Elements of the NASCO Precautionary Approach Action Plan.

Scientific advice

It is very important to agree on the role of science in the implementation of the Precautionary Approach. 'Precaution' is not a scientific concept - we decided in NASCO that we did not want to ask our scientific advisers to answer questions involving how precautionary we want to be. "Precaution" is more of a management issue and it is not appropriate, in our view, to "pollute" science with such concepts. We want science that is independent and free of politics. We invoke the Precautionary Approach because we do not have scientific certainty. Therefore, the first task is to take the necessary steps to try to get the scientific advice needed, but in the meantime it is vital to act cautiously. Science plays a vital role in advising on catch options with assessment of risks and on conservation limits and management targets.

One important new initiative, intended to increase understanding of the causes of marine mortality of salmon, is the establishment by NASCO of an International Atlantic Salmon Research Board. The Board has developed an inventory of research on salmon at sea, identified research priorities and is currently embarking on fund-raising activities.

Management of salmon fisheries

How salmon fisheries are conducted is an element that managers do have direct control over. For this we developed a Decision Structure that will ensure that managers and stakeholders are led through a series of logical steps which should guide them through the process of managing salmon under a Precautionary Approach.

In NASCO, consistent with the Precautionary Approach, more risk averse catch options have been adopted. For example, for the two distant water fisheries managed internationally harvests have been

dramatically reduced to the extent that at West Greenland this year there will be a subsistence harvest only, while at the Faroes there has been no harvest at all for a number of years.

In a simplified form, the Decision Structure involves:

- Establishing reference points or other measures of abundance and diversity;
- Establishing pre-agreed procedures for management;
- Monitoring compliance;
- Introducing appropriate management measures; and
- Monitoring effectiveness of the management measures.

We are currently evaluating this Decision Structure internationally. Each Party to NASCO is trying it out and reporting back on problems and benefits with its use.

Habitat Protection and Restoration

The next subject we tackled was habitat. It is clear that salmon stocks can only be conserved, enhanced and restored if their habitat is also conserved, enhanced and restored. This is an area where decisions are often made not by salmon managers but by other agencies such as those concerned with hydroelectric schemes, road building, etc. Our first precautionary step here was to try to measure what salmon habitat we now have. How else will we know whether we are succeeding or failing in future years? Then we agreed on a policy of "no net loss" and gains where possible. We agreed to:

- Establish inventories of salmon rivers (containing river, salmon production and habitat impact data);
- Protect all existing habitat through a policy of no net loss and:
  - identify risks to habitat and develop corrective measures;
  - place the burden of proof on proponents of activities which may impact habitat;
- Restore lost habitat where possible; e.g. remove dams.

Certainly, there will be a strong need to develop better communications with all the interested parties; e.g. hydro-electricity, forestry, agriculture industries, and road building, and to introduce evaluation and monitoring systems and update them. The most important element is to protect against further loss and make gains wherever possible.

Aquaculture, introductions, transfers, and transgenics

The next areas that we turned to were aquaculture, introductions and transfers, and transgenics. We asked: How can these activities be operated in a manner that gives protection to wild stocks?

First, government agencies which exist to promote salmon farming are often also those that exist to protect wild stocks. Then there is the basic conflict between those whose life and income come from wild salmon and the industries that produce farmed salmon. One way to approach this, of course, is to attack those other sectors privately and publicly with the aim of forcing them to act. In NASCO we have not taken that route. Instead, we have sought to persuade those concerned that it is certainly not in their interest to be seen as causing threats to the wild stocks. This is a slower process but one which should yield lasting results.

When the salmon farming industry started 30 years ago there was a belief that it would have beneficial impacts on wild salmon because prices would fall and exploitation would decline. This was correct, but in addition to the benefits there are now growing concerns about the genetic impact of escapees and of transmission of diseases and parasites, particularly sea lice, to the wild stocks. Salmon farming has grown so rapidly that it has outpaced the scientific understanding of impacts and implementation of

regulations. Also, there has not been appropriate placement of the burden of proof. NASCO, in cooperation with the North Atlantic salmon farming industry, has developed a number of agreements including Guidelines on Containment designed to significantly reduce the number of escapees, since these may cause genetic and other damage to wild stocks. The Guidelines we have developed are now being used by each country to draw up national or regional action plans on containment. The data that will be reported under these plans will enable us to determine how well we are doing in reducing the level of escapees. But the industry has grown so fast that we will have to improve containment significantly each year just to keep the number of escapees from rising.

We have recently reviewed all of our agreements in relation to aquaculture, introductions and transfers and transgenics to ensure consistency with the Precautionary Approach. Although the work done does strengthen existing measures by focusing on implementation, and placement of the burden of proof, it still means that millions of fertile farmed fish are out there and, through interbreeding with wild stocks, they may be altering the millennia-old genetic stock structure in the rivers flowing into the North Atlantic. They may also be causing loss of genetic diversity. That is hardly precautionary. For these reasons we may need to focus more on the use of sterile fish as soon as the research has been done on any ecological impacts they might have. Wild salmon protection areas are also being introduced. We are engaging with the industry in cooperative projects so as to build confidence and trust. We are also stressing to them the likely economic impacts on their industry if they are shown to damage the wild stocks. As well, we have developed guidelines on stocking where it has to be used, since poorly planned hatchery practices can result in adverse genetic impacts and risk the spread of diseases and parasites.

In the case of introductions and transfers we support the establishment of epidemiological zones which are considered free of, or subject to, certain specified diseases and parasites. It obviously makes sense to stop movement from an infected zone to one free of infection. The big issue here is how does one protect against unknown diseases and parasites. For example, we were completely unaware that the parasite, *Gyrodactylus salaris*, which has been associated with Baltic salmon, probably for thousands of years, would have such a terrible effect on Atlantic salmon. In more than 40 rivers in Norway salmon are almost extinct due to this parasite. Therefore, just moving salmonids around within fairly short distances can cause unforeseen serious damage. The Precautionary Approach should not allow that but there is a particular problem of countering a threat of which you are unaware. This also raises trade issues.

Transgenic Atlantic salmon are a new development. They could be the first transgenic animal available for human consumption and they could bring major advantages to the salmon farming industry. But there are significant risks to the wild stocks of irreversible change. A highly precautionary tactic would, of course, be to require that all salmon farming is carried out on-land in secure facilities. That does not seem to be an economic option at present, though if transgenic salmon are approved for use on land it would mean that the industry could have the benefits of much faster growth whilst wild stocks are protected because the transgenics are grown in secure facilities on-land. We are, however, far from that stage. The nightmare scenario would be that transgenic salmon escape to the wild and interbreed with the wild stocks causing irreversible genetic changes.

Stock rebuilding programmes

Currently, approximately three quarters of monitored Atlantic salmon rivers in North America are below their conservation limit. NASCO's agreement on the Precautionary Approach requires that stocks be maintained above conservation limits through the use of management targets and that stock rebuilding programmes (including habitat improvement, fishery management actions and stock enhancement) be developed for stocks below their conservation limits. We have developed guidelines on stock rebuilding programmes.

Socio-economic issues

The latest element that we are looking at is the thorny question of how social and economic issues can interact with implementation of the Precautionary Approach. It is clear that if social and economic issues are given a high precedence then the Precautionary Approach could be negated. Our first step here has been to start the process of estimating all the elements which make up the values of wild salmon stocks. Some of these are fairly easy to measure, the values of commercial and recreational fishing for example. But the wild salmon has significant "existence" or "heritage" values in the public mind (see also Chapters 18 and 19, Farber and Narcisse). These values can get lost when the value of salmon is compared with other industries, yet they could be huge. For example, a study of Londoners indicated that they were willing to spend about CAN $25 million a year to restore salmon to the Thames. We have decided that we need to do much better on this and have agreed on a template internationally so as to measure all of these values. Once we have this we will be better able to study how social and economic values and the Precautionary Approach can interact positively. To do this we will:

- identify all the elements of social and economic value associated with the wild stocks; e.g. fisheries, ecotourism, the salmon itself, genetic diversity;
- agree on consistent methods to assess these values in monetary terms and list values that cannot be assessed in monetary terms;
- consider all these values so as to ensure the wild salmon are 'fully punching their weight'; and,
- incorporate social and economic information in all decisions recognising the need to avoid irreversible change, giving priority to conserving the productive capacity of the resource and protecting the rights of future generations.

We are fortunate that people in general care about the wild salmon. In future we will need to focus more on the public relations and educational aspects in order to maintain and increase support for conserving the resource in the face of increasing pressure on salmon habitats as a result of a growing population's needs for water and electricity, etc. The aim must be to help people without harming salmon.

Unreported catch

Unreported catches amount to about 40% of the reported catches. We need transparent reporting of information giving estimates of unreported catch, a breakdown of sources of unreported catch, and details of measures taken to minimise unreported catch. We are making good progress in this area.

By-catch

There are very large fisheries for mackerel, herring and other pelagic fish in the North-East Atlantic. They are taking salmon as a by-catch but we do not know the extent of this. We need to:

- encourage and seek funding for research on the distribution of salmon at sea, their overlap with pelagic fisheries and on the by-catch;
- encourage pilot studies on technical adjustments to fishing gear in pelagic fisheries so as to minimise by-catch of salmon; and,
- request other fishery commissions to encourage adjustments to fishing methods so as to minimise by-catch of salmon.

Conclusion

This is a brief summary of how, at least in one international fisheries organization, we are grappling with the Precautionary Approach. In some ways it is only organized common sense but it is perhaps a common sense that has been missing. Adopting the Precautionary Approach calls for something of a revolution in the short-term way that we and our political masters have thought. It is not an easy process to do this but I am convinced that we have to do it. There is simply no future in continuing along the present course. We have already lost too much that way. The abundance of wild stocks has declined

markedly and there have been major habitat losses in the last 150 years. Today we have threats that were simply unheard of even 20 or 30 years ago, including loss of genetic diversity from inter-breeding with aquaculture, transfers of parasites from one ocean to another, transgenic salmon and re-stocking practices that can do damage rather than improve. If marine conditions are unfavourable, all the more reason to batten down the hatches until the storm passes and conditions improve.

Future generations have a right to wild salmon stocks but it is us, the present generation here on this earth now, that have to take the tough decisions that will deliver these rights to our descendants. As one angler and conservationist wrote 'if the wild salmon should ever cease to go about its migrations, then our demise may not be far behind'. The Precautionary Approach might be seen as the first step in changing our collective mind sets so that we begin, even if they are uncomfortable, to take the right decisions.

CHAPTER 25

Protected areas for native salmon: A strategy for protecting salmonid biodiversity across the northern Pacific Rim

Guido Rahr, The Wild Salmon Center, Portland, OR, USA

Introduction

The strategy I am going to describe is a result of my experiences in the Pacific Northwest in the salmon "wars". I am a veteran of these wars, which began in earnest around the late 1980s and were triggered by the listing of Pacific Northwest salmon stocks under the US Federal Endangered Species Act (ESA). Despite the impact the implementation of the ESA had across the native range of salmon, many of us came to realize that it was unclear if the ESA would be able to achieve the recovery of salmon. It began to feel as though the sand was running through our fingers. What was becoming apparent, however, was that while we were rushing to try to recover the most endangered stocks, the remaining healthy stocks were languishing until they too were in immediate peril. It became clear that this reactive pattern of waiting until there was a crisis before responding had the potential to keep us in a perpetual cycle of fighting eleventh hour battles and would never let us get ahead of the "extinction curve". For example, today, $80 million are about to be spent on a tube to transport salmon smolts around the Bonneville Dam in the Columbia River. At the same time, fifty miles to the west the Oregon Department of Forestry has just adopted a plan that will result in the logging of 85% of the Tillamook rainforest, home to some of the last regions of healthy native salmon and steelhead stocks. We seem to be locked into this cycle.

Status of salmon across the Pacific Rim

Today, most of the wild salmon stocks in the United States south of Canada are listed under the federal Endangered Species Act. A century of habitat fragmentation and loss, overharvest, dam building and the impacts of fish hatcheries have devastated wild salmon and steelhead runs. In California and Idaho there are very few healthy native stocks while Oregon and Washington stocks are mostly in a state of long-term decline. Fortunately, there are still some wild salmon strongholds in the Pacific Northwest but without rapid conservation efforts, these strongholds will be lost.

The problems we have inflicted on our wild fish and ecosystems were masked, for a long time, by the massive and widespread releases of hatchery salmon and steelhead. We came to a fork in the road about 60 years ago, during a time when we were busy logging our forests and building dams. We knew that these activities would damage our wild salmon stocks, but we reasoned that we could have it both ways by simply building hatcheries to replace the wild salmon that were lost. Today most salmon and steelhead in the Pacific Northwest south of Canada are born in concrete fish hatcheries. I am not going to describe

the multitude of impacts that hatcheries have imposed on wild fish, but it is now clear that this made a bad situation much worse.

Today, our wild fish are fighting for survival and the public, lulled into complacency by the annual returns of hatchery fish, has not responded. Many would argue that if a decision had been made earlier to invest in habitat protection instead of hatcheries, we might have a more stable environment for salmon today. The best hatchery in the world is a healthy watershed, yet this pattern of replacing wild fish with hatchery fish, hand-in-hand with continued habitat destruction, appears to be to be marching up both sides of the Pacific Rim.

Threats to salmon in the Pacific Northwest

Hatcheries

The map in Figure 25.1 shows the Pacific Rim and the distribution of fish hatcheries, which are proliferating and climbing north. In Japan today, there are no more healthy wild stocks; the massive hatchery programs result in 42% being hatchery fish in the Pacific Ocean, from a series of mega-hatcheries in Hokkaido. It also appears that Sakhalin Island in Russia is moving in the hatchery direction. Moreover, the Japanese government is giving support to the Kamchatka administration to build more fish hatcheries in return for driftnet rights to fish sockeye inside Russia's territorial waters. History continues to repeat itself – watershed after watershed and nation after nation. It is clear that we are having difficulty breaking out of this pattern.

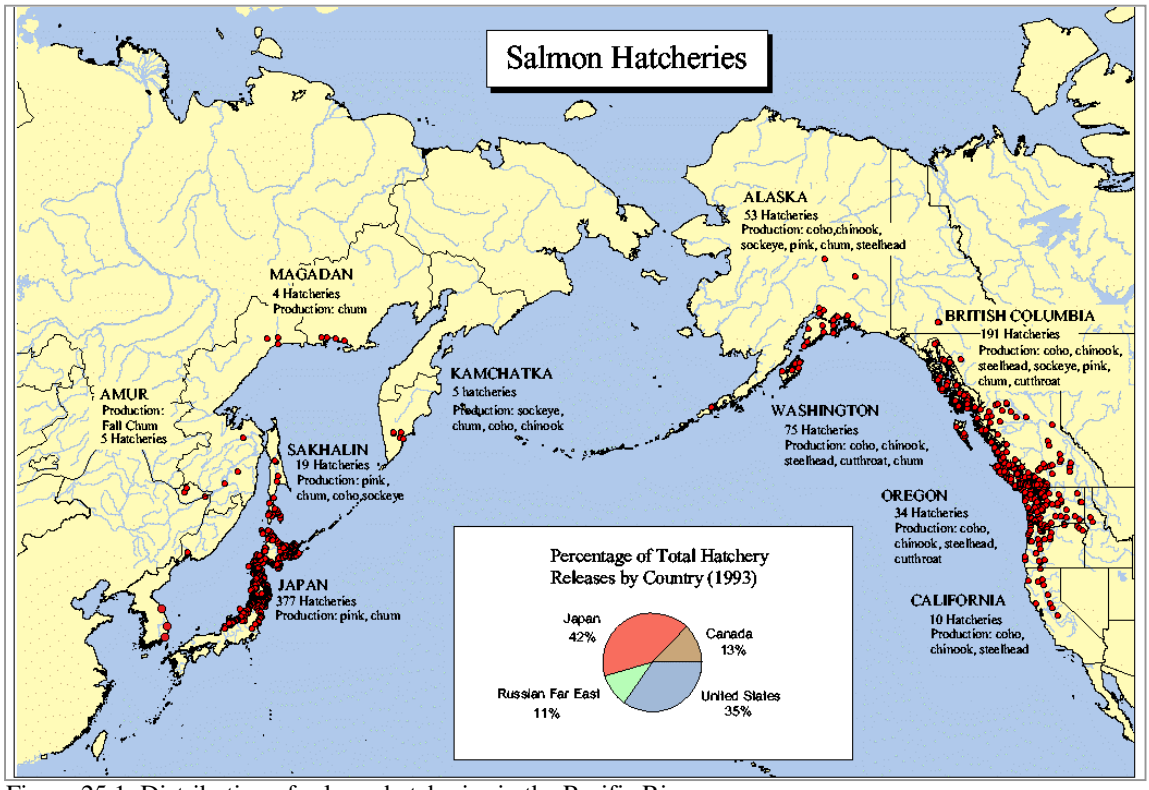

Figure 25.1. Distribution of salmon hatcheries in the Pacific Rim.

Resource Industries

Resource industries such as oil and gas development also pose a threat to salmon. For example, in looking at the distribution of threats, Figure 25.2 shows where the oil and gas, proven or suspected, reserves were in the Sea of Okhotsk in 1998. These threats are going to continue to proliferate – and we have not seen the worst of it yet.

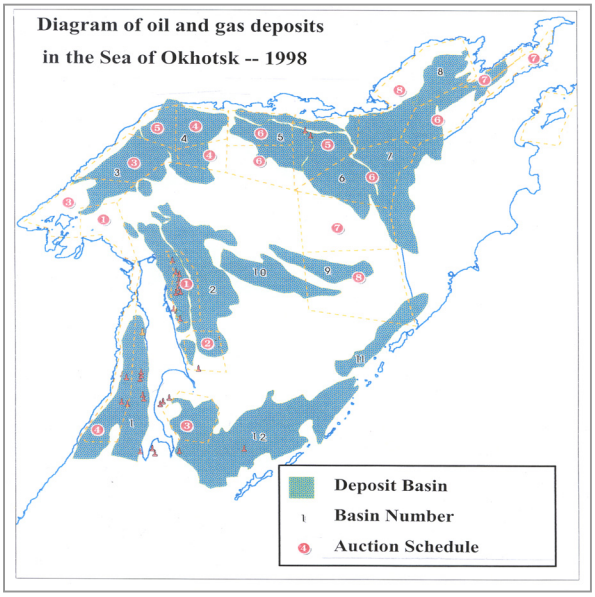

Figure 25.2. Oil and gas reserves (known or suspected) in the Sea of Okjotsk in 1998.

Human population density

The map in Figure 25.3 shows the distribution of the human population across the Pacific Rim - the red areas show where the people are and the darker reds are more people. In the Pacific Northwest of the United States and Canada the human population is doubling every 40 years (See also Lackey, Chapter 13). There is a strong correlation between human population and declining or extinct salmon, trout and Arctic char stocks.

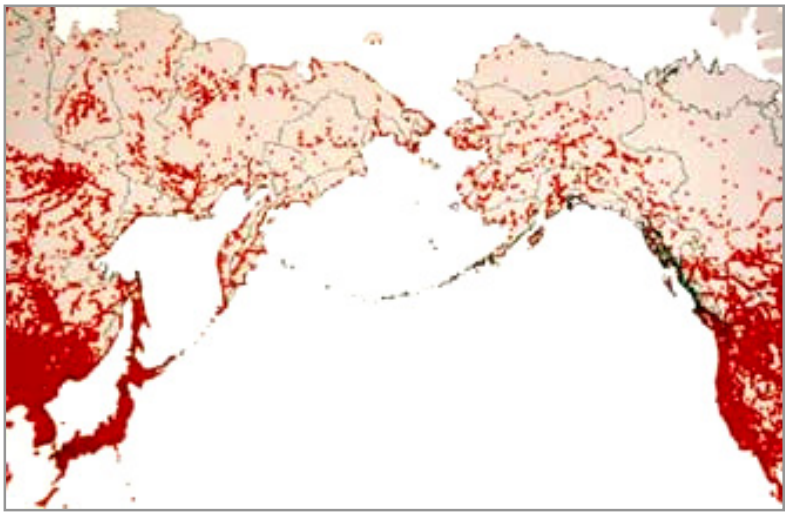

Figure 25.3. Distributions of human population across the Pacific Rim. Red= location of human population, darker red=greater population density areas.

Pattern decline of salmon stocks

What Xanthippe Augerot (Chapter 8) and Brian Riddell (Chapter 7) have shown, is that the native range of Pacific salmon appears to contracting northward. The declines are most extreme in the southern parts of their range and are steadily climbing towards the north. For example, Japan does not have any healthy wild stocks and the southern region of Russia is under threat from logging; the vast Amur River basin up-river stocks of chum are in dramatic decline; Sakhalin Island is under a major threat from oil and gas development and the construction of a pipeline that will traverse the entire length of Sakhalin Island and

cross roughly 1,000 rivers; in southern Kamchatka wild salmon in some river systems, such as the Avacha, are disappearing; most of the stocks south of Canada are now listed for protection under the US federal Endangered Species Act, and some stocks on Vancouver Island and the coast of BC are also suffering dramatic declines. Our challenge is to remain ahead of the "extinction curve" and stop this pattern of south-north declines.

Some say salmon are "dying a death of a thousand cuts", which is compounded by variable ocean conditions. The events that led to these declines frequently occurred years previously. The dams have been built, clear-cuts have denuded the watersheds, fish hatcheries have been built and thousands of people are occupying the river flood plains. At this point, the social and economic costs of reversing those entrenched threats are extremely high.

Restoration

What has been done, at the eleventh hour, is to pour money into restoration. Although some restoration projects are very important, the pattern has been to treat the symptoms rather than the causes of the salmon decline. Stream structures have been installed but at the same time, logging has been conducted in the headwaters. A tremendous amount of money has been put into restoration and although these projects will provide some temporary habitat, the jury is still out about the effects over the long-term (see also Chapter 16, Walters).

We have also spent a great deal of money on techno-fixes, such as fish hatcheries, and have been focused on restoration projects for the most endangered stocks. For example, in the Columbia Basin close to $3 billion has been invested in salmon conservation and related activities, including foregone revenue from hydroelectric spills. Tremendous amounts of money have been invested in fish hatcheries but, meanwhile, the stocks that are still in good condition are receiving very little in the way of proactive investment in their protection. As time goes on history repeats itself in each watershed and the cost of restoration continues to increase.

The Wild Salmon Center strategy for salmon protection

The Wild Salmon Center has made the strategic decision to focus efforts where there is the best chance for long-term success. We asked ourselves, if we want a visible, on-the-ground outcome in 1000 years, what should we do today? We decided on two things: (1) to look at the northern Pacific Rim as one system, or community, and (2) to target the healthiest remaining salmon river ecosystems for permanent protection.

We believe that if we can get in before particular factors are entrenched, then we will have a higher chance of success and the outcomes will be more certain. For example, it is much less expensive to keep a dam from being built than it is to remove it once it is there. In fact, if one really wanted to be ahead of the "extinction curve" and find the maximum impact point or leverage point, it is essential to be there before anyone has even *initiated* the process of building a dam or goldmine.

In learning about the issues in British Columbia, it is interesting to me that people are not as terrified of losing the habitat as they are of the proximate issues such as salmon farming and harvest issues. At the end of the day it is the habitat that is the hardest to reclaim. By the time a firm is bidding on the timber rights, you are behind the curve and fighting a reactive battle with an entrenched interest. The maximum leverage point has to be *ahead* of the curve and anticipate what the future could bring. Malcolm Windsor stated it perfectly when he said, "We can be more effective by anticipating these issues and getting in early before they are front page news and it is a crisis".

For example, the maximum leverage point on fish farms was probably a few years ago. Again, this ties into the "reference points" that Malcolm Windsor pointed out (Chapter 24); if you can get the constituents to agree on a social and economic trajectory that includes wild fish and intact habitat *before* the inevitable competing economic demands are entrenched then there is a much better chance for salmon conservation to succeed. Launching a salmon conservation program in a watershed that still has salmon, and the

economic and cultural benefits from these fish, is the most effective strategy. Once the local economic foundation has switched to gold, or oil, or a coalmine, then there is an entrenched competitor for salmon and a future – usually one without healthy salmon stocks – has been charted.

Assumptions

The assumptions that we have adopted are:

(1) wild salmon and their ecosystems will face increasing threats in the future,
(2) by the time salmon declines are advanced the factors causing the decline (population bottlenecks) are in place and are often entrenched,
(3) fish management problems such as hatcheries and harvest ultimately will be easier to resolve over the long-term than will loss of habitat,
(4) the salmon runs that are healthy today will most likely be threatened in the future, and
(5) targeting the most robust remaining salmon ecosystems within each geographic region does not mean that we are giving up on restoring the rest.

It is important to note that we are not advocating triage, but it does mean redistribution of resources.

Figure 25.4 shows the distribution of salmon throughout the Pacific Rim. We know the impact that salmon have on coastal people and coastal food-webs and we know that their decline would have a dramatic impact on all of those areas identified for the distribution of salmon. The question becomes, "If we cannot save every river immediately, which ones are we going to save first and where?"

I would argue that the minimum action here, given the fact that the key to salmon abundance and health is the locally adapted stocks, such as the steelhead showing up in Southern California and the taimen masu salmon of the Sea of Japan region. We must make sure that we do not lose any of those locally adapted types of salmonid fish. The gradient or genetic and life history diversity extends from the species level all the way down to the reach or the tributary but, at some resolution, we cannot risk losing the native socks that are the building blocks for future recovery within each salmon ecoregion.

Figure 25.4. Distribution of salmon throughout the Pacific Rim.

Xanthippe Augerot and others are been developing a map of salmon ecoregions such as shown in Figure 25.5. This is a very compelling idea. As a minimum, the four nations of the Pacific Rim need to make sure that we do not lose the native salmon stocks that represent each of the different salmon ecoregions. To prevent the extinction of the salmon biodiversity of each part of the northern Pacific Rim, we must ensure that each one of these salmon ecoregions is anchored with a number of salmon protected areas or conservation projects. I would argue that is the minimum outcome in order to preserve our options for the future.

Salmon protected area network

A salmon protected area network would ensure the survival of the different types of salmon biodiversity that characterizes the different bioregions or ecoregions of the Pacific Rim. We need to anchor each of those spots with at least three sites. Why three? Three just seems like a good number - ten is better, all of them are best and zero is the worst. Some of Ray Hilborn's work indicates that it is necessary to be smart about choosing a site because some rivers, based on the life history patterns and diversity of the resident stocks, may be really strong during some ocean periods or climatic phases and others may 'wink' on and off. Today's healthy stocks may be less healthy tomorrow. Enough of the system has to be captured to ensure that the range of genetic and life history diversity is being captured to hedge our bets against stochasticity in the environment. If we could link these places and these rivers together in a North Pacific Rim network of salmon protected areas, and use the same benchmarks and metrics for describing salmon and ecosystem health, we could then begin the process of learning from each other about what is working and what is not and try to weed out the effects of the environment *versus* things such as anthropogenic impacts on the watersheds.

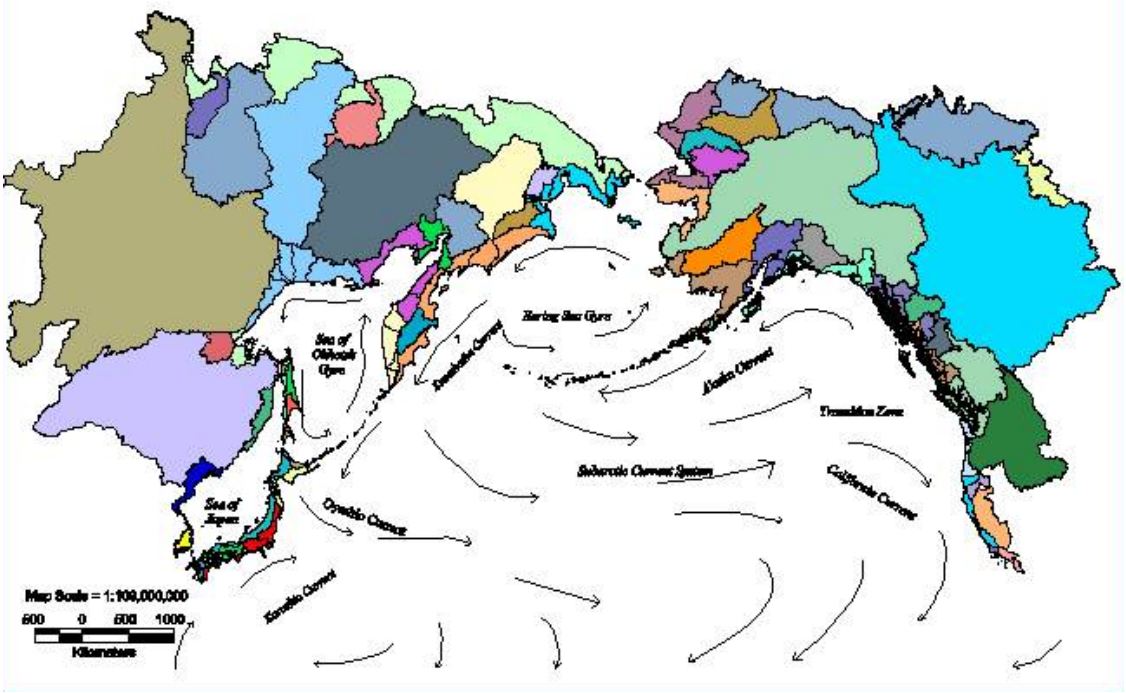

Figure 25.5. Pacific salmon ecoregions.

Priority watershed selection criteria

What follows is a list of criteria which we believe are essential for choosing a suitable watershed system for protection of salmon biodiversity.

1. Represent ecoregion for each salmon biodiversity
We want to choose systems that represent the salmon biodiversity in each salmon ecoregion. For example, in the interior Columbia Basin, the outcome is to ensure that we are protecting a strong stock of native desert-adapted summer steelhead and, in the coastal temperate rainforests of Oregon and Washington, the outcome is to ensure permanent protection of 1-3 winter steelhead and cutthroat trout watersheds.

2. Salmonid species richness
Species richness is desired and, in choosing a site, the higher the genetic life history and species diversity, the more desirable the outcome. This is also being contrasted with the size of the watershed and, as the size of the watershed enlarges, the challenge of protecting it increases.

3. Healthy Stocks
If watersheds are chosen that have relatively healthy stocks, these are systems that do not have entrenched bottlenecks and do not have the uncertainty of knowing if they can be restored. Stated another way, protection of a healthy stock is easier than restoration of one that is in precipitous decline.

4. Rare and endemic salmonids
It is important to target unusual or endemic species and life histories where possible.

5. Ecosystems intactness
We believe that there is a correlation between healthy habitat and healthy fish stocks. Choosing watersheds with a high ratio of intact and ideally protected to unprotected land means that less needs to be done to achieve total protection. The incremental cost of protecting a watershed that is 90% intact is lower than if it is 90% degraded.

6. Local support and political will
Finally, the most important criteria would be local support and political will to save the area. We realize that we can list the highest priorities, within a bioregion, but what it really comes down to is whether the people living there will support and advocate the protection of this region and whether there is local political will. If there is an area with competitors for land and water, whether it is a timber company or oil and gas company, and if they are better armed, then it may be preferable to find an area with a more level playing field. We, as the fish community, are competing for water and land with other uses and we simply have to be as smart, effective and creative as our competitors and willing to move ahead.

What is a salmon protected area?
The answer to this question is very simple: it is a place where there is enough protected habitat to sustain healthy stocks of salmonid fish, whether it is one stock or the full species guild. It is essential to ensure that salmon conservation, which includes escapement issues, is the management priority for that land or that piece of the watershed within a salmon protected area. Sufficient numbers of fish have to escape into the watershed, not only to sustain the health of the fish stocks, but also to take into account ecosystem nutrient loading requirements. As to the escapement levels necessary for that, we really do not know these levels but consider that it should be part of the long-term management plan for each salmon protected area.

Most existing protected areas for salmon look like the map of the riparian buffers in Figure 25.6. A river geomorphologist would suggest that it is probably not good enough to sustain habitat for fish because most of what creates the instream habitat for the fish lies outside of the riparian areas.

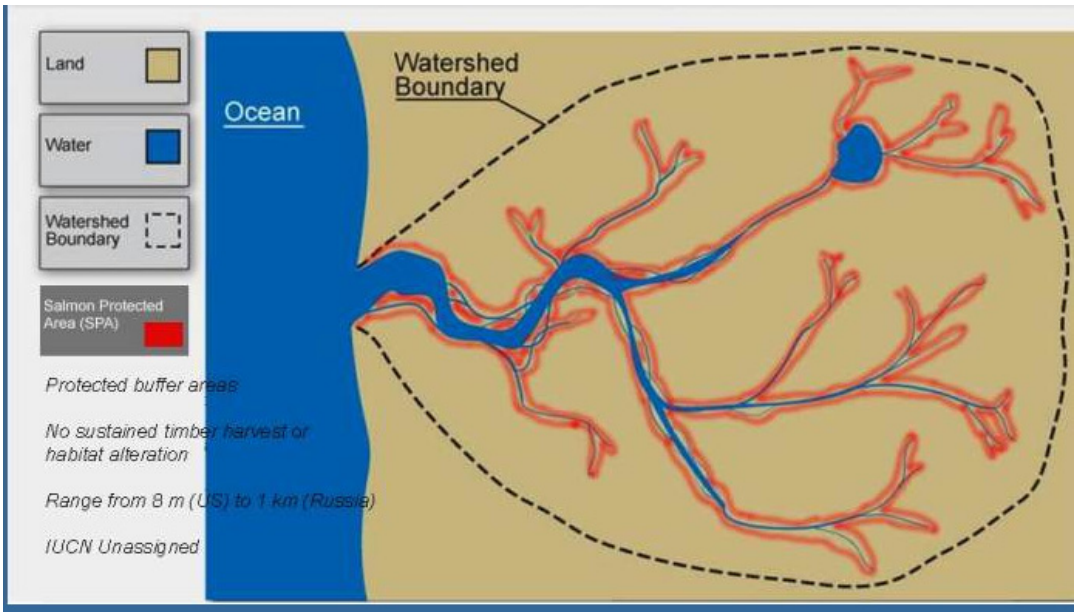

Figure 25.6. Riparian buffer zone.

Tables 25.1 and 25.2 summarize proposed hierarchies of salmon protected areas at a conceptual level that provides some description. For example, there are certain places in the watershed that are more important than others for the production of juvenile fish and staging for adults and they should be identified and protected. Research has shown that frequently the majority of the production in any given watershed is very localized and is the area of the best remaining habitat. The idea is to create a network of protected habitats that go from the headwaters to the ocean and capture the different key habitats needed for each salmon's life history stage. Those can be looked at as beads on a chain.

Table 25.1. Aquatic Diversity Management Area (ADMA) criteria. Adapted from Moyle and Yoshiyama (1994).

Aquatic Diversity Management Area (ADMA) Criteria	
1	Contains habitats and resources necessary for persistence of target species and communities
2	Be large enough to contain range and variability of environmental conditions necessary to maintain natural species diversity
3	Integrity must be protected from edge and external threats
4	Internal redundancy of habitats to reduce effects of localized species extinctions by natural processes
5	Should be duplicated by at least one other ADMA with similar species focus, habitat and environmental conditions at a distance, as a risk averse strategy
6	Support populations of organisms large enough to have a low probability of extinction due to random demographic and genetic events

Each of the levels described in Table 25.2 corresponds with The World Conservation Union (IUCN) protected area categories (noted here as "designation"). The two basic pieces are the habitat and how we deal with the fish. If the habitat is in place without specific policies and programs to address escapement and hatcheries then it will not succeed. Each one of these describes a subsequent phase of implementation over a long-term project.

Table 25.2. Salmon protected area designations. Adapted from IUCN (1994).

Level	Designation	Description
1	Sanctuary L1	Management for conservation and/or science. Whole ocean-draining basin, no commercial or recreational fishing, no habit alteration, no hatcheries, no exotic species. Example: Vostochny Zakaznik (Vengeri/Pursh-Pursh Rivers, Sakhalin, Russia). IUCN Ib.
2	Refuge L2	ADMA at whole ocean-draining basin level, with sufficient escapement and policy direction for management of wild fish. No hatchery fish (except strays), no exotic species. Example: Togiak National Wildlife Refuge (Alaska, USA). IUCN II.
3	Refuge L3	ADMA at whole ocean-draining basin level, no wild fish management policy. Some hatchery impacts. Example: Botchi Zapovednik (Khabarovsk Territory, Russia). IUCN II.
4	Refuge L4	ADMA at sub-basin (or greater) level with wild fish management policy. No hatchery presence (except straying). Example: North Fork John Day River (Oregon, USA). IUCN II.
5	Refuge L5	ADMA at sub-basin (or greater) level with no wild fish management policy. Hatchery presence. Example: Hoh River (Washington, USA). IUCN II.
	Anchor Habitat/Key Watershed	Salmon conservation primary management goal. May be temporary designation and allow some timber harvest and road building. Sufficient habitat, dispersed across basin, for protection of 1+ species. Example: Oregon Department of Forestry Anchor Habitat Strategy (USA). IUCN IV.
	Riparian Buffer	Range from 8 meters (USA) to 1 kilometer (Russia). Along mainstem rivers and tributaries, no sustained timber harvest or habitat alteration. IUCN unassigned (UA).

Five phase process for creation of salmon protection areas

The five phases to create salmon protected areas (SPA) include: prioritization within ecoregions; conducting site assessment and analysis (in the Russian Far East this takes about two weeks); conducting an assessment of the biological and social status of a watershed; determining what the major threats are; and, determining if there are enthusiastic local partners.

The length of time for each phase varies depending on a number of factors. For example, in the more heavily populated eastern part of the Pacific Rim the second phase actually takes longer compared with an area less heavily populated. In one site, the Hoh River on Washington's Olympic Peninusla, we are on our third season of site selection and analysis because it takes that amount of time to map the habitats within the basin. In the second phase the site conservation strategy is developed, followed by the protection of the habitat and implementation of the wild fish management programs – the latter being 90% of the work. This can involve land acquisition and is the actual creation of the protected area or refuge. The inventory continues on throughout the whole process but, over the long term, it is necessary to monitor and conduct research. We are looking at establishing biological stations in our project sites and linking them.

What follows is a more detailed description of the factors involved at each of these phases.

Phase 1. Prioritization

As a precautionary strategy to safeguard each region's endemic salmon biodiversity, we propose that salmon protected areas be created in at least three river basins per salmon ecoregion.

We propose that three classes of criteria be used to prioritize conservation opportunities within each salmon bioregion:

1. Biological – river basins are higher priority if they have:

- relatively higher salmonid species, life history and genetic diversity (at the basin scale);
- salmon species and genetic and life history diversity that characterizes a salmon bioregion;
- presence of robust native salmon stocks ("healthy" stocks);
- uniqueness or endemism.

2. Landscape – river basins are higher priority if they have:

- a high ratio of protected to unprotected habitat (presence of existing protected areas in the basin, preferably IUCN Classes I and II);
- a relatively high level of ecosystem health or intactness (measures of intactness of ecosystem processes, wildness and ownership fragmentation).

3. Institutional– river basins are higher priority if they have:

- relatively high local commitment to salmonid conservation in non-profit, for profit and agency sectors;
- relatively high on-the-ground capacity to implement projects, including financial, organizational and political (e.g., availability of historical salmon and habitat data, GIS systems, skilled local conservationists, funding, etc.).

Phase 2. Site Assessment and Analysis

Site assessment and analysis serves different functions in unfragmented and fragmented landscapes. In the unfragmented landscapes of the Russian Far East, we use rapid assessments of biological and socioeconomic status to select project river basins and assess the political feasibility of creating a SPA. If sites do meet the biological, landscape and institutional criteria, then we proceeded to Stage 2 (development of conservation plans). Inventory, including habitat mapping, is not conducted until Stage 5 (inventory, monitoring and research).

In the fragmented landscapes of Oregon and Washington in the US Pacific Northwest, we conduct site selection and analysis not just to select sites and assess feasibility of establishing an SPA, but also to identity priority habitats within basins for conservation, a process that can take one or more seasons of field surveys.

Phase 3: Development of a site conservation strategy

After project basins are selected on the basis of rapid assessments, conservation strategies are developed for each site. Conservation plans should be developed with key stakeholders and describe the steps needed to take the candidate SPA from Phase 3 to Phase 4. The plans should include a budget and be accompanied with memoranda of agreement with key partners. Site-specific elements include decisions regarding new protected area creation and the appropriate mix of land and easement acquisition. In general, we prefer to focus on stewardship programs, habitat protection and initiation of inventory and monitoring programs prior to focusing on wild fish management issues.

Phase 4: Habitat protection and wild fish management

Habitat protection and wild fish management are the most challenging aspects of creating SPAs. They are also the most important. Without real "on the ground" protection of salmon stocks and their habitats, everything else in this strategy is meaningless.

Phase 5: Inventory, monitoring and research

The implementation of this phase occurs during the entire process of creating a salmon protected area. It is very important to describe the biological status of a watershed, especially the aquatic system, early in the process. Then a monitoring system must be established to assess changes in the ecosystem over time, especially the status of salmonid fish stocks. Unless this can be done, there will be no way to know if the salmon protected area is succeeding in fulfilling its objectives.

Examples of programs

Russian Far East

We believe that the Russian Far East provides the greatest remaining opportunity to protect salmon, at the ecosystem level, anywhere in the Pacific Rim. To date, we have conducted 28 rapid assessments and found some beautiful, completely uninhabited places, where the salmon ecosystems are intact. The First Nations that live there in the local fishing communities are living off the fish and are a natural ally. We are really at the threshold of getting into these places ahead of our competitors and working towards the

creation of salmon protected areas. Once the competitors (oil, gas, gold, timber, industries) are entrenched, it will be much more difficult to protect these places. In Kamchatka, for example, we are targeting 5.5 million acres for protection (See figure 25.7). We are working with the United Nations Development Program to create salmon protected areas and to help establish the angling eco-tourism sector. We are close to creating a Level 1 salmon protected area that will encompass the entire 600,000 acre Kol River basin (Figure 25.8). This watershed will protect ten species of salmonid fish. We are now building a bio-station to monitor salmon and ecosystem heath and house visiting scientists.

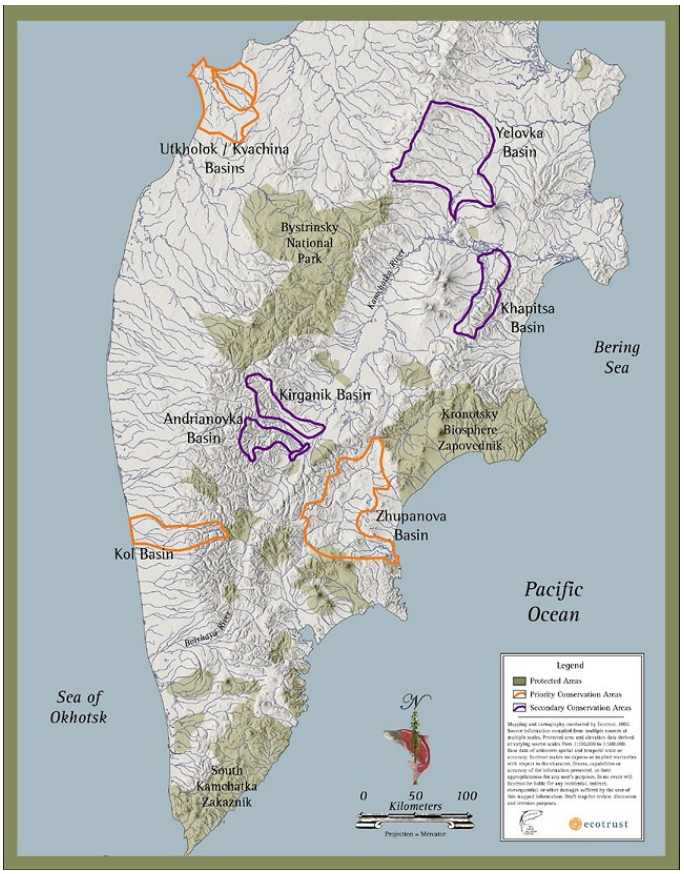

Figure 25.7. Areas targeted for protection in Kamchaka.

Figure 25.8. Kohl River basin.

Oregon and Washington

In Oregon and Washington we have used maps of land ownership and the distribution of relatively healthy native salmon stocks to identify opportunities for the creation of salmon protected areas. The presence of healthy stocks indicates that serious population bottlenecks are not yet entrenched. Watersheds with high ratios of protected or unprotected land and few landowners indicated opportunity for SPAs (Figure 25.9). Washington's Olympic Peninsula is a major stronghold for native salmon and steelhead and char and has ideal land ownership patterns. The first step is to map the habitat

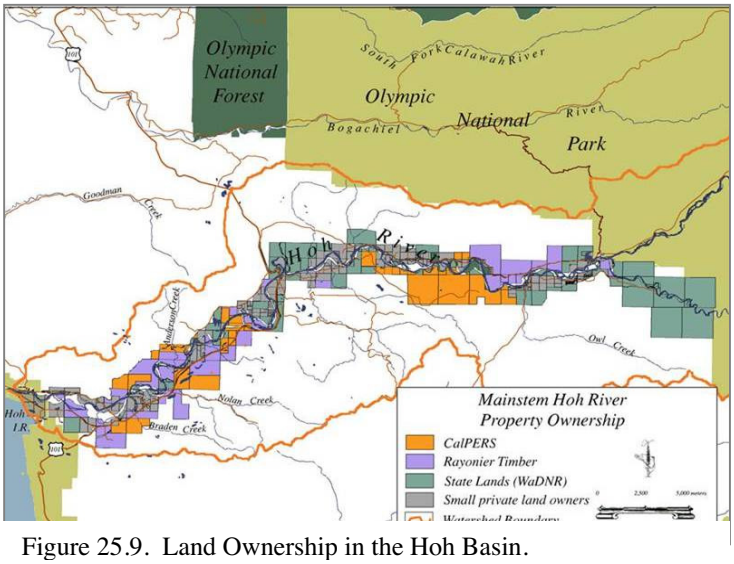

Figure 25.9. Land Ownership in the Hoh Basin.

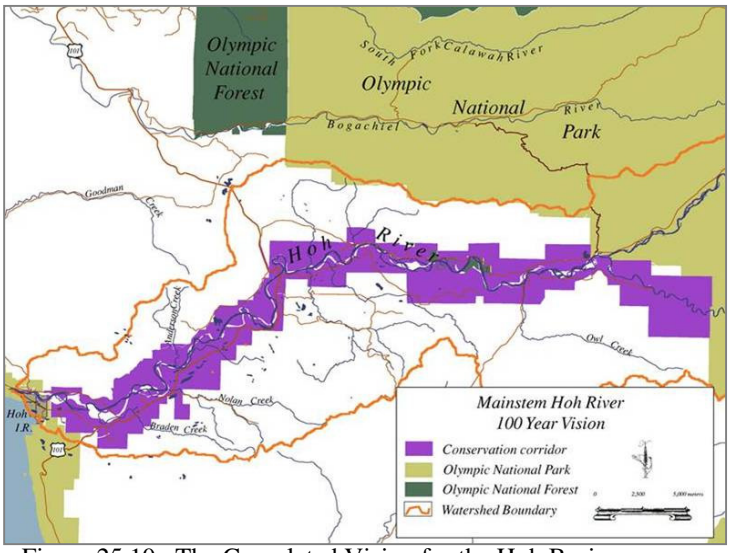

Figure 25.10. The Completed Vision for the Hoh Basin.

refugia on the private land and protect them.

Hoh System – Hoh river sanctuary

The upper watershed of the Hoh River sanctuary is protected and is a beautiful area with cutthroat trout and coho, steelhead and only 230 residents. There are excited local partners in the Hoh tribe.

Together with our partners, the River Conservancy, we are buying up the floodplain. We identified the priority habitats and conducted snorkel surveys and are now in our third season of this activity. We have found that the off channel habitat and instream winter debris is where the production was and we realized the importance of obtaining the flood plain while it was still possible. We targeted the landowners and are continuing to purchase the land, 20% of which is already purchased. The completed vision will result in a conservation corridor as shown in Figure 25.10. We anticipate this project will take ten years and cost $25 million. While on the Pacific Rim we are looking at a $30 million price tag, in the Russian Far East we would be able to do this for $5 million. Those numbers may change but, in looking at the investment, and depending on local will and partnership, we have to think of creative solutions to the problems of expensive land and explore, with partners such as Ecotrust and others, more sustainable timber companies.

The outcomes, for the whole project, would be the establishment of a sanctuary, a laboratory and a model. As a priority, we have to persuade all nations of the Pacific Rim to protect the last best places and implement programs to be commenced immediately.

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CHAPTER 26

Incentives: the key to solving fisheries problems

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This paper focuses on taking the lessons from some of the more successful fisheries in the world and trying to get those lessons more universally applied. The one word, and we have certainly heard it before (it is not my unique message), is that it is all about 'incentives'.

Fishermen's behaviour

After finishing my Ph.D. studies at the University of British Columbia I was employed as an ecologist with Fisheries and Environment Canada and worked on fishermen's behaviour. My job was to look at 'predators' and determine what they did every day. I retrieved the daily records of every British Columbian purse seiner and gillnetter and ascertained where they had fished and what they had caught. What we found is that they behaved in a very predictable way by attempting to maximize their economic well-being. If one place became 'hot', then boats would move to that location until it was no longer 'hot'. However, it wasn't that the catches were uniform because, in some places, the cost of fishing was higher. At that time in the BC purse seine salmon fishery movement occurred between areas to "equalize" catch rates – subject to differential costs of fishing different areas. There was also an interesting unnatural experiment that took place in Barkley Sound with sockeye production, where it had gone from being a very minor fishery to a very significant fishery. However, it took one season before enough fishermen moved to Barkley Sound in the late 1970s and early 1980s so that, instead of the Barkley Sound fishermen making four or five times as much per day as they would have in other places in BC, enough boats fished in Barkley Sound to equalize the catch rates. Clearly then, fishermen maximize their well-being given the rules and opportunities presented to them.

Fishermen maximize their well–being

Steven Fretwell, an ecologist, had the idea of the "ideal free distribution", which was that individuals in a population should distribute themselves so that their fitness, in all habitats, is the same. This idea is simple common sense or economics with respect to harvest opportunity. It applies to all aspects: boat building, illegal fishing etc. It means, look at the rules, see what would maximize well-being and then that is what the group will, in aggregate, be doing.

This has proven to be quite universal. It assumes perfect information and a few generalizations that obviously are not true all the time but it is common sense. Economists have been saying this for a long time and it is a powerful way of viewing the world; people will do what maximizes their well-being. If

you look at how fishermen allocate their effort, whether they build a new boat or whether they fish illegally, groups of people tend to make what would be very rational decisions based on the incentives that they are given.

Example: Abundance of lobsters in Tasmania

Some years ago we studied lobster catches in Tasmania and conducted stock assessments using catch per unit effort. The question we explored was, "What determines catch per unit of effort in Tasmania?" The state was divided into 50 different statistical areas and there were very clear differences between the areas. Figure 26.1 shows the total amount of catch, over about a five-year period, which emerged from different areas. There were very significant differences - some places had, effectively, no lobsters at all and some had enormous amounts of lobsters. Most of the big catches came from the west coast of Tasmania.

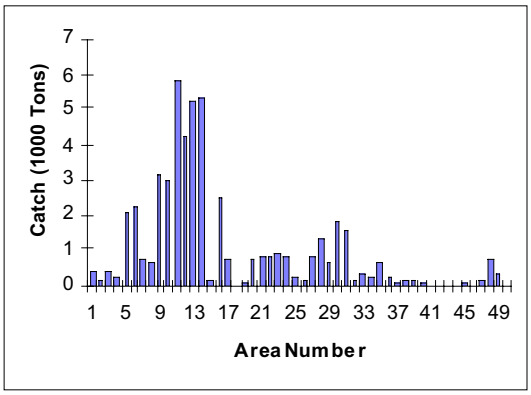

Figure 26.1. Total catch of lobsters in Tasmania by statistical area, over a 5-year period.

When we looked at the catch per effort, it was almost the same everywhere except on the west coast (Figure 26.2). Throughout the east coast and the north coast, in general, the catch per effort was almost constant, despite order of magnitude differences in abundance. This was surprising and people indicated that they had been conducting their stock assessments assuming catch per effort related to abundance. However, it is clear that catch per effort was related to alternative opportunities. The west coast has higher catch per effort because frequently the fishermen find the weather is so bad that they cannot fish and so, on days that they are fishing, they have to catch twice as many fish to make it worthwhile going there. Very simply, people are responding to the incentives in which they are placed and, in this case, how they are going to make money.

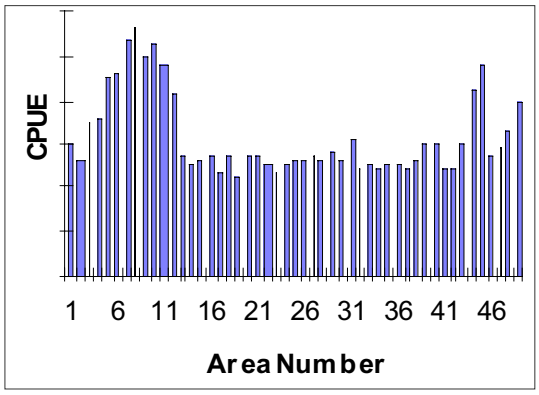

Figure 26.2. Catch per unit effort (CPUE) for lobsters in Tasmania by statistical area.

Managers act to maximize their well-being

Fishermen go to whatever area maximizes their well being - the same thing applies in agencies. Some time ago there was an organization called the International Pacific Salmon Fisheries Commission whose mandate was to split the catch between the US and Canada on an agreed upon sharing arrangement.. They knew their job was to get the right catch in the US and Canada and they did it with staggering precision. They knew their job and they could do it.

In contrast, at the Department of Fisheries and Oceans Canada managers did not know what their job was and they did not know if they were to achieve escapement goals, or to provide sufficient weeks for unemployment insurance for the fishermen in the region, or to minimize fishermen's complaints. They had very ill-defined objectives and the fishery suffered as a result.

In British Columbia's salmon fishery, going back as far as 20 years, it was very clear there were a lot of things going wrong. For example, early coded-wire tag analysis work revealed in excess of 80%

exploitation rates for coho salmon in Johnstone and Georgia Straits - and it was very clear that these were too high. There was also pressure to build hatcheries but there were no incentives, within the DFO system, to recognize the dangers posed. John Fraser referred to that earlier (Chapter 1); that is, the incentives, within the DFO system, are not on the performance of the fishery and instead have to do with many other things. There was one group however that was very successful, and that was the Salmon Enhancement Program. They knew what their job was, which was to keep the money coming and they did a good job of that.

If incentives are set, people will behave according to the incentives. For example, in Australia they decided that Individual Transferable Quotas (ITQs) were the way to go for fisheries and they actually authorized, within the civil service, bonuses for achieving certain deadlines for moving fisheries into ITQs; in the Southeast trawl fishery, located between Tasmania and the mainland, civil servants received their bonuses because they achieved the time-line for inclusion into the ITQ. It was so flawed, however, that it was in court for years and was never implemented. However, the incentives were there and the document was in by a certain date - the civil servants achieved the goal.

In December of 1984, Paul Starr, a scientist at the Pacific Biological Station in Nanaimo, BC, and I conducted an analysis on chinook harvest rates and, for the first time, had coded-wire tag data. It was clear from our data that there was a crisis and the harvest rates were much too high. We held a workshop on the impacts of these harvests rates and how the wild and hatchery fish interacted.

Let us think through incentives and what happens in other salmon agencies. Some of our more successful salmon fisheries include: Columbia River salmon, the Alaska troll fisheries, US and Canada chinook in the 1980s. However, habitat and salmon issues in BC, Washington, Oregon and California, are clearly disaster stories. If you devote five minutes to thinking about who is in charge and what incentives they have, the discovery is that there are complex management agencies with either ill-defined goals or, even worse, conflicting goals amongst powerful actors and, the reality is, no progress will be made. The incentives are completely wrong and the incentives themselves become the end result.

Managers act to maximize their well-being in just the same way that the fishermen act to maximize their well being. If the managers don't know what their objectives are, the results are just as unfavourable. If you have multiple actors in charge and multiple agencies, each with the power to do various things, you will not achieve the kinds of outcomes you are looking for.

Bristol Bay sockeye – a successful fishery

Many people will agree that, within Alaska, Bristol Bay sockeye is one of the most successful salmon fisheries. Bristol Bay is located in southwest Alaska (Figure 26.4) and almost all habitat is protected.

This fishery has a long history of sustainability, largely due, not necessarily to the great management of the Alaska Department of Fish and Game although it has done a good job, but to the fact that there has not been significant habitat loss and there are only about 3,000 people living in a very large area. There have been no hatcheries in the system and that is largely a credit to the good sense of the local residents and the people who fish there. Even more remarkable, it may be the only place in North America that has had no exotic species introductions. There is nothing there that has not been there since glaciation. Within Alaska's Department of Fish and Game, they have very clear objectives and they have a very straightforward decision-making structure. They work on escapement goals and the managers know that is their job and, if they do not succeed then there is a year-end review and they are held accountable. In fact, within the areas of Alaska in which I work, it is much more common to over-escape than under-escape and that is the culture of the agency. The other thing that is very different about Bristol Bay, and lots of other places, is that there is someone who is a designated manager and everyone knows their area

of responsibility and there is very clear line of responsibility. That is very different from other fisheries management agencies.

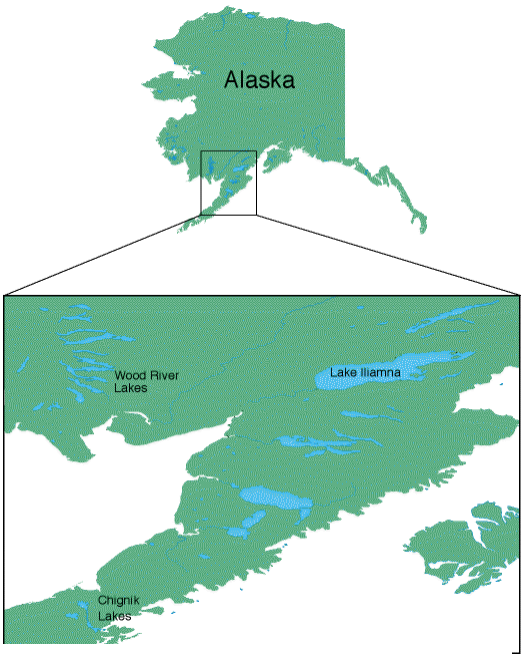

Figure 27.3. Bristol Bay.

Figure 26.4 shows the trend in catch over the past 100 years or more including the record catches that have occurred due to regime shifts. Figure 26.5 shows the trend in escapement since the 1950s – the escapement trends have been upward rather than downward, which is a very positive counter trend. These represent what are in the current definition *over-escapement* and we will probably see lower escapements on average in the future.

However, there is a "dark side" to Bristol Bay and that is that no one is in charge of economic performance. There have been millions of dollars injected into Bristol Bay and it is an economic disaster. It is a biological success but an economic disaster caused by low prices due to competition with farmed salmon, low quality, the way the fish are caught, a very high over-capitalization, too many boats, overly expensive boats, and due to it primarily being a race to fish. The incentives for an individual fisherman are to build as big a boat as possible to compete with the other fishermen. In this area there are probably five times more boats than are needed and many of them are grossly over-powered. The result is, when there are periods of low economic returns, people lose money and face possible foreclosure and bankruptcy.

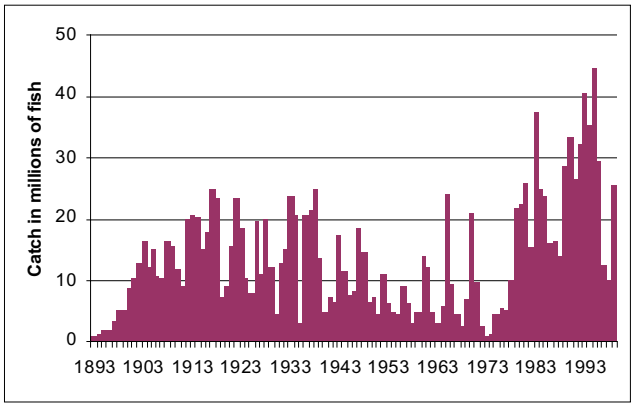

Figure 26.4. Trend in catch of Bristol Bay sockeye since 1893.

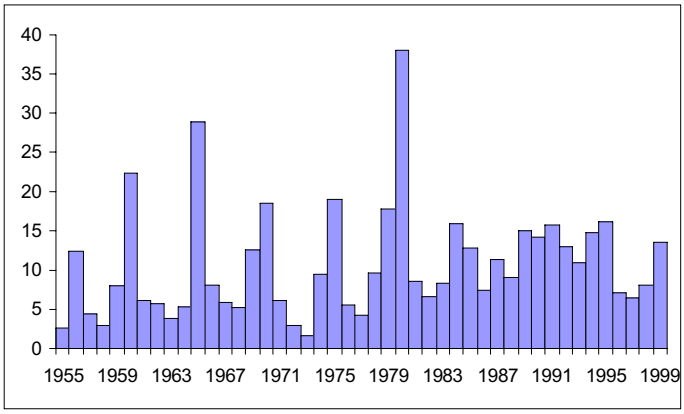

Figure 26.5. Trend in escapement of Bristol Bay sockeye since 1955.

Since there is not a specific mandated position to oversee regulations in order to make it economically efficient, it simply does not happen. There is a giant fishing fleet, although it has limited entry, having gone from 2,000 small boats to 2,000 large boats, and the cost of fishing is probably equal to the current landed value. This has gone from being a $300 million landed value fishery to, in the last few years, probably a $50 million landed fishery value. This is one-sixth of the value without the costs of fishing having changed very much, with the result that people are unable to meet their costs. In fact, one-third of the fishermen did not go out at all in 2002. The result is that there is a fishery that is on its knees for reasons that the economic incentives, in that fishery, are totally wrong. It is almost analogous to the Pacific halibut fishery before it went to the ITQ system, where there was a biological success story but a fishery that landed all of its fish in only 12 hours per year.

A comparison of the Canadian and US west coast groundfish fisheries

The Canadian west coast groundfish fishery has made enormous strides in its management strategy. It has gone to 100% observer coverage, which effectively eliminated discarding of economically valuable fish and resulted in complete reporting of the catch. It went to an ITQ system, which reduced effort dramatically and made vessels profitable. The way the ITQ system is structured means that they cannot go fishing for any of the quota species unless they still have quota. Also, the industry is now funding surveys and research to increase the science base. In contrast, the US west coast groundfish fishery is largely closed due to a combination of discarding and by-catch. This means that it runs on trip limits, so that if fishermen are out fishing and run out of their trip limit for a particular species, they legally have to throw it overboard. Current estimates show that 40% of the commercially valuable product is dumped over the side and the fishery is somewhere between near and total economic collapse resulting in a recently funded $10 million bail-out, buy-back program. The biological status is not nearly as bad as the public perceive; four or five of the stocks are listed as overharvested but none of them are on the verge of extinction. They have recently revised the rebuilding rates from two centuries, to a ten-year or five year period for *bocaccio*. However, this is clearly a fisheries disaster story.

What is the difference between the management strategies of Canada and the US? It is the result of managerial incentives - in Canada, there was and is a manager whose job it is to ensure the success of the fishery. In contrast, in the US, there is no manager; instead there is a committee of seventeen members, the Pacific Fishery Management Council, and no one is in charge. In Canada, the manager knows that his or her job is to determine how to take this fishery from being one of discarding and trip-limits to one that is economically successful and to eliminate many of the problems. He/she does not have power nor is he/she a Minister or decision-maker; rather the job is to manipulate the system. In the US there is the acknowledgement that the trip limits have to be eliminated but nobody has determined how to solve the enforcement problems and nobody has the job to do that.

Moving to property rights (quota) fisheries

Many of the fisheries that I work within have moved to various forms of property rights. Some of the more innovative ones are co-operatives, such as the Chignik salmon fishery, and the New Zealand ITQ fisheries. One of the interesting features of these kinds of fisheries is the elimination of the race to fish. Fishermen think about making money by better product marketing and the value of their product rather than by competing with the other fishermen. In Australia and New Zealand, where they have 100% cost recovery of all management expenses from license holders, the costs of fishing include the cost of operating the boat plus the monies charged for the management system that conducts the research. In a number of these fisheries, the fishermen are beginning to evaluate harvest policies that have lower exploitation rates and also lower research requirements because they are not trying to squeeze out the last fish. Their approach is to draw back on the harvest rate and eliminate the need for conducting surveys every year. By setting the incentives in a positive manner, the outcome is more desirable and will result in a smoother run fishery, more predictability and more profitability. The current incentives in most fisheries

involve a race to fish, building as big and as fast a boat as possible, and pressure to extract the very last fish, and most of the errors are on the side of excess exploitation.

Restructuring incentives

Peter Larkin taught us repeatedly, in the 1970s, that fisheries management is about people management. Yet, if you look at how DFO and NOAA define the precautionary approach, it is almost exclusively in the form of reference points. That is strictly biological and this approach to fisheries says nothing about fishing fleets. The real precaution is in data monitoring, keeping fishing capacity down, and setting incentives in a positive manner. The precautionary approach, as implemented in both the US and Canada, essentially ignores human dynamics - it has taken the people out of the fishery.

We need to think about renewed approaches to the incentives, particularly with respect to salmon. The first thing is to eliminate the race to fish. The ways in which that has been done successfully, in a number of places, is by allocation. For salmon, the most interesting example that I have seen, is that of the Chignik with a co-operative. In the Chignik in 2002, 70 of the 99 fishermen joined the co-op; they fished five boats instead of 70 boats, and all members received a $20,000 cheque. If you take the worth of that $20,000 cheque, in terms of an investment, you would be hard pressed to earn a $20,000 return on a $300,000 investment. This means that possessing a Chignik license is the equivalent of a $300,000 investment. The average value of a salmon license in Alaska has gone from being $100,000 to $300,000; in Bristol Bay it is currently $10,000, and in Chignik, the licenses are on the market for $150,000 to $200,000. Many of the salmon licenses that have lost almost all their value could, by going to co-operatives, probably increase their value ten-fold. It would mean a dramatic drop in employment but it would also mean that almost all the people who fished would be the local people. In Alaska in the future we will see more and more fisheries converting to co-operatives.

If there is anything I have learned in fisheries management, it is that the smaller the scale and the fewer people that are involved, the better the outcome. The successful Alaska fisheries are small-scale or local fisheries - these are people who care about the resource, who live there and take care of it whether it is the fishermen or the managers. For harvest managers, the requirement for smaller scale is the same. This may mean foregoing fish quality to become more economically profitable and achieving sustainable fisheries.

Managers need to have clearly stated objectives and indices evaluation and be subject to a quantitative score card. This is particularly important when there are objectives with respect to hatchery and wild fish. Guidelines do not work – what is needed is a score-card to allow determination of results, which will be the incentive for managers to achieve positive results. For agency managers, clear quantitative wild fish policies and annual objectives are required as well as implementing and ensuring an annual evaluation. When it comes to habitat management, I am not at all optimistic – it is such a diffuse problem with so many people involved that I would not even attempt to provide a solution.

Conclusion

Bill Rees said, “we are self-interested utility maximizers” (Chapter 14). If we want to solve fisheries problems we need to recognize this and design systems so that what is in the interest of an individual is also in the interest of society. If we want to solve fisheries problems, we need to recognize that we are self-interested utility maximizers and we have to design systems to recognize that. We need to look at the systems that work and determine the key characteristics and then emulate the success stories.

CHAPTER 27
Dialogue following Solutions for Salmon Conservation

Linking theory with practice
Malcolm Windsor commented that US President Reagan was apparently interested in economics; what always fascinated him about economists was when they saw something in the real world and something working in practice, they were inclined to wonder whether it would work in theory. He noted that in a way we have had those two approaches with Steve Farber looking at the theoretical question of how to manage these activities and, from Arnie Narcisse, a totally different perspective and one without a single figure on the board. He posed the question: How are we going to reconcile these two?

User perception of a resource might influence the net value through the gross value figure
Jeff Hutchings commented on the points that Steve Farber made about politics and the importance of looking at impact and policy and that this should guide value. He described a situation where that might not necessarily work - where a fishery has declined to a great degree and there is pressure to close the fishery but, those involved in the fishery, would like to keep it going. From their perspective, if the net value is the gross minus the cost, in the short term the gross value might be quite high, whereas the longer-term gross value to them might be lower because of expenses they need to meet. For those users, if the costs are going to be the same and they perceive the gross value of that resource, of taking those fish out of the ocean, to be quite high in the short term but lower in the longer term, then, from a policy perspective, you would actually interpret the value in the short term of taking those fish to be quite high. He expressed concern about the degree to which the user perception of a resource might influence the net value through the gross value figure.

Steve Farber replied that this is a classic problem of short run *versus* the long run. He commented that for the kind of analysis he is suggesting, of looking at net value (which is really gross relative to cost), in this case, he does not think there is a conflict in interpretation. This is because there is, in the short run, an extreme inability of these people to adapt to the changes and to the changing circumstances. In the long run, they have more opportunities for movement to find other economic activities and other places to live and their costs are associated with this changing condition. The serious dilemma here is one of trying to assist those people in getting through this transitionary state, which is so costly to them, for whatever reason. This may be a large social decision to say that we are not going to save these fisheries and these people are going to be inconvenienced, or in China, for example, we are going to put a huge dam in and move 1.5 million people. There are huge transition costs and he believes that it is incumbent upon a society to 'hold those people harmless' - that is an ethical statement. Their problem is that they do not have access to the resources for the transition period, they do not have access in many of these

circumstances to capital, and they do not have the knowledge of what their opportunities are. In his opinion, one of the ethical responsibilities on the part of society is to facilitate their mobility through enhanced knowledge, access to capital and even subsidizations, if that is required. The point is to get people through the short run into the long run.

How can we incorporate non-measurable values into the decision-making process?
Jim Irvine enquired if either Steve Farber or Arnie Narcisse could comment on how we can do a better job of incorporating non-measurable values into the decision-making process. He noted that his concern with the traditional cost-benefit work is that you go through all of the analysis and incorporate all of the estimates of benefits and costs for all the measurable things and then you always end up with non-measurable things such as cultural values and ecological values. The question is whether it is even worth doing a cost/benefit analysis when you admit that those values may be miniscule compared to the non-measurable values. The question is: How can we logically or defensibly incorporate non-measurable benefits and costs into the decision-making process with something like wild salmon?

Arnie Narcisse replied that this was the quandary that they found themselves in during the 'allocation' debate of (May and Toy). They were asking that specific question; that is, How do we measure those non-measurable values that mean so much to us as First Nations' people? He commented that he frankly did not know how to do this. At the time those debates were going on, they had the commercial fishermen say that this fish is worth $10/$15/$20 while others would claim that the same fish was worth $100 to the recreational community. What he, himself, asked at the time was: What is the value of that salmon to First Nations? They do not want to play with these fish, and they do not wish to sell them - they simply want to eat these fish. How do you measure that value? How do you measure a value of something that has kept his people alive for thousands of years? It is impossible to do this. He stressed the importance of recognizing that there are other values that go beyond economics, such as ecological and cultural values. He also referred to the long slow process that is needed to recover those initial values that his people once had and stressed that if we want to get into evaluation then we also need to talk about the lost value that the First Nations people have witnessed since the inception of commercial fisheries.

Steve Farber replied that you cannot measure the immeasurable. What you can do is to begin to think about the whole variety of the natural system services and trace them all the way through the ecosystem. The bears are an example, and he noted that he had not seen anybody talk about those more indirect kinds of ecological values in the context of these issues - they may have referred to them ecologically but did not try to place any kind of monetary value on them. If we think more extensively about ecosystems and how they work and the whole array of services associated with these natural systems, then he believes that we can illustrate the importance of natural systems - that they are more than just commercial and recreational values. That would get us a long way toward actually preserving what people might traditionally think of as immeasurable values. How you deal with immeasurable values, the cultural values to First Nations of critical natural system services, is to not trivialize them by putting monetary values on them but instead by creating a forum in which people can express those values and begin to think a lot more carefully about how to preserve those values by doing things in different ways.

Wayne Jacob commented that what he has seen recently in planning processes, that are meant to drive some of the decision-makers, are 'Multi-attribute Trade-off Analyses'. To accommodate values that you cannot put a dollar value on, they have created artificial scales of 'better', 'the same' or 'worse'. You can attach a numerical value to that and compare that numerical value with another attribute that you may be able to determine a dollar value for. He noted that what he has difficulty with, in those kinds of situations, is that you may find yourself trading off potential multi-million dollars in one attribute *versus* a single digit change in an artificial scale. Taking the collective into account when there are multiple attributes and you are adding up the changes in each attribute, you may not see a relative scale in terms of the importance of that cultural attribute *versus* a much larger scale economic attribute. There are ways to

adjust each and you can create another artificial scale that simply takes into account that there is a change in economics (whether it is better to have all artificial scales and comparing a multitude of artificial scales) but you run into the dilemma where the culture ultimately gets valued somehow in the decision-making process and it is either a $1 value or an artificial value. He emphasized the difficulty associated with trying to capture the cultural significance in decision-making.

Irrigation practices and protection of fish habitat

Addressing Arnie Narcisse, *Wayne Harling* commented that he had been in the region where Arnie resides and noted that when he stood on the bridge of Westwall on the Salmon River in the middle of November and looked upstream and downstream, he saw that it was as dry as a bone. When he finally found water downstream, he saw a chinook salmon redd and a coho salmon redd, and in between the two there was an unscreened intake pipe for an irrigation pump ready to pump the fish onto the fields as instant fish fertilizer. He commented that he had also seen Louis Creek with more irrigation pump houses in the riparian zone than he has seen trees. He posed the question: How successful have you been in getting the ranchers and your neighbours to change their operations in order to protect the fish habitat?

Arnie Narcisse replied that he was the previous Program Manager for Nicola Watershed Stewardship Fisheries Authority and they were experiencing problems with the ranching community then in the Nicola Valley. They pointed out to the ranchers that the easy way to solve the problem was to spend $500, and utilize a simple technology, the Finnegan wheel, which is a small box 6' x 6' and has a big paddle in the middle. It effectively reduces the straying of fry and smolts into those intakes. There is a ranch cattle company on one of the Band lands where they had three intakes and indeed that problem was occurring there. He suggested to the Band that if they installed the screening devices on these intakes they would be providing leadership on the premise that if they did this, then the other ranchers would do it. They put these in and the other ranches did follow suit and so they were able to save the fish. What we need to do is to transpose that to all of the other watersheds that are impacting fisheries resources.

You take only what you need

Stanley Njootli commented that he sits on the Yukon Salmon Committee, which is enshrined in part of the Constitution of Canada as the umbrella final agreement for the Yukon Territory. He noted that with respect to values, it is not a question of measuring value, but looking at need. That is how they have been taught for thousands of years along the Porcupine River, for the use of natural resources. When they harvest waterfowl such as ducks and geese, their elders and parents have always told them that when the ducks start having their eggs and young ones, then their harvest is cut off. "What has been passed down to us is that you take only what you need. It is the same thing when harvesting caribou. If we take five caribou that is what we need for our family for the winter. The rest of the caribou are allowed to swim by and it does not mean that we should sell it, or commercialize it". He commented that they do the same thing with salmon. It is important to look at the question of what a human being needs to sustain himself and to live on this earth, based on need.

He gave the example of the Porcupine River, which has a branch that is one of the best spawning streams in North America for chum salmon - yet there are a lot of problems with that because a lot of these fish have been taken along the Yukon River system and in the Bristol Bay area on the Alaska side. They are looking at plans and in fact do have an interim agreement with the Americans - probably one of the few that the Americans would live up to in terms of having an agreement to sustain an international resource - to bring that level back up. There are not enough salmon coming up to spawn. There are 43 villages that live along the Yukon River system, on the Alaska side, that depend on that fishing system itself for the chum salmon, and chinook and coho salmon. He noted that when we are talking about the values of fish, we need to take into account the fact that we are in a cold climate and a lot of the values depend on sustaining one's life for the winter. The economy is not very good and there are many people who depend upon and use that salmon - that is the lifestyle in rural Alaska and the Yukon.

He also referred to earlier comments about digging a canal from the Columbia River over to Yakima. He pointed out that if you built your house twenty years ago it is not up to today's standard to keep warm in the climate in the North. Then we developed a house with the R2000 standards, and we can now have a warmer house. But you do not have a warmer house - you just build a bigger one and use the same amount of energy and possibly more because of affording to build a bigger one. It is the same thing with that River system. If you have a greater water flow in the Yakima River, then you will have more orchards and probably look at your financial return and determine what product you will grow in order to accomplish a higer yield. That is just human nature. In his opinion, the only changes that can take place are via legislation - changes can be made within the local system and within the Constitution of Canada.

Wayne Harling referred to the figures in Dr. Farber's presentation where worker's earnings were listed as $40 from the chinook *versus* $35 from another job, for a net value of $5. He wondered about the situation where if the alternatives from the earnings from the chinook job was going on 'the dole'? In that case, would the net value not be $40 plus whatever the person would get from Unemployment Insurance?

How do you get the message out to the public?
Karen Munro commented on the presentation earlier in the day about humans as predators and the rather sad story of the direction that society is taking. She noted that we all know this in our hearts. There is a lot of information that we have and, as scientists, we want to be objective and we do not always want to be stuck with making a prediction that may or may not come true. We are still left with the question of what we do with our life and how we live our life. The story of the salmon is closely entwined with that. She noted how much she appreciated the comment that Arnie Narcisse made about the need to build stewardship, as opposed to management, capacity. She commented on the dedication and concern of the participants in the workshop. She suggested that in addition to the initiatives that Bill Rees mentioned when asked about international efforts and legal efforts nationally, that we also think of how to take what we know, as was raised by John Fraser, out into the wider community. How do we keep communication clear? She suggested that this message should be one of the main recommendations from this workshop. She noted that how we value wild salmon is as much a question of how we value human life.

Predation
Robert Kreutziger raised the question of predation and asked: What is happening to those returning fish in terms of predation and what is the role of acoustics?

Malcolm Windsor replied that predation is a very important issue but, to their surprise, at NASCO they found that there was very little information about it. To date they have not done very much other than to set up a working group to accumulate all of the information and determine the effects of predators on salmon and who they are and what are they taking. The first step, like many other cases, is to get the information.

Randall Peterman noted that acoustics are being used as an attempt to reduce the effect of predation. He agreed with Malcolm Windsor and noted that it is very important that we know something about the predators' effects, in particular on juvenile salmon. We have learned from previous presentations about some examples of depensatory mortality – that is where a higher percentage of the salmon population is removed by predators as the abundance of the salmon diminishes. In the context of the precautionary approach, it would be reflected in assumptions about that process, and in stock assessment models. One of the assumptions, in stock assessment, should be that it occurs in a way that has a higher percent mortality at lower abundance– this has been observed in every other system where there is data on predation on natural populations, such as with insect, wildlife, bird, and, in a few cases, fish populations. In that way we would take that lack of information on specific systems about predation into account in the context of the precautionary approach.

Implementation error (Figure 23.2, Peterman, Chapter 23)
Bruce Ward addressed a question to Randall Peterman: With regard to the shape of the distribution of that implementation error I am curious to know if it tends to be skewed more positively or negatively in what you have looked at? Secondly, what actions, in general, tend to decrease a deviation around the mean?

Randall Peterman replied that if you convert the cumulative probability distribution into frequency distribution then it tends to be skewed to the right and there is a long tail out to the high values where you tend to get a few large escapements compared to the target. The factors that decrease the magnitude of the implementation error would be, depending on the species and the location, better pre-season forecasts – these certainly can help because the early fishing season plan is based on them, and it will be less likely to deviate from the necessary harvesting during the rest of the season if the forecasts are close to what the actual in-season abundance estimates are. Another point, which you would intuitively conclude, is that when there is a very large recruitment, there tends to be a much larger implementation error, which is a positive error over and above the escapement goal. When there is much lower than expected recruitment, the tendency is not to make up for that and there are fewer spawners reaching the spawning ground compared to the target.

The role of stewardship groups and public education
Paul Kariya commented that in the dialogue to date we have been hinting about some of the solutions that might involve stewardship and, what he would call, more "every day folk". When one considers the precautionary approach, it is interesting to think about where "every day folk" might fit in. We have a relatively unique social movement evolving in the communities of British Columbia consisting of coalitions of aboriginal people, fishing interests which are both commercial and recreational, and sometimes local government, and some of it is seeded by both senior. Some of this social movement has emerged from the good work of the Salmon Enhancement Program (SEP) and some has come out of the provincial ministries. These are coalitions of people who are out in the field doing mapping, information gathering, and working on small scale restoration projects. These people will ultimately influence decision makers who, in turn, will influence the companies that they work for to donate money and time. He believes that we have a unique solution in the making, in terms of both the precautionary approach, and real solutions to salmon and how they are valued and where they fit within the economy and the social fabric of British Columbia. He asked the presenters to comment on their experience on the role of stewardship and "every day folk", in the solutions that we seek.

Randall Peterman commented that generally, from what he hears indirectly about examples from other people, the stewardship that is engendered in people, such as streamkeepers groups, is a very positive move in the sense that they are going to be seeing what the risks are that are associated with various actions on a day to day basis. He believes that the link between them and whatever decision-makers are receiving in terms of feedback from the citizenry is important to develop more strongly. Perhaps what has not been done very well, is being able to communicate what the scientific uncertainties and risks are to a broader audience and to those people who do not have the background and expertise in those kinds of techniques. This is a real challenge. He referred to the orientation of the group that Greg Taylor described and noted that they probably do not have a similar concern about risks, but they do have economic and social risks to be concerned about. He noted that everyone has their own measures of risk that they are focusing on we would hope that, because they are all dependent upon long-term productive salmon stocks, that there would be some meshing of the actions required to minimize those risks, for all groups.

Malcolm Windsor commented that 'every day folk' do care about salmon and he stressed that these people are a tremendous asset and noted that he is not sure that they have tapped this resource adequately in Europe. They do need to get out more into schools and the public domain and talk about their work. People instinctively like this work and they like the salmon. However, in an organization such as NASCO

they simply do not have the resources to do that. In his opinion, our governments and particularly our NGOs can and are doing a lot. He noted that once you lose that critical level, which he has observed in Portugal and Spain where their salmon are critically depleted, you do not have fishermen or recreational fishermen depending on it, and it begins to disappear from the public domain and then there is no one to support it. It is very important to do something prior to reaching that critical state. If people do not depend on the salmon, or care for it then, then they will not help - work is needed, therefore, before reaching that point.

It is a question of priorities

Otto Langer expressed disagreement with Malcolm Windsor's remarks that governments simply do not have the money. He commented that we have just seen the NASCO countries spend approximately $150 billion waging a war in some distant land against a third world country and worried about mass destruction. He suggested that the environmental decay that we see all around us is a bigger concern in terms of mass destruction. In his opinion it is more an issue of government will - the money is there but it is not going to be spent on a lot of environmental issues, including salmon.

Malcolm Windsor agreed that it is a question of priorities and we do not seem to have the priorities that we once did. He reflected on why this is and commented that it seems that governments are reducing their research and development budgets. It might be that when stocks diminish there are a diminishing number of people who care about them. These governments have told him that they cannot provide any more.

Educating the senior managers

John Fraser commented that he is troubled, as Otto Langer is, with the comment that governments do not have any money to find out what is happening to the salmon once the smolts go into the ocean. He does not believe that Canada does not have the money to do it - in his opinion anybody who insists on that is just caving in to bean counters within the departmental structure - it has nothing to do with whether or not we can afford to have vessels and trained people trying to find and monitor this. He believes that we have the money and that, specifically, one of the problems in Canada, is that it is doubtful whether any deputy minister has ever sat down and spoken with anyone about the necessity to track where these salmon are going. He noted that there is no deputy minister present at this conference and commented that where we once had as good a public service as any country in the world, we now have managers making the decisions and the manager, who happens to be the Deputy Minister of Fisheries, might, by accident, know something about fish, but the probability is that he or she does not know anything about fish. They have been in other departments and have swirled up the managerial line. The difficulty with this is that the leadership that is expected in a great federal institution is not present at the upper echelons. He commented that it is likely the same in European countries. His specific concern is that, first of all, what NASCO and others are doing is enormously important. However, unless this organization determines what it would cost to do what needs to be done and, unless they can sit down with senior people, and not just deputy ministers, and advise them of what is needed, then it will not happen. He stressed that he would like to know what it would cost Canada to make an appropriate contribution to determine what is happening to these fish and who are the people to be talking to.

He then focused on issues related to Pacific salmon. He noted that we have had years of low ocean productivity and we have been asking questions such as, why we do not know where the fish are dying, how many are being taken by predators that have moved up into warmer waters, and who is tracking them? However, there is only silence to those questions. In his opinion this is because somebody, at the middle ranks, indicates that there is no money to follow through. He asserted that Canada does have the money and he believes that the federal government has to know about it. The difficulty is that the mid-rank representative of the department does not have the authority to do anything. Unless you meet with the top people and get those discussions out into the public, they do not see a need to be involved. He noted that we are experiencing budget cuts in British Columbia on the basis of decisions that were made

some years ago to set up certain programs, which were going to be sunseted. If they were important to be carried out, then why are they not important to continue being maintained. He noted that he is not talking about tens of millions of dollars and not hundreds of millions of dollars – rather they are modest sums. The specific thing that we need to know is who in the Canadian system is hearing this message and who in the Canadian system is telling you that we could not find the money to do it?

Malcolm Windsor replied that this analysis is absolutely correct.

The issue of accountability

Bruce Hill commented that it appears that one of the desirable outcomes of the precautionary approach is to generate conservative and prudent fisheries management decisions. He believes that most people can understand that - it is intuitive and is common sense, if not uncommon in practice.

We know that imprudent decisions and chains of decisions, especially in Canada, have led to the collapse of the richest fisheries in the history of the human race. In one of the previous presentations by Randall Peterman he suggested that we not use subsidies because they change the perception of risk and asked a rhetorical question, "How will fishermen react if they know they will be bailed out?" I think that is a very pertinent question, but isn't the lack of accountability, in regard to decision-makers, a form of subsidy? In other words, "How will decision-makers act and what is the history of how they have acted, if they know they will not be held accountable for their decisions?" In his opinion, this is the broken mechanism in the chain of decision-making in the precautionary approach that was presented and he cannot see how we can implement the precautionary approach consistently in the absence of that key issue of accountability.

Randall Peterman strongly agreed that we do not have enough impetus to evaluate the decision-making procedures, as opposed to the outcomes. He noted that often the media focuses on the outcomes and they might be disastrous because of poor environmental conditions, rather than poor decision-making. On the other hand, the outcomes may be fantastic, also because of good environmental conditions and not because of good decision-making. What we need to do is to focus more on how the decisions are made and that needs to be based on thorough documentation of the analyses and the trade-offs made by the decision-makers - and all of this needs to be transparent to those who are trying to hold the decision-makers accountable. In his opinion, we have a long way to go to make that happen. He agrees that we should be evaluating the decision-making procedures, and not just the outcomes.

The need for leadership, strong reporting structure, and accountability at the highest level

Malcolm Windsor commented that there is a structural problem in that top public people often do not spend very long in that particular position; for example, they may be dealing with fisheries negotiations within NASCO for two or three years and are then moved on to something else. This is quite common in civil services and it is a structural problem. How does one deal with that? What has been done is to create agreements with men in suits in hotels and what we need to know is what they have done to follow up with the agreements. We need a reporting structure, which requires that they come back the following year and report on their activities in front of all the other nations. That is the key - in other words, a strong reporting structure that exposes those who have done nothing.

John Fraser commented on the remarks by Bruce Hill with respect to accountability and decision-making and noted that there is a myth, in the Westminster Parliamentary system, that the only people that make any policy decisions are the ministers as a consequence of the deliberations of the Members of Parliament in the House of Commons. Sometimes they do but, far more likely, the real decisions are being made today, in our system, in the Privy Council Office and the Prime Minister's Office and most of those decisions are then put to the governing caucus to be rubber-stamped. In Canada, when we talk about fisheries, we have to talk about another thing which nobody wants to face up to and that is, "Where is the

leadership within the Department of Fisheries and Oceans itself?" There must be people in the Department of Fisheries and Oceans who know perfectly well that we should be tracking where these fish are going in the ocean. Nobody makes a decision to do something because they will be credited with higher marks in making sure that no money is spent.

His second point was with respect to money. Putting aside the Iraq war, he stressed that we should take a look at what it has cost our country to subsidize the people in Atlantic Canada because we did not spend enough money paying attention to what was happening to the cod stocks. The cost has been in the billions and is continuing. The Premier of Newfoundland is looking for money for the 800-900 cod fishers that are left with no employment, with the most recent moratorium. These are very large sums of money. He believes that the short answer to Bruce Hill is that the public service system, in our country, militates against decision-making and militates against responsibility. Many of the issues that circulate around drift off into committees and when something goes wrong nobody in the system is accountable. He noted that there has never been an inquiry into what happened with the Northern cod, and under whose watch it was that we allowed all the evidence, which was building from the mid-1980s onwards, that the cod stocks were in major trouble. What we knew was that the size of the cod was going down in every year's catch and nothing was done – not even an inquiry.

With respect to the Atlantic salmon, he noted that some years ago a decision was made to stop the commercial fishing. This decision was made by a Minister over enormous opposition. That was the only way to stop the demise of the Atlantic salmon in the Canadian Maritime Provinces. One has to say, "Where is the leadership we expect out of a large federal department and where is the public interaction and discussion on these matters?"

He noted the importance of World Summit on Salmon and commented that although we had a provincial minister present on the first day there was not one senior Department of Fisheries and Oceans representative present and no member of the governing party, as an elected Member of Parliament and moreover there was no message from the Department, at the upper echelons of the decision-making system. What should be uppermost in our minds then is that, if the decision-makers do not know what we are talking about, they are not going to do anything. To some degree, there are people within the departmental system who are so concerned about a negative personnel report, in raising issues, that they do not want to hear about it either. He cited an example of how difficult all of this can be. At the height of the Broughton Archipelago sea-lice controversy, when it was very much in the public domain, he contacted the then Deputy Minister of Fisheries and Oceans and advised him of the very great public anxiety over the issue. He was concerned that the department was saying absolutely nothing about the issue and that there was a need to know what action was being taken. He suggested that if the Minister did not have a complete answer, then he should come to the west coast and provide some answers as to what might be contemplated. The general feeling, by the affected and concerned public, was that the minister should have been dealing with this issue many months previously and should be taking some action. A week later, there was an ambiguous press release, which was the first public reaction and, following that, the sea-lice problem received more attention. He believes that we have an endemic problem, within the system itself, which makes what Malcolm Windsor is trying to do, doubly difficult. If we are talking to middle management people, who are sent to these meetings, and they report back to their superiors without it going anywhere, then we have to find a way to deal with this.

The most important right is the right to be responsible

Gerald Amos noted that he is a member of the Haisla First Nation from Kitimat and noted that he personally kills fish. His reason for making this opening statement is that we are all in this together and, in one way or another, we all kill fish. He believes that we have to put ourselves in that frame of mind if we are to do anything about what we have been discussing. He focused on the issue of accountability and noted that when he was first elected in Kitimat in the early 1980s, his grandmother would often call him

to tell her what he was doing when going to Vancouver, Victoria and Ottawa. He talked a lot about their aboriginal rights and title and described what was happening in this country on the issue. Her response, in her own language, was, "That is fine as long as you do not forget that our most important right is the right to be responsible." By extension, this means that in accepting that responsibility, it is also necessary to be accountable.

He reflected on once hearing a basketball coach talking about the game of basketball and how to teach the game. He said, "It is a simple game, it is the players that make it difficult." In his opinion, that is what we are dealing with. We have created so many graphs and charts that we are not hearing the messages, such as that coming from the Yukon First Nation representatives. "There are no fish returning for the elders to eat". This is a simple message but an important one. He wondered how many people present actually took the time to acknowledge this reality. Perhaps what we are doing here is attempting to swim up what he would call "the river of trust". Accountability is something that we all have a responsibility to ensure is instilled in the people who are leaders in this country and in our community. This is about people and how we relate to one another and how we carry out our responsibilities.

The importance of knowledge about the genetic structure of the species

Kjetil Hindar addressed his comments to Greg Taylor and also to those who do the forecasting of run sizes. He got the impression that knowledge about the genetic structure and the sub-divided nature of the species was seen as a threat to considerations based on the maximum sustainable yield of a large group of populations. In his opinion, this is not necessarily the case. Based on some recent studies on how we can conserve genetic variation, referring to the evolutionary potential of a species or of a group of populations, we know that when we think about the long-term genetic future we cannot be only interested in one single population. We have to be interested a large number of inter-connected populations; for instance, all of the sub-populations in the Skeena River system. If gene flow between these sub-populations is reasonably high, then it does not matter to the genetic variation in that system whether you harvest them in the sea indiscriminately or whether you harvest them on the spawning ground with perfect knowledge. If gene flow is very little, then it matters more to harvest them near the spawning ground or when you know which run they are fishing on. If there is one sub-population, which is much more productive than the others, such as Babine Lake, then you can, by harvesting more on the most productive population, keep the same yield and conserve more genetic variation than if you harvest all of the subpopulations at the same rate. It is not necessarily true that genetic knowledge is always to the negative for those harvesting salmon.

Greg Taylor that this is a very technical argument and beyond his capacity to address fully. He noted that his understanding is that gene flow is extremely limited between the 28 sockeye stocks on the Skeena, and he referred to the argument that Carl Walters raised, where most of us would think that all of those stocks have to be preserved but there are some who would argue that there should be a very limited stock out there. That then leads to the question as to whether we are going to lose the fishery over one stock. With respect to the other issues that were brought up concerning whether there is no gene flow and the preservation of these 28 stocks, the questions is at what level do we preserve them? There are several levels, such as their maximum productive capacity. Or is there some other level where they can exist, and what is acceptable to society?

Putting a value on the culture of the First Nations people and the salmon

Kjetil Hindar commented on putting an impossible value on the culture of the First Nations' people in their salmon fishery. He believes that this should be viewed just as we put a threshold on the number of salmon we need to keep in a stream in order for this population to avoid extinction. On top of that threshold, which has no economic value except the perpetuation of the species in the system, he would put another threshold on some number of salmon needed to avoid the extinction of the First Nations' culture. That number could be what Stanley Njootli, the representative from theYukon said; that is, that it

had to do with their need for salmon, which was salmon to sustain themselves and not salmon as a commercial commodity.

Would a certification system create the right incentives to create long-term productive salmon stocks?

Randall Peterman agreed with Jan Konigsberg's basic tenet on the certification of the Alaskan salmon fisheries and that the bar was so low that just about anybody could jump over it. He does not think that is a good model at all and what he would like to ask both Jan and Greg Taylor is whether a certification system, that has a sufficiently rigorous series of tests built into it, would help to create the right incentives on the part of the fishing industry, managers and others who use and abuse fish and fish habitat, to create long-term productive salmon stocks?

Jan Konigsberg replied that the basic assumption of the MSC is that somehow the market forces are going to actually improve fisheries management - at this point he sees little evidence that the profitability from eco-labeling is going to drive an entire industry, particularly one that has as its major source of competition, farmed salmon. He believes that there is a possibility that, regardless of how rigorous the standards are, this also increases costs to the industry to label and increases cost of production generally. He finds it difficult to believe that those costs are going to be met by substantial gains in profitability, simply because of the substitution influences in the market to other fish and food sources. At the root, he does not think the notion that this is going to drive improvement in fisheries management is tenable. He believes that if we are going to have standards, we ought to evaluate them in a public process through a public agency and either decide we are going to impose and enforce them as a matter of publicly owned resource or to tell people what the unsustainable fisheries are and let it go at that.

Greg Taylor replied that he is a little bit more optimistic but only when looking at it from a BC Pacific point of view. He believes that there is an opportunity as we develop a wild salmon policy that it could be linked with some MSC rules that everybody can buy into and can feel comfortable with. He believes that it creates a marketing opportunity for the commercial industry. He noted that they have to face the fact that there is going to be less fish available to the commercial fishery in the future and believes that there are niche markets that they can entertain with that kind of label. If it is done right and viewed as an opportunity, rather than a threat, then we should look very hard at using MSC and tying it in with where we are going with wild salmon.

Vicky Husband referred to the stance of the Sierra Club on the whole fishery. One of their real objectives is to keep people fishing although conservation comes first for them, and it is a very strong objective. She noted that her concerns with respect to the MSC are similar to those that Jan Konigsberg expressed. We are seeing in other parts of the world is no indication that it is actually a sustainable fishery that is being certified, nor that it improves management. She noted that they are watching this very carefully and are a part of the process in British Columbia, to ensure that it is something meaningful.

The value of hatcheries in Alaska

William Heard expressed his agreement with Jan Konigsberg's assertion that Alaska's strong declaration against farmed salmon, while stated in biological concerns, is in reality an economic one, and simply related to the concept of supply and demand. With more salmon in the world today Alaska is struggling to maintain a part of their former position. He also believes that the MSC declaration is politically driven and economic in trying to improve market positions.

He noted however that he takes strong exception to the claim made by Jan Konigsberg that the Alaska hatchery program is a threat to maintaining Alaska's strong biodiversity and abundant and healthy wild salmon stocks. The Alaska salmon hatchery program admittedly, not perfect, was formed under a different set of precepts than most other hatchery programs. Salmon management in Alaska by State Law

has, as its highest priority, to protect and maintain wild stocks. The management is structured on escapement base and not on fishery targets. Vigorous habitat protection is a priority and there are no dams on any salmon producing streams. Mixed stock fisheries whenever possible are avoided. Hatcheries supplement, but do not replace, wild stocks in the fisheries. The stakeholders in the hatchery program pay for the hatchery costs and the hatchery program is designed to minimize hatchery/wild stock interactions. Most hatcheries are located on non-anadromous streams and state-wide genetics policies are designed to protect and maintain wild stocks. There are strict fish health rules and statutes and careful siting of hatcheries with prescribed terminal harvest areas to allow a focused harvest on the more abundant hatchery stocks. Root stock diversities in the hatchery program are rigorous and there are no transfers between regions, and the aggressive marketing of all hatchery production allows targeted harvesting of hatchery fish. The question is: Is it sustainable? He believes that it is and the historical records suggest that it is. He does agree with Jan Konigsberg and others that there is concern about recent administrative changes that will focus on greater developmental use of Alaska's natural resources and reduce some of the habitat protection concerns.

Cutbacks on the Skeena harvest rates

Greg Taylor replied to Vicky Husband and Terry Glavin, that he appreciates their comments and understands that they are coming from a good place. However, he believes that they are missing a key point. For the commercial fishery in the Skeena River, the future is here today. They are faced with a 40% cutback in harvest rates, starting in this current season - under those cutbacks the consequences are that the fishermen are looking at a 50% reduction in their personal incomes. The consequences are being felt now - this is not about 'dire warnings', it is what people are dealing with right now.

Cutbacks on harvest for aboriginal fishers in the Yukon

Juanita Sydney commented as an aboriginal fisher they manage within their traditional territories for their harvest of salmon. She was not aware of the MSC designation that people are talking about. She noted that even though the Alaskan stocks are apparently healthy, in the headwaters of the Yukon River they are experiencing a reduction in numbers, resulting in a reduced level of harvest for aboriginal fishers; their subsistence harvest has been reduced to a level of 75% (this is a recommended reduction). She asked: If there is a sustainable fishery allowed, then why are we being asked to cut back on our fishery? They used to be able to harvest at least 2,000 pieces of fish, which is a small and insignificant amount but what is required to sustain their people. She noted that at one time there were more, but now they have less requirements because the people are going away from the land - yet the numbers are still reduced in their harvest. They are not able to catch what they need to survive and live on. She noted that they do not require the fish to sell or give away, but do need them to eat. This year because they are potentially looking at a much smaller run, the First Nation has taken some initiative and they have paid a citizen to go over to other rivers where there are healthier stocks and to bring fish in to their community because their elders need fish to survive. She emphasized also the importance of *'managing the salmon for the salmon'*. "They are animals and they have a greater right to be here than we do."

How do we harness incentives to effect change in fisheries such as groundfish?

Terry Glavin commented on the groundfish trawl that Ray Hilborn described and noted that, over the 12 month period that ended on April 3, 2003, there were 75 million pounds of fish that were harvested by 75 trawlers that came from managed species – that is species for which TACs applies – and, for most of these species, the fleet is actually well within its total allowable catch. However, over that same period, there were about 25 million pounds of fish that were caught that are not protected by any catch limits at all. There are as many rockfish species that are not protected by TACs as are protected by TACs. There are a series of structural problems within the trawl fishery mainly as a consequence of a lack of complete integration. He posed the question: In terms of incentives for fishermen, to the extent that the fear of Species At Risk Act (SARA) listings, the growing public anxiety over the fact that 30 million pounds of

fish were dumped over a twelve month period, and the fear of external forces threatening what is an otherwise economically viable fishery, how do we harness those incentives to effect change in fisheries such as groundfish?

Ray Hilborn replied that the solution is marine protected areas. There are actually something like 400 species caught in the BC trawl fishery and there is no way that we are going to be able to actively manage even a significant fraction of these. Under the Total Allowable Catch (TAC) right now are the economically most important species and we might imagine having the science to do two or three times that many. He believes that for these very complicated fisheries society will have to choose to be very risk-averse, (see Terry Glavin, Chapter 22) and say that we are not going to harvest anything unless we can prove, at some level, that it is sustainable. Alternatively we will have to determine how to develop a system of reserves where we are going to manage the economically important species under active management and we are going to cover the risks by protecting the rest in some pattern of protected areas.

Randall Peterman asked how we would deal with the situation that is more representative of the fisheries' world than Bristol Bay sockeye; namely, very complex systems and many different objectives going in different directions. He posed the question: Do you have any suggestions on how we might align the interests of all the different groups so that they are headed in the same direction?

Ray Hilborn replied that he believes that we should go to the places where there is some hope and work there.

Nobody is in charge

Wayne Harling commented that there may be fine managers and directors in the trawl fishery but, having worked with the DFO for 36 years and on trawling, he is doubtful. He noted that the senior manager of the DFO Pacific Region is now on a four month French course at the height of the fishing season and he has been replaced for one month by another person who, in turn, will be replaced by a third person for three months, by which time the season will be over and the original manager may return being fluent in French in a primarily English speaking area of Canada but out of touch. In his opinion, nobody is in charge.

Marine protected areas strategy

Otto Langer commented on Guido Rahr's presentation with respect to protected area strategies. He agreed that there is a need for them and expressed the concern in terms of British Columbia moving in the direction of a protected area strategy network. He noted that what came out of a land use planning process was that now that there are protected areas, we could get into resource extraction in the rest of the province. As usual, environmentalists cannot have everything and it could be an overall significant net loss.

Guido Rahr replied that giving areas a higher level of protection does not have to be triage. If that were the fear then we would have no national parks in any nation of the world. He believes that we have to communicate the message that it is important to have a very high level of protection in some places and continue to raise the bar across the landscape, or we are not going to succeed.

Watershed protection

Frank Heinzelmann referred to a slide presented by Guido Rahr with a watershed and a plan to protect some parts of the habitat. He is concerned that we should always see watersheds as a dynamic system where things change all the time. It may actually be better to focus on keeping the major watershed processes within what we would consider acceptable bounds rather than delineating particular areas that you want to protect at all times.

Guido Rahr replied that if you can get an entire watershed in some kind of protected status that is the best and, at least at the sub-basin level, that should be the goal. The point that Frank has raised is especially problematic when talking about the flood plain and drawing circles around specific places in the flood plain. It is true that the watersheds are dynamic and the key habitats do move across the landscape. At the same time, it is essential to hang on to the existing nodes of productivity or there are no anchors from which aquatic and riparian species can re-colonize the other parts of the watershed. The main point is to get as much as you can and especially make sure that the key headwater refugia are protected, which will have downstream benefits to the entire habitat below that.

Jack Stanford added that the flood plain reaches within whole river basins really do not move around very much and there are a lot of dynamics within those key and graded reaches. However, they stay entrenched in the landscape even though sediment plugs move through the system. The whole system is dynamic and, if you protect only certain parts of it, you may block part of that dynamic. On the other hand, as Guido Rahr noted, there are certain places within the landscape that are so vitally important that perhaps 80% of the biodiversity is in those few places and it is essential to use them as anchors.

Should we be protecting more than upland spawning habitats?

Craig Orr commented that what Guido Rahr was describing is really quite admirable; however, given the presentations from Carl Walters and others with respect to marine survival problems, he suggests this is only a part of the solution. For example, Norway has 21 national salmon fijords and 13 of those will be permanently free of fish farms. Therefore, while in British Columbia we seem to be in denial about the risk to juvenile salmon, Norway has actually established a clearly articulated policy that salmon farms will no longer represent a threat to wild salmon by the year 2005. With this issue in mind, the question arises: Should we be doing more instead of just protecting the upland spawning habitats?

Guido Rahr agreed and noted that he wanted to be clear that the strategy that he was describing reflects the freshwater and estuary part of the salmons' life history and that part of the conservation problem. That does not however address the marine areas. We have to think about how we are going to create protected areas in the marine environment to the extent that we can. It may even be temporal marine protected areas that correspond with the movements of fish - that is an area that needs to be elaborated. He noted that his reaction to Carl Walters' point was that, the very times that we need high production freshwater habitat is during times of low ocean survival so that a high number of smolts are necessarily heading out to the ocean to mitigate the effects of a fluctuating ocean. They found in Oregon and Washington during periods of bad ocean conditions, they could have lost significant genetic diversity because they did not have enough production in the freshwater habitat to carry those stocks through poor ocean conditions.

A thoughtful comment

Marion Sheldon, Teslin Tlingit Council, Teslin, YT, Canada

Marion Sheldon commented that she is a member of the Teslin Tlinget people of the Yukon, and referred to the comments made earlier by Juanita Sidney, from their community.

"Prior to my grandfather passing away, I had the privilege of spending the last four days with him and it is believed he was 112 years. He used to tell me about the gold rush when people traveled into our territory and the impacts that it had on our people. I see so many resources in this room and every time I come to a cross roads in my life, in being one of the stewards of our land, I wish I had this much knowledge and technical support to arrive at a common vision. I see a common link - somebody referred to it as a string of beads. It is about time that we, as a global people, look at ourselves in four directions and at what each nation has to offer because each nation of all colours, in this world, has something to offer. The oriental people bring us patience; the Caucasian people in this room are the people of movement and it is very obvious; the black people of our nation are the ones who fight for reason in the world, and we, as the aboriginal people of the world, come to you with vision. When Cook landed here,

the first person he met was an aboriginal of that land. When I go to Russia by boat, I hope that the first person I might meet will be an aboriginal of that land and I will know where I am going on their land and how I am going to sustain myself on their land. Until we circle our resources, we will never make it better for seven generations to come."

"I hear chaos in the media about commercial fishermen, net fishermen, and sports fishermen, but we only have one source of food that we are trying to protect and consume in order to sustain us. We have to circle our resources and acknowledge that every seven years, every species on this land goes through a change. It is not the animals on our land that need to be managed, it is the people who go to harvest, to study and to understand. If people trap on our land, they know which animals they will have success with and know what the market is; if people are going to fish, they know which creeks have the grayling, or the rainbow trout, or the whitefish, or the bull trout, or the salmon. I really believe in circling our resources to look at special management in protected areas."

"In the north, we are affected by global warming from the Arctic Ocean to the Pacific. Juanita Sydney, advised us about the 2,000 salmon needed to sustain our people - elders that have lived on this land who cannot consume the processed food without being physically contaminated themselves. Our people were nomadic and went to the streams to gather ducks in the summer and harvest the eggs of some of those birds. I question how we have been impacted through policies and regulations. We, as young people, have a responsibility to the older people in our nation. They have made us stewards of this land to become educated and to understand the discussions we have been having. I might not know all of your terminology but I do not need to be a scientist to sit here because the knowledge I have gained has come from the First Nations."

"To come out of the North and see one's special protected areas, which is where I go every summer, and what I am a part of, is especially rewarding. Mass production and mass development will affect everything if we are not cautious. All I can say to the knowledge holders here is "Do your best". When you go out into the world, I would ask that you do the best job you can, not for yourself, but for the generations of grandchildren you will have. I encourage you to circle your resources. When we talk about protected areas, remember the evolution of that land you want to protect and how it will change in the seven-year period. For the seven generations that you work, the cycle of life will lead you. The knowledge is there but you must involve the aboriginal people."

"Let's join our resources and let's have a common front when we go to the United Nations so that we don't have discrepancies that discourage our young people – give them clarity. Don't look for greed but rather a sharing of those resources. If it took one salmon to feed this room, I am sure nobody is going to say that they want the whole fish. If we only had ten fish to feed all of us, how do you think we would prepare that food and how would we sustain it so that tomorrow we would have ten more fish to eat? I would encourage everyone to take their neighbours by the hand, rather than continuing to argue over whose theory is the best, which is only wasting precious time. Look for the commonality in your theories and do your best."

SECTION V

Photo courtesy of Jennifer Nielsen, USGS, Alaska Science Center

CHAPTER 28

Endangered species listing process and status of Atlantic salmon in the US

Fred Kircheis, Executive Director (retired), Maine Atlantic Salmon Commission, Carmel, ME, USA

Introduction

The Maine Atlantic Salmon Commission has been in existence since 1947. It was not formed in response to the endangered species listing process. It is a state agency, with mostly state funding but with 50% federal funding for research. The Atlantic Salmon Commission has existed for 56 years under three or four different names but always with the same mission: to protect, restore and maintain Atlantic salmon stocks. However, we have been notably unsuccessful, like everybody else.

To begin with, I am going to give a brief introduction on the biology, history and range of Atlantic salmon. Originally, pre-contact, Atlantic salmon were found all the way down to Long Island Sound perhaps as far as the Hudson River. Previous presentations (Chapters 5 and 6, Hindar and Whoriskey) have identified the Atlantic salmon range in the North Atlantic and on the eastern side of the Atlantic and as far west as Greenland. I will address the status and the endangered species process for Atlantic salmon in New England.

US Range of Atlantic Salmon

Figure 28.1 shows the historic range of Atlantic salmon in the US and the four rivers, the Penobscot, Merrimack, Connecticut and Housatonic Rivers, which were the major rivers for Atlantic salmon in New England. The salmon are now extinct in the Housatonic, the Connecticut and the Merrimack Rivers except for remnant populations dependant entirely upon stocking.

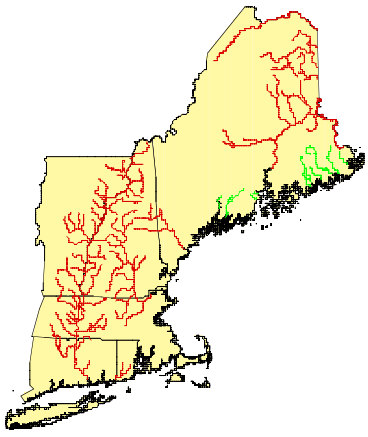

Figure 28.1. US range of Atlantic salmon.

Wild runs have all but disappeared from New England waters. We have had on the east coast a much longer history of trying to destroy our fisheries than on the west coast and we have been notably successful. We have dammed rivers since the 1600s, have had industrial and domestic pollution, and commercial, illegal and recreational harvests that were totally unsustainable. Commercial harvest of Atlantic salmon has been outlawed for several decades. One of the first tasks I undertook when taking over the directorship of the Atlantic Salmon Commission in 1999 was to close the recreational fishery. At that time, it was a catch and release fishery but we had so few fish that we could not even sustain this low impact fishery.

Currently in Maine, there are fifteen rivers which have Atlantic salmon – more or less. Eight of those rivers were listed in the endangered species distinctive population segment (DPS); I will address the genetics used to establish this DPS below. Clearly, Atlantic salmon genetics do not change at the United State's border with the Province of New Brunswick. The distinctive type of salmon that is found along the coast of Maine is also found about halfway across the south coast of New Brunswick including the St. John River. A tributary to the St. John, the Aroostook River, enters northern Maine where we still have a very few fish that are trucked over the Magaguadavic dam.

Maine river systems

Rivers in Maine do not compare to rivers on the west coast of North America - they are small streams or tributaries by west coast standards. Atlantic salmon are found in the Dennys River, and the East Machias, Machias, Pleasant, Narraguagus, the Duck Trap, Cove Brook and the Sheepscot Rivers. These rivers, shown in Figure 28.2, have been listed by the Endangered Species Act as being part of the DPS. Atlantic salmon are also found in the Kennebec, Androscoggin, Saco, and Penobscot Rivers but the endangered species listing process has yet to decide what to do about these populations and they have not yet been included in the DPS.

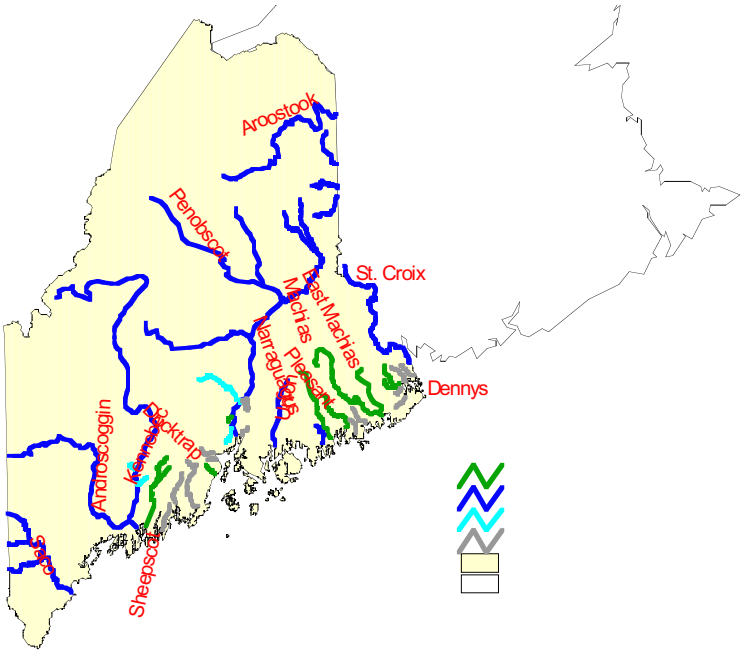

Figure 28.2. Maine Atlantic salmon rivers.

Penobscot River Returns

Figure 28.3 shows the numbers of salmon returning to the Veazie trap, a fish trap located at the head of the tide in Bangor on the Penobscot River. Although the Penobscot River in Maine is not listed in the DPS, this is our longest data set and it clearly shows what has been happening throughout all rivers in Maine. This salmon population is almost entirely dependent upon stocking from a hatchery that is operated by the US Fish and Wildlife Service in cooperation with the State of Maine Atlantic Salmon Commission. Whether or not the hatchery is a good or a bad thing, it is the only thing we have. Without the hatchery, the Penobscot River would not have any Atlantic salmon. The pre-European contact population estimate for Penobscot River Atlantic salmon is about 100,000 fish, which is small by the

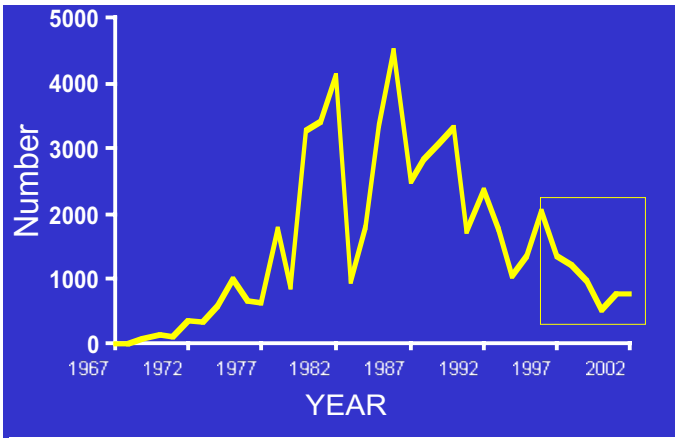

Figure 28.3. Penobscot River returns to the Veazie trap, 1967-2002.

	Penobscot	Union	Narraguagus	Pleasant	Dennys	St. Croix	Androscoggin	Saco	Aroostook	Total
1996	2045	69	64		10	132	39	54	65	2478
1997	1355	8	37	1	0	28	1	28	10	1468
1998	1210	13	22		1	41	4	28	30	1349
1999	968	9	32			13	5	66	25	1118
2000	535	2	23	3	2	19	3	49	17	653
2001	786	0	33	11	17	25	5	69	28	974
2002	**779**	**5**	**8**	**0**	**2**	**20**	**2**	**47**	**7**	**870**

Figure 28.4. Returns of adult Atlantic salmon to Maine rivers equipped with counting facilities, 1996-2002.

standards that have been discussed for Pacific salmon. However, our habitat is different as is our productivity and the species.

Figure 28.4 shows returns of adult Atlantic salmon to Maine Rivers equipped with counting facilities. The total on the right hand column indicates current year returns with the returns for 2002 on the bottom line. The Penobscot River return for the 2003 calendar year through June 9th is 123 fish, well below recent historic levels. There are still (as of June 2003) no salmon returns on the Narraguagus River, Pleasant River, and Dennys River. In the Duck Trap River in Cove Brook, we estimated the numbers in 1991, through redd counts and electro-fishing surveys for parr and young of the year. There were no redds, no parr and no young of the year. Last year the Pleasant River had no returning adults and only 11 in 2001. The Dennys River shows 2 fish last year but it was actually zero because both of those fish were aquaculture escapees.

Possible reasons for salmon decline in freshwater and marine enviornments

A total of sixty-three smoking guns related to freshwater and marine environments were identified by Atlantic salmon experts who analyzed the subject in Halifax, Nova Scotia in 2000. Those occuring in freshwater include: water withdrawal for irrigation (Maine has a significant amount of wild blueberry land that is irrigated with direct withdrawals from some of these very small salmon rivers); riparian zone habitat degradation due to agriculture and forestry operations; and, impassable dams and problems with acid rain. The latter factor is not quite as bad as it is in Nova Scotia but the problem is escalating. Poaching is also a big problem.

In the marine environment, causes include the salmon aquaculture industry, which is a relatively new and, until recently, growing occupation. The border between Maine and New Brunswick includes a shared marine environment called Cobscook Bay where there are many salmon pens in the waters of both New Brunswick and Maine. The same companies own many of the pens and Norwegian interests own many of these companies. The Province of New Brunswick and the State of Maine each have their own set of rules for developing policies to deal with aquaculture, and the corporate owners in Norway try to ignore them or work around them.

Salmon aquaculture

We all know some of the issues associated with aquaculture, including escapees and disease. We do not have an issue with sea lice on wild fish salmon associated with aquaculture in Maine as they do in Norway and other European areas. Our estuaries are broader and wild fish coming through are not

constrained to travel in close proximity to the pens. We do not know exactly where they travel but they do not seem to be accumulating sea lice. Infectious salmon anemia (ISA) is a relatively new disease striking very hard at the aquaculture industry. It was not surprising to us that the industry in Maine denied having the disease whereas the fish in New Brunswick were dying in pens that could be seen across the same body of water. Two years later, coincidentally, when the State of Maine approved an indemnification plan, the aquaculture industry in Maine admitted to the disease and pens were depopulated in an attempt to stem the spread of ISA.

Salmon production in the aquaculture industry in Maine has increased exponentially since the early 1990s but in the last two years there has been a drop in production that is not attributed to a decline in production but because of the ISA disease that required the industry to de-populate their pens and start over again. All salmon pens were removed from the water in Cobscook Bay, taken to shore, hosed down, disinfected and left in the sun for three months before being put back in the water. Whether or not three months was long enough has yet to be determined but ISA has again been documented in Cobscook Bay in 2003.

The aquaculture industry has been under attack from a number of sides and the NGOs have sued the industry for "illegal discharge of pollutants". This is logical if one thinks of fish feed and fish waste, but in the suit, escaped aquaculture fish were identified as a pollutant and the court has agreed with this designation. When the industry de-populated their salmon pens, there was an increase in the number of aquaculture escapees that appeared in the two Maine rivers closest to where the pens were located. These are two rivers with zero, or near zero, wild fish, which meant that the only fish populating the rivers were aquaculture escapees. We know that these escapees are a hybrid between North American females and European males, which is another issue being addresssed in the lawsuits against the industry.

Predation by seals

The harbor seal is an endemic animal in Maine and its numbers have increased enormously since the Marine Mammal Act took effect – they are certainly having an effect on salmon. Reports of salmon taken in traps show evidence of seal bites being common and seals concentrate in estuaries during salmon migration periods. Relatively new to Maine waters is a tremendous increase in the populations of the great gray seal and there are breeding populations that were not previously resident there. The aquaculture industry is concerned because they have to deal with these seals intruding into the pens and causing direct mortality or creating holes that lead to fish escapes. We are not sure what the issue is with seals in the wild because there are no data to support that the number of seals is affecting the number of salmon. However, if a large number of seals are eating some Atlantic salmon, and there are fewer than 1,000 salmon, then that can have a significant impact on salmon recovery efforts. Our fish also migrate northward along the east coast of Canada on their way to Greenland and back and go through an area that has large numbers of harp seals. The harp seals were mentioned earlier with regard to the fur harvest being eliminated and the number of harp seals correspondingly increasing (Chapter 3, Hutchings).

Predation by birds

Avian predators, such as the double crested cormorant, have established tremendous nesting populations in proximity to estuaries on Atlantic salmon rivers. We do know they eat smolts but we do not think, based on several scientific studies, that they are eating enough smolts to make a difference. However, these same fish migrate up the east coast of Canada where, in proximity to the Gulf of St. Lawrence, there is a burgeoning population of gannets, a very large fish eating bird. Suggestions have been coming out of Newfoundland that the gannets are causing significant impacts on marine fishes. We do not know if they are eating Atlantic salmon because it has not been documented, but it is one of the 63 smoking guns mentioned earlier.

The other issue is that the freshwater distribution of the Atlantic salmon in the United States is at the very southern tip of its range. Scientists know that animals at the edge of their range tend to fluctuate in abundance. We may be going through a period that is part of a natural cycle of decline that we do not want to admit to.

Factors impacting recovery

The factor playing into the complex issues of Atlantic salmon recovery efforts is one addressed by Malcolm Windsor (Chapter 24). In the early 1980s and 1990s, Greenland harvested a tremendous number of Atlantic salmon for internal consumption and export to the European market. Once they discovered where the fish were congregating they were very susceptible to floating gillnets, with Greenland fishermen netting as much as 2,500 tonnes in some years. This corresponded to the declines in spawning fish that were being experienced in North America. Recent agreements with NASCO have closed down this commercial fishery entirely but Greenlanders are still allowed a sustenance fishery of 8 to 9 tonnes. This is still a lot of salmon when talking about remnant populations.

About 67.5% of the salmon taken in the Greenland fishery are North American fish and the balance come from Europe. Greenland only has one very small salmon river and it does not produce enough salmon to feed very many people. Greenlanders consider that the fish that grow and flourish in their waters are their fish and that we, in North America, only have fry and parr that are produced by their adult fish. The current agreement with Greenland is for a one-year moratorium on commercial fishing of Atlantic salmon. Last year (2002) there was an agreement between the Atlantic Salmon Federation and other NGOs to close the fishery for one year and prior to that there was a three-year closure on the fishery and a closure of the fishery in the Faeroe Islands. However, the Faeroe Islands fishery is mostly for European fish and their catch of North American fish is minimal. The closure of this fishery can be in part attributed to the NASCO negotiations, but economics is a also factor. When people in Europe and North America go to the market to buy Atlantic salmon and there is an inexpensive aquaculture fish, with perfect color and shape and in possession of all of its fins, lying beside a more expensive wild Atlantic salmon that has been caught in a gillnet that does not look as desirable as the fish lying next to it, the consumer will buy the less expensive aquaculture fish. Figure 28.5 shows the historical catch of Atlantic salmon in the West Greenland salmon fishery and the trend of a declining fishery in the past ten years or more.

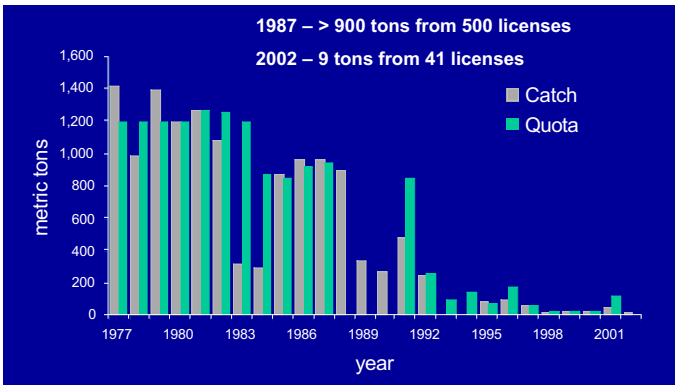

Figure 28.5. Historical catch and quota of Atlantic salmon in the west Greenland fishery from 1977-2001.

Dam removals

The State of Maine has had a number of dam removals in recent years. Those listed in Figure 28.6 have taken place on Atlantic salmon rivers and include the Guilford Dam which is scheduled to be removed in 2003. Some of these have been easy to do while some are decrepit and the owners wanted them removed and the community valued the free flowing aquatic ecosystems more than the structure of the old dam.

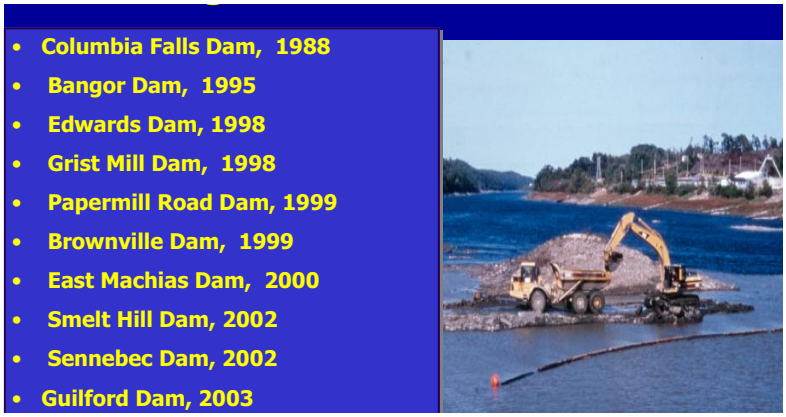

Figure 28.6 Significant dam removals in the state of Maine.

Others have been more difficult such as Edwards Dam in Augusta, Maine, at the head of tide on the Kennebec River (photograph on right in Figure 28.6). The photograph was taken by the dam owner and it was still generating electricity at that time although it was a very marginal dam that generated only a small amount of power. An agreement was struck whereby the dam was taken by the State and removed, opening up fifteen miles of river that had been dammed for almost 200 years. Someone asked me how long it takes to recover from 200 years of inundation behind a dam - my response was approximately until the first major rainstorm. It was very startling for those of us who have had the opportunity to visit the upstream sites on the Kennebec River to see perfectly clean gravel where there had been 20 feet of standing water for almost 200 years. With the removal of the dam, there are now spawning Atlantic salmon, significant populations of river herring, growing populations of striped bass, and relatively large numbers of Atlantic sturgeon for 15 miles up-river from this site.

This dam removal may have been carried out under the guise of Atlantic salmon habitat restoration but there are also a multitude of public benefits which have resulted from this. For example, right now, on this river, there are at least two companies offering guided fishing trips for small mouth bass. It is a one-day canoe trip from the next road upstream down to where the dam had been located and many family groups now canoe this beautiful area for recreational purposes. Although it is in a heavily developed area, by Maine standards, no houses can be seen from the water; instead, there are bald eagles, deer, and moose. As a bonus people can also catch fish from a beautifully clean river. In recent history, Maine salmon rivers have never been so healthy and, right now, none of the Atlantic salmon rivers, other than the Penobscot River is dammed. None of the Atlantic salmon rivers is suffering from industrial pollution and none has domestic pollution problems. There is a small amount of agricultural activity on one of the watersheds but the water quality has not been as good as it is now. Problems with acidity persist on many of our watersheds but, overall, water quality in Maine rivers is excellent.

Atlantic salmon: Endangered Species Act

I have explained Maine's history with Atlantic salmon and now am going to discuss politics and process. In 1965 there was a Status Review carried out as a collaborative effort between the US Fish and Wildlife Service and the National Marine Fisheries Service. The data they collected suggested listing seven Maine rivers as *threatened*, meaning in danger of becoming *endangered*. The Governor of the State of Maine and his cabinet yielded to pressure from various industries and special interest groups, who viewed the listing of these fish as *threatened* as an attack on the State of Maine. These interest groups felt strongly that Maine industry, Maine people and Maine economic interests would be harmed by such a listing.

1997 State of Maine Atlantic Salmon Conservation Plan

The Governor appealed to the federal services, and proposed that the State would create its own Maine Atlantic Salmon Conservation Plan for the seven rivers that were being considered for listing as *threatened*, with the provision that the federal services' listing be held in abeyance for at least five years. The State appointed committees in 1997, and created the Atlantic Salmon Conservation Plan for seven Maine rivers, which was duly accepted by the federal agencies who agreed to a five-year moratorium on the *threatened* listing. Trout Unlimited and the Atlantic Salmon Federation looked at the State's plan and determined that it was inadequate and sued both agencies of the federal government for not listing the Atlantic salmon as first proposed.

Subsequently, another status review was conducted and the data indicated significant salmon population declines since 1995 and, in fact, recommended that eight rivers be listed as *endangered* as opposed to the previous *threatened* proposal. The Governor accused the federal government of breach of promise and then sued the federal services for using unsound science for listing the fish. The NGOs agreed to put their lawsuit on the shelf until the State's lawsuit against the services was settled.

The two federal services, in the meantime, proceeded to list these eight rivers as *endangered* in the year 2000 which, in turn, generated a number of activities within the Endangered Species Act. (As an aside, I am not an expert in the Endangered Species Act but am conveying to you my personal experience with how it has worked in Maine.) A time-frame of 18 months was established for creating a recovery plan which was to be preceded by a draft recovery plan that would be reviewed in the public forum with public input, debate, discussion and discourse. Ultimately, a formal recovery plan would be drafted and used as the standard guide to the recovery of the Atlantic salmon in these eight rivers in Maine. The draft recovery plan was due in May of 2002 and, one year later, we have yet to see a public draft of this document. It is now 13 months overdue but I am told that it will be available next month; I have heard these promises many times. (Note: this manuscript was reviewed in September 2003 and the draft recovery plan is still not available.)

At the same time that the listing occurred, the Maine delegation to the U.S. Senate leveraged $50,000 out of the federal government and gave it to the National Academy of Science to conduct a review of the listing process and the science that was used to justify the listing. The National Academy of Science put together a panel of experts and there were two-parts to their charge:

- The first part was to decide whether or not they supported the federal definitions, based on the genetics, as to whether or not these eight rivers were, in fact, a distinctive population segment and whether or not they qualified for protection. That part of the review was finalized and published in December of 2002.
- The second part was to have been a list of recommendations on how to proceed towards recovery and this was identical to what the Recovery Plan was supposed to do. The Recovery Plan is still not available and neither is the National Academy of Science review, although it was due December 2002.

The National Academy of Science has taken the stance of waiting until it sees what the recovery team recommends and the recovery team, in turn, is waiting for the recommendations of the National Academy of Science. Nobody seems anxious to write a report until the other does and so, right now, we do not have either report.

Another part of the Endangered Species Act listing process is supposed to be the designation of critical habitat and nobody is talking about that.

Dueling Geneticists

During the suing process, the US Fish and Wildlife Services and the National Marine Fisheries Service worked with a highly regarded federal geneticist in the Leetown, West Virginia, laboratories who claimed that these rivers were all different and that they warranted listing based on this difference. In contrast, the State contracted with another renowned geneticist who, using exactly the same data and exactly the same tissues to run through all of his machinations, emphatically stated that these fish are all the same and that they do not warrant designation as distinctive population segments. There has been 50 years of stocking Atlantic salmon from one river to the next and back again – some came from Canada and some came from within the State of Maine. Arguments that insisted that the fish are not different used that stocking history as the basis for showing that there has been too much genetic mixing to show distinction in any one, or any eight, rivers. The people who insist that the fish are different considered that all these stockings over all of those years did not affect the population because they did not interbreed with the fish that were programmed to succeed in those rivers. Both the National Academy of Sciences and the district court have agreed with the federal geneticist and supported the conclusion that the fish are different from other populations and warrant listing.

Main Atlantic Salmon Recovery Plan Team

The Recovery Plan is being drafted by a collaboration of three agencies. NOAA and the US Fish and Wildlife Services are required by law to draft the plan because they are the organizations responsible for the listings. They agreed to work with the State of Maine Atlantic Salmon Commission in a collaborative way in order to create the plan. This has not been a seamless relationship. The US Fish and Wildlife Service assigned a person to the task who is a specialist in avian recovery plans and who does not know a salmon from a smelt. The National Marine Fisheries Service assigned the task to one of their staff people who had recently moved from Hawaii to New England. He was a neophyte concerning Atlantic salmon biology and politics. The person from the Maine Atlantic Salmon Commission assigned to the task was an urban planner, and although he was under the close scrutiny of myself and several other experts in Atlantic salmon, he had no biological background. Some of the problems came from those relationships and some from the way in which these different agencies worked. The US Fish and Wildlife Service, Region Five, could not make decisions on a regional basis and all of their decisions had to be approved in Washington DC, whereas the National Marine Fisheries Service could make decisions on a regional level. The Maine Atlantic Salmon Commission, because it is under the direct line authority of the Governor and because, at that point, the lawsuit was still pending, could say nothing that had not been approved by the Governor's lawyers. It has been stated in other papers that the productivity of any committee tends to be inversely related to its size; this was a large committee and we are still a long way from establishing a Recovery Plan for Maine Atlantic salmon.

Conclusions

In conclusion, the following statements describe the status of wild Atlantic salmon in Maine and the effects of the ESA process:

- Wild Atlantic salmon are in sharp decline in the United States due to a number of poorly understood factors
- The ESA listing is not complete after 8 years of activity
- The ESA has facilitated additional federal funding for salmon research and management
- The ESA process has not had catastrophic social or economic side effects
- The listing of Atlantic salmon as an *endangered* species will not, on its own, ensure the survival of the species.

This process has raised public awareness for issues of Atlantic salmon and aquatic ecosystems in the State of Maine and it has mobilized watershed councils and public groups in a very positive way. It has worked to leverage more money to be put into research and management issues and it has acted as a fulcrum to leverage habitat protection issues, although several participants attending this workshop have argued both ways on that issue. I argue highly in favor of habitat protection, both watershed protection and restoration, which I find preferable to doing nothing. We do not have a lot of State or Federal lands in Maine. Private timber companies, such as International Paper and Georgia Pacific, hold much of the private lands and they are consolidating their interests and selling these lands. We have been fortunate enough to be in a position to purchase some of the lands along Atlantic salmon rivers because of the Atlantic salmon Endangered Species process which has helped generate needed funds. Protecting the habitat will protect more than Atlantic salmon including all of the other fish species that I mentioned earlier. The riparian zones we have purchased include 1,000 feet on each side of the river for the whole length of the watershed. These purchases include a significant amount of acreage that will be beneficial for many different values including fish and especially Atlantic salmon.

CHAPTER 29

A strategy for recovery planning in the Pacific Northwest US

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There is a long history of cooperation between the United States and Canada on the management and conservation of Pacific salmon. Our two countries have worked in cooperation over the years – on fishing access agreements in the 1970s, the removal of a landslide in the Fraser River to help restore that run of salmon, and the Pacific Salmon Treaty, to name just a few.

Recovery Planning for Pacific Salmon

I will discuss recovery planning for Pacific salmon under the U.S. Endangered Species Act. It is a subject that is both embarrassing and exhilarating to describe. It is embarrassing because our first listings of Pacific salmon were in 1991 and, as of this moment, there are no recovery plans in place for Pacific salmon. We did issue a proposed recovery plan, in 1995, for Snake River salmon. That plan was never finalized because of widespread and strident public objection to the plan and the controversy that surrounded it. As a result of the controversy, we decided to re-think our approach and that is what I would like to discuss here. Fred Kircheis (Chapter 28) is correct in saying that the Act does require us to develop a recovery plan; however, there is no deadline established in the Act and there really is no forcing mechanism. The recovery plan itself has no regulatory force or authority and does not compel anyone to do anything. In that sense, it is more of an inspirational type of document which provides guidance for those who would like to recover a species. This makes it a little harder to get people excited about working on a recovery plan. Notwithstanding that fact, we have seen a lot of enthusiasm in the Pacific Northwest.

Our approach to recovery planning for Pacific salmon needed to take into account the reality that salmon are different. Unlike a lot of endangered species, salmon are everywhere - their complex life cycle takes them through many habitats from small headwater streams through agricultural valleys and estuaries to the ocean and back. They travel through forests, suburbs, and cities and are just about everywhere that moving water is present in the Northwest. Consequently, salmon listings under the ESA affect a lot of people. Everything we do on the land ultimately affects the water directly or indirectly to some extent. Timber harvesting, road building, farming, and many other activities affect the water. The combination of salmon being everywhere, and just about everything that humans do having an affect on them, means that a lot of people's lives are touched by any effort to recover salmon.

We had to think about the fact that there were going to be a lot of people who would need to be involved or who, at least, would be affected and would have to be considered in a recovery planning effort. Another difference between recovery planning for Pacific salmon and many other species is that, in the Pacific Northwest, people care about salmon. Northwesterners like the idea that there are salmon in our rivers which represents living in a healthy and productive place. They view salmon as an "icon" of the Northwest. That interest in recovering salmon affected our thinking about how to approach recovery planning.

Recovery Plan Goals

As with all recovery plans, we wanted to ensure that our plans for Pacific salmon were supported by good science that would make them more likely to receive public approval and more likely to work. A plan needs to be not just scientifically credible but also implementable and it should promote confidence that people will actually be able to do what is needed in order to recover the species. To be implementable, a plan must be specific and it must be acceptable to the public as well as to the stakeholders. The stakeholders are people who are directly affected by ESA or salmon, either because they are going to be regulated as a result of recovery efforts, or they are going to benefit from the recovery of the species.

Approach: science and people

I mentioned that we did issue a draft recovery plan for Snake River salmon in 1995, which was developed in the classic way that had been done in the past. A blue ribbon panel of scientists was assembled and questioned on problems and potential solutions. Public hearings were conducted, the panel talked to other scientists, and a plan was written. The problem was that so many people were affected by the actions that needed to be taken, and so many people had invested long periods of time in trying to solve the problem, that they were not really interested in being told by a panel of experts what needed to be done. They felt they had not actually participated in the development of solutions.

Therefore, we decided to try something novel, which was to split the two main tasks involved in recovery planning and have different groups of people with different expertise working on the two tasks. This would involve credentialed scientists, who know and understand the threats, and another group of policy makers and stakeholders who would determine what actions could be taken to address the threats. For the credentialed scientists we looked for independent scientists who were then nominated and selected to sit on the science panel. The science panel was questioned as to what viability looks like and to describe what a viable salmon population would look like, which would then provide us with the biological goals.

On the other hand, we asked the policy teams to select members from within their own groups. I mentioned previously that everyone in the Northwest cares about salmon and, because of that, there were many efforts underway long before we arrived on the scene with the Endangered Species listing. There were a lot of state and tribal efforts and many local groups and watershed councils that had been involved in salmon recovery planning for a number of years. We looked for those existing efforts and for those existing groups and we invited them to take on the task of recovery planning. We offered assistance by providing a science team to look at the science, to help describe viability, and to help them judge whether proposed actions would be sufficient for recovery planning, and where the most value might be. We advised that if they developed a plan that in our judgment (and the judgment of the science team) would achieve the viability goals, then we would adopt that as our recovery plan and publish it in the federal register for public comment.

Recovery Domains

Figure 29.1. Scale recovery domains.

Figure 29.1 displays the scale of what we are trying to do. We have listed salmon on the west coast by groupings - basically population groupings that share a common evolutionary lineage. This map shows what those groupings are - in some cases, we have lumped them together. For example, the interior Columbia includes the Snake River, Upper Columbia and Mid-Columbia components, each of which is different. The idea was to try to organize, at least as a first attempt on scale, the effort along the lines that biologically matched how the species organized themselves. It is obvious, from looking at the map, and as Fred Kircheis pointed out (Chapter 28), that it does not exactly line up with political boundaries. There are complexities, in terms of determining the political entities and tribes involved in the recovery planning effort and they tend to be more compact and do not tend to cross fish boundaries quite as much, which adds another layer of complexity to the planning effort.

Roles

When dealing with such a complex effort, and when asking someone else to do what is essentially our job, which is to develop recovery plans, it is essential to be clear about what needs to be done, who is responsible, and what the expectations are. For example, the Science Teams are led by the National Marine Fisheries Service (NMFS) because that is our area of expertise. That is not to say that there are not other entities with scientific expertise. Our science teams include experts from state fish and wildlife agencies, from tribes, local governments and academia. I mentioned before that the members are selected by a science panel and, to a large and sometimes very frustrating extent, these teams are independent. The members of the teams are not supposed to represent the group that they come from and are only meant to be giving us their best scientific advice.

The Planning Teams, on the other hand, are led by others. Leadership varies from region to region. In some places the teams are being led by tribes, and in other cases by states, such as in the Columbia Basin, where the Power Planning Council has taken on a role in leading sub-basin planning or recovery planning. These are representational and people are expected to come and represent their interests. The idea is that input into the recovery planning is provided from all of these various participating groups and

not just government entities and agencies. Watershed councils have an important role to play in the planning process.

Responsibilities

I mentioned that we listed Pacific salmon by groups of populations that share an evolutionary lineage. The first task of the technical teams has been to identify the population structure for each of these listed units. That identification tells us which populations inhabit a particular area. We try to look for planning groups that line up with those populations – this generally works, although not always. For the most part, watershed councils have more than one population in their area and, for the most part, the populations do not spread across different watershed councils or planning areas. We have also asked the Technical Recovery Teams to set viability goals. When we talk about viability goals, we are not just talking numbers or abundance of fish, but we are also looking at productivity, distribution and diversity to determine whether a given population or a population group is viable. The Technical Recovery Teams also interact with the Planning Teams, providing advice and feedback on actions that can be taken to address threats to salmon and steelhead populations and how much we might expect to get out of those actions in terms of recovery.

The Planning Teams set 'broad sense' recovery goals. Referring back to the observation that people care about recovering salmon, one of the reasons they care is because they want to catch them. If there is a population at minimum viability, in many years there will not be a harvestable surplus. Many of the locally self-appointed recovery teams, in setting their recovery goals have set goals higher than the minimum viability goals because they want to have harvestable naturally producing fish. That is what is meant by 'broad sense' recovery goals. The Endangered Species Act itself does not really have the authority to compel actions that will provide for a harvestable surplus but where planning groups want that to be part of their goal we encourage it.

The Planning Teams are also asked to assess threats and evaluate how current programs meet those threats. Assessing threats is a technical exercise and involves a back and forth between the Technical Teams and the Planning Teams. In some cases, the Planning Teams have actually hired consultants to conduct the threat assessments. Any credible recovery plan will need to include that assessment along with an evaluation of how well the current programs meet the threats. The Planning Teams need to identify specific actions required beyond those that exist in current programs and, finally, they need to develop schedules for carrying out actions and funding plans to determine how those actions will be funded.

Progress

The first report on progress is that we do not have recovery plans available as yet. We do have Technical Recovery Teams established in all areas, at least in the Pacific Northwest. There is one area in California where a Technical Recovery Team has not been established. In Puget Sound and the Lower Columbia and Upper Willamette regions, we have completed the population identification and the preliminary viability goals analysis. These are available for the Planning Teams to use and for the public to look at and comment on. There are a lot of different planning efforts underway. Some are quite sophisticated, well-funded, well-organized and at an advanced stage while some are still trying to establish themselves. Puget Sound is probably the most advanced, in part, because local business leaders decided it was good for business to have healthy salmon populations and started leading the effort four to five years ago.

The Power Planning Council is also a unique entity in the Columbia Basin in that they have jurisdiction over a very broad area and they have used that authority, and their ability to allocate ratepayer funds for power generation, to promote sub-basin planning. In the Columbia Basin quite a bit of progress has been made and it is a fairly well-organized effort. In Oregon and Washington, in particular, there are State laws in place anointing watershed councils to take on certain types of planning activities. There are planning

entities in those two states that we have partnered with in trying to develop recovery plans for individual populations of listed fish.

Conclusion

Keeping in mind that we are trying to be optimistic and the observation of Fred Kircheis (Chapter 28) that "productivity is an inverse relationship to the size of the group", there are certainly days that we wonder about this 'monster' we have created. As I mentioned, there are people who approach us saying we have asked them to do our job. They wonder where the money, resources and guidance are to do the job and what exactly the job is. We do not have the answers to all of those questions. Part of our answer is to ask whether people in the states, counties and watersheds would rather do the planning themselves or have us do it. It is a big job and requires a lot of resources and people are trying to determine how to fund that type of effort. What is most encouraging about the entire effort, although we do not have Evolutionay Significant Unit (ESU) recovery plans to show for it, is that we are starting to see watershed plans and sub-basin plans dealing with individual populations. These small-scale planning efforts ultimately are the building blocks of a full-scale recovery plan.

Going back to the observations from the beginning that salmon are everywhere and that everything we do on the land and water affects salmon, I am persuaded that laws and regulations such as the Endangered Species Act, by themselves, will not recover or prevent the continued decline of species like Pacific salmon. It really is the struggle for the hearts and minds of the people from the area that is critical. What is best about the efforts being undertaken in the Northwest, aside from the theoretical idea that when there is a plan it is more likely to be implemented because people will become involved, is that people are much more aware than they were before. They are much more aware that so many things they do affect salmon and the streams they live in. I see people every day being far more conscientious in their farming practices, timber practices, and road maintenance practices. Most people want to do the right thing for salmon, and if they are shown how to do it, they are willing to do it. I am encouraged by the amount of progress that we have seen in changed habits, if not in the publication of formal recovery plans.

CHAPTER 30

Strengths and weaknesses of the Endangered Species Act: Some insights from the Columbia Basin

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Introduction

During the 1990s various fish stocks in the Columbia Basin were listed as threatened or endangered under the US Endangered Species Act (ESA) (NMFS 1995, 2000, Lohr et al. 2001). These listings included sockeye, spring/summer chinook, fall chinook, steelhead and bull trout. My perspective on the ESA is a function of four sets of related experiences over the last decade, all of which have involved facilitating multi-agency efforts to recover fish populations at risk: 1) data analyses and modeling of listed Snake River chinook salmon to support ESA decisions (Marmorek and Peters 2001, Peters and Marmorek 2001, Deriso et al. 2001, Peters et al. 2001); 2) designing monitoring and evaluation approaches to determine the status of listed species and their responses to management actions (ESSA 2002, CBFWA 2002, ESSA 2001); 3) analyzing the factors limiting unlisted Okanagan sockeye populations that spawn in the Canadian portion of the Columbia Basin (Parnell et al. 2003) and 4) restoration efforts on listed and unlisted salmon populations in Northern California and British Columbia (Alexander et al. 2003, Marmorek and Parnell 2002). While these experiences have provided some interesting contrasts in processes some driven by ESA and some not, my subjective opinions are naturally sculpted by my particular set of experiences. In considering the strengths and weaknesses of the ESA, I also speak from a particular perspective - that of an aquatic ecologist and facilitator, not a lawyer, government regulator or direct user of water and fish resources.

Strengths and weaknesses are terms best judged in a relative manner, compared to some other standard. In this paper I am subjectively comparing the ESA to what I consider to be *the best possible application of scientific knowledge, human resources, laws and money towards conserving and recovering threatened or endangered species and the ecosystems on which they depend*. My judgments draw on experiences of preservation and restoration efforts with and without the ESA. I recognize that the ESA is only one tool in society's toolbox for preventing the extinction and accelerating the recovery of salmon stocks at risk.

I will focus on the application of the ESA to the operation of dams which form the Federal Columbia River Power System (FCRPS). To provide a foundation I will describe the FCRPS, the broader challenges in recovering Columbia Basin salmon, and the general process by which the ESA is applied to federal power projects. I will then delve into some of the specific history of ESA applications to the FCRPS, and conclude by posing some questions and perspectives, relying on comparisons with other processes to elucidate what I believe are the strengths and weaknesses of the ESA.

The Federal Columbia River Power System

The FCRPS consists of fourteen hydroelectric projects: four on the lower Snake River, four on the lower Columbia River and another six in the Upper Columbia River (Figure 30.1). Altogether there are 92 hydroelectric dams in the Columbia Basin, and 30% of the Basin's salmon habitat is permanently blocked from access by the Grand Coulee and Hells Canyon dams (Figure 30.2). The four Snake River projects (completed in the early 1970s) were the focus of much attention under the ESA during the last decade. Since the late 1960s, the number of returning spawners in the seven Snake River index stocks (Figure 30.1) have declined by about 70-80%, though with some strongly consistent fluctuations (Schaller et al. 1999). Currently, only about 10% of Snake River spring/summer chinook smolts migrate down through the eight reservoirs and dams; the remainder are transported in barges past all eight projects and then released below the last dam at Bonneville. One of the key issues facing fish management agencies during the last decade was whether to continue transporting fish or alternatively to breach or remove the four Snake River dams.

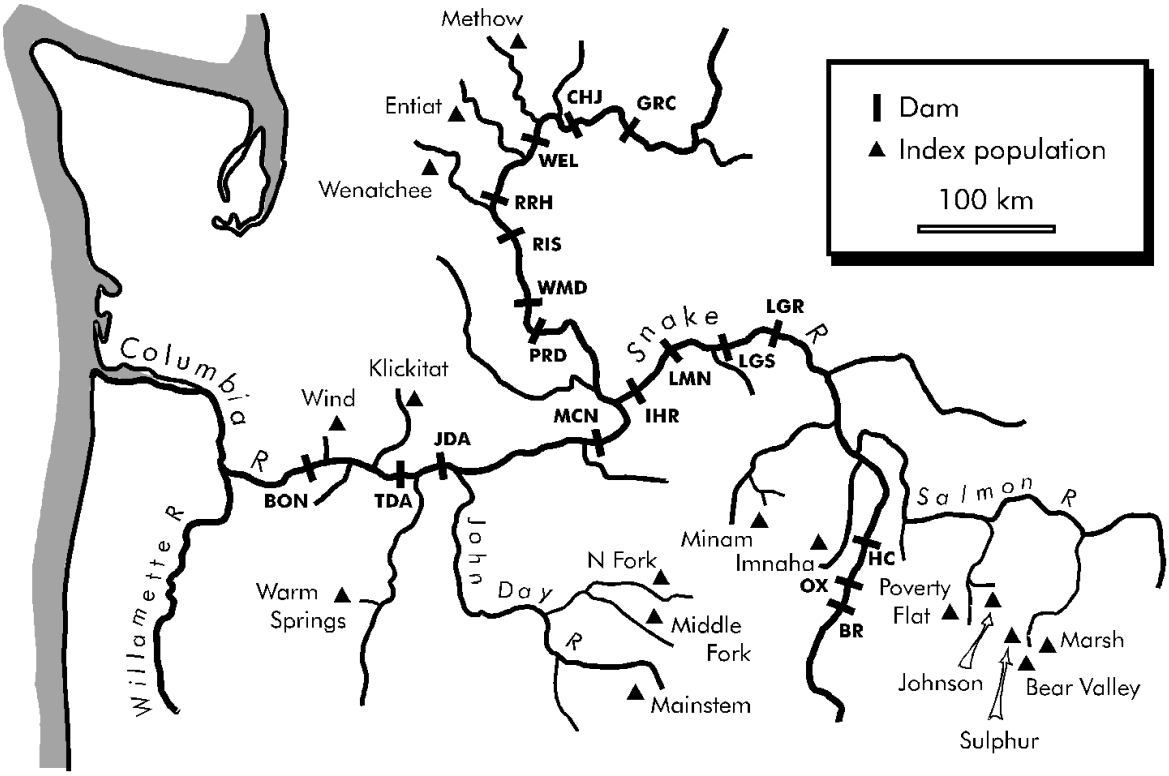

Figure 30.1. The Federal Columbia River Power System and monitored 'index populations' of spring/summer chinook, in both the Snake River basin and lower Columbia River (Schaller et al. 1999; reproduced with permission in Marmorek and Peters 2001).

Challenges in recovering Columbia Basin salmon

Among the many issues, I would highlight the following seven challenges:

1. The Columbia Basin covers an enormous area (Figure 30.2), with complex spatial linkages. For example, reservoir storage at its most northern hydroelectric project (the Mica Dam) affects conditions in the Columbia River estuary. The Alaska salmon harvest affects the abundance of fall chinook salmon in the Snake River (Peters et al. 2002).
2. Multiple stressors (harvesting, hatcheries, hydroelectric development, forestry, agriculture, urbanization, mining, pollution) have cumulative effects on salmon and their habitat.
3. There are both competing uses for the Columbia River, and differing goals for salmon populations (e.g. saving endangered species, increasing harvest, restoring ecosystems).

4. Jurisdictional complexities (2 national, 4 state, one provincial, and hundreds of First Nations/tribal/regional governments) make it difficult to coordinate salmon and habitat management policies to deal with these competing uses and goals and interacting stressors over this large area. Recent efforts have been made to develop a collaborative approach to monitoring and evaluation among federal, state, and tribal agencies (CBFWA 2002).

5. There are large scientific uncertainties regarding the relative importance of different factors on overall salmon survival, particularly since several factors (dams, hatcheries, transportation, ocean regime shifts) changed concurrently during the 1970s.

6. There are legal, technical and political constraints on implementing adaptive management experiments which might help to reduce these uncertainties (McConnaha and Paquet 1996).

7. There is a low level of trust, exacerbated by a history of hearings and court cases wherein modelers working for some agencies advocate transporting fish, and analysts with other agencies advocate dam breaching, thereby thoroughly confusing decision-makers who are seeking a single clear answer.

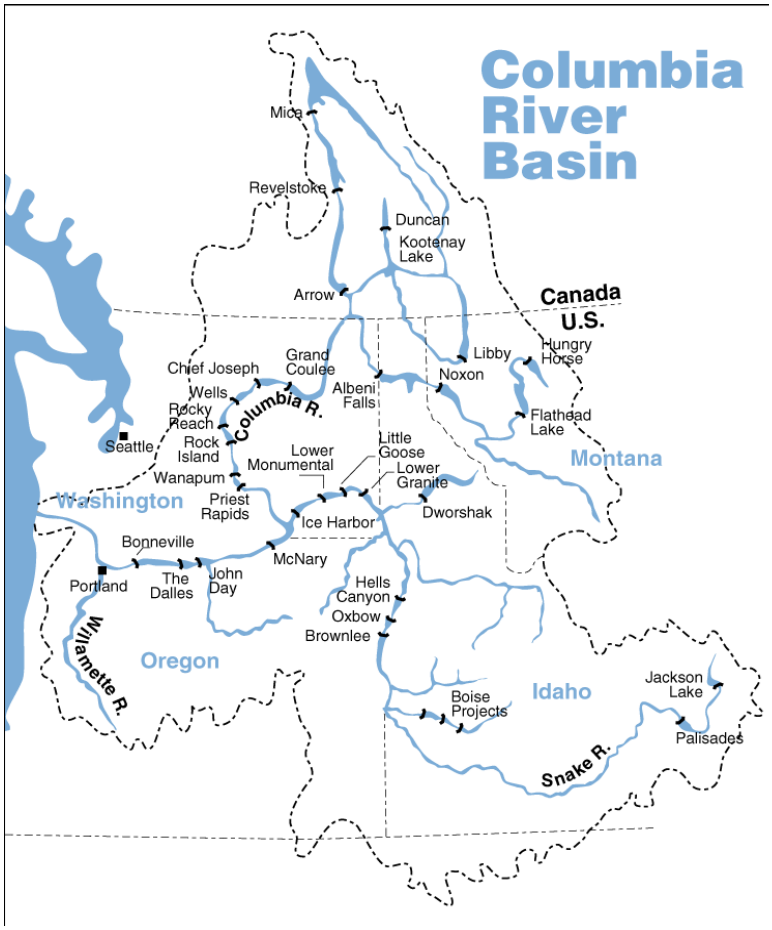

Figure 30.2. The Columbia Basin. Source: NMFS 2000.

The last two challenges deserve some elaboration. By adaptive management I refer to deliberate, well-designed, well-monitored contrasts in management over time and/or space to reduce key uncertainties. Fish agencies are understandably nervous about experimenting with endangered species. Unlisted species and hatchery fish provide the best opportunities for fail safe adaptive management experiments. In addition, risk-averse decision makers are loath to admit that they really do not know what actions are most likely to recover stocks. They would prefer that "scientific research and monitoring" resolve key

uncertainties in the effectiveness of management actions. However, research and monitoring cannot significantly reduce these uncertainties without some spatial/temporal contrasts in management actions. Finally, an important technical challenge is that there is only one mainstem Columbia River, which makes it impossible to provide spatial contrasts in hydrosystem management actions, though temporal (i.e. year to year) contrasts are feasible. Spatial contrasts are possible at the level of reaches, tributaries and sub-basins for habitat management actions. The recent use of PIT-tag technology has provided insights into the effects of different factors (e.g. transported *versus* in-river passage, number of bypasses transited, wild *versus* hatchery, habitat conditions) on salmon smolt to adult survival rates (CSS 2002).

Building trust is a major challenge due to the adversarial nature of past interactions, and the frequently conflicting goals of different agencies. In the FCRPS salmon debates there have typically been three major groups of people involved: quantitative fishery scientists/modellers, field scientists and decision makers (the latter includes both regulatory agencies and the public). Each of these three groups have representatives from multiple agencies. A major challenge is moving from the standard defensive 'within agency' communication, where each agency buttresses its previous position to 'interagency learning teams'. Such teams would ideally have open sharing of information and insights, leading to a consensus on what management experiments, research and monitoring is required to reduce remaining uncertainties in long-term management actions.

How the ESA is applied to the FCRPS and examples from the 1991 – 1995 period

The ESA is a complex piece of legislation and here I discuss only one important section (7(a) (2)), which directs what are commonly referred to as "Section 7 Consultations". The federal agencies operating the dams propose various operations or actions in areas with listed species. They consult with National Oceanic and Atmospheric Agency (NOAA) fisheries for salmon and the United States Fish and Wildlife Service (USFWS) for bull trout. Those regulatory agencies assess if the proposed action would jeopardize the survival or recovery of the listed fish or adversely affect their habitat. If they conclude that the fish or their habitat might be jeopardized, they write a Biological Opinion. The Biological Opinion recommends a "Reasonable and Prudent Alternative" (RPA) to the original action that avoids jeopardizing the fish and recommends measures to minimize the impact on habitat. The RPA measures must be within the federal agency's legal authority and jurisdiction, economically and technologically feasible, specific, and reasonably certain to occur. If those measures are accepted by the agencies operating the dams, they get what is called an "Incidental Take Statement" which means they can continue to kill some fish and continue to operate. The consultation may be re-opened if conditions change or the measures are not implemented.

There are three key issues in Biological Opinions: the survival and recovery standards used to assess jeopardy (are they too lenient or too stringent?); the analytical methods used to determine if actions meet the standards (are the key model assumptions that affect stock trajectories defensible?); and the enforceability of the RPA and associated measures (implementation uncertainty).

The first half of the 1990s was an interesting and intense period for the ESA and FCRPS. In 1991, Snake River sockeye was listed as *endangered*, the first species so designated in the Columbia Basin. In 1994 NMFS came out with a Biological Opinion which concluded that proposed dam operations did not jeopardize the survival or recovery of Snake River sockeye. They were promptly sued by the Idaho Department of Fish and Game and four tribes. The Judge agreed with the plaintiffs, stating:

> *The process is seriously, significantly flawed because it is too heavily geared towards a status quo that has allowed all forms of river activity to proceed in a deficit situation, i.e. relatively small steps, minor improvements and adjustments, when the situation literally cries out for a major overhaul...The Biological Opinion's jeopardy standard and RPA are 'arbitrary and capricious' and* not *in accordance with the Endangered Species Act*

NMFS was sent back to the drawing board. The federal agencies, states and tribes worked together to revise the standards and, in 1995, a new Biological Opinion was issued. At that point Snake River spring, summer and fall chinook were also listed as *endangered*. The 1995 Biological Opinion included a lot more actions in its RPA, such as improving fish bypasses, spills, spring/summer flow, and transportation. It also specified a lot of research to evaluate the relative benefits of transportation *versus* dam breaching, including specifying a collaborative process to assess the evidence underlying the key hypothesis in different models (NMFS 1995; pg. 124, Rec. 17). Finally, and most importantly, NMFS said that by 1999 they would make a decision one way or another to either increase transportation or breach the Snake River dams.

PATH (1995 – 2000)

The new, collaborative process that was formed in response to the NMFS recommendations became known as the Plan for Analyzing and Testing Hypotheses (PATH). Since the process is described in detail in Marmorek and Peters (2001) I will only touch on a few highlights here that bear on processes by which the ESA can be applied to complex, controversial issues. PATH was assigned three specific objectives:

1. Determine the support for key alternative hypotheses from existing information, and propose other hypotheses and/or model improvements that are more consistent with these data (retrospective analyses).
2. Advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels (prospective analyses).
3. Assess the ability to distinguish among competing hypotheses from future information, and advise institutions on research, monitoring, and adaptive management experiments to maximize learning.

One of the key lessons learned from the PATH process was that independent facilitation and peer review is essential to building both trust and rigour. PATH had four levels of peer review. First, the 25 scientists involved in PATH represented about a dozen agencies, and vigorously critiqued each others' analyses. A key feature of PATH was its collaborative structure; it was not simply one regulatory agency (e.g. NMFS) completing its analyses, and then receiving comments from others, which they could accept or reject. Second, there were three independent scientists involved in designing and implementing the analyses: Drs. Randall Peterman, Rick Deriso, and Lou Botsford. They rolled up their sleeves, sat at the table and called the shots as they saw them. That was an extremely helpful form of peer review, and raised the quality of work submitted by all participants. Third, all PATH reports went out to a Scientific Review Panel (SRP) that was not involved in designing or implementing any of the analyses: Drs. Carl Walters, Jeremy Collie, Saul Saila, Jim Kitchell and Steve Carpenter. In addition, the Independent Scientific Review Panel (ISRP), reviewed PATH funding proposals. Fourth, there were peer reviews of journal articles.

PATH's work on the first objective focused on restrospective analyses. In a conflict-ridden environment, it is extremely valuable to have extensive data and long time series to evaluate the relative probability of alternative hypotheses. One of the retrospective analyses completed by PATH was to compare the 40-year record of recruits per spawner for the seven Snake River stocks, which pass 8 dams, with the similarly long record for the six lower Columbia stocks that only pass 1-3 dams (Schaller et al. 1999; Deriso et al. 2001). Two interesting insights emerged (Figure 30.3). First, there were common year effects for all 13 stocks, with generally higher recruits per spawner before 1975, and generally lower recruits per spawner after 1975 (Figure 30.3 – upper graph). Second, after 1970 the Snake River stocks had on average about 67% more mortality than the lower Columbia River stocks (Figure 31.3 – bottom graph). Interestingly, in more recent brood years (1995 to 1997), better ocean survival has resulted in more positive year effects and generally higher returns coming back to both the lower Columbia and Snake River areas (Rich Hinrichsen, unpub. data). However, the Snake River stocks still have about the same level of incremental mortality over lower Columbia River stocks, in fact at the upper end of the range shown in the bottom

graph of Figure 30.3. These results are consistent with significant negative impacts from dams and transportation. While other factors could also be partly responsible for this pattern (e.g. differential survival of the two stock groups in the ocean; effects of hatcheries), any such hypotheses must explain the observed patterns of change in recruits/spawner in both time and space. The collaborative effort at retrospective analyses made it clear to the group that certain hypotheses were indeed less tenable than others because they could not reasonably reproduce the observed pattern and magnitude of survival changes. This level of scientific consensus would not emerge through the standard ESA process in which the regulatory agency completes its own analyses and then sends them out for comment.

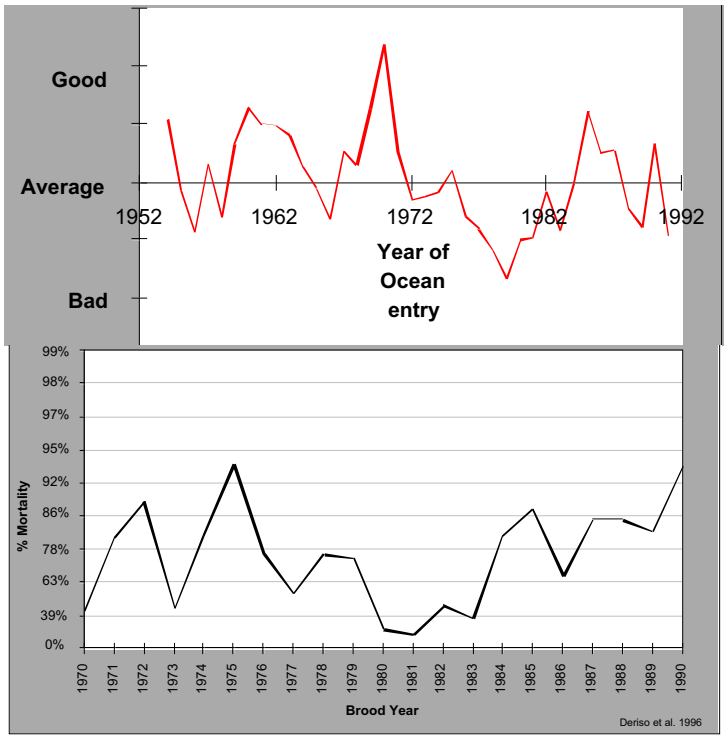

Figure 30.3. Upper graph: Common year effects (common changes in recruits per spawner) for 7 Snake River and 6 lower Columbia River spring summer chinook index stocks. Lower graph: Incremental mortality of Snake River stocks over lower Columbia River stocks (measured in terms of differences in recruits per spawner). Simplified from Deriso et al. 2001.

The PATH group systematically examined other factors: harvest, habitat and hatcheries (Marmorek and Peters 1996). Harvest was really not relevant to spring/summer chinook because the harvest rates were very low (less than 5%) during the post-1970 decline in abundance of Snake River spring/summer chinook. Habitat change also cannot explain the decline of these stocks, since stocks in pristine habitat in the Snake subbasin showed about the same rate of decline as stocks in degraded habitat. There is also a consistent recruitment curve of smolts *versus* spawners since the 1960s, which suggests no significant change in survival during the freshwater spawning and rearing stage (Petrosky et al. 2001). When it comes to hatcheries, there are certainly possible effects but they are hopelessly confounded with changes in the transportation program (see Figure 2 in Marmorek and Peters 2001). The only way to tease apart these competing hypotheses would be to vary either transportation and/or hatchery releases to improve the contrasts in these actions. A lesson drawn from this experience is that mitigation actions should be carefully planned through an experimental design that will reveal their effectiveness (or lack thereof) with high statistical power (e.g. an ON-OFF-ON-OFF sequence over several years).

Collaboration on objective 2 (prospective analyses) was made easier by a decision analysis framework which permitted open exploration of the consequences of alternative hypotheses for changing the relative

value of different management actions (Peters and Marmorek 2001, Peters et al. 2001). There were many sets of alternative hypotheses, and people would argue about each one of them for weeks at a time. We found it helpful to critically examine the evidence for each proposed hypothesis and then look at how each of the three alternative actions (i.e. continue current operations, maximize barging, or breach four Snake River dams) performed across *all* of the combinations of about 15 different hypotheses. For the breaching action, this resulted in about 2,000 combinations of hypotheses, each of which were simulated 3,000 times to cover all of the uncertainty in stock recruitment parameters. After all of this sensitivity analysis, we found that only 3 of the 15 sets of uncertainties (i.e. transportation assumptions, stock productivity and extra mortality) really made any difference to the ranking of alternative actions. Other assumptions just scaled survival up or down, but did so equally for all actions. This allowed the group to focus their discussions on uncertainties which really made a difference to decisions. This effort made a significant difference to subsequent work completed by NMFS for the 2000 Biological Opinion, even though NMFS did not conduct as detailed a decision analysis.

PATH's initial decision and sensitivity analyses were helpful but were criticized on the grounds that all hypotheses were weighted equally. Decision analyses can be manipulated by including unreasonable hypotheses or probabilities that tilt expected outcomes in a desired direction. To avoid this, we conducted an intensive process to compile all of the available evidence for and against the critical hypotheses. This formal Weight of Evidence Process was concluded with an independent weighting of the probability of alternative competing hypotheses by each SRP member, after reviewing a detailed Weight of Evidence report. We then took each of the panel's independent weights and applied them to determine if they yielded a different outcome to the results from weighting all hypotheses equally. With all of the SRP members' weights, breaching was consistently the better action for recovering Snake River spring/summer chinook, even more so than with all hypotheses weighted equally (Figure 30.4). The SRP strongly recommended that PATH pursue experimental management actions to resolve key uncertainties, which we subsequently did.

In summary, PATH's retrospective analyses narrowed the range of tenable hypotheses and focused both the debate and future research priorities. A decision analysis clarified the effects of both alternative decisions and alternative hypotheses. PATH's analyses of experimental management actions demonstrated tradeoffs between learning and conservation for a number of alternative approaches. Finally, a lot of mutual respect and trust evolved among PATH scientists. The main weaknesses of the process were that it was slower than what would occur with a single agency conducting their own analyses, and that it was difficult to explain to non-technical audiences (Marmorek and Peters 2001).

ESA and the FCRPS during the 2000 – 2003 period

NMFS (2000) completed its own analyses for their 2000 Biological Opinion, although they did extensively reference PATH. One of the reasons for this separate analyses is that by the year 2000, there were 9 more populations of salmon and steelhead listed under the Endangered Species Act. These stocks were found in areas such as the Upper and Mid-Columbia regions, which PATH had not analyzed.

Nine federal agencies were brought together and developed a Basinwide Recovery Strategy, which embraced an "all-H" approach, with hydro, harvest, habitat and hatchery actions. The 2000 Biological Opinion presented an RPA with a lot of "off-site" habitat mitigation for hydrosystem mortality. The RPA proposed detailed monitoring and evaluation, and "check-ins" after 3, 5 and 8 years. If the stocks were not doing well during these check-ins, NMFS would reconsider breaching and other kinds of actions. Like PATH, NMFS found that breaching was the most certain way to recover Snake River stocks, but the 'all-H' approach was considered by NMFS to generate sufficient survival improvements to avoid jeopardy.

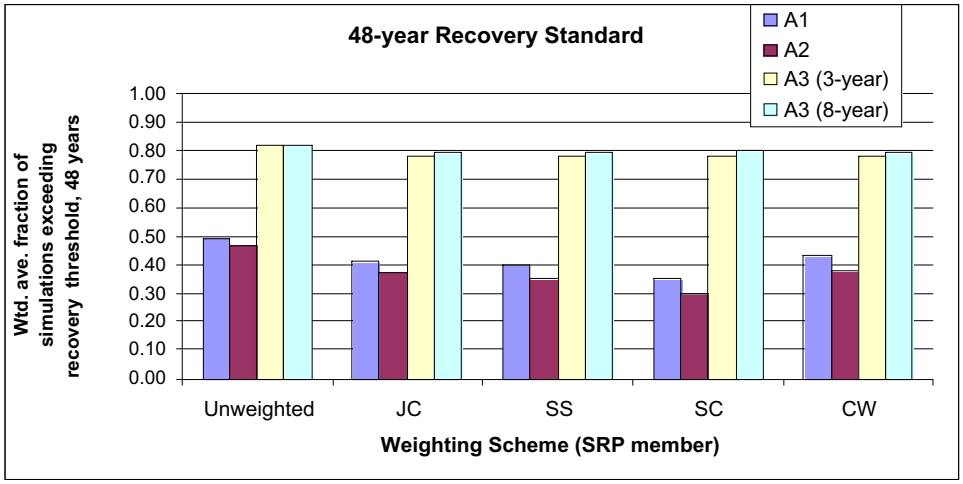

Figure 30.4. Results of independent weighting of alternative hypotheses by four Scientific Review Panel members on the probability of recovery of Snake River spring/summer chinook, compared to the unweighted case (all hypotheses equally probable). Actions: A1=current transportation; A2=increased transportation; A3 (3-year) = dam breaching with 3-year delay for Congressional Approval; A3 (5-year) = dam breaching with 3-year delay for Congressional Approval.

In 2001, a lawsuit was initiated against the 2000 Biological Opinion by 12 environmental and fish groups, the State of Oregon and 4 tribes. In 2003, Judge Redden rejected most scientific criticisms as inadmissible, but sided with the plaintiffs on the implementation uncertainty of the proposed RPA:

> *NMFS improperly relied on range-wide off-site federal mitigation actions that have* not *undergone Section 7 consultation, and non-federal mitigation actions that are* not *reasonably certain to occur in order to reach the no-jeopardy conclusion*.

NMFS was asked again to rework their Biological Opinion.

Insights and Questions

What kinds of insights and questions can we draw from the above history? I believe that the ESA and its associated court decisions have both strengths and weaknesses. Some of the strengths include: the judge is a neutral party and does not work for any of the entities involved; the ruling has the force of law and is not just a scientific 'opinion'; legal decisions can force collaboration to occur among parties (e.g. PATH was created by the 1995 Biological Opinion, interagency Recovery Teams were created out of the 2000 Biological Opinion); and legal decisions can force beneficial mitigative actions to occur.

There are also some weaknesses to court decisions about ESA matters. As a scientist, I find it frustrating that the court's focus is almost entirely on administrative procedure (i.e. did the regulatory agency follow the law?) and not on science. As a result many key issues are ignored. There is also a deference to the regulatory agency's science, rather than a rigorous examination of alternative hypotheses as occurred in PATH. Finally, the judge tends to rule on as little of the complaint as necessary, and these rulings vary with the wisdom of the judge. A huge amount of scientific brainpower ends up being focussed on a legal process that often does not deal with the critical issues affecting the future of salmon.

The strengths probably outweigh the weaknesses. ESA has forced valuable improvements in fish passage, habitat, recovery plans and monitoring, which otherwise would never have occurred. For example, at Rocky Reach dam the Chelan Public Utility District recently spent $112 million on a smolt bypass, with significant survival improvements. Some may say that this is just a techno-fix. However, without those techno-fixes, the cumulative effect of an Okanagan sockeye smolt going through 9 dams really starts to hit hard. If you reduce the mortality at each of 9 projects, it can make a big difference to overall survival.

Do court cases erode trust among scientists from different agencies and undermine collaboration? The answer to that question will depend on the people involved, but I would answer "yes". Courts are

inherently adversarial, and tend to be hard on the people as well as the problem. Lawyers on all sides put pressure on scientists to state their case as strongly as possible, beyond their comfort level. My experience in talking to people from NMFS is that while ESA is a useful hammer, court cases make the agency very defensive. This can lead to a 'crisis response' atmosphere rather than an open 'interagency learning' atmosphere. I suspect that the trust built up during PATH has been somewhat eroded with recent court cases.

What about stocks that are not yet listed? Does the ESA, perhaps not intentionally but nevertheless incidentally, lead to too much money being spent on listed stocks and not enough on unlisted stocks? Okanagan sockeye is a good example (Parnell et al. 2003). These salmon spawn in Canada in the Okanagan River above Osoyoos Lake, and the fry rear in Osoyoos Lake. Once grown to migrating size, the smolts move down the Okanagan River, and then through the Columbia River and its 9 dams to the ocean, returning as adults two years later (Figure 30.5). That stock has varied in spawner abundance from about 2,000 in the lowest year to as high as 80,000 (measured at Wells Dam Figure 30.6).

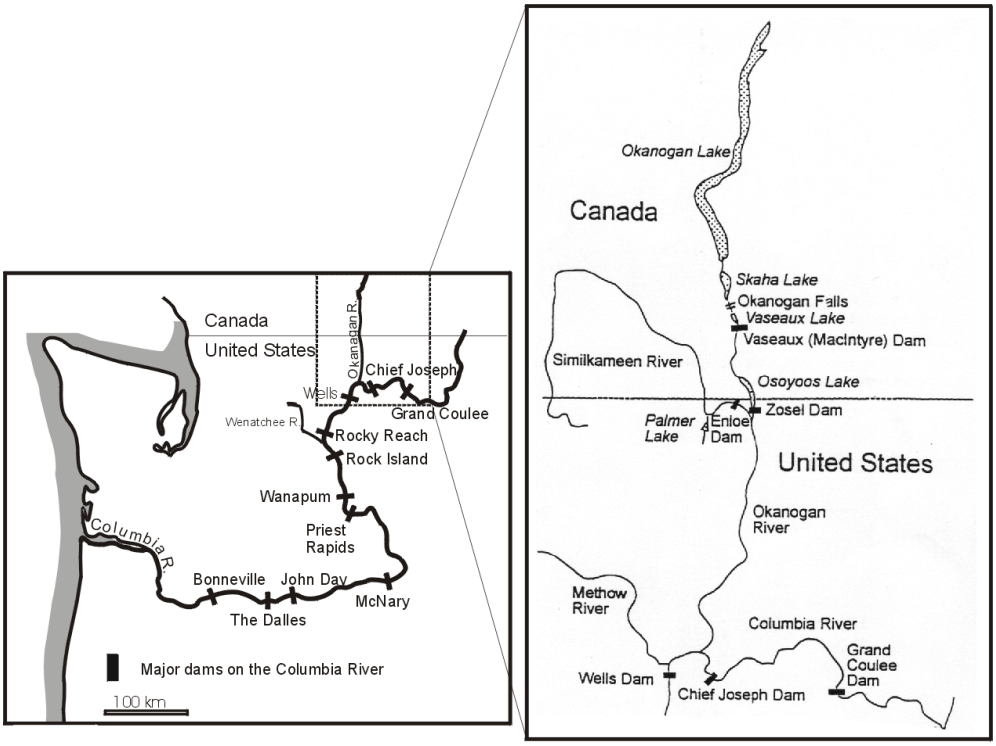

Figure 30.5. Time series of spawner abundance of Okanagan sockeye, and migratory route. Source: Parnell et al. 2003.

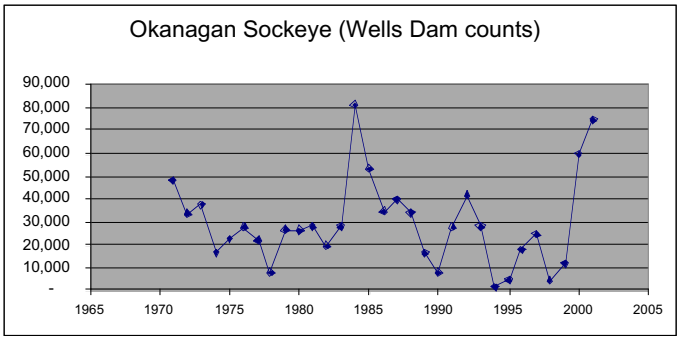

Figure 30.6 Abundance of Okanagan sockeye (Wells Dam counts) from 1970-2002.

Okanagan sockeye are not listed as *threatened* or *endangered*; over the last decade the Bonneville Power Administration (BPA) has spent about $0.5 million on this stock. By comparison, BPA has spent about $12.5 million on a captive brood stock program for *endangered* Red Fish Lake wild sockeye in Idaho. In 1992 Redfish Lake had one returning spawner (named 'Lonesome Larry'); it is a bad sign when individual fish are named. Does it make ecological and societal sense to spend 25 times as much money on Redfish Lake sockeye as on Okanagan sockeye? Unlisted stocks provide opportunities for implementing Adaptive Management experiments to reduce key uncertainties. The lessons learned can then be applied to listed stocks.

Is the ESA too species-centric? Williams et al. (1999) wrote an innovative report, "Return to the River", which recommended a more 'normative' river for the Columbia, increasing natural ecosystem processes and functions. The ESA is by definition focused on species, and Biological Opinions do not tend to talk much about ecosystem processes. I think the structure of the ESA generally gets in the way of adopting an ecosystem perspective, although Recovery Plans do consider meta-populations and other ecosystem processes. Restoration efforts on the Trinity River in northern California, which are driven by tribal fishing rights rather than the ESA, have adopted more of a normative river approach. On the plus side for ESA, the numbers of animals are still a measurable and enforceable metric, whereas ecosystem integrity is a much less well-defined concept.

How can we build on the strengths of the Endangered Species Act and overcome its weaknesses? I think it is important to keep the hammer represented by the ESA, but to also add other tools to the toolbox. In particular, we need to improve methods of interagency collaboration on science, and learn from successful stakeholder-scientist processes. This would include the Water Use Planning processes being used in British Columbia for reviewing operations at hydroelectric facilities, and the Grand Canyon Restoration Program. We need to focus a larger fraction of the total dollars spent on unlisted stocks, investing in Conservation Plans to maintain these stocks before they decline to the point where they are *threatened* or *endangered*. Finally, we need to develop metrics for ecosystems that help create more of an ecosystem approach.

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CHAPTER 31

The Species at Risk Act and recovery planning

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Abstract

Canada's Strategy for the Protection of Species at Risk is three-fold: the Federal-Provincial Accord for the Protection of Species at Risk, the Habitat Stewardship Program of Canada, and the Species at Risk Act. Each element provides a part of the foundation for this strategy. The Canadian Species at Risk Act (SARA) is the first of its kind to provide legal protection for species and their habitats and aims to protect wildlife at risk in Canada from becoming extinct or lost from the wild, with the ultimate objective of helping their numbers to recover. The Act has five key elements, a species status assessment process by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and response to the status designation by the responsible Minister, a formal legal listing process for species designated by COSEWIC under SARA, immediate protection measures upon species being listed under SARA, a recovery planning process including the development of recovery strategies, action plans and management plans, and stewardship. A fundamental component of the Act is the requirement for transparency and public participation in the decision-making processes throughout the various elements of the Act.

Introduction

The Species at Risk Act (SARA) came into force on June 5, 2003, bringing to a close a nine-year legislative process to protect Canada's species at risk and their habitats. The Act was introduced in a phased approach with several provisions coming into force as of June 5, 2003, while others will come into force in June 2004. SARA is one of three elements of the government's Strategy for the Protection of Species at Risk. Other elements include the Federal/Provincial Accord for the Protection of Species at Risk and Stewardship initiatives.

Under the Federal-Provincial Accord for the Protection of Species at Risk the Government of Canada works with provinces and territories on a common approach to protecting species at risk. This includes complementary legislation and programs to protect habitat(s) and species. Stewardship, the other key component of the federal strategy, is a cornerstone of the Government of Canada's approach to species protection. One such initiative is the federal government's Habitat Stewardship Program for Species at Risk which funds projects that support habitat conservation and stewardship.

The Species at Risk legislation ensures that species designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) are assessed under a rigorous and independent scientific process that operates at arm's length from the federal government. It also requires the development of recovery strategies and action plans for species that are found to be most at risk. The Act also recognizes the essential role of Aboriginal Peoples in the conservation of wildlife by requiring the establishment of a National Aboriginal Council on Species at Risk and an Aboriginal Traditional Knowledge sub-committee of COSEWIC.

The three federal departments responsible for implementing SARA are Environment Canada, Fisheries and Oceans Canada (DFO) and Parks Canada, with Environment Canada being responsible for the overall coordination of the Act. This approach respects that the authority for species management lies with the responsible jurisdictions but also recognizes that successful protection and recovery needs to be a collaborative approach between all three ministers. DFO is responsible for protecting and recovering aquatic species and their habitats listed under SARA.

The key responsibilities of DFO are to enforce the Act, provide technical support to the species assessment phase, initiate the development of recovery strategies and action plans for *endangered* and *threatened* species, and develop management plans for species listed as *special concern*. DFO will also, in cooperation with other governments, First Nations and interested parties, carry out on-the-ground species recovery work.

Canada has long been waiting for such an Act to be created in order to protect the intrinsic value of our multitude of species. This paper introduces the key elements of Canada's Species at Risk Program, and how species are assessed and designated as being at a particular level of risk.

The legislation

The purposes of the Act are to prevent Canadian wildlife from becoming extirpated or extinct, to provide for the recovery of *endangered* or *threatened* species, and to manage species *of special concern* to prevent them from becoming endangered or threatened. Designation of species status occurs through COSEWIC. Significantly, the Act serves to protect species and their habitat(s) by creating prohibitions preventing the killing or harming of the listed wildlife species. Compensation may be provided at the Minister's discretion for losses incurred by any extraordinary impact of protecting critical habitat. This will be subject to regulations which have yet to be developed.

A fundamental element of the Act is transparency. The Minister of the Environment is required to post SARA-related documents and decisions on a public registry. The web-based public registry (www.sararegistry.gc.ca) acts as a comprehensive source of information relating to matters under the Act. The public registry serves as a key instrument in fulfilling the government's commitment to encourage public participation in environmental decision-making by providing timely and comprehensive access to public documents relating to the administration of SARA.

The main elements of the SARA include science-based species assessments, response statements, a legal listing process, immediate species protection, recovery and management planning, stewardship measures, and enforcement.

Species assessment and response statements

COSEWIC (http://www.cosewic.gc.ca/eng/sct5/index_e.cfm) is the body responsible for designating status to species according to the degree of risk of extinction. It has 28 members all appointed by the federal Minister of the Environment. Membership consists of thirteen provincial/territorial representatives, four federal government representatives (Environment Canada, Fisheries and Oceans, Parks Canada, Federal Biosystematics Partnership), representatives from the eight Species Specialist Sub-

Committees (SSC), and 3 representatives "at large" chosen through a public nomination process. The eight SSC's are responsible for the production and revision of status reports for plants, freshwater fish, marine fish, molluscs, terrestrial mammals, marine mammals, birds, and reptiles. DFO interacts with, at minimum, the Marine Mammal, Marine Fish, Molluscs, Aboriginal Traditional Knowledge (ATK) and Freshwater Fish SSCs. The ATK sub-committee is responsible for ensuring that Aboriginal Traditional Knowledge is incorporated into COSEWIC's assessment process. Species to be assessed/re-assessed are selected from priority candidate species lists based on information from jurisdictions, non-governmental organizations (NGOs), or from suggestions made by taxonomic specialists. Species are assigned a level of priority based on the perceived degree of risk, and are collated to comprise the SSC candidate species. Status Reports are then commissioned by COSEWIC through an open bidding process. The status assessment is based on biological factors and uses rigorous assessment criteria. COSEWIC usually meets twice a year (May and November) to assess status reports, release species designation decisions and publish species status reports. There are six status designations: *extinct, extirpated, endangered, threatened, of special concern* or *not at risk*.

Following the bi-annual meetings, COSEWIC reports on its designations to the Canadian Endangered Species Conservation Council (CESCC), and issues a press release indicating the results of decisions made at the meeting. The CESCC is a multi-jurisdictional body, composed of federal ministers of Environment Canada, Fisheries and Oceans Canada and Parks Canada, and provincial and territorial wildlife ministers. Upon receipt of the COSEWIC assessment the Minister of Environment must, within 90 days, post a Response Statement on the public registry, for each species designated by COSEWIC as *extirpated*, *endangered* and *threatened*. The Response Statement describes the reasons for designation by COSEWIC, key threats to the species, current protection or recovery measures, and it identifies lead jurisdictions for the species.

Legal listing

A species designated by COSEWIC has not received the protection and recovery measures that SARA contains until the species is legally listed under the Act (i.e., added to Schedule 1). The decision to add a species to SARA is the responsibility of the Governor-in Council (GIC), a special cabinet committee. Specifically, the federal GIC, on the recommendation of the Minister of the Environment has nine months to:

1. Accept the assessment and add the species to the legal list under SARA;
2. Decide not to add the species to the legal list; or
3. Refer the matter back to COSEWIC for further information or consideration.

While the final recommendation to the GIC comes from the Minister of Environment, as far as aquatic species are concerned, in practice, the Minister of Fisheries and Oceans would provide a recommendation to the Minister of Environment. Should the GIC fail to take one of these three courses of action within nine months, the Minister of Environment will be required to list the species by order, as assessed by COSEWIC. Once a species is legally listed by the GIC it receives immediate protection and mandatory timelines for recovery strategy development.

Protection

Once species are legally listed under SARA as *extirpated*, *endangered* or *threatened*, automatic prohibitions will apply to the species and their residences and critical habitat (if identified). The prohibitions in the Act pertaining to protection state include "No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated, endangered or threatened species…" (Section 32.1), and "No person shall damage or destroy the residence of one or more individuals of a wildlife species that is listed as endangered, threatened or extirpated…" (Section 33).

The Act authorizes the responsible minister to enter into an agreement with, or issue a permit to, a person to engage in activities that may affect a listed species, its critical habitat or residence under certain conditions (Section 74). However, this provision can only be used if certain conditions, as set out in Section 73.2 are satisfied. These conditions include:

a) the activity is scientific research relating to the conservation of the species and conducted by qualified persons;
b) the activity benefits the species or is necessary to enhance its chance of survival in the wild; or
c) the activity affecting the species is incidental to carrying out the activity. In this case, authorizations will only occur if the Minister is of the opinion that:
    - all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best alternative has been adopted, based on scientific, technical and socio-economic considerations;
    - all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residence of its individuals; and
    - the activity will not jeopardise the survival and recovery of the species.

Issuance of a permit is subject to a formal assessment to determine whether the conditions above have been met.

Recovery

Recovery planning under the SARA legislation consists of two components – a recovery strategy and an action plan. If a wildlife species is listed as *extirpated, endangered* or *threatened* under the Act, then the minister must prepare a recovery strategy and an action plan for the species. For species *of special concern*, a management plan must be prepared.

Recovery strategies and action plans must be updated every five years until the species is considered recovered. Generally, recovery teams are established by DFO to provide advice to the responsible minister, in the form of a recovery strategy, on how to recover the species. Recovery teams can be comprised of, but not limited to, technical experts, partners including First Nations, provincial and municipal governments, and other experts that can contribute to or advise on recovery efforts. The Act states that a recovery strategy should contain:

a) a description of the species and its needs that is consistent with information provided by COSEWIC;
b) an identification of the threats to the survival of the species and threats to its habitat that is consistent with information provided by COSEWIC, and a description of the broad strategy to be taken to address those threats;
c) an identification of the species' critical habitat, to the extent possible, based on the best available information, including the information provided by COSEWIC, and examples of activities that are likely to result in its destruction; a schedule of studies to identify critical habitat, where available information is inadequate;
d) a statement of the population and distribution objectives that will assist the recovery and survival of the species, and a general description of the research and management activities needed to meet those objectives;
e) any other matters that are prescribed by the regulations;
f) a statement about whether additional information is required about the species; and
g) a statement of when one or more action plans in relation to the recovery strategy will be completed.

Upon completion of the recovery strategy, the competent minister is required to include the proposed recovery strategy in the public registry. This provides the public with an opportunity to file written comments with the minister within 60 days. Following the expiry of the 60 days the minister is required, within 30 days, to consider any comments received, make appropriate changes and include a final copy in the public registry.

Development of an action plan will flow from the recovery strategy which sets out how the recovery strategy will be implemented. The Act also states what must be included in an action plan:

a) an identification of the species' critical habitat, to the extent possible, based on the best available information and consistent with the recovery strategy, and examples of activities that are likely to result in its destruction;
b) a statement of the measures that are proposed to be taken to protect the species' critical habitat;
c) an identification of any portions of the species' critical habitat(s) that have not been protected;
d) a statement of the measures that are to be taken to implement the recovery strategy, including those that address the threats to the species and those that help to achieve the population and distribution objectives, as well as an indication as to when these measures are to take place; the methods to be used to monitor the recovery of the species and its long-term viability;
e) an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation.

As with the recovery strategy, the competent minister must also include a copy of the action plan in the public registry.

In anticipation of the Act coming info force, DFO has completed a recovery strategy for Northern abalone, and has several in progress including recovery strategies for the North Pacific right whale, sea otter, sticklebacks and the Pacific leatherback turtle, as well as action plans for Northern abalone and Pacific leatherback turtle. Several others have been identified as next in priority for recovery strategy development, including three populations of Pacific salmon, Southern and Northern resident killer whale populations, Salish sucker and Nooksack dace.

Schedules and timelines

There are four lists of species in the Act, Schedules 1, 2 and 3 and 'Newly Listed', each with different timelines for protection and the development of recovery strategies.

Schedule 1 (the SARA 'legal list') lists all species for which SARA now applies. These species will be subject to automatic prohibitions as of June 2004 and require the development of recovery strategies within specified timelines. From the date the Act came into force (June 2003) recovery strategies must be developed for species on Schedule 1 within three years for *endangered* species and four years for *threatened* and *extirpated* species, and a management plan must be developed within five years for species *of special concern*.

Schedule 2 includes all endangered and threatened species on the COSEWIC list that have not yet been assessed against the new International Union for the Conservation of Nature (IUCN) criteria. Once COSEWIC reassesses these species and designates a status, these species will go through a normal regulatory legal listing process.

Schedule 3 contains species *of special concern* that are on the COSEWIC list but have yet to be reassessed. However, there is no automatic requirement for COSEWIC to reassess these species.

Newly Listed Species are those species that have been assessed or re-assessed by COSEWIC since May 2002 (after the Act was introduced to the House of Commons, but before the Act came into force). Therefore, these species are not yet legally listed in Schedule 1 of SARA and are required to go through a normal regulatory listing process. Once legally listed, the development of recovery strategies and/or management plans will be required within one year for *endangered* species, two years for *threatened* species and three years for species *of special concern*.

Salmon listings in BC

Currently COSEWIC has designated three salmon populations in the Pacific. These species are considered newly listed and include: Interior Fraser coho, Sakinaw Lake sockeye, and Cultus Lake sockeye. Interior Fraser coho were designated as endangered by COSEWIC in May 2002. Both the Sakinaw and Cultus Lake sockeye populations were designated as *endangered* by emergency listing in October 2002. COSEWIC confirmed both designations in May 2003. Listing of the two separate sockeye populations is possible under SARA because COSEWIC considered each to be a "wildlife species", which under SARA is defined as: a species, subspecies, variety or geographically or genetically distinct population…" (Section 2).

Fisheries and Oceans Canada has identified the three COSEWIC-designated populations of salmon as a priority for recovery planning and is anticipating the completion of recovery strategies by early 2005. Recovery teams will be established for each of the three salmon populations to provide technical expertise required to develop the recovery strategies. The recovery planning process will work in cooperation and consultation with a diverse range of interests and partners including First Nations, municipal, provincial and regional governments.

Conclusion

The Species at Risk Act provides a framework for actions across Canada to ensure the survival of wildlife species and the protection of our natural heritage. This Act represents a milestone in that it provides legal protection for species, puts stewardship at the forefront of recovery initiatives, and establishes penalties for failure to obey the law. Together, we can work to ensure the ongoing survival of species by using the Act as a tool in our joint efforts for conservation.

CHAPTER 32

Language, logic and legislation: The recent Irish experience of Atlantic salmon management

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Introduction

In this paper I will describe the way in which Ireland set about bringing order into its salmon fisheries in recent years. It may also help you to understand why we respond in the way we do to the unremitting, strident calls for the banning of our commercial fisheries and show you that we are nevertheless achieving our aim of increasing protection of the wild salmon stocks.

In Ireland, spoken language and body language are necessary, but not sufficient, to achieve good legislation that people will willingly embrace. When calls for legislation are based on poor or inadequate reasons, or on reasons that do not appear to be *ad rem,* then language alone is never sufficient to drive legislation.

"Ban drift netting", "Stop commercial fishing", "Over-exploitation", "Mass slaughter at sea", "Buy them out!" Throughout the 1980s and 1990s, commentary on the Irish salmon resource was widely couched in these or similar words. The aim was to force changes in the legislation that would put an end to the commercial drift and draft net fisheries for salmon in coastal waters. Salmon catches and stocks were in serious decline all over the Northern Hemisphere and it was felt that something ought to be done legislatively to halt the decline. It stood to reason that the commercial fisheries were to blame.

What logical reasons could be invoked to enable the sentiments underlying such language to be translated into legislation? The obvious articulation, the one most commonly used, was "For conservation", more especially "To conserve wild salmon stocks". Such logical or rational reasons might be expected to gain widespread approval and to support good legislation. After all, there are 42 parliamentary constituencies in the Irish jurisdiction and 21 of these are coastal, returning a total of 76 members to the 166 seat Dáil (parliament). But anglers and netsmen make up about 1% of the population. The other 99% should also understand the logic of any legislation that might be proposed.

The meaning of conservation

But what exactly do these conservation terms mean? What logical or conceptual constructs underlie them? There is no consensus over the meaning of "conservation". That it involves "doing no damage or harm to the thing conserved" is a necessary element of whatever definition we choose:

[Conservation is] preservation from harm or decay, or protection from loss or consumption.

Many people would be happy with this, leaving aside the question of whether it is a sufficient definition. Most would also, I believe, subscribe to the view that living organisms are worthy of protection and conservation *for their own sake*, not just because they may or may not be of value to man. Cormorants, for instance, are a protected species in Ireland although they have no economic or user value and are, in fact, serious predators on juvenile salmon. Many species of plants and animals are deemed worthy of conservation in this way.

"Conservation of wild salmon stocks" then means doing nothing to damage or harm the indigenous wild stocks and their habitat, either in the rivers or in the sea. Wild salmon are worth conserving because, like cormorants, they are part of the rich diversity of life on our island.

True conservation of wild stocks therefore implies that we refrain from all actions that impact on the stocks, *even positive actions like habitat rehabilitation, enhancement and restoration*. Hatcheries, for example, are anathema to true wild stock conservation. We must leave the habitat severely alone and leave natural selection to determine the abundance, the fate and the nature of the indigenous stocks. That is the only way we can conserve truly *wild* stocks. If wild stocks fail through natural causes not caused by man, there is no way we can, or maybe even should, interfere with them without altering their wild status. "Restoration" can never restore a lost wild stock. Nor can a wild stock be enhanced or augmented and still remain truly wild. That is the logic of a pure conservationist approach. About 15% of the "wild" salmon taken by the Irish west coast fisheries are hatchery-reared, ranched fish. They are not, therefore truly "wild". Would it really help matters if we were to give up producing them?

Obviously, if we espoused a purist approach our legislation would end up prohibiting all management action, good and bad, affecting wild stocks. Such an approach is, of course, entirely unrealistic in this day and age. For that reason, the appeal to pure "conservation" as a reason for a legislative ban on commercial fishing alone – there was no talk of a ban on angling – was both hollow and inadequate. As a justification for the banning of commercial salmon fishing it certainly never cut any ice with Irish coastal fishermen.

But modern definitions of conservation are much less stringent than we might think. One example is the Ramsar Convention on Wetlands definition (1):

> *Conservation is "the protection, improvement and wise use of natural resources to provide the greatest social and economic value for the present and the future".*

Put simply, *it is the wise use of a resource*.

In this perspective, the idea of conserving something *for its own sake* is replaced by the concept of its *sustainable use* because the thing has a value to man. Because sustainability entrains the idea of usefulness or other value to humankind, it includes the user within the ambit of conservation. Without value to the user the logic of sustaining something fails, unless, of course, we return to the ideal of true conservation "for its own sake".

Replacing *conservation* with *sustainability*

With this new approach, "sustainability" can replace "conservation" as a rational and pragmatic basis for protective legislation regarding wild salmon stocks. This altered perspective is not just mere semantics and it can have a dramatic effect. "Conservation" has been used as a verbal club with which to batter some resource users. "Sustainability" involves inclusive language and behaviour that are more realistic and more management oriented, taking account of the need to consider all the users and the common good. Its language encourages sharing and balancing of rights and benefits, enhancement and restoration of stocks where necessary, and overall regulation in the common interest of the resource and the users. It makes parties of stakeholders in the resource rather than simple exploiters of it. The interrelationship of

language, logic, legislation and management under the different perspectives can be illustrated as in Table 32.1:

Table 32.1. The interrelationship of language, logic, legislation and management for the perspectives of *conservation* and *sustainability*

	CONSERVATION	SUSTAINABILITY
Language	Exclusive, confrontational, "Them and us"	Inclusive, supportive, "All of us together"
Logic	Adversarial	Cooperative
Legislation	Prohibitive	Facilitative
Management	"Hands off"	Regulatory

The value of a resource may be economic, cultural, social or political and the exact value will be different for different users. In Ireland, the net fishery for Atlantic salmon has an economic and social value in the coastal communities that harvest salmon in the sea. At the same time salmon has a leisure and economic value in angling by tourists and locals. Within a sustainability framework, the rights and shares of all the different users fall to be determined by many factors, which will include stock abundance, among other things.

The language illustrated at the start of this paper is not primarily the language of conservation, although it purports to be about conservation. It is language about the way in which the salmon ought to be divided between the various user groups, in this case the angling and the commercial interests. It implies that no share at all in the salmon harvest should be allocated to the net fishermen. The net fishermen realised all along that *resource allocation*, and not *resource conservation* was the basis of this language and that is why it cut no ice with them.

Examples of what I call the cross-wiring of language and logic – where the language appears to be based on one idea but in fact relies on another – are common in resource-based conflict. For instance, when the European Commission justified, on wide conservation grounds, certain policies affecting sea fisheries in Irish waters the fishermen quickly responded (2nd definition of conservation – O'Driscoll and Hassett, 1996):

> *[The Commissioner's]* philosophy and concepts *are anathema to us…. Conservation is the battlecry which she and other EU figures use and everyone has to agree with that. If this is so, why did the EU allow 40* ***extra*** *Spanish vessels into Ireland's coastal waters from January 1, 1996? This wasn't supposed to happen until the year 2002.*

Problems with the meaning of "conservation" are not unique to Ireland or to the salmon. As Dr. Crawford of the University of Guelph said in the Canadian context:

> *…Conservation has become a political tool which is shaped and re-shaped to serve the needs of the party defining the term. There can be no rational discussion of fisheries conservation, when the basic values and principles are not clearly understood and accepted. 'Conservation of what, for whom, and for what reason?'*

Another example concerns one of the supposedly most cogent arguments for banning salmon net fishing used by Irish and other "conservationist" interests. The value to the country of a salmon caught on rod and line by a tourist angler is said to be fifty times the value of a net-caught salmon, and therefore the net fishery ought to be banned or bought out. That, of course, is not a conservation argument at all (although it may be a good reason to rebalance the catch towards greater harvesting on land). Such economic

arguments are based on the logic of sustainability and not of conservation. If the economic benefit of tourist angling is to be an appropriate consideration at all, then simple equity and plain economics dictate that it needs to be balanced with the social and economic consequences to coastal communities of the closure of the net fisheries.

When language becomes uncoupled from logic, confusion is inevitable and good legislation is unlikely.

Salmon Management Task Force

Throughout the 1980s and 1990s, beating the Irish netsmen over the head with the battle axe of "conservation" was doing more harm than good, so that by 1995 salmon management was in crisis and was costing millions of pounds to monitor and maintain in some semblance of order. The then Minister for the Marine set up a Task Force to develop new practical proposals for the management of the wild salmon stocks. It was made up of one member of the commercial and one of the angling sector along with one member of the scientific and two members of the fishery management services. I was the Chairperson. It sought and received over 200 written submissions and held meetings at the regional level at which all parties were invited to participate fully in the consultation process.

The Task Force was fortunate that the salmon resource was not entirely *in extremis* so that it could take a "sustainability" rather than strictly "conservationist" approach to the problem. Its first recommendation (3rd definition of conservation – Task Force Report to the Minister) was to identify the stakeholders in the resource, clearly and specifically including the commercial net fisheries among them:

> *The legitimate interests are the spawning escapement, the legal commercial fisheries (drift, draft and other nets and traps), the recreational fisheries (rod anglers and fishery owners) and the wider economic community…*

Once "sustainability" and not strict "conservation" was adopted as a rationale, no other position seemed realistic or pragmatic. Recognising the legitimacy of the commercial sector and guaranteeing it a share in the resource signalled the profound change in strategy and approach that the Task Force was attempting. To have recommended the banning of commercial net fishing – as conservationists were insisting in the language already quoted – would have pushed the net fishermen further away from management and regulation and could thereby have exacerbated the trend towards unregulated net fishing. Any legislative ban could also have alienated legislators in coastal constituencies from their constituents and it would have greatly increased the difficulties facing regional fishery managers.

Instead, the Task Force eschewed the calculus of blame inherent in the language of "conservation" that would have aggravated the "them and us, conservationists versus exploiters" approach to salmon.

The inclusion of the net fishermen was seen in some quarters as an abject failure to aid in conservation. But in fact the inclusive approach proved to be one of the principal drivers of the new management strategy that the Task Force was initiating. The commercial fishery interests, up until then largely criminalized and excluded from all participation in the management of the resource (on which their livelihood depends in part) now became central to its success. They were brought firmly within the community of stakeholders who would share, in an equitable way, the gain (and the pain) of any new management strategy. This gave them respect, recognition and a voice, for the first time, in the development of the salmon stocks.

The Task Force's second principle placed the salmon, not the fisheries, at the core of its proposals:

> *The maintenance, and in due course the augmentation, of the spawning escapement share at the best practically achievable level is the most fundamental, inclusive and necessary demand on the resource; all other shares must be subservient to this…*

This principle was unique in Ireland. All previous strategies had attempted to address directly only the fisheries; that is, they attempted to control the catches by effort and gear limitation alone. The new strategy is pro-active and its chief aim is to maintain the spawning escapement. That may, or may not, require limits on the fisheries, but it will also involve attention to other aspects of the salmon life history and habitat. Practical spawning escapement levels depend on the carrying capacity of the rivers and that is dependent on extraneous influences like water flow, pollution control, removal of obstructions, restoring substrate quality and so on. In other words, sustainability means more than just fishery limits. Once attention was diverted from the obvious net fishery scapegoat these contributors to the decline in the stocks came more sharply into focus.

Introduction of Total Allowable Catch (TAC) and quota

The third principle was a recognition that the salmon resource is finite and therefore the harvestable surplus over the spawning escapement is finite too. The finite, harvestable surplus is the Total Allowable Catch (TAC) in any year and this is what must be shared equitably among the legitimate interests.

The sharing process, between the netsmen and the anglers, is managed by quotas allocated to each sector. At a practical level, the Task Force proposed the introduction of carcass tags to monitor the catches and to assist in allocating the quotas.

TAC and quota are so often allied that the subtlety of their distinction is sometimes lost. TAC is a pure biological conservation measure – it limits the number of fish to be killed. It can be set by reference to criteria like conservation limits that are based on stock abundance and the carrying capacity of the environment. These are measurable with a fair degree of confidence. Reasons for TAC changes, upwards or downwards, are based on stock abundance and can be transparently explained.

Quotas, on the other hand are not conservation actions. They are simply the means whereby the TAC is allocated between competing interests. Quotas can be set and altered using criteria that have no relevance whatever to the salmon stock. Legislators can, for instance, decide to allocate or alter a zero, or any other, quota to any sector based on historical, social, economic or any other consideration. In the words of the Task Force report, "…The apportionment of quotas between the catching sectors, and it is rebalancing from time to time, is a matter of policy to be decided by the Minister…"

By refusing to be swayed by calls to ban commercial fishing on spurious conservation grounds the Task Force succeeded in creating a sustainability ethos which encompassed and gave respect to all the traditional resource users and in which the salmon spawning escapement, not the fisheries, was at the heart of the strategy. By introducing TAC and quota it provided a mechanism in which the utilization of the resource by different interests could be controlled, partitioned and monitored, with an effective and transparent mechanism for modulating the catch and its partition as circumstances dictated.

The net fishery sector embraced the new regime positively in the spirit of compromise and a willingness to give it a try. The commercial fishermen were already familiar with TAC and quota regulations in EU sea fisheries so the new scheme raised fewer fears among them. They have continued to operate the strategy and the carcass tag monitoring scheme, with over 95% compliance. This cooperation was achieved despite the increased catch and effort regulations that were introduced concomitantly by the Task Force. There was a real cost of admission to the community of stakeholders: numbers of fishing days were reduced, territorial fishing limits at sea were restricted, and night time fishing was made illegal. These controls are unlikely to have been acceptable if the fishermen did not feel that they now had a stake in the health and abundance of the stocks. From now on, whatever damaged the stocks was seen as a threat to the salmon harvest in which they had a guaranteed share and it was in their own interest, not that of the land-based anglers alone – that the stock be maintained and restored. A methodology for proper long-term regulation and stock maintenance was being put in place with their consent and participation. Extreme conservationism on its own had never achieved, and never could, that level of cooperation.

On the other hand, some angling leaders, self-styled conservationists, were less willing to embrace the new strategy. Their language remained as unchanged as their ideas. They resisted the introduction of the carcass tags and logbook scheme, even as they saw the net fishery come under reductions in TAC. As recently as January of this year (2003) they resisted proposals for a token annual bag limit of 20 fish per rod licence on the basis that it was not enough for them. Yet, if all the 30,000 rod licence holders were to catch 20 fish each, the total rod catch would exceed the TAC for the nets, by a factor of over three times.

Individual anglers, realising that everyone was sharing the pain, and that the new strategy was addressing all aspects of the fisheries, came around to supporting the strategy despite their leaders' opposition. They, too, were more impressed with the philosophy and concepts of the Task Force approach than with their leaders' language of purported conservation.

To have detoxified the previously poisonous atmosphere that pervaded Irish salmon management by so simple an approach was itself a remarkable achievement of the Task Force. As an editorial in the Irish Times (4th definition of conservation) saw it:

> *The [Task Force] report struck an equitable balance between the needs of competing interest groups, and between the demands of conservation and coastal livelihoods. Human life-cycles too are at stake.*

Progress since the Task Force Report

Since the Task Force report, salmon management in Ireland has progressed, by consensus, to regulation, enhancement and considerably lowered harvesting of wild stocks. The TAC for the nets in 2003 is set at 182,000 salmon against 240,000 in the 2002 season. Another step in the process of optimising the salmon resource was the recent release (June 2003) of an "Economic/socio-economic Evaluation of Wild Salmon in Ireland" by INDECON International Economic Consultants (5th definition of conservation). Remarkably, the very first recommendation of that Report is couched in a partial negative:

> *We do **not** recommend the ending of commercial salmon fishing but believe that the level of catch should be aligned with sustainable development. (Emphasis original).*

This new Report builds on the logic and the sustainability approach of the Task Force. It says nothing new that was not already said by the Task Force. In brief, it proposes that greater economic benefit will accrue to the State if the quotas are re-balanced to permit a greater portion of the catch to be made by anglers. But it will not be universally acceptable. Its analyses appear simplistic and it takes an economic impact rather than an economic value approach to the resource when the latter might have been more appropriate for the long term. There is also a very real danger that some interests will misinterpret or misuse its scenarios for sustainable development as pragmatic options, rather than as the very simple illustrative models that they really are.

In Irish we have a saying "Tús maith leath na hoibre – "well begun is half done" is a fair translation. The Task Force Report was a new beginning for salmon management in Ireland. It initiated and fostered a sustainability ethos within which the latest Report has relevance and some realism. It is much to be hoped that the consensus won by the Task Force will prove robust enough to permit all sides to give the new Report the careful and balanced consideration it warrants.

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CHAPTER 33

Development of the Canadian Wild Salmon Policy

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Abstract

The need for a Wild Salmon Policy was spelled out in DFO's 1998 policy document entitled "*A New Direction for Canada's Pacific Salmon Fisheries*". This "New Directions" document set out twelve principles based on three elements: conservation, sustainable use and improved decision making. The Wild Salmon Policy is one in a series of papers written subsequent to the release of the New Directions policy paper. A draft Wild Salmon Policy Discussion paper was the subject of extensive consultation in 2000, the results of which have guided revisions to the policy. Currently, work is underway to develop operational guidelines for fisheries management, habitat, enhancement and aquaculture and a decision framework that links these guidelines with the policy principles. The policy is scheduled for release in late 2003.

Please note that this chapter was not available at time of printing.

CHAPTER 34
Dialogue following Policy and Legislative Initiatives

International considerations of the endangered species status

Otto Langer directed his comments to Carol Eros. It is his understanding that Cultus Lake sockeye runs are in dire straits and he is concerned that we would expose that fishery to a full fledged fishery with exploitation rates of 25% in 2003. He referred to her description of the protection of Cultus Lake sockeye as a priority but noted that it seems to be a slipping priority already. Canada has not worked out how COSEWIC or SARA will fit into the international treaty with the US and moreover, in the discussions for the Integrated Fisheries Management Plan, US counterparts have rejected recognition of the threatened status of Cultus Lake runs and have indicated this is really a domestic issue and, therefore, as the sockeye come through, they can exploit as high as 20% as agreed upon in the draft plan. Canadian fishermen will then have to make the sacrifices to allow more of the Cultus Lake fish through the fishery. In his opinion, there seem to be some real flaws and the priority should have been on the 2003 fishery. He posed the question: How do you relate SARA and COSEWIC to an international treaty? Why aren't we moving sooner and how do we address those concerns?

Carole Eros replied that she could not specifically respond to the fisheries' management decisions in terms of Cultus Lake and the Integrated Fisheries Management Plan at this stage but could only comment on what the plans are for the implementation of the Cultus Lake sockeye recovery plan and the timelines of how that would occur under SARA.

Donna Darm commented that they have asked themselves the same question in the US, because there are numerous fisheries in Canada, particularly off the west coast of Vancouver Island, that harvest threatened and endangered Puget Sound and Columbia River fish. She noted that this is a dialogue they would be very interested in having.

Brian Riddell noted that there are three specific examples under the Pacific Salmon Treaty that he knows of that when Canada was asked to assist with particular conservation concerns, they assisted. In his opinion, we should try to cooperate on this and this is an important dialogue that should be followed up on.

David Cunnington addressed the question about trans-boundary management and the Species At Risk Act. He commented that this is an important issue and it is a gap that is recognized in a number of different organizations. Now that there are negotiations between the two governments, US and Canada, at the National Office level, there is a discussion paper on how to manage species at risk across boundaries.

Don Lawseth commented that the cooperation will likely be at the recovery team level. He noted that they (DFO) did this with the sea otter recovery team where they invited experts from the US to participate - they found that relationship very rewarding and they synchronized their recovery approaches with those of Washington State, and Alaska to some degree. He believes that that is the level where the cooperation will happen.

Is habitat restoration required under the Act as well as habitat protection?
Wayne Harling commented that under the recovery section there is a requirement for protection of habitat, but he was unsure whether there is also a requirement for restoration of habitat, which may be the reason the sockeye species is on the endangered list in the first place. He noted that the minister said "may" allow activity affecting the species. He posed the question: Must the action plan require habitat restoration or does it merely mandate identification of habitat?

Carole Eros explained that right now it requires the identification and protection of the critical habitat, so if the critical habitat is identified, it is a requirement in the recovery strategy and action plan to protect it. If the recovery strategy identifies habitat restoration as one of the primary threats and in need of restoration, then that would be identified and included.

Wayne Harling commented that he did not see it listed as 'mandatory' and Carole Eros agreed that it is not 'mandatory'. Mr. Harling replied that without it being 'mandatory' it is meaningless.

Positive aspects of SARA
Jeff Hutchings commented as a member of COSEWIC, and noted that the current discussion has been focusing on the negative rather than on identifying some of the positive things that have resulted from SARA. He has been very concerned about conservation from a variety of perspectives and applauded the fact that the Species At Risk Act has been proclaimed. Among the many positive aspects coming out of SARA, particularly for aquatic species, is the legal listing process. He noted that the COSEWIC list is made public at the end of each COSEWIC meeting so that the Canadian society knows what this independent science body feels about each of the species in question. Society can then assess the appropriateness of not 'listing' species, should the Governor in Council decide not to do so.

He noted two other good things about SARA, notwithstanding the species production measures: first, there is a requirement for recovery targets and recovery targets have to be identified in the recovery strategies. If we go back to the Atlantic cod situation and a number of marine fish issues, we lack recovery targets and we have not had any since those fisheries were closed. In his opinion, that has been the single biggest problem facing us in identifying responsible management strategies. His second point is to do with the habitat side and he made reference to marine fish. SARA indicates that if critical habitat is not known for an endangered or threatened species, then the recovery strategy must address that and identify means by which that critical habitat can be identified. This would be of enormous benefit given that we have not got a clue as to what essential habitat is for any marine species.

Is there a recovery team currently in place for *Bocaccio*?
Jeff Hutchings posed the question to Carole Eros: With respect to *Bocaccio*, which was listed as *threatened,* does the Department of Fisheries and Oceans have a recovery team in place for *Bocaccio* at this time?

Carole Eros replied that this has been identified as an upcoming need for recovery planning for *Bocaccio*. She noted that there have been some informal discussions taking place about *Bocaccio* with industry and other interests but there has not been a formal recovery team established at this stage.

Recovery plan efforts underway in BC

Rich Chapple referred to the presentation by Donna Darm on recovery planning experience in the Pacific Northwest of the US and noted that there is significant progress in recovery planning in British Columbia with the establishment of the Pacific Salmon Endowment Fund in 2001 together with the Pacific Salmon Foundation's efforts to develop recovery planning. They have taken on seven projects in total and have recovery plans completed and are in the process of doing recovery plans for Squamish River, Salmon River, the Thompson Basin and Sakinaw Lake sockeye. He commented that Sakinaw Lake is going to be interesting because as a non-government organization, they will be collaborating extensively with DFO. In regard to the Nimpkish River salmon recovery plan, he noted that it took a number of months to complete and cost $15,000, and as a result there are already several projects underway. In developing the guiding principles for their recovery planning they learned some lessons fairly quickly and have done some things in a 'Canadian' way; that is, it is an intensely collaborative effort and driven from the bottom up as opposed to the top down. That may explain why they have been able to be fairly expedient.

Brian Riddell commented that from his experience, in the southern US, there is an enormous amount of work going on with recovery planning and watersheds and watershed councils and it would be very worthwhile meeting together and sharing these experiences. He believes that in Canada we are probably a little behind but going in the right direction.

The Wild Salmon Policy process

Wayne Harling referred to Mark Saunders' presentation and commented that in his opinion there is obviously in-house polarization between science and management on the issues around the Wild Salmon Policy and expressed his concern that if drags on much longer then the final product will bear little relationship to what was discussed during the consultation process. He posed the question: You have described several issues that still must be dealt with but is there one key stumbling block to moving this forward and, if so, what exactly is it?

Mark Saunders replied that the critical points are about values and the questions about what it is we are trying to conserve. He believes that there has been a misunderstanding and much of what Noel Wilkins described applies to this situation. A lot of it is about the words of what conservation means; there is a misconception that conservation means 'no fishing'. They are working through the words as to what conservation means and the question about what it is that they are trying to conserve.

Maurice Coulter-Boisvert explained that he works with volunteers in the Lower Mainland who, since 1980, have been involved in small scale fish culture operations and, in the face of habitat loss and development, are trying to preserve salmon populations. He believes that most of these volunteers are not particularly concerned with the fact that the salmon are 'wild' and noted that there has been a lot of discussion here about our primary concern that the salmon be 'wild', as opposed to having salmon at all. He expressed his concern that the Wild Salmon Policy will recognize that, so as not to cause the involvement of those 10,000 volunteers as well as potentially 20,000 others involved in watershed stewardship and stream keepers, to back away from their commitment and involvement to the resource by being denied the opportunity because the salmon they are producing are not 'wild'.

Mark Saunders noted that it was said earlier that it is a mistake to not engage, in this process, all of the people that are involved and, in particular, the streamkeepers. The advantage that they have here is that such a huge proportion of the population is engaged in this issue. Much of this speaks to the education that needs to be done to bridge the link between the science that is behind the concerns over the wild salmon and what maintaining our genetic diversity brings to it. He believes that we need to be responsible for making sure that we understand the implications of enhancement and the fact that we have made large strides in our application of enhancement. A lot of their concerns come from earlier stages and points in

time when we knew less about the enhancement process. As much as anything, a big part of this is education and engagement.

Amit Kumar Goel explained that as a Simon Fraser graduate student who comes from India, Australia and Thailand he came to the summit with an idea to identify key issues. What he has identified is that we all need to have a genuine desire to solve the problem of fisheries around the world and have genuine participation of all the stakeholders. As scientists, or as managers, we need to look at ourselves and what it is we have contributed to this state of affairs and we have to work through that situation.

Otto Langer encouraged Mark Saunders to continue to work on the implementation of the wild salmon policy in DFO. He cautioned that this is an agency that has lost a lot of its trust and public respect over the last decade and is suffering low morale, resources cuts and, to some degree, it has created polarization such as in aquaculture and other issues. He noted that in a sense, there is also a need for a pre-plan, which would be a 'recovery plan' for DFO before we can make a Wild Salmon Policy work. He believes that over the years, when he was employed by DFO, too much money was spent on salmon and now there is a need to diversify and go into other species. He expressed concern about how this can all be brought together and made to work now, especially considering the limited consultation time and the limited time to start changing the system.

Mark Saunders replied that one of the interesting things raised in the workshop is that it will be interesting to see the comparison of how fast science moves, which is where he is based, to a group of larger government bureaucracy that moves just slightly faster than the salmon can actually evolve. He noted that they are taking steps internally to interact across the different branches, sectors and groups to improve communication and decision-making to meet the schedule they have established – an interesting problem is that there is not any part of the department that is not touched by salmon.

A follow up meeting of policy makers

Noel Wilkins observed that during the meeting someone said that it is a pity there aren't more policy makers present - he believes that it was perhaps quite good that there weren't because it allowed us to talk frankly and openly. What might be a good idea is that when the proceedings are produced the policy makers in Canada be identified and the nodes in the policy system and a copy of the proceedings be forwarded to them and explain that you propose to have a meeting later in the year called "A Policy Response to the World Summit on Salmon" and invite them to come along. He believes that they might attend and they would give a response and, if they did, then that would give Canada a good grounding and credibility to then extend to the wider continents and look across the Atlantic and encourage the Europeans to establish a policy, such as has been accomplished in Canada. The idea is to have a follow-up meeting of policy makers and include the more Canadian-based important people at this meeting.

Wrap Up Statement – John Pierce

I am sure that all of us have found this Summit tremendously informative and stimulating and worthy of the title "World Summit". The prospects for protecting and enhancing species have been enhanced through a better understanding of the long history and experiences of fisheries in numerous regions and jurisdictions and what is clear to me is that, while there are disturbing trends with respect to certain species facing extinction in the Pacific Northwest, we should not confuse trend with destiny – trend is not destiny. We can effect positive change and, while scientific uncertainty exists, it must be reduced particularly over ecological interactions. Many of the current problems have their origins, in my view, in lack of political will and mismanagement including lack of funds for research and inventorying various things in British Columbia. I am reminded, and I have been reminded on several occasions during the Summit, of Homer-Dixon's book, "The Ingenuity Gap". He distinguishes between two types of ingenuity: technical ingenuity, which is something that I believe we do very well, and social ingenuity which we are

far less successful at – in other words creating adaptive and novel institutions, organizations and approaches to deal with increasing complex problems that we have created ourselves.

Our challenges, which have been reinforced at this Summit, are to clarify management objectives, to understand trade-offs and the links between ecosystems and socio-economic systems to provide flexible, legal, regulatory frameworks in order to educate the public and to sustain the diversity of this vital public resource for future generations. Without question, habitat stewardship is far more complicated than many of us have realized as is ecosystem planning. Social ingenuity must act as a counter-balance to technical ingenuity and it is precisely because of the existing imbalance between these two, between technical ingenuity and our success at that *vis-à-vis* social ingenuity that this imperils, in my view, the future of salmon fisheries. I will refer back once again to the Honourable John Fraser who has reminded us of the need to provide politicians and decision-makers with guidance through clearer understanding of options, trade-offs and consequences of various actions. This we can do and we do not need perfect information, nor is a scientific certainty a requirement. The momentum that has developed over the last three days is very significant and I would not like to see this lost. We can move forward and the Wild Salmon Policy that has just been discussed is obviously encouraging but we need leadership and we need leadership from many different quarters and not just from politicians and decision-makers. The policy response to the World Summit on Salmon is a worthwhile objective and goal and I would like to see that pursued.

References

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APPENDIX I
THE WORLD SUMMIT ON SALMON
Morris J. Wosk Centre for Dialogue
Simon Fraser University, Burnaby, BC, June 10-13, 2003
Presenter Biographies

Xanthippe Augerot is the Director of Conservation Programs at the Wild Salmon Center's home office in Portland, Oregon and the Co-chair of the IUCN Species Survival Commission's Salmon Specialist Group. Dr. Augerot earned a masters of marine affairs from the University Washington, and a PhD in Geography from Oregon State University. She honed her Russiona language skills and became interested in fisheries policy while working for the first US-Soviet joint venture company, Marine Resources International. Augerot spent a year in Washington, DC working for the Senate Commerce Committee on a Knauss Fellowship, which led to a five-year tenure at the Washington Sea Grant Program, in Seattle. She founded the Russia Far East Salmon Biodiversity Program at the Wild Salmon Center and, in addition to oversight of the conservation programs, is now the Co-Director of the joint Ecotrust (Portland, OR)- Wild Salmon Center State of the Salmon Program.

Donna Darm is a Northwest native and graduate of the University of Washington Law School. She spent 5 years as a lawyer at the State Department in Washington, D.C. before returning to the Northwest to continue her work on fisheries issues. She has been with NOAA Fisheries since 1992 in a variety of policy positions. Currently she is the Assistant Regional Administrator for Protected Resources, responsible for managing the agency's listing decisions, critical habitat designations, and 4(d) rules under the ESA. Prior to formation of a new Salmon Recovery Division, she was involved in the agency's recovery planning efforts.

Carole Eros is responsible for species at risk recovery planning for Fisheries and Oceans Canada, Pacific Region and is currently initiating recovery planning processes for three populations of Pacific salmon. Ms Eros has a Masters degree in marine biology from James Cook University, Australia. After completing her Masters degree, Carole held a research position in the School of Tropical Environment Studies and Geography developing national and international management and conservation strategies for dugongs, a threatened marine mammal throughout the Indo-Pacific. Carole joined Fisheries and Oceans Canada (DFO) in 2000 and has held positions within Fisheries Management including Aboriginal Fisheries and was directly responsible for managing the Canadian Pacific halibut and sablefish fisheries.

Stephen Farber is the Director of Public and Urban Affairs, Graduate School of Public and International Affairs, University of Pittsburgh. Dr. Farber has a Ph.D. in economics from Vanderbilt University. His research and policy interests are in valuing and managing natural capital. He has particular interests in the valuation and management of wetlands systems. He has served as consultant and advisory board member for coastal management and watershed management organizations.

The Hon. John Fraser is the Chair of the Pacific Fisheries Resource Conservation Council. He was born in Yokohama, Japan and raised in Vancouver. He graduated from the University of British Columbia and practised law until his election to the House of Commons. During his years in Parliament, John Fraser served in key positions, including Minister for the Environment and Minister of Fisheries. He was the first person to have been elected Speaker of the House of Commons by his peers, a practice instituted in 1986. In 1994, John Fraser was selected to head the Fraser River Sockeye Public Review Board investigating the salmon fishery. He subsequently represented Canada as Ambassador for the Environment, responsible for Canadian follow-up to commitments made at the United Nations Rio Conference on Environment and Development. John Fraser is a Queen's Counsel, an officer of the Order of Canada, and a member of the Order of British Columbia and he holds the Canadian Forces Decoration. In 1999, he was awarded honorary Doctor of Laws degrees by Simon Fraser University and St. Lawrence University for his contributions to environmental causes.

Terry Glavin is a Canadian conservationist and the author of several books whose most recent major work, *The Last Great Sea: A Voyage Through the Human and Natural History of the North Pacific Ocean*, won the 2001 Hubert Evans Prize as well as the Roderick Haig-Brown conservation award from the North Pacific chapter of the American Fisheries Society. Mr. Glavin was a founding member of the Pacific Fisheries Resource Conservation Council and has worked with a variety of conservation organizations in British Columbia. He is currently the marine conservation adviser to the Sierra Club of Canada, B.C. chapter. He is also the editor of *Transmontanus Books* and a frequent contributor to various newspapers and magazines in Canada.

Ray Hilborn is the Richard C. and Lois M. Worthington Professor of Fisheries Management in the School of Aquatic and Fishery sciences, University of Washington. His general areas of research are fisheries population dynamics, management, and natural resource conservation, and he has worked extensively on the fishery resources of the West Coast of the U. S. and Canada and New Zealand and Australia. He currently serves on the scientific advisory panel for the Presidents Commission for Ocean Policy, the Editorial Board of the Canadian Journal of Fisheries and Aquatic Sciences and the Independent Advisory Panel for the Commission for the Conservation of Southern Bluefin Tuna and has worked with a number of other national and international fisheries management organizations. His is the co-author of 5 books and monographs on natural resource management, as well as 100 articles. His long-term areas of research have been explicit spatial modeling of populations, design of adaptive management systems for natural resources, the behavior and dynamics of fishing fleets, relating models to data using maximum likelihood and Bayesian methods, fisheries stock assessment and population viability analysis. He currently has major projects on salmon in Western Alaska, salmon, and marine fishes on the west coast of the lower 48 states, and stock assessments and marine mammal interactions in New Zealand marine fisheries.

Kjetil Hindar is a Senior Research Scientist with the Norwegian Institute for Nature Research in Trondheim, Norway, a leading center in Europe for research on applied ecology and natural resource management. His research focuses on the population genetics and ecology of salmonid fishes, and on the effects of releasing non-native fish into natural environments.

Jeffrey Hutchings is an evolutionary ecologist whose research focuses on the life history, behaviour, population dynamics, and conservation biology of marine and anadromous fishes, particularly Atlantic cod, Atlantic salmon, and brook trout. A member of faculty at Dalhousie University since 1995, he is a Non-Government Member on COSEWIC and Editor of Canadian Journal of Fisheries & Aquatic Sciences.

Fred Kircheis is a Certified Fisheries Scientist and Life Member of the American Fisheries Society, and a Fellow of the Americana Institute of Fishery Research Biologists. He was a Fishery Biologist with the State of Rhode Island and a Fishery Research Biologist with the State of Maine. He specializes in all aspects of landlocked Arctic charr, and management and conservation issues. Other research interests include brown trout, lake trout, and diamadromous species such as American eel, alewives, and smelt. Fred was the Executive Director of the Maine Atlantic Salmon Commission from 1999 to January 2003 when he retired to pursue other interests including spending time with his grandchildren, boating and outdoor recreation.

Jan Konigsberg established Trout Unlimited's Alaska field office in 2000 to direct the Alaska Salmonid Biodiversity Program. Prior to his Trout Unlimited work, Jan served several years as executive director of Alaska Conservation Foundation. He has a Masters in Philosophy from the University of Montana.

Robert T. Lackey is a fisheries biologist at the U.S. Environmental Protection Agency's research laboratory in Corvallis, Oregon, and is also courtesy professor of fisheries science and adjunct professor of political science at Oregon State University. For the past 35 years, he has dealt with a range of natural resource issues from positions in government and academia. Among his professional interests are natural resource ecology and the interface between science and public policy. He has written 100 scientific journal articles. His current professional focus is providing policy-relevant science to help inform ongoing salmon policy discussions. He is a

Certified Fisheries Scientist and a Fellow in the American Institute of Fishery Research Biologists.

David Marmorek is an aquatic ecologist, and President of ESSA Technologies Ltd., a company based in Vancouver, B.C.. He enjoys combining his technical knowledge (modelling, experimental design, adaptive management, decision analysis) with people skills (facilitation, team leadership) to tackle problems dealing with fish populations and habitat at various spatial scales. He's also an Adjunct Professor in the School of Resource and Environmental Management at Simon Fraser University.

Mitsuhiro Nagata is a Research Scientist at the Hokkaido Fish Hatchery with the Department of Fisheries and Forestry of the Hokkaido Government. Dr. Nagata's current research includes population dynamics and forecast of Hokkadio salmon (chum, pink and masu), behavioural ecology of masu salmon, monitoring activity for population dynamic, age structure, hatchery programs, and conservation activity for river restoration. He also is involved with forum activity for the restoration of wild salmon and better habitats.

Arnie Narcisse is a Stlatlimx-Blackfeet Indian who is the Chairman/Speaker for the BC Aboriginal Fisheries Commission. The Canadian Wildlife Federation recently awarded Arnie the prestigious "Roderick Haig-Brown" award in June 2000 recognizing his outstanding contribution to resource conservation. Arnie has also worked with Universities on the west coast in an effort to conserve wild salmon and to encourage First Nation students to pursue fisheries, science and education programs. He is a river fisherman and former manager of the Nicola Valley Watershed Stewardship and Fisheries Authority. As manager of the NWSFA, Arnie was instrumental in bringing the various stakeholders together to work on a number of fisheries projects in the Nicola Valley including construction of a permanent Coho Enumeration fence.

Jennifer L. Nielsen is Fisheries Supervisor and Research Biologist with the USGS Alaska Science Center, Office of Biological Science. She has conducted salmonid and fisheries research throughout the western Pacific for the past 23 years. Dr. Nielsen holds Associate Faculty positions at the University of Alaska, Fairbanks, School of Fisheries and Ocean Sciences and the Marine Science Institute; the Department of Biology, University of Alaska, Anchorage; and serves on the Graduate Faculty for Fisheries and Wildlife, Oregon State University. From 1995-1999, she was a visiting scientist at Hopkins Marine Station, Stanford University. From 1995-1999, she was an Adjunct Professor in Ichthyology and Fisheries at the University of California, Berkeley and Moss Landing Marine Laboratory, and served on the Scientific Review Board for the Monterey Bay Aquarium. Dr. Nielsen has published over 40 peer-reviewed journal publications and book chapters, numerous technical reports, and gives frequent national and international presentations at scientific meetings addressing research issues in fish conservation, behavior, evolution, and genetics. Her research is recognized internationally for its contribution and focus in fisheries conservation and management.

Randall M. Peterman is a Professor in the School of Resource and Environmental Management at Simon Fraser University (Burnaby, British Columbia, Canada). He holds a Canada Research Chair in Fisheries Risk Assessment and Management and is Director of the Cooperative Resource Management Institute, a unit on campus that facilitates collaboration among university researchers, resource management agencies, and industry. Randall's research focuses on quantitative methods to improve the understanding and management of fish populations, particularly in the presence of uncertainties and conservation risks. His research group specializes in developing and applying quantitative methods to improve fisheries management. Randall has served on various policy advisory groups and helped to write the 1995 United Nations Food and Agriculture Organization's (FAO) "Precautionary Approach to Fisheries".
Website:
http://www.rem.sfu.ca/faculty/peterman
Research: http://www.rem.sfu.ca/fishgrp

John Pierce is the Dean of Arts at Simon Fraser University. He is also principal investigator in the Promoting Community Economic Development for Forest-Based communities research project being funded by Forest Renewal BC, and the co-investigator in the collaborative Social Sciences and Humanities Research Council funded project, the Georgia Basin Futures Project at the University of British

Columbia. Prior to becoming Dean of Arts, Dr. Pierce was the Director of the Community Economic Development Centre and Chair of the Department of Geography at Simon Fraser University. He is a leading scholar in sustainable land use, food resource and community change.

John R. Post is Professor and Chair of the Division of Ecology in the Department of Biological Sciences at the University of Calgary. His research program focuses on recruitment dynamics of freshwater fishes, climate impacts on northern fishes and the development of quantitative tools for management policy assessment of recreational fisheries.

Guido Rahr is the President of the Wild Salmon Center. Rahr earned a Masters of Environmental Studies from Yale University and has more than seventeen years of experience working for regional and international conservation organizations, including Conservation International and Oregon Trout, where his work won the President's Fisheries Conservation Award from the American Fisheries Society. He has also served as a consultant to the United Nations Development Programme. Rahr serves as Chair of the World Conservation Union (IUCN) Salmonid Specialist Group and Chair of the Tillamook Rainforest Coalition, and has published articles on salmon and river conservation in both scientific and popular literature.

William Rees received his Ph.D. in population ecology from the University of Toronto and has taught at the University of British Columbia's School of Community and Regional Planning (SCARP) since 1969. He founded SCARP's 'Environment and Resource Planning' concentration and from 1994 to 1999 and served as director of the School. Professor Rees' teaching and research focus on the public policy and planning implications of global environmental trends and the necessary ecological conditions for sustainable socioeconomic development. Much of this work is in the realm of human ecology and ecological economics where Professor Rees is best known for inventing 'ecological footprint analysis.' In 1997, UBC awarded William Rees a Senior Killam Research Prize in acknowledgment of his research achievements and in 2000 *The Vancouver Sun* recognized him as one of British Columbia's top "public intellectuals".

Brian Riddell is currently Science Advisor to the Pacific Fisheries Resource Conservation Council and is on assignment from the Canadian Department of Fisheries and Oceans. Brian has been a research scientist at the Pacific Biological Station since migrating west in 1979 from McGill University and his studies on Atlantic salmon. He has worked extensively in the stock assessment and genetics of Pacific salmon, and in domestic and international salmon management issues. Since 1996, he has also participated on the Independent Scientific Advisory Board and Independent Scientific Review Panel, scientific advisory boards in the Pacific Northwest U.S. providing advice on science programs and salmon recovery initiatives. He has received several awards for his work in salmon management and conservation and his interests continue to be in the population biology and genetics of Pacific salmonids, including conservation genetics of small populations and the impacts of intensive culture on enhanced and wild populations.

Mark Saunders is the Wild Salmon Policy co-ordinator, working in the Fisheries and Oceans Canada's (DFO) Policy Branch in the Pacific Region. He has worked as a stock assessment research biologist at the Pacific Biological Station for the past 20 years with recent emphasis on the development of applied technologies for fisheries stock assessment.

Greg Taylor graduated from Simon Fraser University with Masters in Resource and Environmental Management. He began his career with the last remaining isolated cannery on the North Coast. He worked on the QCI for two years in the 1980s buying troll fish and clams. Greg Taylor began working for Ocean Fisheries Ltd. in 1985. He participated on the Skeena Watershed Committee Steering Committee and worked with First Nations to develop the first in-river commercial fishery on the North Coast. He is the Co-Chair of the North Coast Advisory Board and Past President, and current spokesman, for the Northern Processor's Association. He is currently Director of Acquiring for Ocean Fisheries Ltd. in Vancouver.

Carl Walters is a Professor at the Fisheries Centre at the University of British Columbia. His areas of research include the development of rapid techniques for teaching systems analysis

and mathematical modeling to biologists and resource managers. He mainly works on fish population dynamics, fisheries assessment and sustainable management. He believes the heart of fisheries is how to manage harvest: "The main thrust of my research is to figure out how to design management systems that are robust in an area of really high uncertainty".

Reg Watson is a senior research fellow at the Fisheries Centre at the University of British Columbia. Reg Watson has expertise in a range of fisheries areas including penaeid biology, trawl fisheries, stock assessment and computer modeling. He has published extensively on the simulation and optimization of trawl fisheries, and on bias in underwater visual census. In addition to scientific journals, his work on global fisheries has recently been published in Nature, La Recherché, National Geographic, and will soon appear in Scientific American. An experienced ecological modeler, he was a principal researcher in a study of the impacts of marine protected areas and artificial reefs in Hong Kong. He led a team that developed national marine biodiversity policy for Indonesia. He has 30 years of experience working internationally in fisheries and ecology projects. Dr Watson is currently involved with the acquisition, management, analysis and visualization of global fisheries data with the 'Sea Around Us' project.

Fred Whoriskey is the Vice-President of Research and Environment at the Atlantic Salmon Federation. He received his PhD from l'Université Laval in 1984 and has held various positions at Woods Hole Oceanography Institution (WHOI) in Woods Hole, Massachusetts, the University College of Wales in Aberystwyth, UK and at McGill University. His research interests include fish biology and ecology, and the impacts of exotic species on native ecosystems and is heavily involved in public policy issues, especially with regards to environmental impact assessments. He was appointed Deputy Scientific Coordinator of the Great Whale Scientific Support Office in 1993. He has served as a scientific advisor to the Moose River/James Bay Coalition, the Grand Council of the Cree (Quebec), and the Atlantic Salmon Federation on hydro-electric development on the Moose River, Great Whale River, and Ste. Marguerite/Moisie Rivers respectively. Presently, Whoriskey serves on the Board of Aquanet (Canada's National Centre of Excellence in Aquaculture), the Huntsman Marine Science Centre, the Atlantic Salmon Broodstock Development Program, and the St. Lawrence Valley Natural History Society.

Noel Wilkins is a geneticist and Professor of Zoology in the National University of Ireland, Galway. Previously he was employed by the Department of Agriculture and Fisheries for Scotland studying salmon at West Greenland. Nowadays he runs a salmon-breeding programme in conjunction with the Electricity Supply Board on the River Shannon, the biggest river in Ireland. He was Chair of the Salmon Management Task Force set up in 1996 by the Irish government and first Chair of the National Salmon Commission. He and his students work on all aspects of the Atlantic salmon and on the restoration of stocks to areas where they have become severely reduced.

Ken Wilson is a consulting fisheries biologist working as Scientific Advisor to the Sierra Club of BC Marine Committee, and with Fraser First Nations in the capacity of Stock Management Coordinator. In this capacity, and through the Marine Fish Species Specialist Group of COSEWIC, he is involved in the assessment, listing and recovery planning of BC salmon stocks including Upper Fraser Coho, and Sakinaw and Cultus Sockeye. Ken's work is primarily concerned with assessing the status of Fraser salmon stocks, and working with First Nations, Environmental Non-government Organizations, and Government management agencies to build stock assessment capacity and address stock management concerns through harvest regulation.

Malcolm Windsor is the Secretary of the North Atlantic Salmon Conservation Organization (NASCO) based in Edinburgh, Scotland. NASCO is an inter-government organization arising from a Treaty to conserve and internationally manage the North Atlantic Salmon with virtually every North Atlantic nation as a member. Dr Windsor's task was to set up and run this Organization following international concern about the future of the species. One of its tasks is to reach international agreement on regulatory measures based on scientific evidence to conserve stocks. NASCO has developed close links with the International Council for the Exploration of the Sea in setting the scientific questions which must be answered

if NASCO is to achieve its aims. The NASCO Secretariat has recently put significant effort into developing agreements and guidelines on implementation of the Precautionary Approach to fishery management, habitat, introductions and transfers, aquaculture and transgenics. It is also developing approaches to socio economic evaluations of the salmon resources and how such aspects of the resource can be instigated in the Precautionary Approach. Dr Windsor's post has many aspects: diplomatic, scientific, administrative, financial, publishing, legal and other elements.

Previously Dr Windsor was with the British Chief Scientist's Group within the Ministry of Agriculture, Fisheries and Food in London. There he reported directly to the Chief Scientist and his task was to implement, for fisheries research, the UK Government's policies for R&D. Before that he worked as a researcher at the UK's Torry Research Station and was concerned with the food and feed aspects of fishery resources. Earlier he worked in the field of physical chemistry in the US at the University of California. His earlier experience was in industry.

APPENDIX II
THE WORLD SUMMIT ON SALMON
Morris J.Wosk Centre for Dialogue
Simon Fraser University, Burnaby, BC, June 10-13, 2003
Participant List

Gerald Amos
Ecotrust Canada
Vancouver, BC

Brian Assu
A-Tlegay Fisheries Society
Campbell River, BC

Mary-Sue Atkinson
Pacific Fisheries Resource Conservation Council
Vancouver, BC

Xanthippe Augerot
The Wild Salmon Center
Portland, OR

Jeffrey Barnard
The Associated Press
Grants Pass

Tanya Bettles
Simon Fraser University
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28 May 2003

The Honourable Robert G. Thibault
HOUSE OF COMMONS
Minister, Fisheries and Oceans Canada
Parliament Buildings, Wellington Street
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Dear Minister Thibault:

As you are no doubt aware, two weeks ago the cover article in Nature, arguably the world's top general scientific journal, reported a joint Canadian-German study showing that, after only five decades of industrial fishing, the world's commercial fishing fleet had succeeded in stripping 90% of large economically valuable and ecologically critical fish species from the sea. My colleagues in fisheries science suggest the situation is actually worse, that the overall fish biomass of much of the world's oceans has been reduced by up to 90% and that, as the most valued top carnivores are depleted, fishers everywhere are compensating by "fishing down the food web." This may help to maintain gross catches, but raises fears that we will merely repeat the sequence of over-exploitation at lower trophic levels in marine ecosystems. (Indeed, we are seeing the potential unfolding of this scenario here in Canada, where ineffective management has essentially destroyed North Atlantic cod and other fin-fish stocks, and pitted fishers against each other as they squabble over rights of access to crab and shrimp 'fisheries.')

The depletion of the oceans is an all but unprecedented global ecological (and potentially human) tragedy, yet after a mere day or so in the news, this story seems to have disappeared from public consciousness. Given the scale of the problem, I would have expected that, by now, responsible government agencies in Canada and elsewhere would be all but falling over each other to reassure their citizens that they will respond appropriately to the implosion of ocean fisheries before the process leads to the (essentially permanent) collapse of key marine ecosystems. Note that life in some parts of the sea has already been but reduced to little more than algae, bacteria and jellyfish. In tragedy lies opportunity.

I would urge you, as Minister of Fisheries of Canada (one of the nations responsible for the sorry state of world fisheries) to assume affirmative world leadership on this issue. As minister, you should announce that this country, through Fisheries Canada, intends to convene as soon as possible a major international congress on fisheries science and global fisheries management. The ultimate goal would be a consensus scientific report on the state of the oceans with an emphasis on marine fisheries and, most important, an international management plan designed significantly to reduce global fishing effort and enable the recovery of fish stocks for sustainable use by future generations. We have no choice but to reduce humanity's "ecological footprint" in the sea.

The industrial world proclaims itself as the first mainly knowledge-based culture and economy. Let's prove it by responding to the growing body of scientific evidence that humanity is destroying the ecological basis of its own existence. Canada should be proud to assume leadership in this endeavour—indeed, in the circumstances, it is the responsible thing to do.

Respectfully submitted,
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