State of the Salmon
2009 Conference

Bringing the Future *into* Focus

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Conference Proceedings

The Wild Salmon Center

ecotrust

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Opening ceremony

Brian Riddell & Rich Lincoln, conference co-chairs

Riddell welcomed all participants to the second State of the Salmon conference before inviting First Nations to offer a traditional welcome.

Welcome inspirations

Deanna George (Tsleil' WaututhFirst Nation) and Bob Guerin (Musqueam First Nation)

George and Guerin welcomed participants to the traditional territory of the Coast Salish, who also call themselves "the Salmon People." A prayer was offered to restore the health of the salmon and the earth, and the elders wished participants success in their efforts to save the salmon that are so important to the way of life of indigenous peoples.

Brian Riddell, Pacific Salmon Foundation

Riddell noted the diversity of the conference participants and the strong turnout reflects how many people care about salmon. Everyone is concerned about climate change and what is needed to study effects of climate change on salmon in the North Pacific, he continued. All five nations of the North Pacific Anadromous Fish Commission (NPAFC) have expressed interest in working together on ocean research, so it has hoped that by working together and sharing common knowledge, progress can be made.

Guido Rahr, Wild Salmon Center

Thanking key sponsors, Rahr noted the State of the Salmon conference is a joint program of Ecotrust and the Wild Salmon Center, with the conference goal to strengthen the conservation status of salmon in the Pacific Rim. Much work has been done, but threats are mounting, and while some populations are doing well, others are not. Salmon conservation is one of the most important issues we face, and the most challenging, and it's up to the people in this room to figure it out. Salmon are trans-boundary species, so it's important for the five nations to work together, and we can accelerate the pace of learning if we work together and share, he said.

Rahr reviewed the conference agenda, noting keynote speakers would lay out the broad challenges and stress the need for new thinking. Presenters would discuss strategies that have worked (or not), wild salmon conservation principles, opportunities and impediments and attempt to wrap up with a Pacific Rim-wide salmon conservation framework – a roadmap to go forward – to try to prevent history being repeated in watershed after watershed. Integral to that is the need for a strategy to protect salmon strongholds in each region. That's one piece we need to get right, Rahr stressed, and nations must make a commitment to protecting diversity and abundance.

Come together and save what's important to us, Rahr urged participants, describing the Pacific as a big blue arc – an ecosystem that includes ocean, land and the gift of wild salmon coming back every year. This is a key species; in biological and cultural terms, it holds importance for human wellbeing, and we are the ambassadors of the salmon nation.

Rich Lincoln, State of the Salmon

Lincoln thanked sponsors and encouraged participants to engage in the discussions following each plenary. The conference is intended to create a spirit of collaboration and problem solving, he said, welcoming candid but respectful comments and a focus on broad issues. We're here to work across borders and to build bridges for a common cause.

Keynote plenary:

Pacific Rim challenges, opportunities and leadership

Co-chairs: Rich Lincoln & Brian Riddell

Lincoln introduced the keynote speakers who would set the stage regarding key challenges and opportunities, noting the urgency to take action in the face of a rapidly changing landscape.

Politics and economics – imbalance with nature

David Suzuki, David Suzuki Foundation

I salute all who are here to work for a future of abundant and diverse salmon populations, Suzuki said. You are at the frontlines of the challenges and you are the experts. I guarantee the future of salmon is bleak, he added, so long as politics and economics are the major drivers of decisions, rather than salmon being the central focus. He described salmon as a key link in the "incredible interdependence" between forests, oceans and other species. Humans come along and see opportunity and subdivide a single interconnected system into different departments, ensuring that we will never manage these resources in a successful way.

We were taught that the oceans were filled with limitless fish, but that's no longer true, Suzuki continued. There used to be a salmon derby right here in Vancouver. The oceans cover 70 percent of our planet, but as air-breathing land animals, we focus on land. Our knowledge of ecosystems and species is unbelievably primitive. We haven't taken advantage of the incredible knowledge that First Nations gathered over thousands of years. How can we manage sustainably if we don't have the knowledge? We may be missing 90 percent of the biodiversity that exists. We have not even identified most species and we know very little about those we have identified. Despite the enormous effort devoted to studying fruit flies, we still don't know much about them. One of the most important lessons is the extent of our ignorance, Suzuki said. We don't know enough to manage any species. The best we can do is to manage ourselves.

We are driven by human imperatives of economics or politics, he continued. We try to pump up nature on steroids to meet our demands. Nature has had thousands of years to learn how to deal with the basic challenges of life. Now we're in an economic downturn and we immediately ask nature to absorb more. In the four billion years that life has existed, never has a species been capable of altering the earth as we have done. Just the basic act of living, with 6.7 billion of us, means we have a very heavy ecological footprint; and all the technology, consumption and waste add to the impact. We have become a force that is altering the planet at a major scale.

How did we arrive at this point? Man emerged when woolly mammoths were still around, Suzuki noted. Our brains made up for our lack of physical attributes. We're the only animal that considers the future: we can look ahead and foresee dangers and opportunity. Foresight was the secret to our success and it brought us to this position as the dominant creature on the planet. Now we have computers and scientists, and top scientists, including many Nobel laureates, have been warning for years that current practices are putting us at risk and that fundamental changes are urgently needed. They warned that only one or two decades remain if vast human misery is to be avoided and our home on this planet not horribly mutilated. But no major media reported this. Thankfully, there is now a new regime in the U.S., Suzuki said, but I'm embarrassed to have a Canadian government that's still following former U.S. President George Bush.

Why are we turning our backs on these challenges? A hundred years ago most people lived in rural villages, and farmers knew the importance of the seasons, he said. Now, 75 to 85 percent live in urban settings. Nature is not important in the urban setting – the economy is what matters. Even the Minister of Environment elevates the economy above ecology. Both economy and ecology come from the same Greek root, e*cos*, which means household or home. A fundamental flaw in our system is that economists consider forces of nature as an externality to the economy. Our model is predicated on the unachievable notion that the economy must grow forever. But nothing can grow forever in a biosphere. It's like cancer. We need a Bretton Woods II to introduce nature back into our economy, Suzuki concluded.

Ecosystem breaking points: turning crisis into creative opportunity

Crawford "Buzz" Holling, University of Florida

Holling described leaving Vancouver for Florida in 1989 to study the same issues Suzuki mentioned. It had become clear to him that new initiatives were opening up fundamental new ways for people to interact with their environment and economy.

There are two aspects to his work, Holling noted. The practical side includes continuing the work that he and Carl Walters started on adaptive management. The other involves fundamental studies that seek to understand how complex adaptive systems operate and function to maintain persistence and sustainability while maintaining the ability to generate novelty.

In exploring the latter, a series of workshops were held over five years. They were all held on islands and sought to attract people who enjoyed wedding their ideas. Perhaps 25 to 30 people of the 400 who attended were "good on islands," Holling noted. But working with this small group that was geared towards addressing the issues that Suzuki raised led to wonderful discoveries.

This resilience project – or resilience alliance – now consists of 17 groups from around the world, all led by people who are "good on islands." They established an internet journal called *Ecology and Society*, as there was no other way to link the work of the different disciplines. From this work emerged four books on economics, social organizations, large-scale ecosystems, and a synthesis volume: *Panarchy: Understanding Transformations in Systems of Humans and Nature*. This alliance also led to major new institutions focused on complex adaptive ecosystems, including one in Alaska, a coral reef center in Australia, a social innovation center at the University Of Waterloo, and the Stockholm Environmental Institute, which links social and ecological dimensions of these problems.

A key purpose was to develop the link between economy and ecology. I think we failed in that, Holling said. We got people to agree on other things but the fundamental way that ecosystems are structured is very different from how economists still think.

Ecologists see two basic phases in the life cycle of ecosystems. The first is a period of pioneering and growth. At first slow and incremental, ecosystems begin to accumulate capital and rigidity and becomes less open to novelty. As resilience is lost, they reach the point at which an accident is waiting to happen (like the example of the spruce budworm). Once an ecosystem crosses the break point, novelty can occur again, launching a new spin of the cycle. This is the stage of extraordinary importance, Holling stressed. It's much shorter than the long stage of growth and it's the period of greatest unpredictability. When we're operating in that long growth phase, we believe it means increasing certainty. So on one hand, the break point is a crisis, but it's also creative. It's creative destruction that opens opportunity.

That's where we are now with the current economic crisis, he continued. This is the phase in which the individual has the most opportunity to influence the big picture. Political forces are trying harder to defend the status quo, but they are increasingly powerless to do so. This is where individuals can begin to

combine their own enterprise into a synthesis. Inherent in that synthesis must be the recognition that uncertainty needs to be part of the plan. Management can be part of the mechanism by which our knowledge expands.Climate change in the North Pacific raises opportunities and challenges for us to be a voice heard around the world.

Studies with the resilience alliance each focused on a particular region, Holling said. The ones that succeeded in discovery of the unknown shared a common feature – a way of capturing in a few words a broad vision of the whole system. In the Everglades, it was the "river of grass." Here it is the "salmon nation" that captures what you're about.

You're at a critical stage, Holling concluded. What happens will influence salmon in this region of the world but it will also create an image that can be conveyed more broadly, and a set of regional foci on ecosystems and social systems can serve as an integral part of how to join humans and nature.

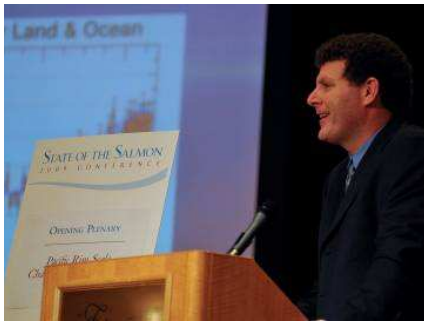
Discussion

Q: If we're in the reorganization phase of these cycles of growth and collapse with the current period of salmon collapse, the outcome of reorganization may not include salmon.

- Holling: It would be a shame, but that might be the case. I don't say we can return to the past but we can identify what processes exist to harness in building the new system. Salmon may not persist across the whole region, but the majority of the region. Salmon may also provide the focus that breaks through the political and economic vice that squeezes out the novelty we need. The time of novelty is right now. It's true globally, with the financial collapse, and also true regionally, in sub-situations as with salmon. Salmon should be part of the solution.

The climate change challenge for Pacific salmon (and salmon people)

Nate Mantua, University of Washington



The distribution of Pacific salmon around the Pacific Rim is bounded to the north by the cooler, shorter growing season, and to the south by warm river temperatures and low levels of productivity in the. This range changes through time, Mantua noted. Climate variability also has a powerful influence on salmon productivity. Historical abundance estimates from the past century show that shifts in the Pacific Decadal Oscillation (PDO) amounting to just 1 to 2º C in ocean temperatures were associated with a doubling of salmon biomass. Salmon are not just affected by temperature, but by winds, currents, rain and snowfall patterns. Underlying cyclical patterns such as the PDO, there has been an overall global warming trend, with the 10 warmest years on record occurring since 1997. Hydrology has responded to climate trends. Arctic rivers are carrying more water into the ocean, partly because of changes in regional wind and weather patterns. Runoff in snowmelt rivers has been coming earlier over the last 50 years, driven by a warming climate. Glaciers are retreating in western North America and worldwide (Figure 1). This is creating new salmon habitat by opening up new streams and inlets. Such deglaciation has happened on a much more dramatic scale in the past, Mantua noted, and salmon evolution has been shaped in part by glacial/interglacial cycles that occurred about every 100,000 years. We know salmon were able to weather the interglacial peak during the Holocene period before the most recent ice age, when temperatures were a couple degrees warmer than the present.

Figure 1. Muir Glacier/Muir Inlet, Glacier Bay Alaska in 1941-left, and 2004-right (http://nsidc.org/data/glacier_photo/special_high_res.html)

However, atmospheric carbon dioxide levels today, at 386 parts per million, are far higher than at any time in at least the last 800,000 years (Figure 2). Scientists have modeled various scenarios of how much CO_2 we can expect in the future, depending on the societal choices made in the short term, and these projections all show CO_2 concentration levels responding very slowly, no matter what is done now. This makes a very big difference for Pacific salmon, Mantua said. Current emissions are also growing even faster than the most pessimistic scenario modeled in 2000.

We are in the early stages of rapid climate and environmental change, he continued. There is no denying that. Models of expected patterns of warming consistently predict more warming than average over the Arctic. By the end of this century, average temperatures may be warmer than at any time in the past million years.

Changes in precipitation will also be important. Rainfall will increase in parts of the world that already have high rainfall and decrease in places that are already stressed by drought. Projections include more rain and less snow in locations that are currently near freezing and also more arctic snow. Stream flows will be altered, with higher flows in winter, lower summer flows and longer, dryer summers. Major changes in disturbance regimes are expected, with more fires, floods, disease and insect outbreaks in stressed forests. Increased conflicts over water are also expected. Mostly negative impacts are expected in the southern range for salmon, though in higher, colder latitudes, there will be positive impacts, at least up to a point.

The oceans will also see big changes, some of which are already underway, Mantua said. Salmon feed in the cool, nutrient-rich waters of the North Pacific. Most of their growth and mortality happens there, so the ocean has big impacts on salmon abundance and growth. In the coming decades, changes in the ocean will not occur in a predictable way. Currents and temperature have historically been driven by changes in wind patterns. There will be competition between the effects of increased greenhouse gases, oscillations such as the PDO and El Niño/La Niña and the forces that cause natural climate variability. However, by about 2040 or 2050, climate models predict human-caused warming will overwhelm these other forces to shape a new climate.

Salmon habitat and life history are highly complex, which poses a challenge for scientists trying to predict how this will all play out for salmon. A diverse suite of impacts is expected, Mantua said, and this will vary for different stocks, watersheds and sub-basins.

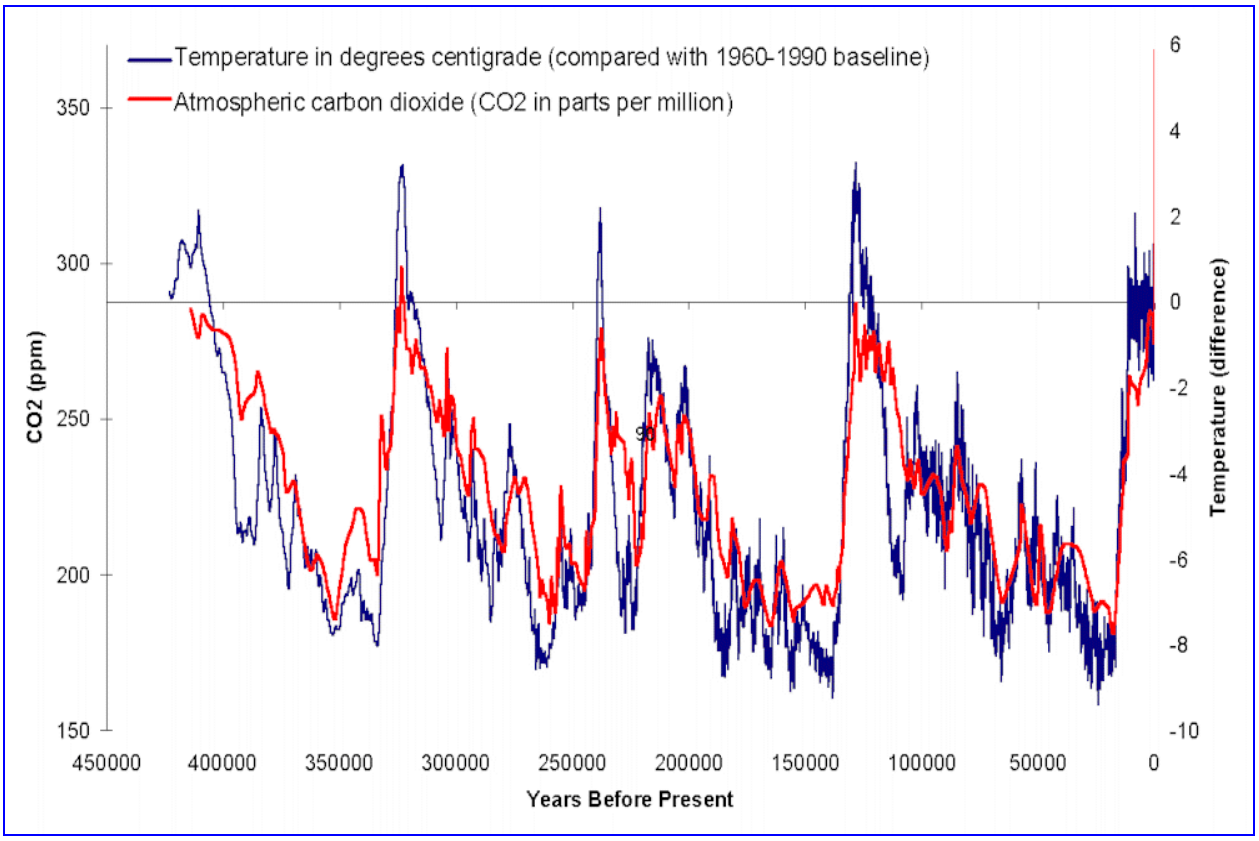


Figure 2. Historic and current temperature and carbon dioxide levels (IPCC2007: WG1-AR4)

Perhaps the worst news is that the ocean has been mitigating the impacts to date by absorbing about one-quarter of the anthropogenic CO_2 produced in the past few centuries. This has caused ocean pH levels to decrease by about 0.1 units (30 percent more acidic) and ocean pH is expected to decrease by up to 0.5 units by the end of this century, which would be the largest change to occur in the last 20 – 200 million years. Biological implications include risks to critical parts of the food web (like copepods) due to reduced calcification rates and reduced tolerance to other environmental stressors. Scientists are just starting to study the implications, but there is a high potential for very large changes. Climate change is not a mystery to us, Mantua said. We know it is posing a risk. We're just not clear how far along the road we are and whether there is time to change. He concluded by posing two challenges to the "salmon people:" First, to reduce the risk of catastrophic climate change, greenhouse gas emissions must be reduced by burning less fossil fuel and finding ways to take CO_2 from the atmosphere. Secondly, salmon will need to adapt in the face of rapid environmental changes, and this lies under our influence. We are the drivers of environmental stressors and our actions will shape their potential for adaptation.

Discussion

Q: For the southern range, the suite of impacts is largely negative. Can we act in time to sustain abundant populations of salmon in the southern part of their range?

- Mantua: Competition between other climate cycles and the longer-term impacts of increased greenhouse gases will have huge implications for whether stocks remain abundant enough to sustain fisheries. There is optimism regarding an increasing abundance trend for southern salmon stocks in the very near term. If that can persist for a decade, yes, there is a chance. Otherwise, there could be rapid depletion and endangered species listings.

Q: Salmon adapted over thousands of years. Were these past changes as sudden as what's expected, in terms of the time period required for salmon to adapt?

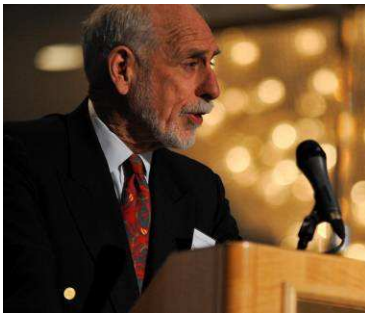
- Mantua: The rate of change is a key issue. The changes now occurring are about 10 times faster than those that occurred in past glaciation cycles. There have been periods that were rapid in the past but in terms of chemistry, atmospheric CO_2 levels are rising about 100 times faster now.

Q: What about theories relating to dimming, which suggest that as we address pollution we will accelerate climate change? Also, salmon had access in the past to alternate habitat that no longer exists.

- Mantua: Pollution and smog have mitigated climate change to date. It is projected that for regions like SE Asia, Europe and the eastern United States, as the atmosphere is cleaned up there will be local and more rapid warming. But these are mostly places that don't have salmon. Access to habitat is another big challenge, which suggests the need to reopen access. The places that have seen the most change are in the southern range, which is at most risk.

Political aspects of Pacific salmon conservation, the role of science in policy & current opportunities

David Anderson, Guelph Institute for the Environment



In democratic systems, it is a challenge to get scientific knowledge into a policy-making system in which decision makers have little knowledge of science. Political decisions, funding and priorities do not automatically follow the identification of a problem or opportunity, Anderson noted. The process is much more complex and good proposals may not be adopted, even when the merits are widely recognized.

Few people realize just how many players there are, how many people want to be involved and how strong "the dead hand of the past" is in protecting the status quo. There is competition between an enormous number of issues vying for limited attention and resources and only a limited amount gets done. Political capital erodes very quickly, so there is limited time to get things done, which is why political leaders focus on their first 100 days in office. For leaders trying to establish priorities between competing demands and deciding where to allocate resources, evaluation is extremely difficult. Comparisons must be made, but how do you weigh the merits of early childhood education against early cancer detection or salmon?

To illustrate the challenges, Anderson described his experience as a former Fisheries Minister, after his staff advised that management of Prince Edward Island's lobster fishery was leading to increasing risk. Catch size restrictions were proposed. But the canning industry, which relied on smaller lobsters, argued that the population had not yet collapsed. They cited the important social benefits and undertook strong lobbying. But the collapse of East Coast cod stocks had made government wary and Anderson was supported by the Prime Minister. He made the changes, which turned out to be a success. Nevertheless, the stance he had taken was politically risky and shortly later, he lost his Cabinet post.

This story illustrates the strong opposition to change among constituencies, even when they end up benefitting. Those who benefit are often hard to identify and their voices may not be heard. Policy decisions create constituencies that make future policy much less flexible. Inertia is a major feature of the public policy process: it is so much easier to add a little to an existing program than to create a new one.

There are major knowledge gaps in salmon management, particularly in the open ocean, and a great deal more to be done, Anderson said. Major uncertainties include the impact of the enormous number of hatchery-raised fish on wild stocks. Little ocean research has been done because it is expensive. Watershed work appears to have more immediate impact and political return.

Looking to the future, he noted a major shift in the political climate towards oceans research, with a substantial increase in such work beginning. Two major factors will change the policy process in a fundamental way and offer significant opportunity to do more oceans research.

The first factor relates to the quick reaction of governments to the economic downturn, Anderson said. The willingness to fund deficits turns on its head the conventional wisdom that has guided policy selection in recent decades. President Obama's Chief of Staff, Rahm Emanuel, has argued that no crisis should go to waste: It's not enough to just spend money to provide fiscal stimulus – such spending should offer useful value and long-term results. Ocean research offers those benefits but the first step is to meet the economic objectives of the Canadian and U.S. governments: Can we show that fisheries and oceans research can quickly lead to achievement of economic stimulus goals? The barriers to ramping up such work are not that high, Anderson argued. This won't require years of preparation. If we can do it for Coast Guard vessels, we can also do it for research vessels.

The second factor is climate change and the marked recent shift in interest in this. While hesitating to suggest what specific work was needed, Anderson said that from a political perspective, the ability of oceans to handle CO_2 is a very important topic. And any study of climate change and the North Pacific will inevitably encompass salmon. Indeed, salmon are so integral to our identity that that they could serve as the poster species for such efforts, just as the polar bear has come to symbolize global warming effects in the Arctic.

The economic situation and climate change are the important factors to consider, Anderson stressed, and the research community needs to exploit a current opportunity not seen in a very long time. In seeking to establish such a program, simplicity is a virtue. Anderson cited the international polar year as a successful model, with a defined time period and a clear focus to generate public interest. There is enough knowledge in this room to put together a proposal very quickly, perhaps even before the end of President Obama's first 100 days. Anderson closed by urging participants to depart from the status quo and to recognize and seize these opportunities.

Discussion

Q: Would things like basic monitoring, setting up structures to promote adaptive management or marine use planning be a higher priority or would they fall under the same umbrella?

- Anderson: They can all fall under that umbrella. There is an appetite for big ideas, so we can phrase the work that people are trying to do under the big idea.

Q: A major research project is needed, but it would be good to see something that carries on after the current crisis. There may also be more traction with research in the Arctic, if that is to be the last stronghold. And how do we bring ecology and the environment above economic priorities in policy making?

- Anderson: I'm thinking of a broad program, and such things would come out of it, instead of getting too caught up right now in what has to be done over the decades. The funding will go to roads and bridges instead if we spend too long discussing a long-term problem. This is the way to sell the concerns in the current context. On how to balance economy and ecology, we are moving towards recognition of those "externalities" in economics. Having a U.S. president who accepts climate change represents a major change and I think Canada will follow the U.S. lead. We need to focus on the strengths that we have.

Q: The coho crisis was exploited to drive changes. SARA (Canada's Species at Risk Act) was seen as an opportunity to drive change, but economic value trumps everything in its implementation. Is there a way to make it a more effective tool to protect salmon?

- Anderson: It took six years to pass SARA and compromises were made. It did provide an opportunity for stewardship programs and a focus. Although it does focus on individual species instead of ecosystems, it achieved a reasonable amount and could be further strengthened. The dilemma is that

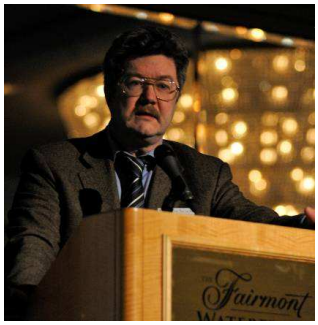
you have to change public attitudes. There is a long way to go before the public puts forward the right questions. ENGOs need to focus more on public education and put less emphasis on lobbying.

Q: There is nothing green in the recent (Canadian) Federal budget, so it's hard to see where we can get any money. Maybe there is a way to influence the Opposition leader regarding the need to invest in the Wild Salmon Policy and in changing our management structure, but we're not seeing any green lights in Ottawa.

- Anderson: We may have to tie programs to major government objectives instead of arguing about salmon policy from square one. Show government how it achieves their objectives. And we need to persuade the public, not just individuals.
- Riddell: What could be more important in the Pacific Northwest than salmon? Separation of salmon and economics would represent false economy.

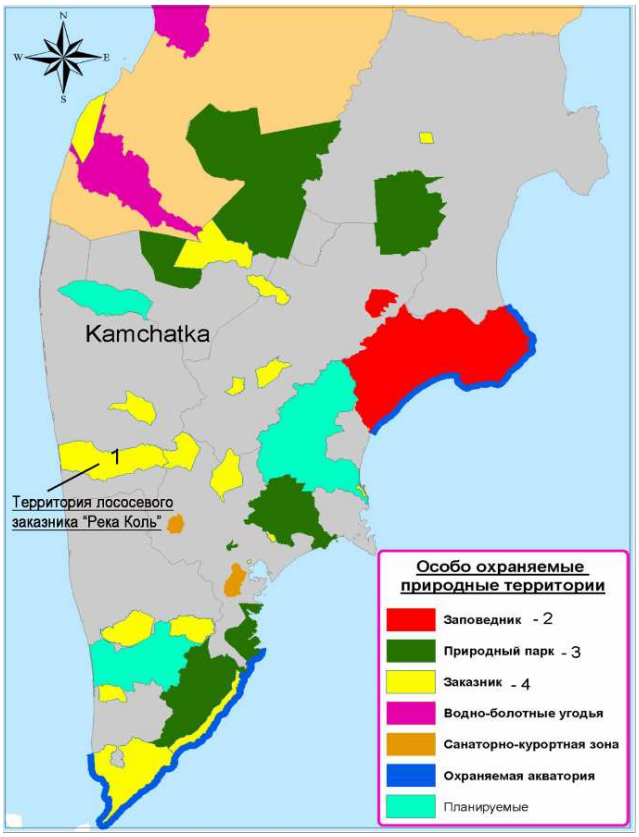
Conservation of salmon and creation of Fishery Protected Areas in Russia

Vladimir Belyaev, Director, Department of Science & Education, Russian Federal Agency for Fisheries



There are many questions for research, including issues like ocean carrying capacity and problems in the rivers, Belyaev said. The big picture in Russia looks fine, but there are no protected areas for salmon except the one created recently, and thus the recent creation of the salmon protected area on the Kol River is very important.

Six species of salmon migrate in the convention area covered by the NPAFC, some of which return to Russian rivers. The biodensity, abundance and number of salmon populations vary significantly across different regions of Russia's Far East. Some parts have extensive human influence, some are doing relatively well, and some, including Chukotka and Kamchatka, are doing well. The impacts of human activity vary from area to area. In some cases, it's about impacts of human development and industry, while elsewhere it may be due to commercial fisheries or illegal poaching (the latter is a great problem that has been solved on the high seas but not in the rivers of Russia's Far East). The main challenges include conserving the diversity of salmon, conserving the number of populations, restoring destroyed river ecosystems and limiting the numbers of artificial populations and their impacts on wild salmon.Last year, a new law defined a process to create various categories of protected areas, including fully-protected areas and areas that permit fisheries or fish farming. Belyaev shared a color-coded map of protected areas in Kamchatka Region, noting that only one area (marked in yellow on the map) is a protected area dedicated to salmon, even though Kamchatka is one of the richest regions for a variety of salmon species (Figure 3). A second map showed designated hunting grounds on a protected river, and Belyaev noted that interaction between hunting grounds and protected areas is not contradictory. Our main task is to work on a watershed level to address conservation, he added, because the entire watershed must be part of a protected area in order to protect and preserve all spawning grounds and all species of salmon.



	Protection area - 2
	Nature park - 3
	Zakaznik (a special form of protected area) - 4
	Wetlands
	Recreation area
	Protected area
	Planning areas

Figure 3. Protected areas in the Kamchatka Region

The Kol River experimental area is an oblast level protected area (Russian oblasts are roughly equivalent to US states and Canadian provinces), though the aim is to make it a federal protected area. Oblast level protected areas are subject to decisions of the local governor, but federal protected areas are governed by federal laws, including fisheries laws and protected area laws. Lack of financing for regional protected areas is a significant problem, whereas federal areas get preferential treatment. So the hope is to make the Kol River a federally-protected area in order to protect the entire watershed.

The global financial crisis has had a serious impact on the ability to finance science in Russia, and it's expected that the U.S. and Canada are facing the same challenges. But if we combine efforts and share information, Belyaev said, we can all save money. The more protected areas we create where fishing and human influence are limited, the more we can preserve our biodiversity. Kamchatka is now facing pressures from oil drilling and mining, which can create issues for the efforts to restore areas that are valuable for salmon. We all have to combine forces to solve the problems we face at the moment.

There has been considerable analysis of the role played by protected areas in supporting salmon fisheries, Belyaev said. But there has been very little study on the role of fisheries reserves in supporting conservation of biodiversity. This is important, because fisheries reserves are largely discounted from assessments of protected area conservation, yet obviously, they do make a contribution. There is some knowledge of how salmon fishery reserves contribute to the exploited species, but the broader contribution to biodiversity conservation is largely unknown. It will also be important to improve national and international reporting systems to incorporate reserves established for salmon fisheries.

Belyaev closed by thanking the Wild Salmon Center, saying that without their efforts, there would not be a salmon protected area in Kamchatka today. This shows the important role that NGOs can play when they go after specific objectives within the Russian federation and "put money where their mouth is."

Discussion

Q/A: It was clarified that the reference to farmed salmon and artificial populations was a reference to hatcheries. Belyaev said these may be very useful for some regions where abundance is low, but for Kamchatka, hatcheries are not useful for conservation.

Q: It may be better to create an area of limited protection that permits some economic activity, as opposed to areas that prohibit all activity.

- Belyaev: You should go step by step. A combined area provides a good first step, whereas totally-closed areas could be too limiting. It's also a challenge to find the right river, as you should choose rivers with the least human intervention.

Q: How important is it to protect salmon from exploitation?

- Belyaev: Every year, our scientists calculate the number of different salmon populations to give a forecast for catch. If the fishermen have a quota, they must not catch more than that. The 1990s were a very hard time for Russia, but now the pressure for illegal fishing has been lowered.

Q: To have protected areas for salmon throughout their freshwater and marine ranges would require cooperation through the NPAFC to achieve the objectives.

- Belyaev: For salmon, it is more important and effective to protect rivers than create protected areas.

Day 1: Afternoon plenary

Highlights from around the Pacific Rim

Co-chairs: Kate Myers, Vladimir Karpenko, Xan Augerot

Salmonid status in relation to environmental conditions in Hokkaido, Japan

Mitsuhiro Nagata, East Research Branch, Hokkaido Fish Hatchery

Historical data on run size and hatchery releases show the status of Hokkaido chum and stocked juveniles declined around the 1950s. Commercial catch peaked at 10 million in the 1880s before falling to half of that due to overfishing, Nagata explained. That led to the introduction of hatchery production a century ago but it did not have much impact until hatcheries started releasing fed fry in the 1970s. After that, releases continued to climb and returns have soared to 60 million.

Pink abundance was low, with odd-year dominance, until the 1980s. Abundance increased sharply in the 1990s and shifted to even-year dominance, despite consistent hatchery releases. This suggests that wild pinks are contributing to the returns, he said. In the past few cycles, the pattern of returns has flipped back to odd-year dominance.

Records for total catch of Pacific salmon since the 1920s show that abundance of pink, chum and sockeye – the three major species – varies in 50-year cycles. It has been suggested that these abundance cycles are consistent with climate regime shifts. The period of high abundance for Hokkaido pink and chum since the 1970s coincides with high abundance of Alaskan wild sockeye and pink, so this is believed to be not just due to hatchery releases but also ocean conditions.

Recent variations in local chum abundance are thought to relate to coastal water conditions, Nagata said. Japanese chum spend their first spring in coastal waters off Japan, moving north to the Okhotsk Sea for their first summer and fall and then out into the Western Subarctic Gyre for the first winter. They all spend the next few years in summer feeding grounds in the Bering Sea and overwintering in the Gulf of Alaska, before returning to their natal stream. So except for their early life and homing period, Japanese chum all have the same migration pattern.

Since the early 1990s, return rates of Honshu and Korea chum have declined markedly, while those for Hokkaido chum have increased. Honshu and Korea chum are strongly negatively affected by the Tsushima warm current, which could be getting warmer due to global warming effects. For Hokkaido chum, recent return rates for systems in the Okhotsk Sea and Nemura Strait were higher than in the 1980s, while returns to systems linked to the Japan Sea were very low.

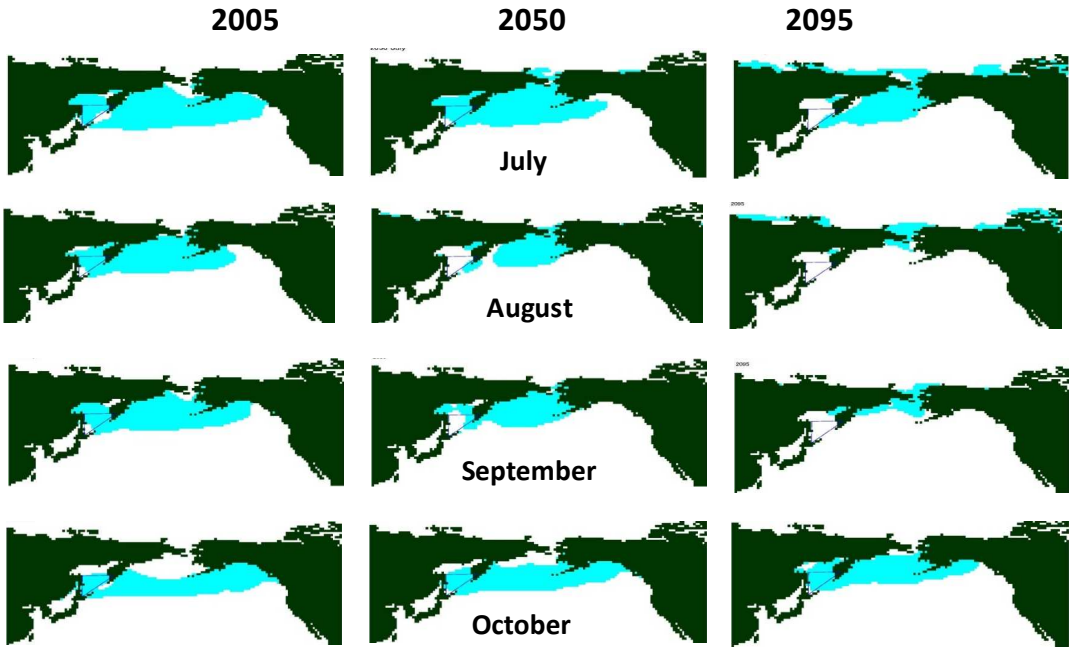


Figure 4. Predicted effect of global warming on chum salmon distribution (Kaeriyama, 2008)

Why such a difference? It is known that high mortality occurs in coastal waters during the early marine stages, Nagata said, so this prompted an investigation looking at spatial distribution of chum juveniles and growth patterns in relation to sea surface temperature. High abundance was found in waters between 8° and 13º C. In cool years (below 8º C), most juveniles were found in freshwater and near shore. Juveniles grew faster in the warm years and were able to disperse further offshore. It is thought that this seawater temperature-dependent effect on distribution patterns may have affected mortality. A comparison to return rates showed that when these coastal waters reached 8º C earlier in the year, chum salmon survival was higher. It was also found that in recent years, this critical temperature was being reached earlier in the season, a pattern that might be due to global warming. However, projections of future impacts of global warming suggest that the area of optimal temperature for chum in the Okhotsk Sea will decrease significantly by 2050 and be all but gone by 2095 (Figure 4).

Meanwhile, masu (cherry) salmon, which are found mostly in northern Japan, have seen a steady decline in abundance in recent decades, despite more hatchery releases. This species has a very different life cycle from pink and chum. There are two types, one of which spends two years in fresh water and is thus more vulnerable to freshwater impacts such as habitat loss and impacts of hatchery activity. Fortunately, he noted, wild masu still exist because they inhabit almost all streams around Hokkaido, and adults are very difficult to catch by weir. Masu favor spawning in the upper reaches of rivers and tributaries.

In summary, Nagata, said, Hokkaido pink and chum have seen higher abundances in recent years, due to favorable ocean conditions and hatchery programs, apart from the recent problems for chum that rear in the Japan Sea and southern Pacific Ocean. However, global warming poses future threats, even for those that rear in the Okhotsk Sea. Hatchery programs alone cannot drive recovery of masu salmon, due to deterioration of freshwater habitat and immature hatchery techniques. Thus more urgent attention is needed to conserve wild salmon, which have greater biodiversity, and to restore freshwater environments.

Status review of chum salmon in Korea

Sukyung Kang, Korea National Fisheries Research & Development Institute

Korea has only two species of salmon (chum and masu) and is at the southern range of salmon distribution. Korea began chum enhancement in 1967, Kang noted, and hatcheries have become more active since 1984. The Yeongdong Inland Fisheries Research Institute is responsible for 60 to 70 percent of total Korean chum releases from three main hatcheries, as well as adult catches.

Returns since the 1970s show a marked increase starting in 1991, then a drastic drop in 2000. The return rate was about 0.4% in the 1980s, but increased to over 1% during most of the 1990s, until a sudden drop to 0.1% in 1997, which is thought to be due to the strong El Nino.

Mean sea surface temperature in Korea's coastal waters in 2004 was two degrees higher than in 1981 (Figure 5). Water temperature has significantly increased at all levels of the water column, and in all areas, particularly to the south of the Korean peninsula. Pink salmon catch in Alaska coincides with air temperature at Kodiak. Pink salmon catch in North Korea over the same period reflected this same pattern, she said, indicating an effect of global climate change.

A key factor in improving the condition of salmon stocks is increasing the return rate. Anomalies in the return rate and in sea surface temperature in coastal areas appear to have an inverse relationship. Warmer waters in April when the juveniles migrate to the ocean appear to have affected the return rate of hatchery chum salmon. A comparison of return rates by hatchery showed all three were down in 1997 due to the El Nino. The most profound drop has been for Uljin hatchery, the most southerly of the three. The hatcheries can't release salmon any earlier, because the rivers are still too cold.

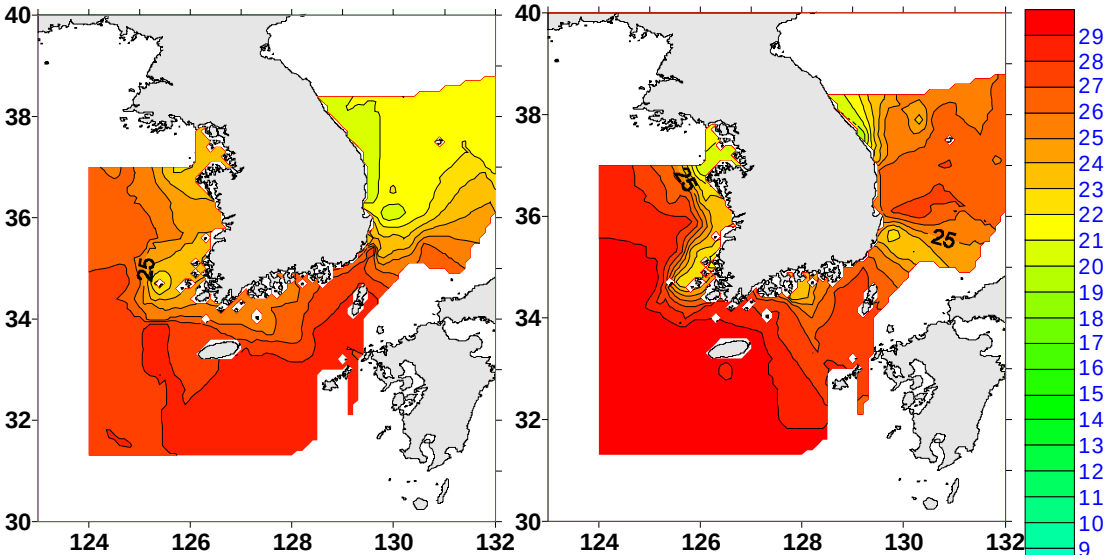


Figure 5. Mean sea surface temperature around the Korean Peninsula in August of 1981 (left) versus 2004 (right).

Summarizing, Kang noted that Korea's hatchery program has sought to improve the condition of chum salmon stocks for the past 40 years. Recently, the return rates of chum to Korean waters were seriously reduced from 1.5% in the 1990s to around 0.5 % in the 2000s. Future climate change is expected to reduce production of chum salmon in Korea.

Climate change & Pacific salmon catch dynamics in Russia: do trends cross a ridge?

Vladimir Radchenko, Sakhalin Research Institute of Fisheries and Oceanography

This presentation offers a more optimistic view, Radchenko said, reviewing a graph of rising Pacific salmon catches for Russia over recent decades. Most of the increase has been due to increasing abundance of Russian pink salmon, although chum and sockeye abundance is also growing. However, pink catch dropped significantly in 2008, following historic catches in previous years: the 2006 pink catch for Aniva Bay at the southern tip of Sakhalin Island was 5.5 times the historical high recorded in 1994 and represented an extraordinary return rate of 20%.

The chum catch from most regions also increased in the last decade. In contrast to pinks, chum increases have accelerated in the past two years, reaching more than 60,000 metric tons in 2008. Sockeye harvests have also continued to grow.

It is believed that environmental factors, not management, are the driving forces behind these changes. Increases in ocean heat content since the 1960s correlated with the increases in Russian pink salmon catch, but both trends have turned down since 2007. Cyclic fluctuations of total Pacific salmon production have been shown to correlate with changes in the PDO. Alternating shifts between warm and cold atmospheric processes also influence local conditions in the Bering Sea and the Sea of Okhotsk, and those reflect a cooler period in the past two years. Analyses have also shown that pink salmon harvest trends correlate with cyclical changes in the solar activity index, and the inception of a new cycle in 2008 bodes well for pink abundance in coming years.

Russian hatchery releases of Pacific salmon have climbed over the past decade (Figure 6) and are expected to continue growing. Pink salmon juvenile abundance estimates in the western Bering Sea, based on pelagic trawl surveys in fall 2008, estimated a total abundance 1.3 billion fish vs. a previous high of 0.6 billion.

Notable changes of Pacific salmon stock conditions and their harvest remain predictable, he concluded, but these could be supported by the rapidly-developing hatchery program, habitat conservation measures and realization of the natural potential of Pacific salmon populations.

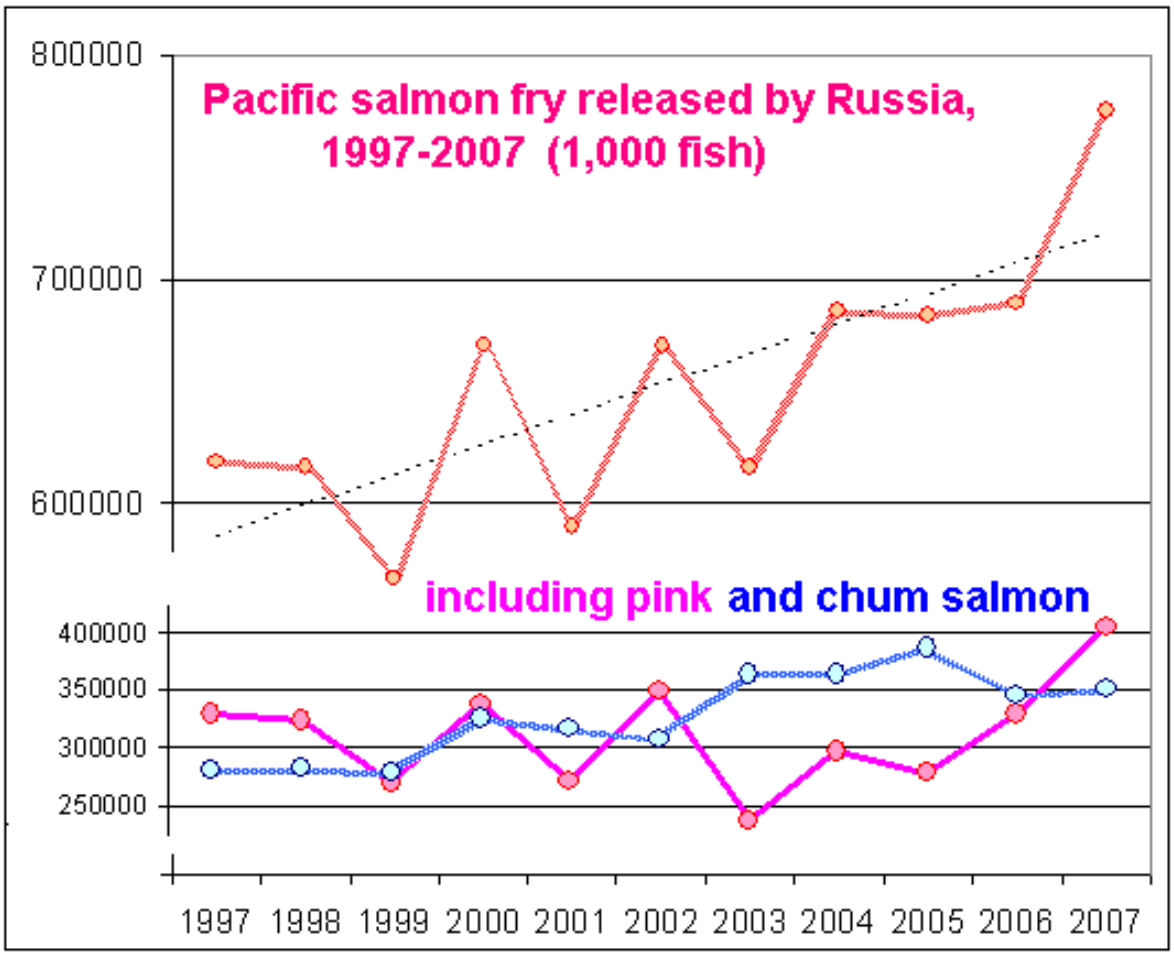
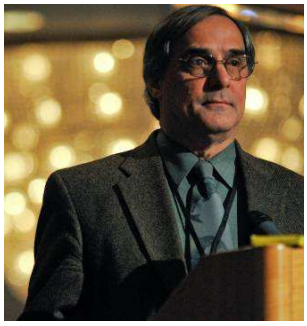


Figure 6. Pacific salmon fry released by Russia from 1997-2007, in thousands of fish

Alaska's salmon management: 50 years of sustainability

John Hilsinger, Alaska Department of Fish & Game



The concept of sustained yield is written into the Alaskan constitution. Knowledgeable local managers manage runs in season and have authority to open and close fisheries, Hilsinger explained. Escapement goals and other management objectives are set to sustain yield over the long term and managers have been relatively immune to political intervention. A key aspect of the regime is the role of the Alaska Board of Fisheries, a lay board that sets fishing seasons, harvest guidelines, methods, regulatory plans, management policy and allocation decisions.

Alaska has policies that guide management of mixed stock fisheries, sustainable salmon fisheries and establishment of spawning escapement goals. Salmon fishery management plans are developed that can be very specific. Three types of escapement goals are used: biological goals based on maximum sustainable yield (MSY); sustainable goals based on indices or estimates where there is less data; and optimal goals that balance biological and allocation factors. Monitoring is done through aerial surveys, weirs, mark recapture and other programs (Figure 7). These provide information used on a daily basis to open and close fisheries. Between 2001 and 2007, the average number of goals that were not met was 14%. On average, 38% of goals were met and 48% exceeded.

Figure 7. **Salmon monitoring techniques**

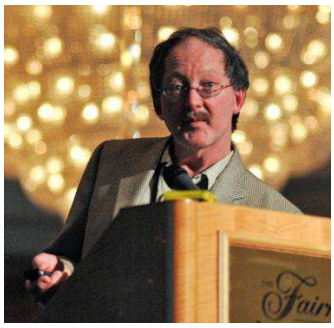
Overall, Alaska has seen exceptional salmon runs since the 1970s, Hilsinger said, though this is not just due to good management. Elimination of high seas catches, good environmental conditions and diligence in protecting habitat have combined to protect runs. Commercial harvest values for all salmon species combined peaked in 1980 at over $700 million, with recent catches numbering close to 220 million fish.

Production is augmented with large hatchery production, he noted. About 95 percent of the sockeye catch consists of wild fish, mostly from Bristol Bay. Returns declined in the early 2000s but have since rebuilt and remained stable in recent years. Chum has also been bolstered by hatchery production in recent years. Coho were very strong in the mid 1980s and early 1990s and have stabilized since then. Chinook have not increased, and there have been some very poor runs in western Alaska in recent years. More chinook are now being allocated to recreational fisheries.

Future challenges include increasing management complexity, with more in-season monitoring, genetic stock identification, etc. Increasing variability in timing and run size in many runs, which is at least partly attributable to climate change, has also increased the difficulty of assessing runs in season. Other challenges include dealing with assessment and certification of sustainability, hatchery and wild stock issues (especially in Prince William Sound) and high interest in resource development (mining, hydro, coal), which will pose real challenges for protecting fishery resources.

Canadian highlights – Pacific salmon

James Irvine, Fisheries and Oceans Canada, Pacific Biological Station



The types of data used to assess the status of salmon stocks includes distribution and abundance data, such as catch and spawner escapement, and data on survival or recruits per spawner. Irvine noted that status can be assessed at various scales: by species, by large geographic areas, by stock groupings (fishery management units), or by conservation units (CUs) defined under Canada's new Wild Salmon Policy (WSP). Canada currently does an acceptable job at the first three levels, but the future calls for assessment at the level of over 400 distinct salmon groups or CUs. Under the WSP, Canada is attempting to assess and categorize the biological status (not MSY) of each CU, using a rating system based on three levels (zones) denoting spawning abundance and distribution, separated by upper and lower benchmarks (Figure 8).

Canadian commercial catch data for all species of Pacific salmon show that 2008 was the lowest year on record in Canadian history. Catch data for sockeye alone show a similar pattern. These data show low catches during the most recent climate regime, odd/even year patterns reflective of pink returns and a general decline for all species in recent years. Catch data can indicate what's happening at the species level, but for smaller stock groupings or CUs, finer-level information on abundance, distribution or survival is needed.

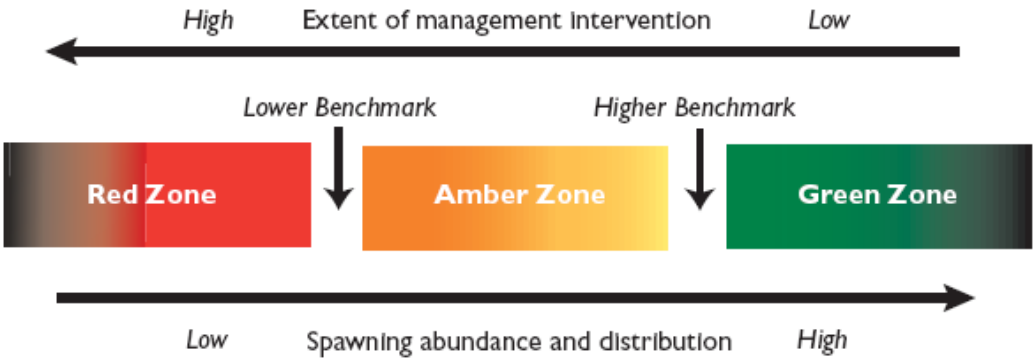


Figure 8. Rating system from Canada's 2005 Wild Salmon Policy

Assessment of sockeye stock groups (the 29 population groupings used currently will expand to over 200 under the WSP) shows a great deal of variability in status, even within a single watershed. Similar analysis for 19 coho stock aggregates shows that stocks in southern British Columbia and Georgia Strait are not doing well, Irvine noted, while stocks in northern BC are more mixed. Pinks seem to be doing better than other species, though there is a lot of uncertainty due to data gaps. Chum are doing relatively well. A number of chinook stock aggregates in the Fraser are doing poorly, though summer-types are doing exceptionally well, so there is considerable variability even within one watershed. The same red-amber-green method of categorizing stock status is also used to denote the overall status of each species (Figure 9).

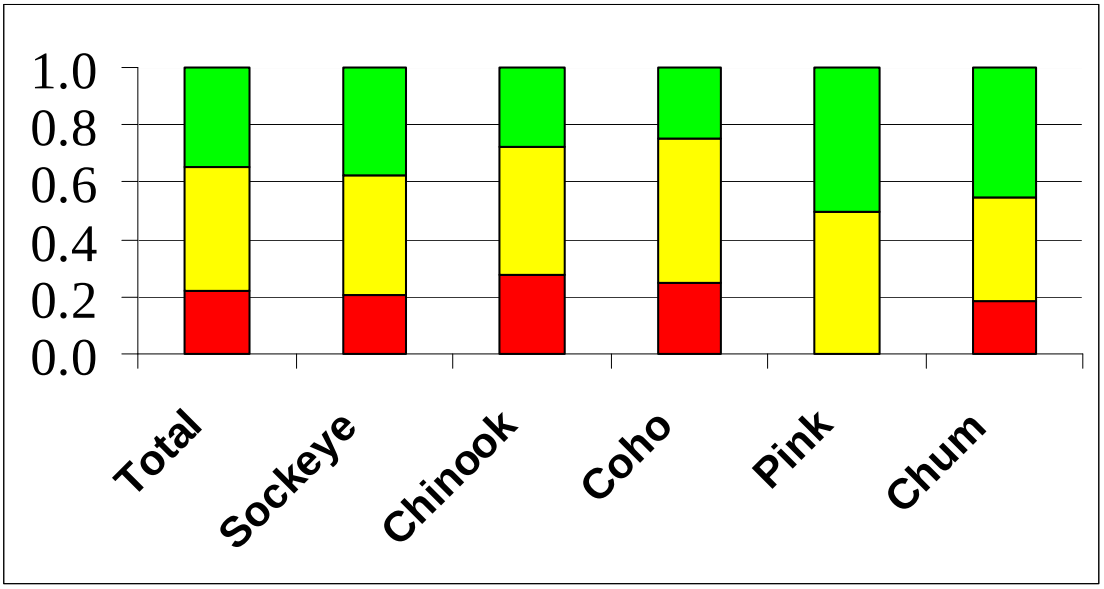


Figure 9. Biological status of 93 stock groupings under Canada's WSP

Unusual climate conditions can help managers to understand, and in some cases, anticipate changes in stock status, Irvine said. Canada is shifting to an assessment approach that includes a suite of marine indicators as predictors of marine survival. An annual State of the Ocean report pulls together fishery and oceanographic information from a number of sources to provide a categorical rating for each marine indicator linked to smolt years. He provided examples showing that smolts going to sea in spring 2000 faced all good indicators. For 2005, all but one indicator suggested poor marine conditions. Since then, it's been a mixed bag, Irvine added, and it's not clear how to interpret that.

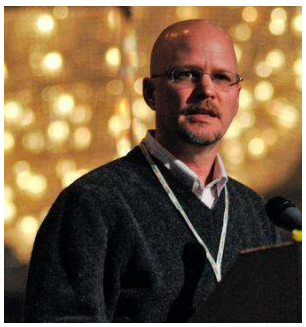
Returns for most smolts that went to sea in 2005 reflected poor marine survival, consistent with the poor indicators. In contrast to other species, however, chum did not seem to be affected. Subsequent analysis to determine the cause of this widespread collapse revealed chlorophyll anomalies for April to June 2005 compared to previous years. Levels were much lower than average for the west coast of Vancouver Island and Juan de Fuca Strait, but much higher than usual for the Strait of Georgia. Managers are now trying to incorporate this sort of information into pre-season planning to produce better forecasts, although many questions remain, such as why chum did better in 2005.

Irvine summarized, noting that status indicators are scale-dependent. Catch data show that overall status of Canadian salmon is poor, but finer-level information shows much variability in status within areas and species. Needs for the future include more ecosystem studies, studies that focus on identifying marine mortality and whole-life studies that help distinguish between mortality that occurs in freshwater and marine systems. Canada's new Wild Salmon Policy recognizes that diversity is key to allowing salmon to adapt and thus seeks to conserve diversity within individual populations, habitat and ecosystems.

Salmon & climate in the western US: recent highlights

Tim Beechie, National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center

The story of an Oregon lake where sockeye were extirpated due to dam construction reflects the wider story of salmon in the western U.S., Beechie said. Much human impact and change have occurred, with most populations at 10 percent or less of their historical levels, plus a large number of extirpated populations. The sudden disappearance of chinook in the Sacramento River in 2008 also reflects these challenges. Chinook runs in the Sacramento and Columbia had been going up and then both recently declined. The Sacramento runs declined precipitously, while Columbia sockeye abundance continues to fluctuate.



Around the Pacific Rim, everything is getting wetter except the western U.S., which is seeing a drying trend, with longer fire seasons and more area burned in fires since the 1990s. This is not just climate change, Beechie noted, but also partly due to a legacy of forest management practices (a strong fire suppression mandate that created heavy fuel loads). This results in more and larger fires and more frequent landslides and sedimentation (Figure 10).

A suite of ocean indicators shows conditions mostly in the red in 1998, improving between 1999 and 2002, and then back to increasingly unfavorable conditions between 2003 and 2005, followed by another flip to favorable indicators in 2007 and 2008. So conditions have been changing rapidly, though it's not clear why.

Figure 10. Effects of large, widespread forest fires

At the policy level, two important developments relating to the Endangered Species Act (ESA) have brought to a head many of the conflicts over how to manage rivers and water for salmon. In the Columbia, a decade-long conflict over whether to take out dams or restore habitat in other ways was resolved when Native American tribes agreed to suspend legal action and the Bonneville Power Administration in return agreed to spend $900 million on salmon habitat restoration. The other development related to hatchery/wild fish policy, when the federal court overturned an earlier decision that hatchery fish should be included in evaluating population status.

In summary, Beechie concluded, past land and water management constrains salmon resilience in the western U.S.. So many life history options have been removed, and when salmon face climate change challenges, they're very poorly situated to accommodate new disturbances. Competing needs for water also force political compromises in salmon management. For the future, methods must be found to increase salmon resilience to climate change, giving them a greater ability to cope and adapt when negative impacts occur. A key question is: When is it time to say "enough is enough," in terms of investing money in small individual salmon populations that are nearly extirpated? We haven't had to deal with that question yet, Beechie noted, but we see it coming down the road.

Managing, restoring & conserving salmonids: southern Pacific Northwest & northern California

Frank Lake, US Forest Service

One of the main species of concern is coho, Lake noted, with stocks in southern Oregon and northern California generally at or less than about 10 percent of levels 100 years ago. Coho are threatened by modification to habitat from a wide range of factors, including agriculture, mining, dams, forestry, roads, water quality, diseases tied to water temperature and hatchery issues. Chinook face similar threats. Dams have blocked spring chinook, once one of the largest runs on the Klamath River, from access to most of their historic habitat. Hatchery production poses challenges from mixed-stock fisheries. Threats to remnant wild populations include in-river migration conditions, mining and habitat modification, harvest, poaching, wild fires and invasive weeds. Summer steelhead is proposed for a threatened listing and faces threats similar to coho and chinook. The tribal perspective is that the whole ecology, including other species, should be protected.

Climate change implications include hydrology changes, less snowpack, higher winter temperatures and a longer wildfire season, he added. Long-term effects of more wildfires are not well understood, but fires are expected to increase, with direct and indirect impacts on salmon habitat. This will require more sub-basin planning and research to link impacts to habitat and populations.

Monitoring and research efforts that guide restoration and conservation include harvest management and monitoring of escapement, spawning success and out-migration, Lake said. This work feeds into other studies, such as research on thermal refugia and on disease and density. An example is research linking coho life history, migration, thermal refugia and wildfire research (Figure 11). Additional research includes flow and temperature modeling (comparing situations with and without dams, looking at the benefits of higher levels of cold water to fish downstream, etc), juvenile and adult dive surveys and work on river geomorphology and flow conditions.

Is multiparty restoration and monitoring working? Efforts have included road decommissioning, fish passage enhancement, stream flow management, entrapment prevention, riparian improvement and post-fire repair work. One of the largest political issues is dam removal, which involves political, social and ecological tradeoffs. The recent Klamath River Basin Restoration Agreement, whose parties include federal, state, county, tribal, agricultural-industry and community organizations, is expected to result in major, basin-wide funding to remove four dams and undertake restoration, including work to improve water flows and quality.

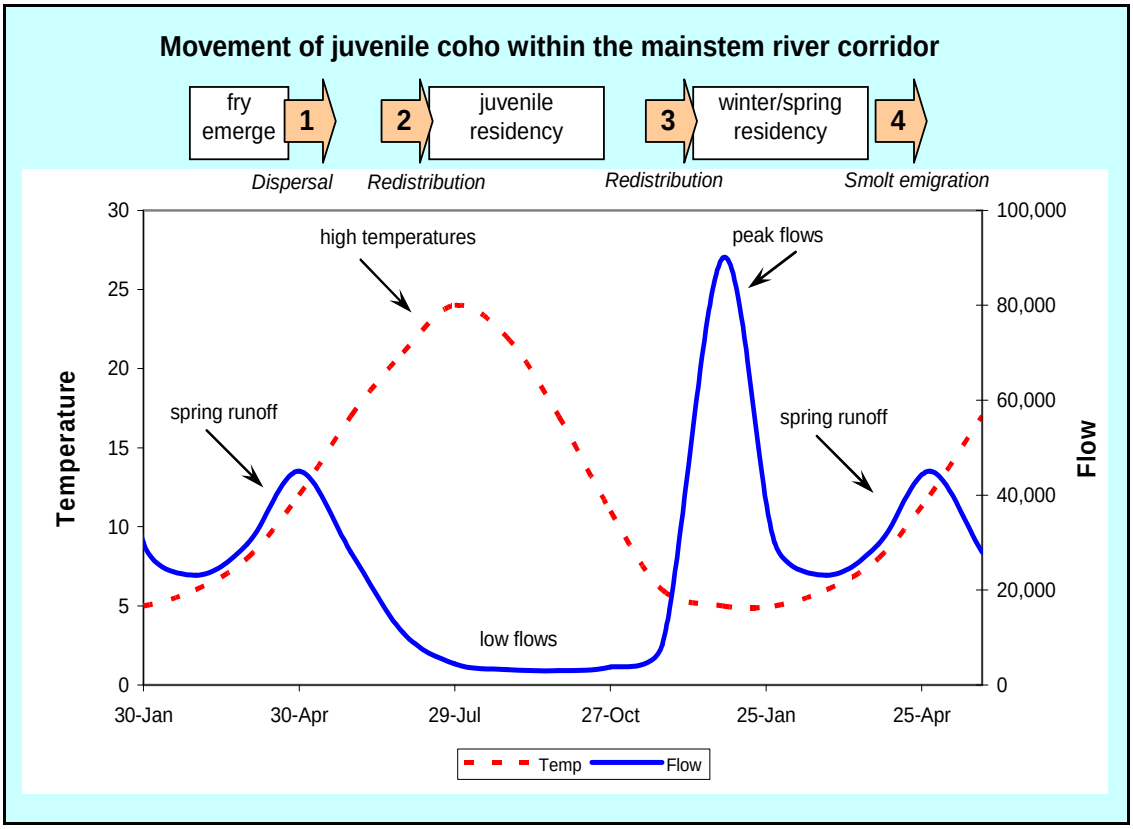


Figure 11. A schematic linking coho life history migration, thermal refugia, and wildfire research

Summarizing, Lake noted that coho, chinook and steelhead continue to decline, though it's hard to quantify declines because abundance has not been systematically monitored throughout the basin. Other species important to tribal culture are also declining or extirpated from historic habitats that are linked to salmon. Climate change is supported by fire frequency and intensity data but effects on salmon are not well understood. The Klamath River Basin Agreement and all the collaborative research that has led to it hopefully represent a turning point in the fate of this salmon ecosystem.

NPAFC role in conservation & protection of Pacific salmon

Vladimir Fedorenko, North Pacific Anadromous Fish Commission

The NPAFC was established in 1993 by Canada, Japan, Korea, Russia and the United States. It is based on recognition of several issues: that anadromous stocks intermingle extensively during their high-seas migration; that the states of origin have primary responsibility for such stocks; that fisheries should only occur within 200-mile coastal zones; and that member states invest and forego economic opportunity to establish favorable conditions to conserve and manage stocks.

The Convention covers a huge area of the North Pacific and encompasses seven species, Fedorenko explained. Total North Pacific Rim salmon catch is about one million metric tons, with a gross value of more than $1 billion annually. Approximately five billion juvenile hatchery salmon are released per year to augment natural salmon runs. Total annual commercial catch of Pacific salmon has grown steadily since 1972. In 2007 it reached a historic high, representing more than three times the tonnage caught in 1972. Comparison of catch composition over time shows that pink salmon is the most abundant species, followed by chum and then sockeye. Coho and chinook have declined as a proportion of overall catch,

while pink has increased. Comparison of annual commercial catch by country since 1972 shows a bright picture for Alaska, Japan and Russia, but not for Canada and the southern U.S.(Figure 12).

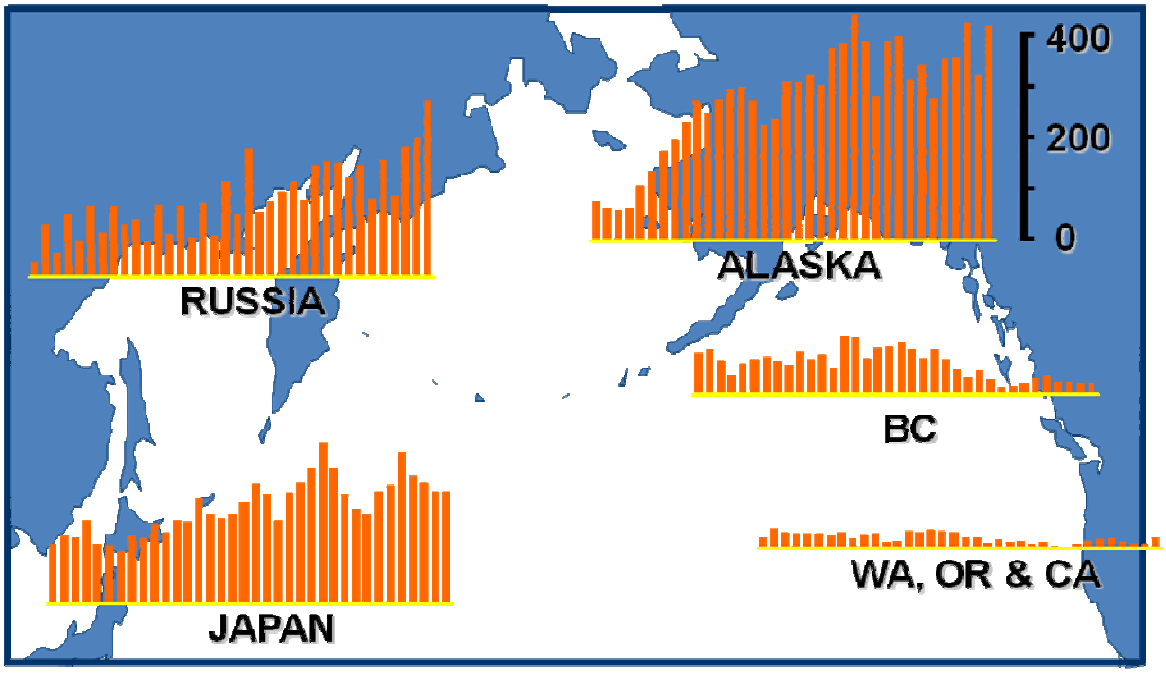


Figure 12. Annual commercial catch of Pacific salmon (in thousand tons) by region, 1972-2007

The NPAFC has two mandates: research and enforcement. The Committee on Scientific Research and Statistics has several working groups that manage programs on stock assessment, salmon marking, stock identification, salmon tagging, and the Bering-Aleutian Salmon International Survey (BASIS). BASIS is a new coordinated program of cooperative research started in 2002 to clarify the mechanisms of biological response by salmon to the conditions caused by climate changes.

The first phase of research (2002-06) has just finished and preliminary results include the following:

- The Bering Sea ecosystem is influenced by atmospheric processes that affect primary and secondary productivity.
- In warm years, abundance of salmon is higher in all regions of the Bering Sea, migration pathways shift, and salmon are distributed further north
- The Bering Sea does not appear to be at or near the carrying capacity, despite high abundance of salmon during BASIS Phase 1.

Future international research includes an international strategic research plan that the NPAFC's long-term research and monitoring project team is developing, with funding from the Moore Foundation, to better understand climate and marine ecosystem mechanisms that determine salmon production. BASIS (Phase II) will also be resumed for further monitoring in the Bering Sea, Fedorenko noted. Future international research will also focus on critical periods of ocean salmon life history, such as early ocean life and the overwinter period in the North Pacific Ocean.

The other key activity for NPAFC is enforcement. Huge enforcement operations are conducted on the high seas with the support of multiple agencies from the five countries. Surface vessels, aircraft, helicopters and satellites are used to prevent illegal high-seas fisheries for salmon (Figure 13). Since 1993, this resulted in detection of 41 vessels driftnet fishing for salmon, of which 16 were apprehended.

Figure 13. Enforcement vessels of the NPAFC

In conclusion, Fedorenko said, the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean established a comprehensive international regime for salmon conservation in the North Pacific. This includes prohibition of directed fishing for anadromous fish in the Convention area. The NPAFC promotes salmon conservation in the North Pacific and adjacent seas and serves as a forum for cooperation and coordination of enforcement and research. The Commission's strength lies in the shared purpose and active efforts of the parties to conserve and sustainably utilize salmon resources, and it has become a model of positive and successful international cooperation.

Open Discussion

Q: It's a surprise to learn of increasing variability in run size and timing, which makes it difficult to open and close fisheries by traditional rules. Are other countries seeing this and if so how are they coping?

- Hilsinger: For the large sockeye run in Alaska's Upper Cook Inlet, the last seven years have included two of the earliest runs on record, two of the latest and three within the normal range.
- Lake: Challenges have included conflicts over harvest, related to closure of offshore ocean fisheries and opening of tribal fisheries.
- Irvine: We're seeing variability at various levels. In 2008, the Columbia did very well, the Fraser did poorly, and systems further north did well. Within areas, there is also evidence of more variability in survival within and across species. Shifts in timing include runs entering the Fraser much earlier and suffering high mortality. There has been some interesting recent work in genomics, in which scientists can now tell if an individual fish sampled out in the ocean is more or less likely to hold at the mouth of the Fraser instead of migrating upstream early.
- Radchenko: Most of the changes that occurred last year (2008) were positive. As with the Commission's efforts, positive changes in management can contribute to positive catches. There are interesting processes with natural stocks, including pinks, and there have been management improvements in Russia.
- Kang: Run timing of chum salmon in Korea is getting earlier. Peak run time in the 1980s was mid-November; now it's late October. It has become about two weeks earlier in the last 20 years. Managers have changed the fishing season in response to this.
- Nagata: Chum salmon management in Japan is established through a bottom-up process. Recently chum salmon abundance was not so good and it was difficult to meet hatchery escapement goals.

Q: How big a problem is disease in southern U.S. coho and chinook? Is it affecting juveniles?

- Lake: Disease outbreaks have been associated with low flows and warm temperatures in-river that primarily affect adult fish. There are others that affect juveniles. Some are temperature-dependent. But as fish crowd together in refugia, density dependence effects may contribute to transmission to other adults or juveniles.
- Hilsinger: Alaska has had problems with *Ich* disease. It makes the fish inedible but does not appear to affect spawning. Monitoring continues, to try learning more, but it doesn't appear to affect stock status.

Q: Explain the conclusion about the Bering Sea not being near carrying capacity. How much confidence is there that this will be true for future carrying capacity, given climate change?

- Fedorenko: Those are just preliminary conclusions. A bulletin is being prepared for publication and conclusions of Phase 1 BASIS research are still being finalized.

Q: The BASIS study included two points of view that were diametrically opposed. The situation in the Bering Sea is very peculiar. If you look at the Asian and American sides of production, you get two very different results. It could be a record level on our side and on the opposite (Alaskan) side you could have a below normal return. There will be a poster presentation on this. Perhaps for the first time ever, Kamchatka will get half of the Alaska catch. But carrying capacity of the Bering Sea is a tremendous enigma. It is good to note that these data are very preliminary and that we need to study more.

- Radchenko: I support the optimistic view of Bering Sea carrying capacity. Recent discoveries include the very wide distribution of pink salmon along the coast in the summer months. As presented earlier, there was also the record abundance revealed by the survey of pinks that will migrate this year. I think carrying capacity of the Bering Sea is growing now and that this is the main feeding area for all common Pacific salmon species.

Q: In talking about ocean predictors, has consideration been given to factors besides temperature, such as spawning success and health of forage fish and factors in the near-shore environment like eelgrass?

- Beechie: There have been efforts to understand some of those components in Puget Sound, and the level of effect on chinook from year to year. Factors found to be important in freshwater include flood frequency, which affects survival of eggs in gravel. With the near-shore stage, we're not sure how to relate the ecosystem to survival, though we do know it is an important life stage. We haven't looked at forage fish populations, but freshwater and near-shore habitat factors provide pretty good indicators of returns, so we know they're important.
- Irvine: A Canadian group meets once a year to pull together all the information available on forage fish, ocean indicators, etc. We're trying to do a better job of forecasting survival, but it's a challenge because climate change can create situations outside the range of known experience. Our annual State of the Ocean report includes information on forage fish, salmon survival and other indicators.
- Lake: Informal stomach analysis can show which prey species salmon are eating. We encourage managers to work with indigenous communities to take advantage of that indigenous knowledge.
- Nagata: I will share actual examples from Hokkaido. Warm and cold currents intermingle in offshore feeding grounds. The cold currents have very little plankton. In some years it's too cold and juveniles can't distribute further away from the shore. Growth is affected by water temperature, but it's complicated. However, warm and cold currents can adversely affect prey supply.

Q: Has anyone looked at the possibility of species using rivers like the Mackenzie? If salmon abandon southern rivers, would federal legislation still protect those rivers?

- Irvine: I just wrote a report on salmon in the Mackenzie basin that concluded chum are the only natal species there, although all five species have been found. There have been episodic events of several hundred to a thousand sockeye, and coho and chinook have similarly been reported. Pinks may be in the process of establishing, but the main limiting factor is marine winter conditions. There is still a lot

of sea ice and the young would have to be down at 200 meters' depth to survive. There are other ways that they could persist – perhaps by going out to the Bering Sea. We're likely to see an expansion of salmon in the Arctic but it's still a long way to swim, especially for pinks that only have 18 months in the marine environment. Perhaps it will happen in Alaska and Russia

- Hilsinger: We're looking at Alaska's North Slope. We are seeking funding to do work in 2009 -2010 and should soon have information on species abundance and distribution.
- Beechie: Regarding protection for rivers in the southern range, when a population is listed under the Endangered Species Act, it is only listed in its current range. Historical habitats don't receive protection. We haven't had to grapple yet with the question of what happens when they no longer exist in a river. It's hard to tell when they're no longer present, and it would have to be a policy decision to state that they're gone.

Q: Given the increasing challenge of making forecasts due to increasing variability in abundance and run timing, what has been the experience in convincing harvesters to lower their expectations regarding the ability to provide certainty?

- Irvine: The lousy forecasts themselves are pretty convincing. Forecasts should be more categorical than numerical. It must be recognized that in this time of greater uncertainty there are limits to our ability to generate forecasts.
- Radchenko: In Russia, fishery management is based on pre-season forecasts. In the last few years, the forecast is translated to TAC (total allowable catch) and that in turn is broken into distributed quotas. Sometimes we need to develop additional in-season forecasts. Of course we know there are some unformalized factors. We have had some success, but also some failures in forecasting fluctuations in the coefficient of return with changing periods. In 2006 we predicted a 1.5 increase in abundance but it actually increased by five times.
- Nagata: For Hokkaido chum we are not forecasting wild runs, just hatchery returns. We try to gather daily catch data quickly and compare it to the forecast. Depending on the outcome, we may urge fishermen to voluntarily curtail catch if the results are not good. Some experienced fishermen would not catch the fish that we rely on for reproduction, but when returns are too low, we must ask fishermen to use voluntary restraint.
- Hilsinger: Alaska uses a variety of forecasts, some based on spawner recruit models, which work with varying degrees of success. In Bristol Bay, the fishing industry also hires an expert to do a forecast. We may start the fishery based on the forecast, but as soon as we get enough in-season information, we manage according to that. The forecast is mainly a planning tool that helps industry decide how much they should gear up. We've improved the accuracy of forecasting in recent years, but since we're relying on historical data, changing patterns will pose challenges.

Q: Clearly, climate change is not a good thing for salmon. What can the five countries do in terms of disincentives (e.g. carbon tax)?

- Irvine: We're not experts in that area. We need to provide advice to resource users on how to adapt to the future. It's not all bad. Some elements of the environment will benefit. The other thing is to conserve diversity, which is why we're starting to manage at the CU level, and also to protect habitat diversity.
- Fedorenko: The five countries are doing much scientific research. One of the new projects is a long-term monitoring project. We don't lack ideas; what we lack is funding to conduct studies. For example, BASIS Phase II is delayed due to insufficient funds.

Q: With five billion hatchery fish being released into the North Pacific annually, how does this affect the ability of wild salmon to adapt and survive?

- Hilsinger: It's been a pretty significant issue in Alaska. Are poor chum runs related to hatchery production? One of the things lacking is better information on where those fish are in the ocean. Without that, you can potentially take actions that don't solve the problem but that come at a cost.
- Irvine: The impact of hatcheries on wild fish is a very complex issue. It depends on the purpose of hatcheries: Is it to produce fish for conservation or for harvest, for public education or for employment? It gets into social as well as scientific issues. The jury is out as to whether density-dependent effects are occurring out in the North Pacific. Asian scientists have one perspective, and North American scientists have another.

Day 1: Concluding comments

Vladimir Karpenko, KamchatNIRO

These forums are usually convened in response to a crisis, Karpenko said. But there is no obvious crisis – nothing is about to blow up. It has taken many years for humans to start thinking about helping Mother Nature. So I'm happy that we are here and having this dialogue, not just because we're afraid of climate change or of having salmon for our dinner plates. We're here to talk because we seek sustainability. We don't want future generations to be robbed of what we have.

The first few presentations were worrying, he added. I don't want this for my future. This is the first day of our conference and I'm very happy that we are working from the ground up. We have started off by explaining what is happening in our countries and discussing what can be done to improve things, moving forward very cautiously and responsibly for the sake of the future. Tomorrow we will provide a more detailed picture. Our employer is salmon, which are in a bind. There is not much we can do about climate change. But we can address the human factor – it's not about trying to coerce nature but about what we can do ourselves.

Forty years ago we used to know more, but not to the same extent. Human territories have been depopulated, with people moving to cities. I'm also working with the Bering project and I used to meet with locals and ask about how it was in the past compared to now. For example, the structure of catches in western Alaska has changed. We're at the point where we need to think of strategic efforts, and technical issues will follow. We're not at the point that we need to think about details. We need to think about how best to conserve salmon for the children.

Karpenko closed by wishing success for the conference and for all participants in their endeavors.

Day 2: Opening remarks

Rich Lincoln, State of the Salmon

Recapping the previous day's discussion, Lincoln noted the morning keynotes offered important but sobering messages about various disconnects: ecosystems with economics, loss of ecosystem resilience, accidents waiting to happen and ocean acidification. But it was a call to action, he stressed, despite the sobering message. We should take advantage of this sobering time to experiment, to implement monitoring strategies, to recognize the opportunities that crises bring, and acknowledge successes such as the development of protected areas in Russia. There is reason to be hopeful if we rise to the creative challenges. That's why we're here: to share creative approaches in an uncertain environment.

Later we heard highlights from around the Pacific Rim, Lincoln continued, including climate effects at different spatial scales. These vary in surprising ways, in some cases offering a hopeful current picture. They are not uniform across the landscape. This highlights the need to increase salmon resilience – to protect biodiversity by conserving wild stocks and habitat. The audience discussion started to probe the response needed and it was noted that we have two more days to explore strategies.

Reviewing the Day 2 agenda, Lincoln challenged participants to engage in more active dialogue regarding solutions to the challenges.

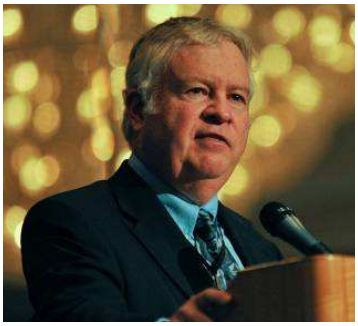
Morning plenary

Conservation principles and their integration

Rich Carmichael & Mark Trenholm, plenary co-chairs

Principles for proactive conservation of aquatic resources

Jack Williams, Trout Unlimited



In the freshwater realm, much is known about causes of salmon decline, Williams said, but there is a sense that science alone is not the answer. Why hasn't more progress been made in restoration? Despite significant investment in scientific knowledge and strong laws, much of the remaining resources remain threatened.

Bigger things are going on. We have an environmental crisis because we have consented to an economy in which by the simple acts of living we are destroying the natural world. Can we have sustainable salmon without a broader sustainable lifestyle? The predicted future may not be kind to salmon: there will be more people, more demands on resources and a series of new threats linked to climate change. Williams proposed six principles to respond to these challenges:

1. 'The first rule of intelligent tinkering is to save all the pieces' - *Aldo Leopold*. The Pacific Northwest and California have already lost 29% of salmon populations, 27% of genetic diversity, 15% of life history diversity and 33% of ecological/spatial diversity. Research in Bristol Bay has highlighted the importance of bio-complexity in maintaining aggregates of stocks.
2. Protect and secure salmon strongholds: key questions include how to select and connect a network of salmon strongholds and how to manage and fund them.
3. Protect-reconnect-restore (Figure 14: Take a watershed-scale approach to restoration. Protect the headwaters, reconnect headwaters to the mid-stem and restore lower plains most degraded by

agriculture and urban development.

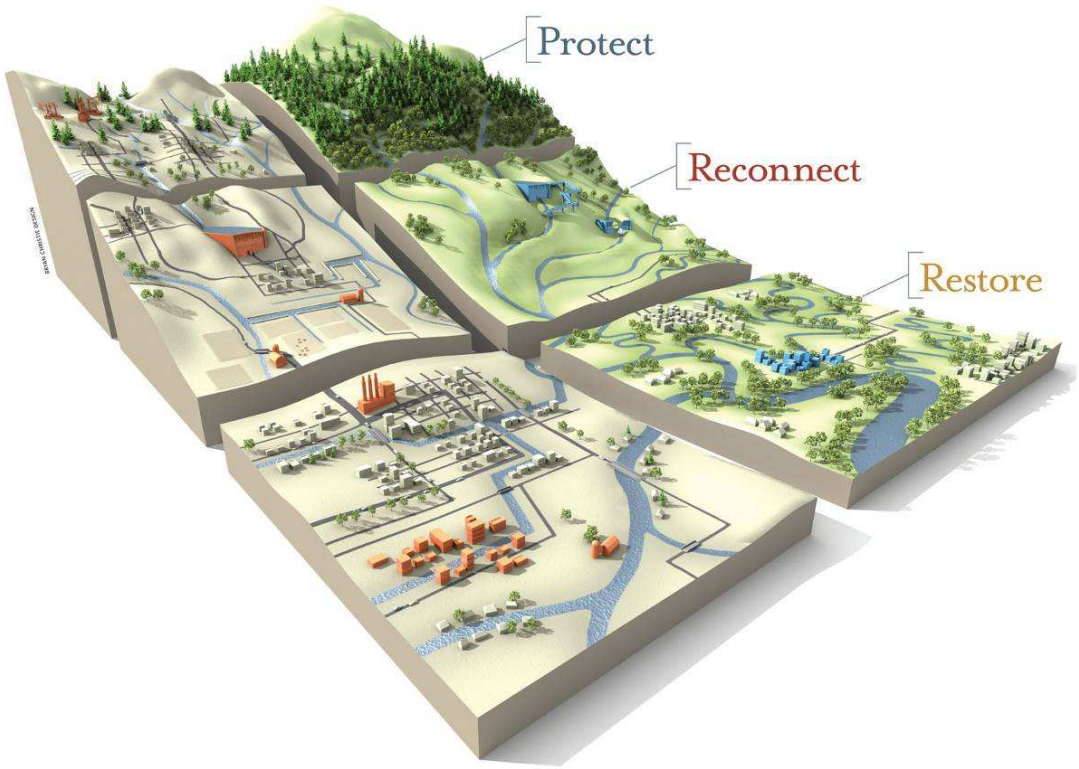


Figure 14. **Watershed –scale approach to restoration**

4. Be proactive about major salmon stressors, including increased human population and footprint, climate change and related impacts such as exotic species. Action can be taken now to make ecosystems more resilient: restore riparian systems and better manage roads and stream crossings, for example.
5. Manage in an ecosystem context: a management strategy that relies on artificial propagation without addressing causes of decline is not facing reality. The 1998 Snake River Review found hatcheries alone can't solve the problem. How can we reform hatchery management to better support wild stocks?
6. Improve monitoring and evaluation: key factors include cross-boundary cooperation, long-term data sets and being able to distinguish oceanic, estuarine and freshwater responses.

It's also important to consider how you do this work, Williams stressed. Solve for pattern by addressing primary stressors, not just the symptoms, by working across multiple scales and boundaries and by paying attention to context. He quoted Wendell Berry, who said "the whole problem must be solved, not just some handily identifiable aspect of it.'

Williams also stressed the need to create an ethic for salmon restoration by tackling broader issues such as economic models, sustainable lifestyles and the need to foster a land ethic. Quoting Leopold again, he said a land ethic changes man "from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such."

How do we change public values? The public must be convinced of the need to save salmon, he said, not just for the sake of salmon, but for the sake of saving ourselves.

Discussion

Q: In monitoring and trying to separate the different phases, we also need to understand how the different phases connect.

- Williams: Agreed.

Q: It's important to also talk about the larger issues – the externalities. Often there is not much we can do to address them, but it's worth spending time on the larger issues as well and paying attention to population and climate change as a result of over-population.

- Williams: We can spend more time on these things. We should be working now to prepare and plan communities to meet future challenges.

Q: I come from the headwaters of the Yukon, where the fish can't reach the headwaters. Everyone needs to get together, including scientists and native people, and we need to use traditional knowledge.

- Williams: Agreed
- Carmichael: We need to think of addressing challenges and survival across the whole cycle, not just in small pieces.

Fishery selection: size, age and timing of migration

Tom Quinn, University of Washington

Studies have shown the potential for evolutionary change as a result of harvest, Quinn said. These changes don't just affect phenotypes but also genetic make-up.

Ricker pointed out years ago that fishing could cause trends for declines in body size. Recent research on gillnet fisheries in Bristol Bay showed that, in most years, the fish caught were longer than those escaping to spawn, especially females. The nets were not very size-selective for males and while smaller females were safer, the very largest fish were not the most vulnerable. Exploitation rates have increased in the Nushagak district as run-size has gone up. Fisheries have also become less size-selective than they used to be, due to a combination of factors. The fisheries operate on a population complex (aggregate), Quinn explained, and since length at maturity varies between populations, the exploitation rate for each population therefore also differs.

The evolutionary effects of fishery selection on length at age are mitigated by opposing natural selection and strong environmental influences. But fishing is also often selective for migration timing and this trait is under strong genetic control.

Conservation efforts (i.e. allowing only limited fishing until the run shows its true size and thus focusing effort on the late part of the run) can make fisheries selective with respect to timing. Comparing catch data for 1997 to 2003 against run timing showed that about 80 percent of exploitation happened on the back end of the run. Run-timing data also show the runs are shifting their migration timing and arriving earlier, as would be predicted from selectively fishing the later part of the run. There are two possible mechanisms for the change in migration timing, he noted. Higher exploitation later in the run may reduce populations that arrive later, or it may selectively remove late-migrating individuals from each population.

While Bristol Bay sockeye are known for their compressed, unimodal run timing, some systems do have bimodal timing (earlier and later runs). This can reflect two populations, whose runs overlap considerably. Sometimes, bimodal run timing does not reflect a simple two-population system, but rather groups of early and late spawners that overlap. A tagging study of the bimodal sockeye run in the Bear

Lake system found there was actually an overlapping group of several populations, and that harvests that consistently hit the middle of these runs hardest were creating the appearance of bimodality.

Selection on timing can also affect other patterns within populations. Early migrants tend to be older and larger than later ones. They tend to spawn earlier and may use different parts of the stream, further complicating the effects of fishing. For example, larger Wood River females migrate earlier, though they don't necessarily spawn early. They also differ in habitat utilization, tending to spawn in the upper parts of the stream.

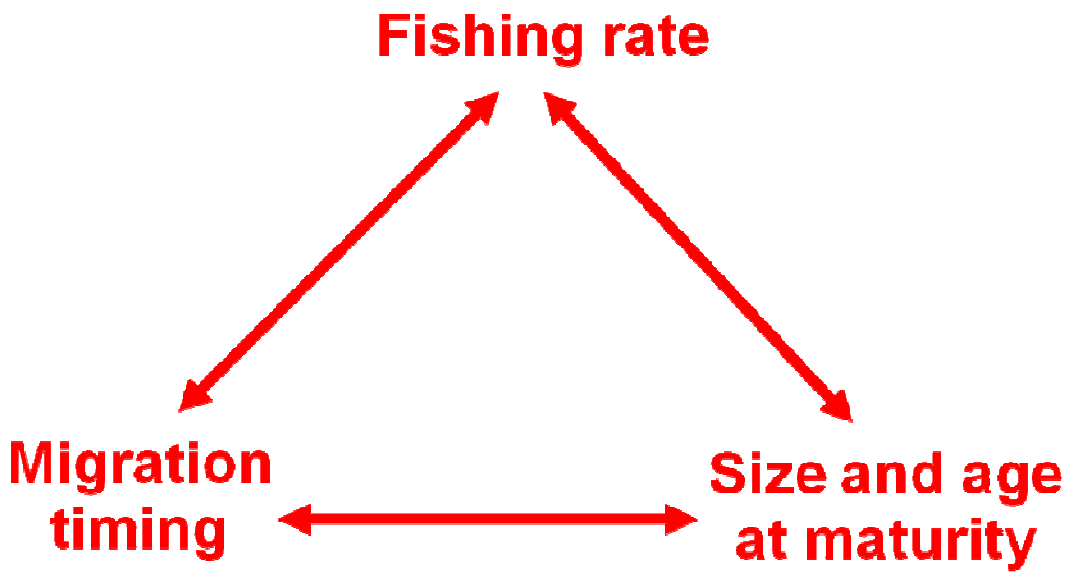


Figure 15. Interactions between size, timing, and evolutionary effects of fishing

Most salmon fisheries are selective with respect to timing, Quinn concluded, whether this is intentional or not. Given interactions between size and timing, it's important to ask what the evolutionary effects of fisheries are on salmon, in terms of population diversity, how they use habitat, etc. Selective fishing impacts on timing are widespread and pose challenges for management. These effects may be at least as important as selection on size and age (Figure 15).

Discussion

Q: Is there similar research on other fish in North America and how can we get hold of that?

- A: In eastern Canada, extensive work has been done on cod and other species.

Q: Did you consider selectivity due to high-grading at sea?

- Quinn: We haven't looked at that. There will also be fish that were scarred and whose viability may be compromised.

Q: Regarding differential productivity of individuals across the run-timing spectrum, if larger fish migrate earlier, they may produce larger eggs and have better survival of juveniles. Are there any data on outcomes other than just the number of spawners?

- Quinn: If we are allowing more of the earlier fish and crowding the front end, this raises a whole host of issues. There is typically higher productivity in some subset of the run, but it's not consistent. We've had a huge effect on density and shifting it over the run-timing spectrum.

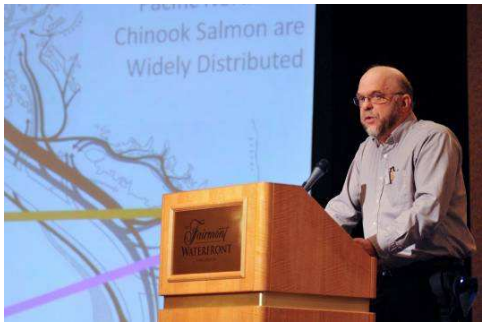
Q: Are there practical recommendations for fishery managers?

- Quinn: Managing a fishery is much more difficult than what we do. In Bristol Bay, 100,000 fish are caught in a 12-hour opening. It's very challenging, and the best you can do is to be aware of it, and

where possible to spread it out. Also bear in mind that there are natural compensatory mechanisms. Populations are healthy but we're still seeing changes, and this is a warning for other areas where populations are not as healthy.

Coordination of harvest, hatchery & habitat management for recovery of Puget Sound chinook

Kit Rawson, Tulalip Tribes



Puget Sound chinook, which includes 22 populations in 14 watersheds, was listed as threatened under the ESA in 1999 Rawson said. A recovery plan was adopted in 2007.

Historical run-size data for Skagit chinook show a steady 50-year decline. Causes include offshore mixed stock fisheries, though tags show that 80% exploitation rates in the 1980s have been reduced to very low levels. Hatcheries have also contributed to declines, he added. The assumption that we could produce salmon more efficiently than Mother Nature led to hatcheries in almost every watershed in Puget Sound. The risks and benefits of hatcheries are now well documented. Habitat is the third and key factor in the decline of Puget Sound salmon. Between 75% and 90% of estuary habitat in Puget Sound has been lost (Fiugre 16). Increases in peak stream flows due to land-use changes is also tied to a decline in egg survival

To better understand what is happening in habitat systems, an Ecosystem Diagnosis and Treatment (EDT) model was used. This model looks at a wide range of habitat indicators to produce a spawner recruit curve that compares current levels against recovery goals and historic levels (Figure 17). This analysis shows that managing harvest alone is not sufficient to achieve recovery. All three factors – harvest, hatcheries and habitat – must be managed to reach recovery targets.

The harvest management approach for Puget Sound chinook is based on a "rebuilding exploitation rate." For hatcheries, a reform program reviewed every hatchery in the state to address risks. A 2005 Memorandum of Understanding for the Snohomish system called for conversion to indigenous brood stock, mass marking and selective fisheries. In the Stillaguamish system, hatchery output supplements a low wild population.

With respect to habitat, the Puget Sound recovery plan is mainly devoted to restoration, Rawson explained. It includes detailed plans for 14 watersheds, funding for restoration projects linked to system needs, and annual proposals, reviews and grant awards. It is proceeding but slowly. Habitat protection remains a gap, however. There are many agencies with varied and overlapping authority, but they are not working together. There is little public confidence in the process and continuing degradation is occurring. Recent land-use trends analysis compared satellite photos from 1991, 2001 and 2006, showing that mature forests continue to decline and development is expanding.

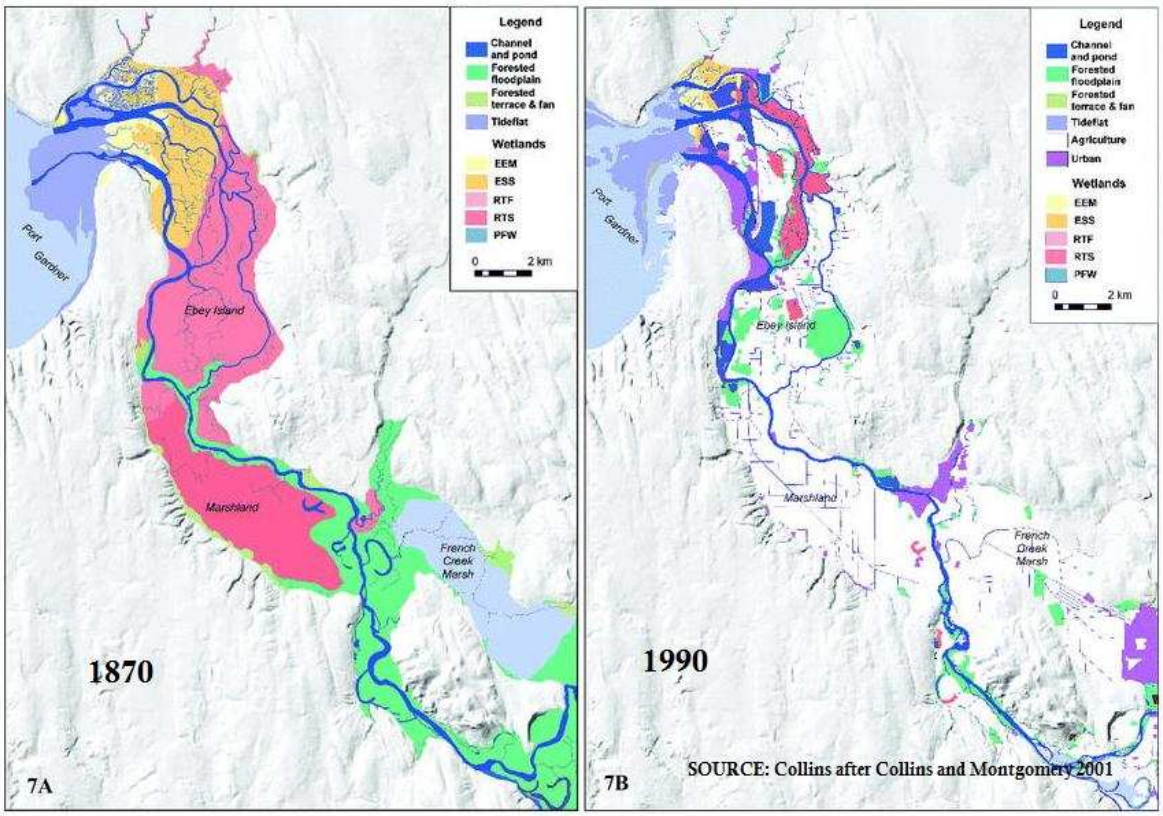


Figure 16. Loss of habitat in the Stilliguamish basin

As things currently stand, habitat remains a problem. For hatcheries, there is some uncertainty and disagreement as to the level of improvement made and needed. Harvest management has improved, though more can be done. Summarizing, Rawson noted that while some improvement has been made, much remains undone and improvement is needed in all three areas. Habitat protection is still not integrated into the recovery plan and this is an essential piece. Why not launch a similar program for habitat protection reform? The steady human population growth in Snohomish County can't be ignored, he added. As Suzuki said, all we can do is manage ourselves. We know what to do; we just need to figure out how.

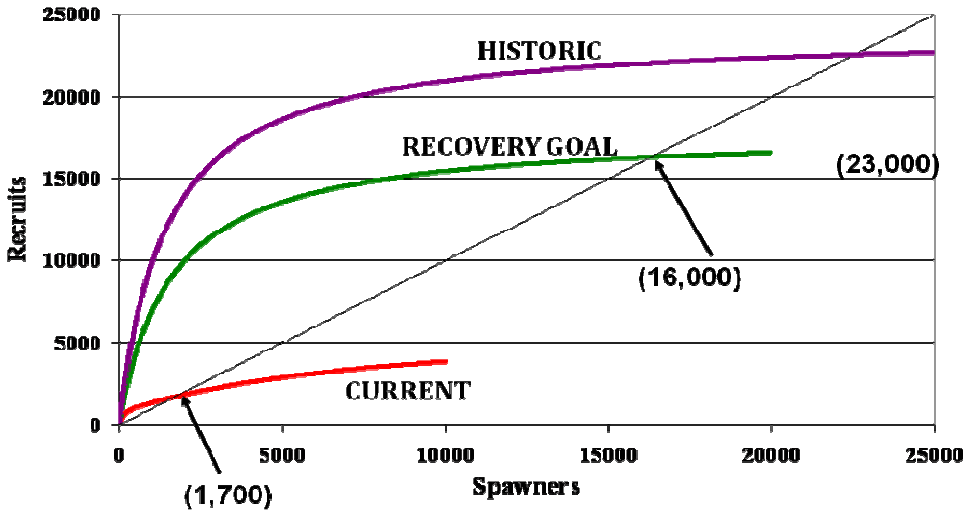


Figure 17. Spawner-recruit curves for the North Fork of the Stillaguamish River, Washington, US

Discussion

Q: How is the recovery exploitation rate set and is it being met?

- Rawson: Variability in recruitment and other aspects of variability are factored in developing projections of production and risk analysis to set the recovery exploitation rate such that escapement exceeds reference points a certain amount of the time. A five-year review is being done and the targets have not always been met. Some factors are beyond our control, such as northern fisheries.

Q: Expand on the surveys about public confidence.

- Rawson: This was a San Juan initiative in response to a review of the recovery plan that said habitat protection was not being addressed adequately. People were asked how that could be improved. They did a case study in the San Juan Islands, and interviewed landowners, etc.

Q: It is assumed in Puget Sound that habitat is the most significant of the three H's, but are there time series that allowed the partitioning of mortality into freshwater vs. marine mortality to determine how much of the decline might be due to natural events in the marine environment? Also, how much effort is there to evaluate effects of the different programs, in terms of measurements that relate to responses of the fish themselves?

- A: One issue with the ESA listing was the need for more separation of freshwater and marine issues. There were independent estimates of marine survival from coded wire tags (CWTs). Monitoring and evaluation is a huge part of it, but it's hard to get it off the ground, so a new bottom-up effort will be tested in three watersheds.

Panel: Obstacles and opportunities for implementing wild salmon policies

Conservation principles of natural spawning of salmonids in Hokkaido, Japan

Mitsuhiro Nagata, East Research Branch, Hokkaido Fish Hatchery

Wild salmon were protected in the Tanegawa River in the Edo period, during the 1700s. Policies were changed in the late 1800s to support hatchery production, Nagata said. This has been successful for chum salmon, but not for masu salmon, which remain at low abundance levels. Now Marine Stewardship Council certification of Alaskan salmon has challenged Hokkaido to pursue MSC certification of its own set net fishery in order to maintain a competitive edge in export markets. Securing full certification will require development of a wild salmon policy.

Currently, commercial and game fisheries are prohibited in all rivers around Hokkaido to conserve wild salmon. However, sustainable escapement goals and a management plan need to be established. Other requirements include accumulating a separate data set for wild salmon.

Proposed objectives for the wild salmon policy include conserving wild salmon and biological diversity of hatchery salmon and also restoring freshwater habitat. The concept of harmony between ecosystems and co-existence of wild and hatchery salmon is to be achieved via a zone management system to spatially separate wild and hatchery salmon in freshwater. Weirs would be used on all systems to count wild salmon or catch hatchery salmon, he added.

There are currently three different types of rivers in Hokkaido: wild salmon rivers that have never had hatchery fish; mixed rivers in which hatchery juveniles are released and returning adults are captured in river, and rivers where hatchery juveniles are released but returning adults will be left to spawn naturally (Figure 18). Under the MSC system, the latter will be considered wild systems if the returning adults spawn naturally. Research so far has focused on qualitative assessment of spawning habitat conditions in streams around Hokkaido. Work will begin next year on quantitative research and monitoring, Nagata said, such as adult counting and biological data to estimate tentative escapement goals for wild chum.

This concept of ecosystem-based sustainable conservation and management, based on co-existence between wild and hatchery fish, will rely on three components:

- Biological monitoring (evaluating ocean carrying capacity, size and age composition of populations and genetic and reproductive characteristics) is already done for hatchery fish and will begin for wild fish this year.
- Separation (zone management) of wild and hatchery salmon in freshwater to protect genetic diversity and endemism, and recreational and commercial fisheries.
- Rehabilitation of wild salmon populations and natural riparian ecosystems.

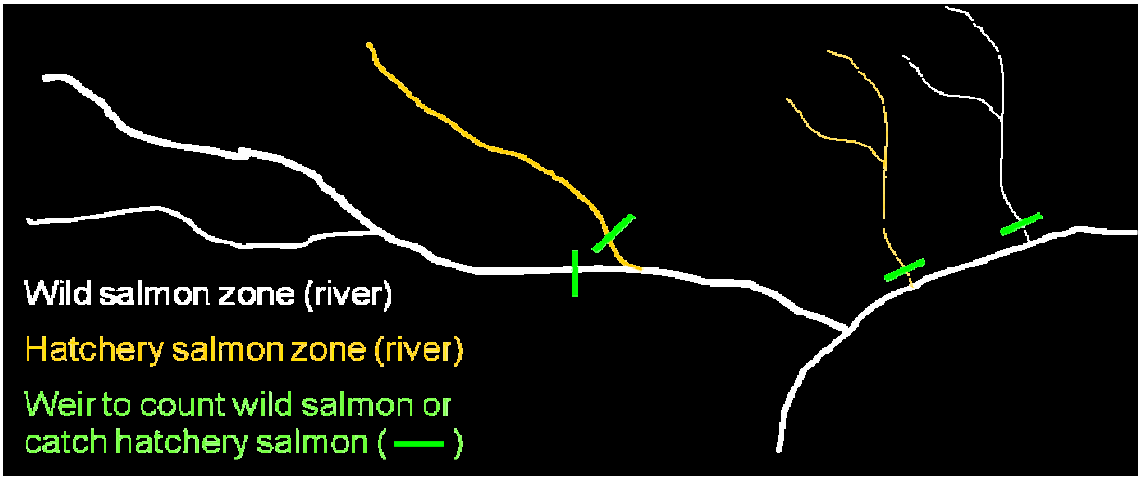


Figure 18. Three river types in Hokkaido, Japan

In Kyushu, which has a salmon shrine, the local people believe chum is a kind of God or messenger of God, Nagata noted. There is no custom to separate wild and hatchery salmon among the Japanese people. So there is need to establish a new system for these efforts to conserve wild "samurai salmon" as following from the principles of wild salmon conservation in the Edo period.

Wild salmon conservation approaches in Russia

Alexander Kulikov, Regional Wildlife Fund, Khabarovsk

Kulikov's presentation described the development of a system of protected areas for Pacific salmon conservation in Khabarovsk, in Russia's Far East. A complicated network of protected areas already exists in this region (Figure 19). There are different categories and groups of protected areas. Some are managed by federal structures; others by the regional government. There is also a special service for protecting natural resources at the local government level.

The current system was developed over many years, with the oldest protected area established in 1928. When the system was developed, many changes were introduced via legislation. Protection of salmon has

different priorities and significance, but "the building is already constructed," so the idea is to use this existing system to protect wild salmon and to make it more effective for that purpose. In addition, efforts are underway to create a new system. Last year, new legislation was approved to govern the use of natural resources and establish a system of protected areas.

The team from Khabarovsk includes multiple partners working together to create a new protected area for salmon. About half of the park is marine area. A paper has been written establishing the ecological basis and we hope the necessary legislation will be created, Kulikov said. We want to use the watershed approach and look at the entire watershed, but are encountering challenges due to inter-jurisdictional complexities regarding land ownership and legislative authority. Still, the hope is to resolve this in the current year in order to start work in the protected area.

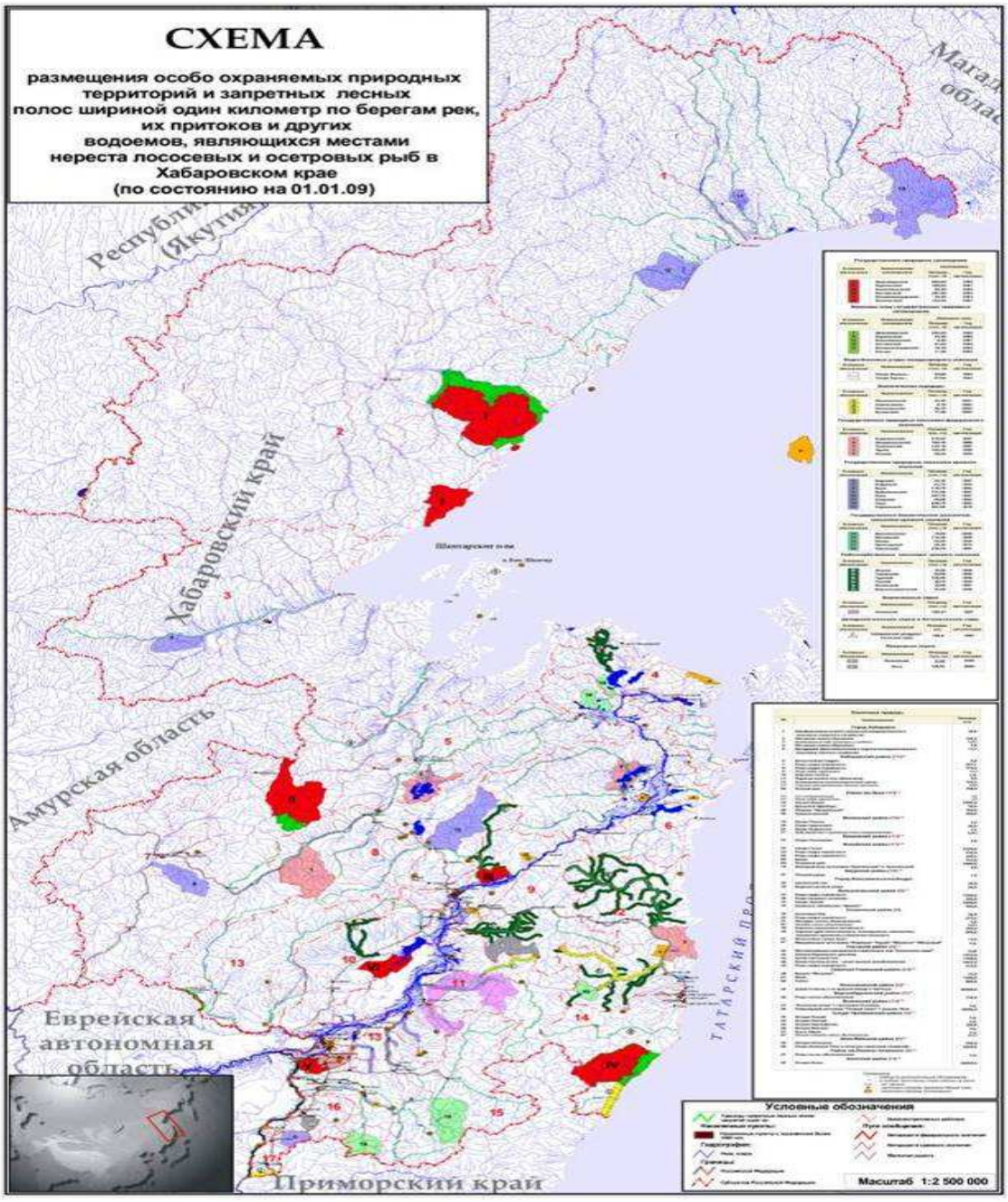
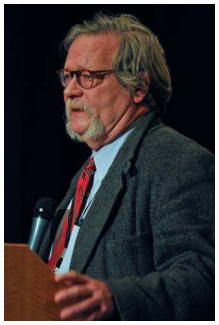


Figure 19. Complicated network of protected areas in Khabarovsk

Some ecologists are not happy with the legislative changes, but many protected forests also offer benefits for salmon, so the limited logging allowed will probably be forgiven. Non-profits can lease the protected forests for goals such as scientific research, education or recreation. These protected forests that surround salmon rivers thus also offer useful additional protection.

Alaska's sustainable salmon fisheries policy: a bridge to innovative approaches to research & collaborative management

John White, Alaska-Yukon-Kuskokwim Sustainable Salmon Initiative



Alaska's sustainable salmon fisheries policy was a joint effort of the Alaska Department of Fish and Game and the Board of Fish Sustainable Fisheries Committee, White explained. It was based on feedback from users at over 30 public meetings, a technical review panel and external scientific peer review.

The result was a policy for sustainable salmon fisheries management and an implementation plan. The principles were adopted in regulations and provide a template for the Board of Fish to do a stock-by-stock review of status in three-year intervals to protect wild salmon and habitat to ensure sustained yields. The policy deals specifically with management plans, sustainable escapement goals and encourages public involvement. In times of uncertainty, it calls for conservative management plans, White noted. If a stock is not doing well, criteria in the plan will determine the level of concern and an action plan will be developed for that stock.

The policy identifies three levels of concern: yield concern (chronic inability to maintain yields), management concern (chronic inability to maintain escapement goals) and conservation concern (chronic inability to maintain sustainable escapement). Action plans may include habitat restoration, protection, stock rebuilding efforts, management actions, a research plan and communication with other agencies.

The regulatory mechanism thus provides a clear focus on stocks of concern, he explained. That focus links to the role of the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI), which provides a forum for collaborative research and responses to deal with identified problem stocks. The AYK SSI was established in 2001 to provide a forum for non-governmental organizations, users, indigenous people and state and federal agencies to cooperatively identify and address salmon research and restoration needs. The initiative covers 40 percent of the total area of Alaska, bridges disciplines and addresses the full salmon life cycle at the watershed scale or larger (Figure 20).

This co-management model brings all the parties together and has allowed us to expand on the importance of the AYK SSI by implementing research to understand underlying causes of identified conservation issues, White noted. When the current research program is completed in 2012, the parties will look at ways to implement the findings into management regimes.

Summing up, White noted that co-management melds aspects of governmental and community-level management to improve fisheries information and management by making it more inclusive and more adaptive to changes in human communities and ecosystem changes.

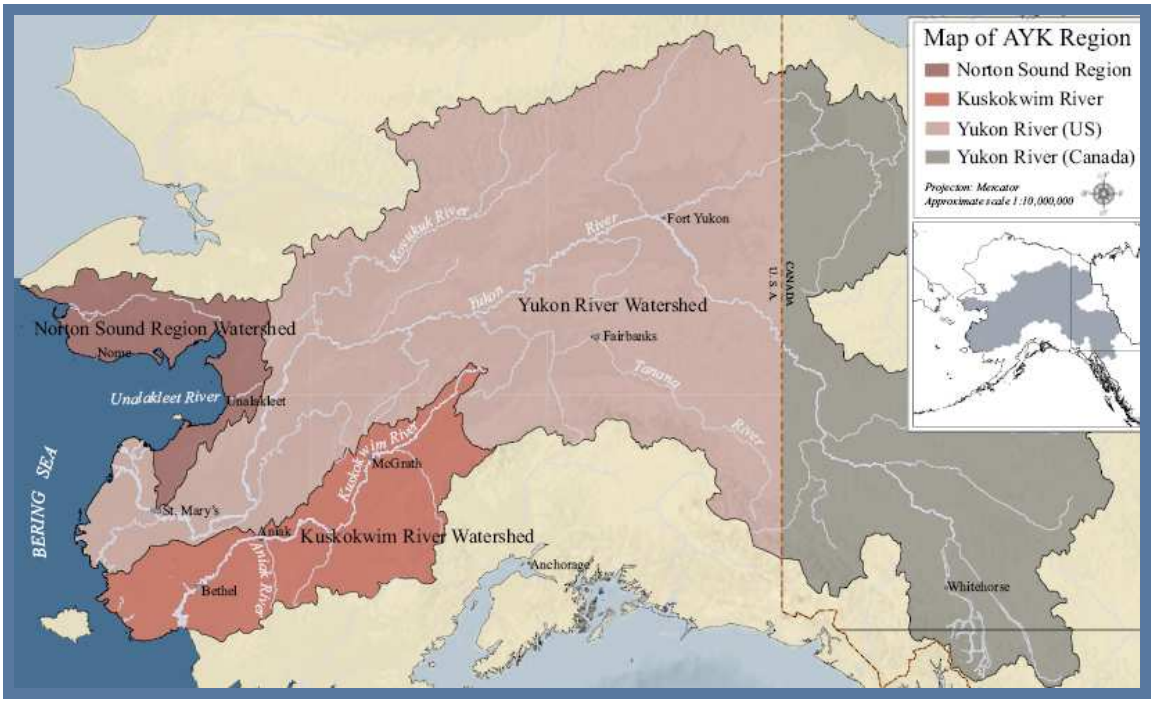
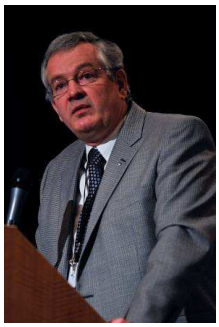


Figure 20. Land area covered by the Alaska-Yukon-Kuskokwim Sustainable Salmon Initiative

Canada's Wild Salmon Policy: conservation planning for an uncertain future

Brian Riddell, Pacific Salmon Foundation



Canada's Wild Salmon Policy (WSP) recognizes that in dealing with uncertainty and future conservation, protecting diversity is the most prudent policy for protecting salmon, the ecological processes they depend upon and the important cultural, economic and social benefits that they provide. The WSP is an explicit commitment to not just manage production levels but also diversity among streams, Riddell explained. It links to ecosystems and monitoring and to directly involving the people affected in decision making.

The policy sought to re-define and clarify what is meant by "stocks" in terms of the level of protection required to maintain biodiversity. The guiding principles are "conservation first," respect for obligations to First Nations, sustainable use and transparent decisions (Figure 21). The WSP calls for standardized monitoring of the status of salmon and their habitat, inclusion of ecosystem values, integrated regional planning, annual program delivery and independent performance review. Six strategies provide direction for implementation.

The first step involved identifying salmon conservation units (CUs). These are defined as "groups of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, that area is very unlikely to be re-colonized naturally within an acceptable time frame." This approach recognizes the natural spatial organization of salmon across varying habitats, the need for precaution in the face of uncertainty and the need to manage at an appropriate scale that protects adaptability, Riddell said. A total of 423 CUs have been identified for the five salmon species in BC, with further CUs to be identified for the Yukon River. The next step is implementing a new system to determine the biological status of each CU. This will be a categorical assessment of spawner abundance and spatial distribution, denoted by three status zones separated by upper and lower benchmarks (Figure 8 – Jim Irvine). This approach is not the same as managing for maximum sustained yield, he noted, and the intent would be to avoid falling below the lower benchmark.

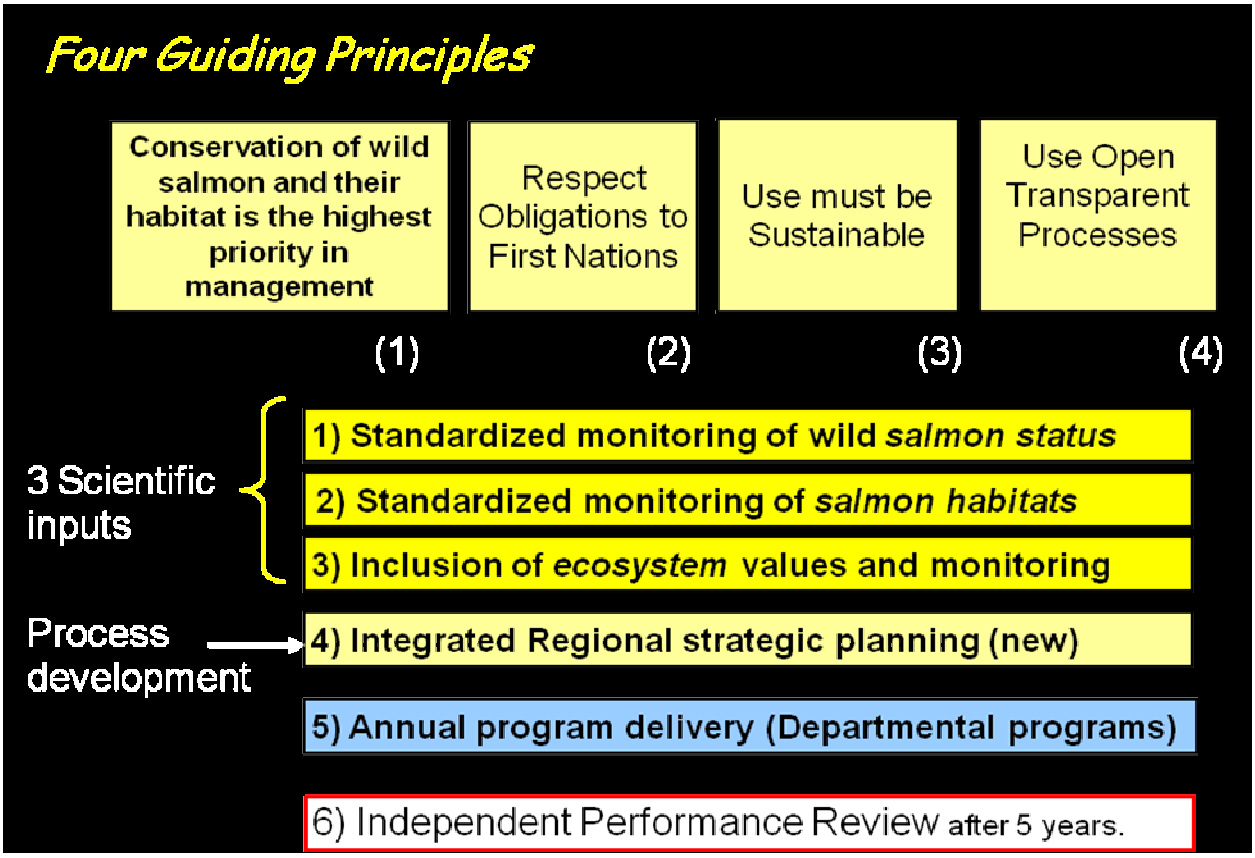
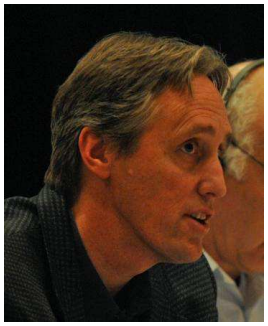


Figure 21. Principles and Action Steps within the WSP

The WSP seeks to address an uncertain future by conserving salmon at the CU level; by using a more precautionary assessment base and annual monitoring for each CU; through habitat monitoring and inclusion of ecosystem indicators in annual management planning; and also through new community-based regional planning processes. While the importance of ecosystem-based management is widely recognized, such an approach involves more people and more complexity and uncertainty, so decision-making processes are being restructured to address this.

Oregon's Native Fish Conservation Policy

Ed Bowles, Oregon Department of Fish & Wildlife



The three goals of this policy are to prevent serious depletion of native species so that natural production is sustainable, to maintain and restore natural species to provide substantial ecological, economic and cultural benefits, and to foster and sustain opportunities for fishers, consistent with conservation. Connecting the public with fish and overcoming apathy are seen as very important to achieving these goals, Bowles noted.

Conservation is seen as "job one" with a focus on naturally-produced native fish (hatcheries play a supplementary role but are not a replacement). The intent is to manage for sustainability of population groupings, to err on the side of conservation and to provide fishing opportunities consistent with conservation. Implementation is through conservation plans with specific standards, a range of management options and emphasis on local adaptation as the foundation for recovery. Conservation efforts involve working closely with management partners but the pace is scaled to resources, which creates a bottleneck.

The fish management foundation provides all the basic elements to put these conservation strategies in place, Bowles continued. These include providing well-described management unit boundaries at the population level; describing both desired and existing status in terms of abundance, production, distribution and diversity; and analysis of causes for the gap between the two (i.e. what is causing bottlenecks in the life cycle). Appropriate management actions must then be identified and, because this all takes place in a context of uncertainty, investment in appropriate monitoring and evaluation is also required.

Expected outcomes include collaborative recovery plans that focus on key limiting factors and threats while building on local efforts and public input, a shift to recovery actions and adaptive management, and key management actions that address conservation and utilization objectives. Currently, 23 conservation and recovery plans have either been completed or are in progress (Figure 22).

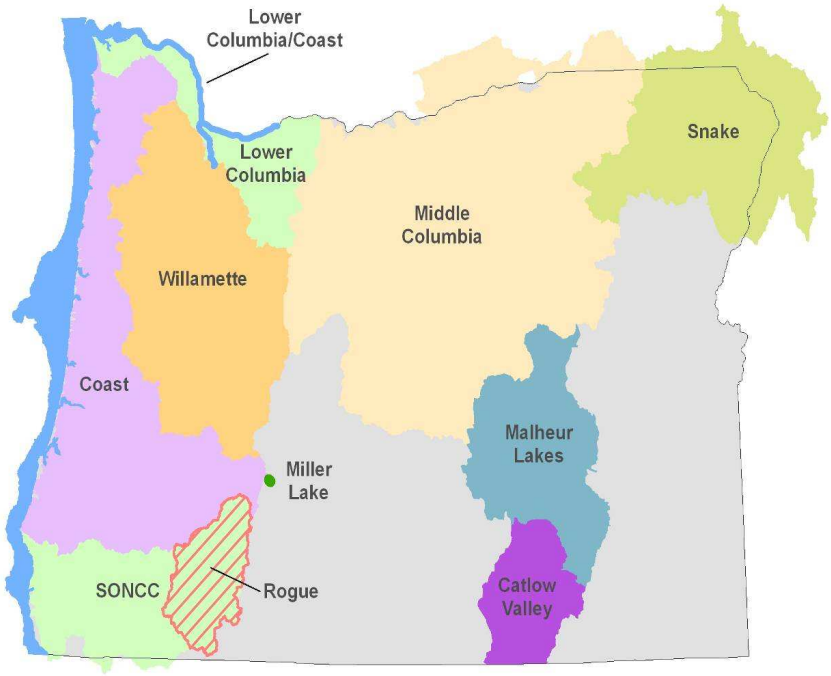
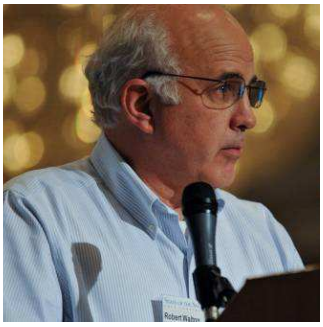


Figure 22. Conservation and recovery plans completed or in Progress in Oregon, US

Endangered Species Act perspective

Rob Walton, National Oceanic and Atmospheric Administration (NOAA)



Implementation of Endangered Species Act (ESA) listings for salmon includes writing non-regulatory recovery plans, hatchery regulation and regulation of inland harvest. We've been working on recovery plans for a long time, Walton said, and it's clear that without broad support, even great recovery plans don't go far. One of NOAA's primary duties is to review actions that may affect endangered salmon to see if there is substantial effect on the listed species and if so, to work with proponents to come up with reasonable and prudent alternatives.

More than half the salmon populations on the U.S. west coast have been identified as endangered, threatened or as species of concern under the ESA. Key issues in addressing this challenge include the need for a common vision of wild salmon conservation; how to balance support and resistance to such a policy; how to change human behavior; the knowledge needed to conserve wild salmon, ocean and freshwater habitat; and fisheries management.

The basic problem is depleted runs and the goal is to restore them, Walton said. But it's not clear that there is a common vision of what this means and it's important to have agreement on a wild salmon policy. Science suggests that in implementing the ESA, the focus should be on achieving viability at the population level, as this is the single most important point and offers the greatest opportunity to protect salmon in the North Pacific, especially where runs are strong. This holds potential lessons for places like Russia and Alaska, he noted. If you want to protect the whole, you need to look at the individual pieces. Otherwise, the experience elsewhere serves as a warning that the whole may end up in trouble.

Given the many competing interests – forestry, hydropower, housing, etc. – it's also necessary to find a balance and to secure compromises that change human behavior to permit both sustainable harvest and sustainable populations. We know what salmon need but there is still a lot more that we don't know, so we also need continuing research, he added. A recent report highlighted the need for broad monitoring of the effects of hatchery supplementation on the fitness of wild populations. After a century of using hatcheries, there are still key uncertainties and we don't know if they can benefit the recovery of wild salmon. And we all need to be very worried about the ocean, Walton continued. If this is not addressed, all the efforts to address freshwater habitat will be moot.

The message to places that want to maintain strong runs is: "Don't ruin your rivers," he said. The salmon strongholds concept is also interesting, given the amount of effort going to the weakest stocks. This will be a losing cause if we don't also support the strongest ones. Harvest can also be a limiting factor for recovery. Mark-selective fisheries can address that but hatchery and harvest reform will be crucial to the survival of wild salmon. To protect wild salmon, he concluded, it is necessary to consider viability at the small population level, using our sophistication in the natural sciences and creating incentives to change our behavior.

Panel discussion

Mark Trenholm, moderator, Wild Salmon Center

Q: How do you define wild salmon and what type of chum do you have – hatchery or original wild chum?

- Bowles: We have definitions in law. Wild salmon live their full life cycle unaided; hatchery fish live part of their lives in captivity. It's about trying to preserve, protect and accentuate local adaptation. Some wild fish are the legacy of all natural parents while others have former hatchery fish among their ancestors.
- Nagata: The Chum Hokkaido Fishery Cooperative is trying to get the necessary data to secure full MSC certification. The MSC defines wild salmon as those that live their life cycle without human intervention. This includes second-generation hatchery fish that spawn naturally. Most important is that the stock has to be the same origin. In 2008, a paper by Beecham et al. reported on native stocks surveyed in Hokkaido.
- Riddell: The Canadian definition includes successful second-generation fish living in the natural environment.

Q: What kind of net pens are used for aquaculture and do you have problems with sea lice?

- Nagata: Hatchery juveniles are reared in concrete pens and released into the river. There are also hatcheries in the port area with net pens where fry are reared to a certain size and released when ocean conditions are favorable.

Q: What would trigger a concern under Alaska's policy?

- White: There are three different kinds of concerns. A yield concern, for example, is a chronic inability to maintain harvest above escapement goals (e.g. Yukon kings)

Q: These developments are impressive. Sometimes communities make important steps that represent huge fundamental changes. We want to recognize what a huge step Japan has made and to stand behind and respect your vision and courage in doing that.

Q: Monitoring and assessment are important, but are often the first programs to be cut. It's important to convey to policymakers how little information they will have in 10 years if programs are cut today.

- Walton: It's incumbent on us to describe cost-effective ways to monitor. We have the luxury of competing funders but there are opportunities to avoid duplication
- Trenholm: Education is so important in shaping community values and is often the first thing to be cut.

Q: Are there examples of innovative efforts that we could duplicate here?

- Riddell: The clear message is about the need to keep populations above minimal levels. Very low populations don't recover rapidly, so you need to keep them at healthy levels. You must also maintain diversity and that includes having the widest diversity of habitat possible. Reliance on technology gives highly variable success rates because of environmental factors
- White: There was an example where passage was re-opened after a dam had blocked access for 100 years. There were delays in restoration work and the fish ended up colonizing the new habitat on their own. This highlights the natural colonizing ability of salmon. They seize opportunities if habitat is intact.
- Walton: In one Oregon watershed, old practices in mining, ranching and road building are being cleaned up as conservation groups work with ranchers, farmers, etc. to find ways to sustain local economies without ruining salmon populations. It's a good example of traditional enemies working together.
- Nagata: Fishermen and farmers tended to have conflicts in the past over issues like water use and pollution, but farmers are now trying to clean up riparian areas, planting trees and helping to construct fishways to enhance production.
- White: The AYK research program will hopefully contribute to developing tools that allow in-season management practices to be objectively evaluated in terms of risk.

Q: Given the broad policy consensus on conservation of native fish in the U.S. and Canada, why have government institutions failed to provide mechanisms that express this scientific consensus?

- Walton: The challenge is that when governments try to apply this consensus, they step on the toes of very strong interest groups.

Q: There seems to be an underling assumption that the future will be like the past and that we will be able to address problems by managing harvest and habitat. How will we address freshwater and ocean temperature increases?

- Riddell: This is what drove Canada's Wild Salmon Policy: recognition of the need to maintain and restore as much as we can in order to distribute risk among all the populations. We know there will be challenges in some areas, so we may have to adjust fisheries to avoid reaching the lower benchmarks. There is also the habitat aspect and a shift to regional management to address risks. It's not legislation, but it could get to that. The big question we haven't been able to address is what to do multi-nationally in the open ocean, but we are now working on a collaborative ocean research program to identify issues.
- Williams: We need to get the message out that people must fundamentally change how they live, not just to save salmon but to save ourselves.

Q: It's encouraging to hear the high standards being put forward and about the listing of Yukon kings. In the Yukon headwaters, this is a huge concern. We rely a lot on Alaskan management to get our fish back to the Yukon. We've been taking measures but the fish are still declining a lot. It was stated that part of the policy is to address the full life cycle, but there is no Canadian participation in that initiative. What opportunities exist for such participation and for cross-boundary collaboration in general?

- White: The process has been open since 2001 to whoever responds to requests for proposals. There have been Canadian research projects, though most are Alaskan.

Q: It is laudable to finally see a focus on conservation at the local population level, but the concern is that there is still too much focus on the big picture and the big producing systems and insufficient support to protect smaller systems.

- Walton: Agreed. It's hard to get money for habitat protection and restoration without a large constituency. In trying to address ocean harvest, it's very hard to sell when a small population threatens to shut large fisheries.
- Williams: It's very important to involve local communities and to protect small local systems.

Q: When you have an early-timed run that is almost completed dominated by hatchery fish, is that a compatible paradigm for management of wild salmonids, given the changes we can anticipate?

- Quinn: It's hard to distinguish how much of the effect is related to hatcheries vs. climate change. It's not clear that we explained the timing patterns for steelhead in the first place, so it's not clear how it will play out in a changing environment.

Q: What's the greatest challenge to implementation?

- White: The word "should" in the Alaskan context has provided enough wiggle room to dilute a very constructive conservation piece.
- Riddell: Implementing the change in regional decision-making changes existing power structures, which is a challenge, so we are investigating prototype areas.
- Bowles: A lack of chutzpah/fortitude. Policymakers are very adept at exploiting grey and hiding behind uncertainty to maintain the status quo.

Q: What is the theoretical genetic basis for considering a fish to be wild if it descended from hatchery parents one generation ago?

- Riddell: If a population is dominated by hatchery fish, it would not be included in determining the status of a conservation unit, but the WSP does not address the issue of hatchery strays as long as they are second generation. No question it's a very grey area. Canada has committed to monitoring natural productivity, so if they are not tracking with wild fish, they would be treated differently.
- Nagata: Japan is trying to get MSC certification. These grey-area fish pose a challenge. They are defined as wild if they are second generation but we need to keep monitoring scientifically to see how similar or different they are from hatchery or pure wild fish.
- Walton: In some cases, U.S. goals for restoration and recovery talk about a combination of hatchery and wild fish.

Morning plenary concluding comments

Jack Williams, Trout Unlimited

Williams summed up key themes, including complexity and uncertainty in how to manage fisheries. Clearly, we have to integrate the three Hs – habitat, harvest and hatcheries – and to evaluate the impacts of management on all life history stages. We need to work across spatial and temporal scales, and the protected areas concept is very important. The importance of monitoring and effectively evaluating were

also stressed. A lot of funding is allocated to salmon, relatively speaking, so it is necessary to be very efficient and effective. If there was one simple lesson from this session, he added, it was that the highest priority is to protect wild salmon and their habitat. In the long haul, we need a shared vision, good science and management. The more partners and common ground, the more we can achieve. The importance of the general public was also stressed, particularly in a future that may not be all that kind to either salmon or people.

Afternoon plenary:

Innovative approaches to applying conservation principles: I

Nate Mantua & Rich Lincoln, plenary co-chairs

What are the benefits of population diversity to fisheries and conservation?

Daniel Schindler, University of Washington

There are many reasons to be optimistic about salmon, Schindler began. Salmon are very opportunistic and successful at colonizing and flourishing in a wide variety of conditions. Adaptations to local conditions create diversity within salmon populations. Biocomplexity describes the biodiversity seen within salmon stocks. Equally important is the connection to habitat diversity that is responsible for salmon biodiversity (Figure 23).

An important theme in salmon management and conservation relates to the future and climate change. Climate doesn't affect salmon directly. It's filtered through the heterogeneous and dynamic salmon landscape – that's what salmon feel.

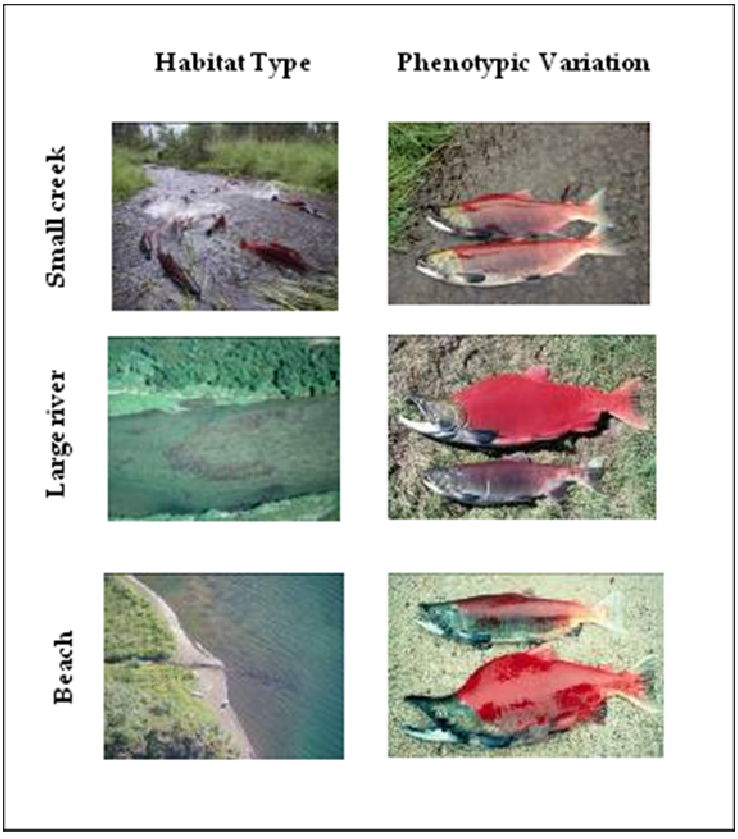


Figure 23. Biocomplexity in habitat type and sockeye phenotype

Analysis of Bristol Bay sockeye catches in the gillnet fishery at river mouths reflected high, sustained returns, although contributions of different populations changed over time. The overall variability of the aggregate was however about one-third less than the variability of individual populations, Schindler said. Does this buffering or "portfolio effect" reflect multiple strategies outperforming a single strategy? It depends, as the strength of this effect is determined by the amount of co-variation between elements of the

portfolio.

A study of Snake River chinook showed that as the number of dams and hatchery production increased over the last 40 years, stock components became increasingly similar over time. While adding more stocks enhanced buffering in earlier years, the same does not hold true with more recent data. So it's not just biodiversity that matters, he said, but the response diversity within the population.

The "portfolio effect" doesn't just benefit salmon. Variation in the arrival timing of sockeye stocks to Bristol Bay helps to stretch out the fishing season. It also benefits predators that can move around the landscape, like grizzlies.

There is much documented diversity in salmon stocks; there is also much cryptic diversity that we don't understand but that is nevertheless probably important. Analysis of spawning times for Wood River sockeye shows differences in spawning timing between those that spawn in streams, rivers and lakes (Figure 24). Recent work by Sue Johnson linked habitat size to feeding at different trophic levels, indicating that geomorphic variation in freshwater produces variation in trophic strategies in the ocean. Such small differences may be important to population dynamics, even though we don't understand them.

Nitrogen isotope signatures derived from lake sediments were traced over time to recreate pre-historical abundance estimates for comparison to current levels with commercial fishing. The results suggest salmon respond to climate regimes over the longer term.

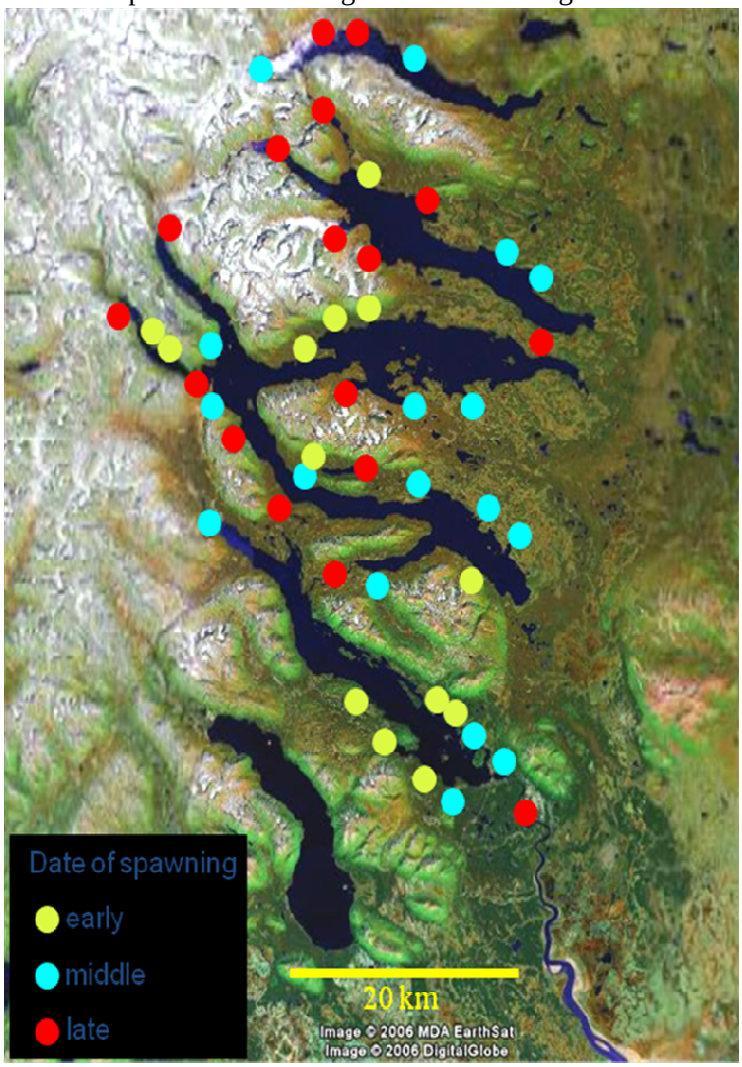
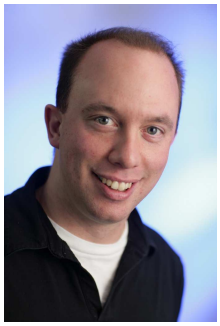


Figure 24. Varying spawning timing for Wood River sockeye, Alaska, US

New approaches for sustainable Pacific salmon fisheries in Canada

Jeffrey Young, David Suzuki Foundation



The David Suzuki Foundation has participated in policy and planning bodies including development of the Wild Salmon Policy, the Salmon Integrated Harvest Planning Committee (IHPC) and recently in the Fraser Panel of the Pacific Salmon Commission (PSC) process, Young said. Key roles include reviewing fisheries management performance, and looking at access and the role of market design as incentive.

Many salmon populations have seen substantial declines across western Canada. Four populations have been identified as threatened or endangered, but were not listed under Canada's Species at Risk Act (SARA) due to economic considerations. The IUCN has placed 12 sub-populations of sockeye on its Red List of threatened species, he added. Threats include overfishing, habitat loss, production-scale enhancement and changing ocean conditions.

Canada's commercial salmon fishery mostly consists of competitive mixed stock or lower river fisheries, based on pre-season forecasting of annual abundance and joint management with the U.S. under the Pacific Salmon Treaty (PST). Exploitation rates are down since the 1990s and the new IHPC process reflects efforts to develop co-management.

Fraser River sockeye are subject to commercial, First Nations and recreational fisheries. Joint management under the PST is based on four run-timing stock aggregates, with total mortality rate and escapement objectives for each. Some 44 Fraser sockeye CUs have been established but benchmarks have not yet been set and stocks are not yet being actively managed at the CU level. There have been issues with en route mortality and one stock is endangered, though others are also struggling.

A 2006 paper showed mortality objectives for the four stock groups were rarely achieved; more often than not, mortality was higher than the targets. A key challenge is poor forecasting performance, with returns most often over-estimated (Figure 25). In-season information is used, but some fisheries do occur based on the forecasts, which create strong pressure to fish. The Fraser Panel is also dominated by harvest interests. Climate impacts are increasing the level of uncertainty and productivity is declining. Forecast models rely heavily on weak stock-recruit relationships, Young added. A key issue is the assumption of the future being like the past, but variability can overwhelm the utility of such approaches to effectively manage fisheries.

Overall mortality rates are high. En route mortality and other sources of non-fishing mortality have been key drivers, but management is not explicitly evaluating whether fishing mortality is sustainable in this context. Early analysis of the run timing of component stocks within the management aggregates shows that the timing of these individual stocks is not consistent and that there is considerable timing overlap between stocks in the four groups. This means that some component stocks can be hit with harvest rates that are higher than planned. Other Canadian fisheries face similar issues, though there is less information than that in the Fraser River.

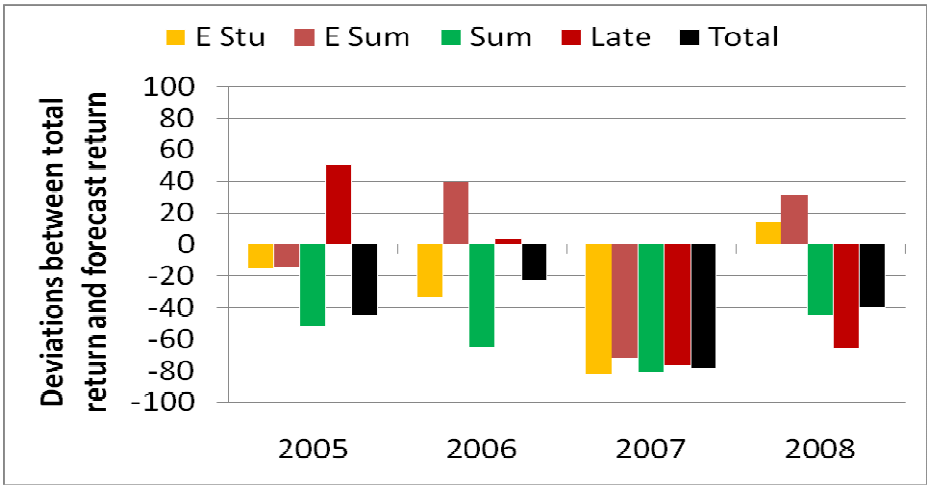


Figure 25. Fraser River sockeye salmon deviation from forecast

Improvement will require clearly defining and communicating management objectives to explicitly state uncertainty, he added. It is also necessary to manage for inherent and increasing uncertainty, which is overwhelming the current management approach. Better integration of science and management is needed, along with integrated stakeholder processes that take responsibility and explicitly express objectives and trade-offs. Incentives and changes in the fisheries regulatory structure are also needed to support objectives such as those expressed in the Wild Salmon Policy. Funding is an issue, in terms of achieving monitoring requirements, along with political support.

The 2008 Skeena independent science review provided a process for evaluating trade-offs more explicitly and understanding how uncertainty affects outcomes (Figure 26). There are opportunities for change, Young concluded. We have reached a crisis point for many salmon stocks and restructuring of salmon fisheries provides a key opportunity to build effective structures to support more sustainable fisheries, including incentives, demonstration quota fisheries and shifting of access to more selective fisheries.

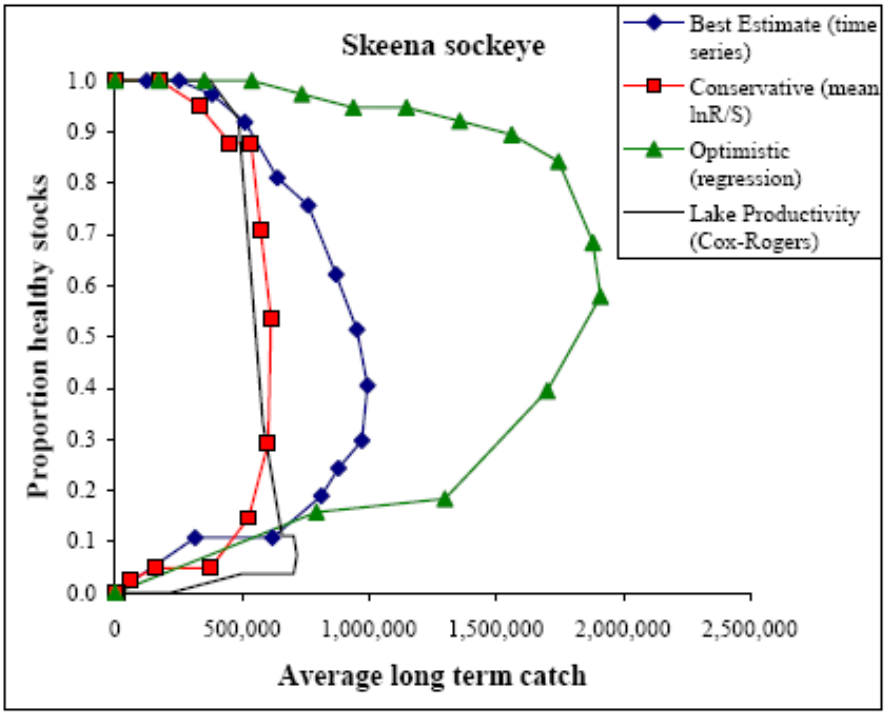
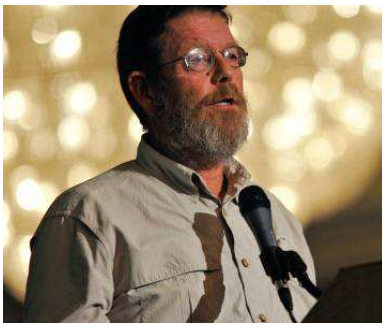


Figure 26. Understanding how uncertainty affects outcomes (Walters, C.J., J.A. Lichatowich, R.M. Peterman, and J.D. Reynolds, 2008. Report of the Skeena Independent Science Review Panel)

What's going wrong with BC salmon stocks

Carl Walters, University of British Columbia



Central BC provides a dividing line between stocks to the north that are quite healthy and severe declines for some stocks in southern BC, where biodiversity is threatened by factors other than fishing.

In the north, there is very strong co-variation in abundance among stocks and biodiversity is improving. The challenge is finding a reasonable balance between harvest and diversity. A key tradeoff is between maximizing catch and preserving biodiversity. Managing for maximum sustained yield (MSY) would likely cause extinction of 10 to 20 percent of smaller stocks. This requires a social and risk management decision and better ways to deal with that challenge.

Chinook and coho stocks to the south have seen sad declines due to reduced marine survival rates. There has not been major habitat loss over the period of decline. Nor has the decline been reversed by closing fisheries, so overfishing was not the problem. Marine survival data from coded wire tags (CWTs) reflect a massive decline in marine survival that started in the 1980s and continues for both hatchery and wild stocks. Similar declines are also being observed in some stocks for the other species.

BC started hatchery production of coho in the 1970s with the goal of doubling coho stocks. But this did not result in increased abundance and in recent years there has been a catastrophic decline. Coho demonstrate very strong compensatory responses but numbers are now low enough that wild stocks are suffering as well, Walters noted. Chinook in southern BC have shown the same pattern, though the decline started earlier. Commercial fisheries on Harrison chinook stopped in the 1980s and there has been no sport fishery since the 1990s, but numbers continue to decline.

We're engaging in a catastrophic misdirection of resources by focusing on habitat that doesn't need restoration and chasing trivial local problems like salmon farming, while ignoring huge problems like public hatcheries, Walters said.

We don't know what's causing the declines. We don't know where and when the high mortality is happening and the costs of addressing it are prohibitive, he continued. Acoustic tagging in Howe Sound to determine where out-migrating fish were dying showed there was some concentration of mortality at the river mouth, which is thought to be due to harbor seals. Other than that, the mortalities are spread out. Similar tracking in the Strait of Georgia showed the fish were not leaving for the open ocean. They were dying somewhere in Georgia Strait (Figure 27), but it's not clear where or why. Several strong ocean survival hypotheses have been proposed, including a progressive increase in disease transmission from public hatcheries, a warming ocean that is less favorable for species that stay close to the coast or predation from other fish (of which, there are no known major increases) or marine mammals. There has been huge growth in harbor seal populations coincident with the period of marine survival decline. Seals consume an estimated 60,000 metric tons annually, double the amount taken by fisheries. If just 3 – 4% of the seal diet is juvenile coho, that's enough to explain the survival decline. Ecosystem models estimate large seal impacts on several fish species, but they also warn that seal culling could backfire by supporting increases in salmon competitors and predators, like hake.

Challenges include vested interests in continuing to spend money on the wrong things, prohibitive costs of ocean research and social acceptability of marine mammal culling. So about all we can do at this point is to hope that the problem will solve itself, Walters concluded

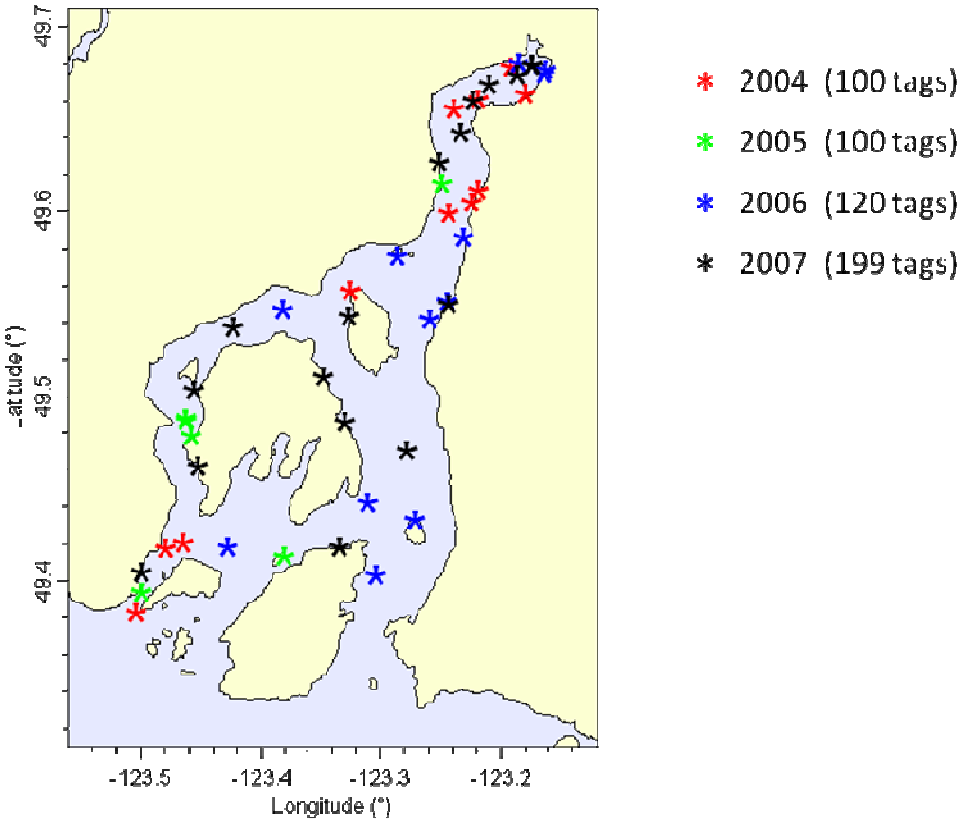


Figure 27. Locations where coho smolt tags stopped moving (most likely due to death)

Discussion

Q: I don't agree that it's too expensive to study what's going on in the marine environment. We currently measure fishing impacts and estimate natural mortality, but we have to look at natural mortality as an over-riding concern. If we devote some time to working with oceanographers and the electronics industry, we can bring the costs of this research down.

- Walters: We've spent over $300 million on habitat restoration and enhancement. Spending one-tenth of that on oceans research could have addressed this problem.

Q: Thompson River fall chinook that go to sea in late August are doing very well. How does that fit with a predation theory? If marine conditions are improving, we can learn something from that.

- Walters: It's the chinook stocks that spend a long time in Georgia Strait that aren't recovering, not the ones that move north very quickly.

Q: I agree it is critical and will get worse. We're seeing high mortality in our Georgia Strait juvenile surveys from mid-May to mid-July. There are very good data showing an increase in early marine mortality. I'm now focusing on disease. I think we may be seeing reduced growth rates that are making coho more susceptible to disease. Marine survival has dropped to 0.5% from 15% and this may be related in some way to warming in Georgia Strait, which is now 2º C warmer. In comparison, Puget Sound is a little cooler and survival there is a bit better. But if this is a reasonable expectation with climate change, we can project that we're on a trajectory that is pretty serious for chinook and coho.

Q: Harrison is an ocean-type chinook, but I want to talk about ecosystem-based management, factors relating to coho and chinook survival in Georgia Strait and the potential role of marine mammals. Whether this is the case or not, what can we do about it? We're biologists – we don't dictate policy. The future vision for Georgia Strait goes way beyond science to questions about whether we want to protect

marine mammals, have lots of golfing opportunities or do commercial and recreational fishing. What bothers me is the lack of a societal vision about what we want to see in Georgia Strait and other places, and about how to incorporate all the non-scientific aspects.

- Walters: We all want more of everything. We need a scientific vision and an adaptive program to address what we think is causing the problems. The only way to find out for sure is to link science and management in a large-scale experiment, for example with hatcheries and then maybe also with seals.

Q: Many people care more about the existence of salmon than about catching salmon. We're still seeing past patterns of management. But if the public is concerned more about biodiversity and management is more concerned about the fishery, how do you get to the tradeoff position?

- Young: I see the Wild Salmon Policy as a commitment to protecting diversity. I think we need to make explicit tradeoffs. We're making tradeoffs all the time, but it's important to do it more carefully and more openly.
- Walters: We can say that we will lose 10 – 20% of stocks at MSY, but that we can reduce that risk to near zero by backing off on fisheries. The hard question is whether the rights of people who want to see salmon spawn trump those of people who fish for a living

Q: Thompson chinook, the largest chinook population in the Fraser, has exploded since 1995 and it is a far-north migrating stock. I have to question some of the results of POST tracking of coho. There are a number of controlling factors and I'm not convinced, given the explosion of Thompson chinook.

Q: I'm concerned by the comments regarding hatcheries and habitat enhancement. Without such efforts, there wouldn't be any salmon returning to the upper Sunshine Coast. There's nothing more gratifying than seeing salmon return to a spawning channel that you built. Instead of shutting down hatcheries, which would mean losing some of the runs, why not make the tough policy decision of doing a seal cull?

- Walters: The risk with a seal cull is that they may be eating small or diseased fish. The Salmon Enhancement Program was supposed to be helping streams on the edge, not promoting concrete production monsters like Capilano that may be "Typhoid Marys."

Q: The Amur is a big watershed – bigger than the Columbia. Historically, we had the biggest populations of fall and summer chum. The numbers of those stocks started declining and by around 2005, they had declined to a level where everyone understood the stock would not survive. Biologists said we had been overfishing chum at the mouth of the estuary and that the Russian people were responsible. The Russians in turn blamed the Chinese for overfishing. The problem was actually to do with the climate. Starting in 2006, autumn chum started to enter the Amur River again in growing numbers. Biologists said 24 million entered the river. Suddenly, all the fisheries people said this was the result of their hard work. Everyone believed them, though I don't think there was any basis. No one believed the climate had changed. People believed that suddenly the hatcheries worked very well, after 100 years. We also have a lot of seals in Russia. A professor wrote in the 1980s that seals were eating as much as the fisheries. But it was no problem; the salmon were still going up. How do we monitor and manage? I think we got those numbers because we were not allowing people to hunt seals. We have some tribal people who were forbidden to hunt seals. So maybe you should permit native people to hunt seals. Maybe we are trying to forbid too many things.

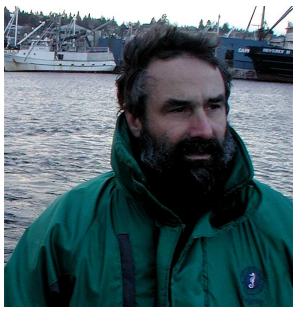
Q: I challenge the suggestion that habitat loss has not been significant. Cumulative habitat loss in the Lower Mainland has been substantial. There is also no evidence of disease transfer from hatcheries.

- Walters: No, we don't have evidence of disease and yes, we can go ahead and save the habitat. But this has been exactly the problem.

Panel: Challenges & opportunities surrounding hatcheries

Growth & survival of salmon at sea in response to competition & climate change

Greg Ruggerone, Natural Resources Consultants, Inc



Salmon occupy a vast region of the North Pacific and the Bering Sea, so it's hard to say if there is competition out on the high seas, Ruggerone said. Hatcheries were built on the premise that food in the ocean was unlimited and that there was no competition between wild and hatchery fish. Some studies have indicated that competition can affect growth, but few have looked at whether this impacts survival and abundance. High abundance implies high survival and it is difficult to tease apart the effects of competition at sea.

Total Asian and North American hatchery releases have skyrocketed since the 1970s and now total some five billion annually, mostly chum and pink. As hatchery chum releases increased after the 1970s regime shift, wild chum abundance did not change while abundance for other salmon species increased.

Some studies have suggested that competition is not likely important. However, others point to density-dependent growth and other factors that suggest it could be important. Ruggerone and his colleagues undertook a series of studies looking at possible competition between Bristol Bay sockeye and Asian pinks, and whether this affected growth, survival and abundance.

Abundance of Eastern Kamchatka pinks has grown over the past 50 years to a recent peak of 100 million on the odd-year run, which is strongly dominant. Tagging data show that Bristol Bay sockeye overlap extensively with Eastern Kamchatka pinks during their second and third years at sea, he noted. Further studies showed considerable diet overlap between sockeye and pinks in the Bering Sea. These studies also showed that both sockeye and pinks have significantly less food in odd years compared to even years, with a decline in stomach contents of 36% and 24% respectively in odd years. Scale analysis provided a historical record of growth, revealing that Bristol Bay sockeye growth was reduced during odd years at sea compared to even years. The difference was greater during recent years with increased abundance of Eastern Kamchatka pinks.

Analysis of smolt-to-adult survival for three stocks found a reduction of about 45 percent in survival for Age-1 smolts that compete with pinks in their second year at sea, he said. Age-2 sockeye smolts also experienced reduced survival. Abundance data covering the period from 1977-1997 for five Bristol Bay sockeye stocks showed a consistent pattern of reduced abundance for sockeye that spent their second year at sea during odd years (i.e. strong pink years). The difference amounted to an estimated 91 million fewer sockeye (Figure 28).

Other studies have focused on what mechanisms were responsible for the increase in Alaskan sockeye abundance after the 1977 regime shift, Ruggerone noted. Mantua and Beamish suggest this is related to greater growth at sea, but the lack of long-term data on prey abundance poses a challenge in testing this. Other studies suggest adult size for all species has been getting smaller over time, which would seem to contradict the growth hypothesis.

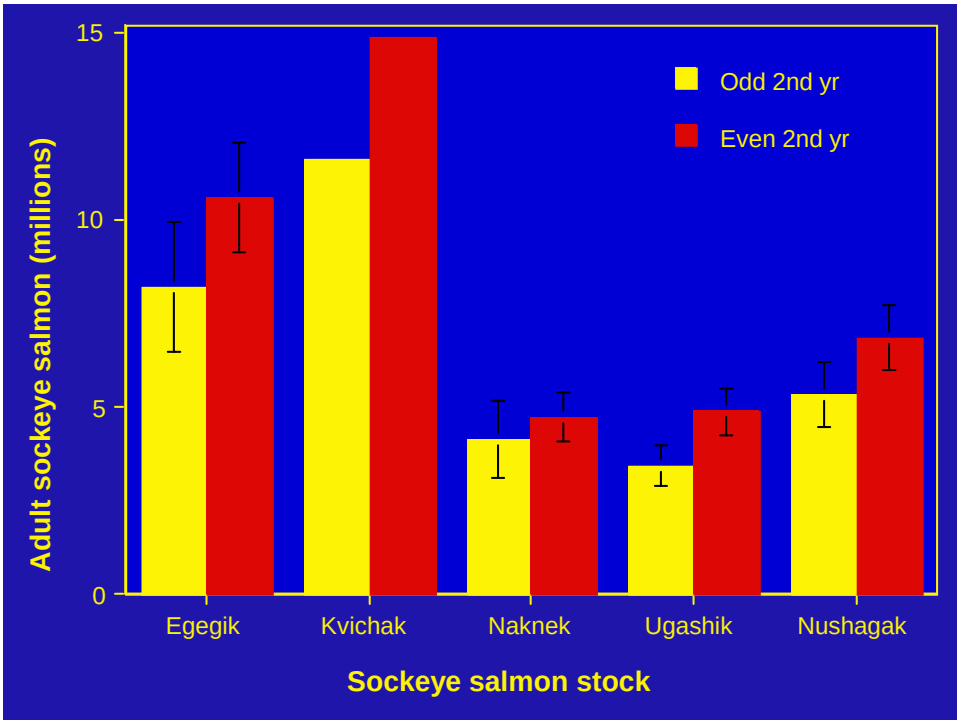


Figure 28. Reduced abundance of sockeye salmon spending their second year at sea during an odd (strong pink) year

To test the hypothesis that the 1977 regime shift led to greater growth at sea and greater survival and abundance, Ruggerone analyzed growth patterns for scales collected from Bristol Bay and Chignik stocks between 1955 and 2001. Growth in Year 1 and 2 was consistently low before the regime shift and then consistently high afterward. However, growth in Year 3 and migration showed the opposite pattern. A statistical model was developed to look at the relationship between Alaska sockeye run size vs. growth at sea. It found a positive relationship between run size and growth at sea in the first two years and a negative relationship between run size and growth in the last two years. This suggests a density-dependent effect in later life, he noted.

Ruggerone also looked at adult size of Bristol Bay sockeye over time. Asian pink abundance explains a significant portion of the variability. When that is excluded, growth patterns clearly match climate regime shifts. Comparing sockeye length vs. abundance suggests a strong density-dependent effect on size. Likewise, when there are large numbers of Eastern Kamchatka pinks, Bristol Bay sockeye length at age is reduced.

Summing up, Ruggerone said these studies provide evidence that in these northern waters, climate and prey availability are important to salmon survival. There is increasing evidence that competition at sea can affect salmon growth and possibly survival. Prey patches and large prey (squid, fishes) may be key to salmon growth, though this has not been very well sampled.

Discussion

Q: We checked our data for 37 years but do not have access to Alaskan data. Your conclusions are somewhat different from ours. When we compare the state and productivity of Kamchatka salmon, in and around Kamchatka, we have a positive correlation with increase in length for all species except chum, which exhibit a downward trend. When I talk about Kamchatka, I talk about a positive trend. Since 2000, in recent years, we are seeing record weights for pink salmon. But we are seeing changes for age structure in other types of salmon. So if we can share data from the Bering Sea it would be useful.

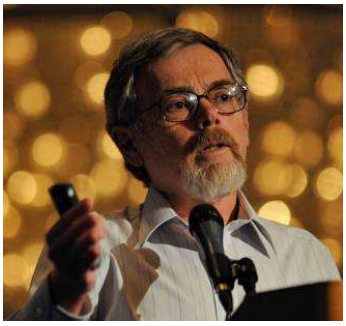
- Ruggerone: Ocean productivity varies quite a bit in different parts of the Bering Sea. Climate has had major effects on growth and survival. This evidence indicates some competition within and between salmon species. We would like to work cooperatively with Russian scientists to look at some of these growth patterns.

Q: We are seeing declines in stream-type chinook in BC, and similar collapses in Fraser sockeye and other populations that are resident off the continental shelf for a large part of their life. Is there a chance the large ramping up of hatchery chum and pink on the other side of the Pacific could be affecting them?

- Ruggerone: Kate Myers has a lengthy report on high-seas distribution of salmon based on tagging data. It's safe to say that BC chinook migrate to the North Pacific and even to the Bering Sea, so there should be interaction between them and Asian fish. The question of whether there is an impact is a good one and it's one we should address. Hatchery production is fairly steady. We were able to look at impacts of Kamchatka pinks on Bristol Bay sockeye because of the odd-even year discrepancy. Manipulation of hatchery production to produce similar contrast has been proposed, but it's a very costly experiment.

Proportionate Natural Influence (PNI): a genetic risk management tool for salmon & steelhead hatcheries

Craig Busack, Washington Dept of Fish & Wildlife



Washington has a long history of hatchery production going back over 100 years. Today, at least a dozen stocks are listed and hatcheries have been identified as a factor in the declines, Busack noted. This prompted a large-scale analysis of hatcheries in Washington and has caused a huge change in thinking regarding management of hatcheries.

Hatchery rearing environments are very different from the natural environment and thus can be expected to result in different selection regimes. Cultured populations become more adapted to the hatchery environment than to the natural environment. Interbreeding between cultured and naturally-produced fish may then weaken the fitness of natural populations in the wild environment. People used to argue about whether domestication was real, he said, but now the argument is about how serious it is. Addressing domestication is a major part of hatchery reform. Solutions include reducing selection pressures, reducing time spent in hatcheries (though this may increase competition with wild fish) and reducing interbreeding between wild and hatchery fish.

Recommendations for managing gene flow include segregated programs with minimal gene flow between wild and hatchery fish, which are desirable but very difficult to achieve (Figure 29, left). Another option is to manage gene flow to limit domestication through integrated programs (Figure 29, right). Gene flow between hatchery and wild fish can go both ways, Busack explained, with the extent of the flow dependent on the proportion of natural spawners in hatchery brood stock and the proportion of hatchery fish on natural spawning grounds.

An integrated program lives in both environments, so the mean for any trait should stabilize at some point between the natural and hatchery optima, he noted. This equilibrium point equates to the relative balance between hatchery to natural gene flow vs. natural to hatchery gene flow. This ratio (called the proportionate natural influence or PNI) is determined by comparing the proportion of natural-origin fish in hatchery brood stock against the proportion of hatchery fish in natural spawning populations. The intent of using this model is to increase the PNI ratio so that natural selective forces dominate.

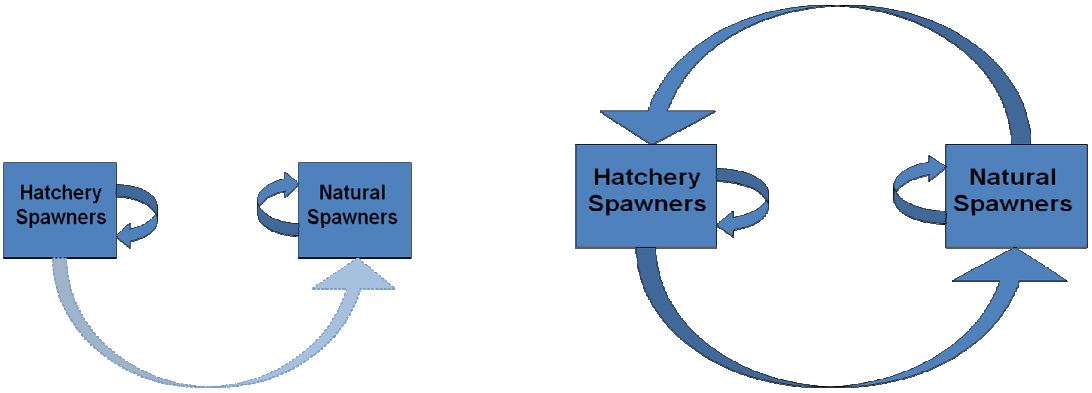


Figure 29. Graphic representation of segregated (left) and integrated (right) hatchery management programs

Major considerations include the need to be able to identify fish by origin (marking) while they are still alive and to be able to control gene flow rates (e.g. selective fisheries to control the ratio of hatchery fish on spawning grounds). Appropriate PNI ratios cannot be attained if hatchery production is too large relative to the natural population, which forces production shifts to a scale consistent with basin productivity, he noted. This concept has provided a unifying element for managing hatcheries, regardless of the program purpose, and unified the three Hs – hatchery, habitat and harvest – in an unprecedented manner.

Caveats include the need to understand that PNI is a tool to limit domestication, not to eliminate it, Busack concluded. It's not a direct fitness measure or a total theory (it addresses just one aspect of domestication). Domestication is also only one type of genetic risk, and genetic risk is not the only concern with hatcheries, which may also pose ecological risks relating to competition, predation or disease.

Discussion

Q: If the hatchery population is isolated, it reaches maximum fitness for that hatchery environment; the wild population, if isolated, reaches maximum fitness for the wild environment. So when gene flow occurs between populations, these mixed fish will have lower fitness for both environments. Why then is it better to maintain a mixture instead of having isolated populations? From a genetic viewpoint, it's better to isolate.

- Busack: A segregated program would be preferable, but it is very difficult to do that in reality. You may also want hatchery production to help restore a stock because the alternative is extinction, but you want to avoid depressing the fitness of the natural population. The intent is to try to move to less hatchery interference as management is improved.

Q: When might you get an idea regarding PNI as a potential predictor of fitness?

- Busack: It would take a couple generations at least. In the Columbia Basin, we can calculate PNI and do reproductive success tests and correlate these, but it would take a few generations before you can do this.

Q: How is it disturbing the genome of a population if you are bringing fish to a hatchery?

- Busack: The model guides ideas about how that occurs. That gene flow occurs is now fact. You haven't allowed the parents to choose their own mates and you're raising them at high density in crowded conditions in a uniform environment. They are not identical to wild fish, phenotypically and genetically. The changes may be subtle but they increase over time.

Q: Are we creating mutations that are changing the basic genome of a particular river? I think gene flow is a good thing. I don't understand how the fish I put in the creek are domesticated.

- Busack: The changes are not fundamental but there are different selection pressures. They are subtle shifts and an accumulation of subtle shifts can result in profound changes over time. A study found fitness declined 37 percent for hatchery vs. natural steelhead over one generation.

Selective fisheries in Washington State

John Long, Washington Department of Fish & Wildlife

Washington State manages a variety of fisheries, including marine commercial fisheries, marine, shore-based and freshwater recreational fisheries, and fisheries that are co-managed with tribal counterparts. Management covers five species of salmon, as well as steelhead, Long noted. Marine distribution and run-timing overlaps result in situations where more selective harvest is needed.

Fisheries are managed for the conservation of wild salmon but are dependent on large hatchery programs for chinook and coho, with hatchery fish dominating most harvests. To address the challenge of harvesting abundant hatchery fish while meeting conservation objectives, mass marking has been used to identify most hatchery releases (Figure 30, left). Reasons to fish selectively include ethical responsibility, ESA requirements and social and economic benefits. The goal is to maximize harvests of healthy wild and hatchery stocks while minimizing impacts on non-target species and stocks. Selective fishing approaches include time and area restrictions. These include focusing harvest at the mouth of the river near hatcheries, timing harvest to avoid certain runs or opening and closing specific catch areas as necessary. Another way to promote selectivity is through regulating or modifying gear for commercial and recreational fisheries or using traditional methods like fish wheels. Long reviewed specific examples, such as modifications to purse seines and reef nets and regulating mesh size for gillnets or tangle nets. Soak times can also be specified to limit the time fish are entangled. For recreational angling, gear requirements include barbless hooks and knotless nets. There are also retention restrictions, including size/length restrictions and mark-selective fisheries to avoid harvest of wild fish. Other measures include fish handling rules for recreational anglers and the use of recovery boxes (Figure 30, right) in commercial fisheries.

Figure 30. Marking of hatchery fish by removing the adipose fin (left) and an example of a fish recover box (right)

Buy-in from stakeholders is important in implementing selective fishing measures, Long concluded. Effective educational programs are needed, in addition to very visible enforcement.

Open Discussion

Q: Is there a timely way to know prey abundance to help time hatchery releases to take advantage of favorable conditions?

- Ruggerone: In Prince William Sound, prey abundance is sampled to determine hatchery release timing.

Q: If domestication reduces fitness and that leads to reduced survival, what about those that survive? Can you relate fitness to resilience? Does a mixed fish have more resilience?

- Busack: If you were using a hatchery to rescue a crashing population, resiliency would come from cross breeding two wild fish vs. running them through a hatchery program.

Q: The Pacific Salmon Foundation supports people who do enhancement and we try to keep abreast of hatchery practices. Are DFO's practice guidelines contributing to sound management?

- Busack: We haven't reviewed those guidelines. If they are not using hatchery fish as brood stock, that is better. There are places where hatcheries provide an important tool for conservation; but there is a genetic cost, so the issue is how to minimize it.

Q: We need a clear message about the role of conservation vs. production hatcheries in Canada.

Q: There has been much talk about wild salmon policies and hatchery policies, including laudable changes happening in Japan. We also heard there are now five billion hatchery releases annually around the North Pacific. There are also maybe 25 billion wild juveniles going out. About 75% to 80% are pink and chum from Alaska, Russia and Japan. How do we best integrate wild and hatchery salmon policies to have a successful wild salmon program?

- Ruggerone: That's the ultimate question, in terms of competition in both the ocean and freshwater environments. In times of low prey production in the marine environment, should you reduce hatchery production? We need to do more work on these questions.
- Busack: We also need to know a lot more about disease and interactions, so that too needs more study.

Q: Regarding the precision of PNI estimates, how do you collect data for the proportion of hatchery fish in natural spawning populations where there is no weir?

- Busack: It's all based on models. Hatchery fish don't tend to spawn in the best habitats, so you need to make some adjustments for that and we haven't done that modeling yet. This approach allows you to estimate where you are now and to put current projects in perspective. We looked at projects where runs were low and found very low PNI, no matter what the precision levels.

Q: Prior to the mark-selective fishery in Puget Sound, there was no recreational opportunity, so it has met some goals. The fishery is also achieving target mortality on wild stocks.

- Long: The mark-selective fishery has existed for five years and we've had very good success. It has replaced non-selective fisheries, so you end up saving more wild fish by default. But we also have detailed reports from excellent sampling programs for commercial and especially recreational fisheries for estimating total mortality.

Q: Are you meeting mortality targets?

- Long: At the beginning we were using a quota and we started off tracking in season what our impacts were. We're pretty comfortable that we met objectives in all pilot fisheries.

Q: I applaud the work on hatchery reform. The central conclusions of the hatchery reform program were really about broader salmon management reform. The first decision to be made about a hatchery was whether you needed one; then other choices had to be made to minimize hatchery influences. The scientific review group released its final report in 2005 – their Web site includes the report and all the recommendations. What they did was fundamentally interesting. They pulled together people to determine what was in a watershed, then set goals for the stocks and looked at what the habitat could support. Then, based on all that, they looked at whether it was the right hatchery program for the goals. All the information is at www.hatcheryreform.org.

Q: Would the goals for PNI result in recommending a reduction in hatchery releases?

- Busack: In some cases, people were just releasing a certain number of fish because that's what they always did; no one was sure who was fishing them.

Q: What do we have against fish released from hatcheries? They may be more impoverished in genetic variation and that perhaps can cause mortality if there is climate change. We also think they are more spoiled and mollycoddled as juveniles, though not as adults. When the fish returns to the spawning grounds, it has proved that its genetics are viable. It has earned the right to spawn and that should be equal to natural fish. It is only when we have changing conditions that we should have directed selection. Experts in genetic stock identification say the population maps are so stable that we can divide even small streams by genetic maps, although climate has changed dramatically. So before applying these practices – it is too early to apply them if everything is not clear from a practical standpoint.

- Busack: Regarding the stability of patterns of genetic markers, the microsatellites and SNPs used in genetic stock identification are parts of the genome which you don't expect to be indicators of selection. It would be interesting to compare transcriptomes, before and after. Secondly, the argument that fish that make it back deserve to spawn is a common one. But if these fish are going to be less effective than the native fish, then it is cause for concern in terms of long-term genetic degradation. No one is suggesting that it's a road to "Frankenfish." If you keep PNI high, the population can equilibrate at a level high enough to control impacts.

Q: I've tried to be very open minded to domestication arguments but I can't find any example of domestication. It didn't make sense that there was no problem in the first generation, but a big problem in the second. If there is this problem, why can't you see it anywhere? Each individual can tolerate a wide variety of conditions. I suggest the optimal environment is a very broad range, not a point or a line. What would you use to measure whether a fish is in its optimal environment? Survival should be a good indicator and hatchery fish survive very well in the hatchery environment. Maybe that's why we don't see domestication – because we've designed hatcheries to reflect the optimal environment for fish. I'm skeptical, but because of the solid theoretical basis, Canada is considering the use of PNI. I don't see domestication as a fact but accept it as a possibility that should be considered. The statement that hatchery diseases are affecting wild fish is irresponsible. We need to see if disease is a problem and if so what factors are involved, not to blame each other.

Day 2: Concluding comments

Pearl Keenan , Teslin Tlinglit Elder

Riddell introduced Keenan, a Teslin Tlinglit elder from the headwaters of the Yukon River who has spoken for the salmon of the Yukon River for many years, inspiring generations of youth to respect the land, the water, the salmon and the people who depend on them.

Keenan recalled the many changes she had seen in her lifetime, from the days long ago when she used to run a dog team and feed the dogs dried salmon, because it was so plentiful and easy to carry. The biggest worry has been to see how our land and fish and wildlife are being depleted, she said. So it's good to see all the foreign people here. If you all put all your efforts together, you can make a difference.

For the last 10 years, Keenan continued, we have seen our salmon going down and down. The Yukon is their home and they give their life to return to it. It's up to every one of us to save our species, especially our salmon. We also used to raise mink and they too lived off the fish. We were always careful about what we used, but trout, caribou, porcupine and rabbits are all going now too. The Lord gave all this to us; but it's up to us to look after it. I pray that each of you give it everything you have, she said. We have to be stricter than we've been. We need more restrictions at the mouth of the rivers, where these fish are easy prey. They were plentiful for the people at the mouth of the river, but it was a very poor year for us above in the headwaters, so maybe they should cut off fishing for a few days each week to let some of the fish go.

Keenan closed by thanking organizers for the opportunity and wishing participants success.

Day 3 Opening remarks

Rich Lincoln, State of the Salmon

Welcoming participants back, Lincoln reviewed key themes heard the previous day, starting with a review of conservation principles, the importance of linking habitat, hatcheries and harvest, the need to protect all the pieces in conserving wild populations and habitat and to manage for adaptability. Also discussed was the importance of creating incentives for adequate monitoring by creating consequences from not having enough information (e.g. reduced harvest opportunity).

Later speakers talked about the connection between population diversity and habitat complexity and how important this is from a portfolio perspective, in terms of sustainable populations and fisheries in the face of environmental change. Others spoke about the challenge of managing fisheries in the face of uncertainty, especially at the population level, and how fragmented systems may have different productivities. Other themes included the tradeoffs between biodiversity and harvest, implementation of Canada's wild salmon policy, impediments to growth and survival relating to competition at sea, and questions about large releases of hatchery fish in recent decades and their impact on wild fish at different spatial scales. There was also discussion of tools being used to make decisions about hatchery programs in an integrated approach and selective fishing approaches that have potential for wider application.

Morning plenary

Innovative approaches to applying conservation principles: II

Jeffrey Young & Pete Rand, Plenary co-chairs

Differentiation of chum salmon populations in the Russian Far East with DNA markers

Lev Zhivotovsky, Institute of General Genetics

A population is an elementary unit of a species that has importance in evolutionary studies, conservation biology, stock management, certification assessment and other studies, Zhivotovsky noted. Each population has its own distinct genetic profile, due to limited gene flow between populations, and various types of genetic markers offer differing abilities to distinguish between such populations. In order to use genetic markers for research and management, the first step is to develop a genetic database to determine what levels of differentiation exist across populations and for the entire species.

This presentation will discuss genetic analysis based on a collection of 89 samples assembled for chum salmon populations in the Russian Far East. Ten microsatellite genetic markers were used. Another type of genetic marker (allozymes) was also used for 29 samples from the Sakhalin-Kuril region. These markers reveal a high level of differentiation between populations. When there is large geographical separation and little mixing among populations, there is large genetic differentiation.

Comparison of populations from Sakhalin Island against those from the South Kuril Islands showed differentiation amounting to 6.23% with microsatellite markers and 2.73% for allozymes. This is a pretty large value, Zhivotovsky said. (In comparison, human populations, including isolated populations like pygmies, show total differentiation of about 15%.) Allozymes exhibit much lower differentiation than microsatellites, which have a higher rate of polymorphisms.

These studies also looked for local genetic differentiation within a region: Iturup Island has two hatcheries that are not widely separated. Samples were collected from both throughout the spawning runs in 2006. Allozyme markers do not differentiate well between the two hatchery populations; they would suggest it is a single population. But microsatellites show clear genetic differentiation. Including more years of data provides similar differentiation, so the data are very robust, he noted.

Comparison to a wild population just a few kilometers away showed good differentiation between hatchery and wild stocks with microsatellite markers. At Porozhisty Creek, there are two distinct types of chum – one group that spawns in the lake and another that spawns in the river. Samples were collected from throughout that system and compared to those from another river and another lake. The results showed that all the lake-spawning samples formed one genetic cluster, while all river-spawning salmon created another genetic cluster (Figure 31). So there are several levels of genetic differentiation that may have practical applications, Zhivotovsky noted.

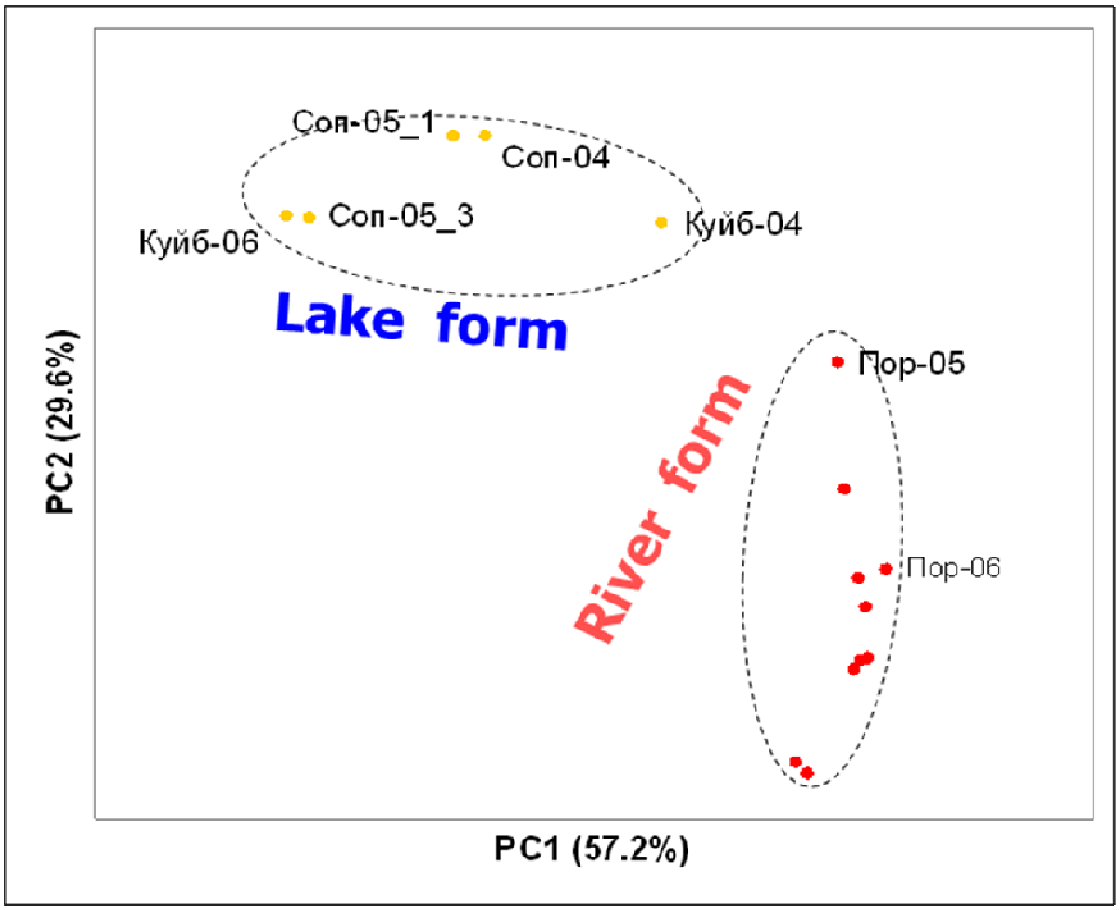


Figure 31. Samples of lake and river forms across locations and years

For genetic fish identification, we have now developed a microsatellite database, with allele frequencies at those 10 loci for microsatellites, he continued. By comparing the genotype – the allelic content – for fish from Sakhalin or Iturup Island to the baseline, a high percentage of fish can be correctly identified because these two groups have very good differentiation. The 10 microsatellite markers correctly

identified Sakhalin vs. Iturup chum samples 98% of the time, based on the probability of an individual genetic profile belonging to one or the other group.

Finer-scale stock identification to local populations within the Sakhalin-Iturup region resulted in correct assignment between 71% to 95% of the time, depending on the population. This success rate is not as good as the previous example, he noted. Although they differ, 10 loci are not enough to distinguish individual populations with a high level of probability, so more markers need to be developed to distinguish more reliably.

Summarizing, Zhivotovsky said chum salmon populations in the Russian Far East show significant genetic differentiation at many levels using DNA (microsatellite) markers. Development of a genetic database is a very important step for using genetics to help solve practical problems in conservation, genetic management, certification, etc. For chum salmon in the Russian Far East, efforts will continue to develop the database and to increase the number of loci to improve precision. The strength of differentiation varies across habitat and probably depends on histories of natural straying, population size, ecology and hatchery transfer. The more DNA markers in such a database, the greater the ability to provide fine-scale population resolution, but also the more expensive it becomes.

Discussion

Q: With the lake and creek spawning populations, is it known whether they spawn at different times and whether they use different aspects of the substrate?

- Zhivotovsky: This is not well understood. They probably don't differ much in run timing but they probably spawn at a slightly different time. They seem to be reproductively isolated from each other and using different resources.

Q: This is the first I've heard of beach (shallow) spawning lake chum. How widespread is this?

- Zhivotovsky: Lake spawning chum are probably rare. They are probably only in a few places in the South Kuril Islands.

Indicators of status and benchmarks for conservation units for Canada's Wild Salmon Policy

Carrie Holt, Fisheries & Oceans Canada

The Wild Salmon Policy (WSP) represents an innovative approach that is conservation-oriented, with benchmarks for status assessment and a focus on maintaining genetic diversity as well as abundance by focusing assessment at the level of Conservation Units (CUs). Holt noted her presentation would explain the conceptual framework for status assessment along with a proposed methodology for evaluating candidates for the benchmarks to be established under the policy.

The first step in identifying benchmarks is to consider the types of information required (i.e. dimensions of status) and examples of metrics that might be used to indicate status in each dimension. Fisheries management will provide some answers; science will provide others.

The goal of the WSP is "to restore and maintain healthy and diverse salmon populations and their habitats for the benefit and enjoyment of the people of Canada in perpetuity." The policy sets out strategies for achieving this, starting with standardized monitoring of wild salmon status. The first step under Strategy 1 is to identify salmon CUs, which is now complete. The next step, now underway, is to identify criteria to assess biological status and to develop upper and lower benchmarks that will delineate three zones indicating biological status in terms of abundance and distribution. The lower benchmark must be high enough to allow a buffer that avoids reaching a level that might be considered posing a risk of extinction.

The WSP protects not just abundance but diversity, Holt noted. This is important in allowing salmon to adapt to changing conditions and in reducing the probability of loss. It means that populations would retain the ingredients to allow re-colonization if some individual spawning groups are lost.

Assessing status will involve looking at four categories of indicators that describe abundance levels, abundance trends, distribution, and fishing mortality relative to productivity. It is also important to consider uncertainty in assessment data. For each class of indicator, quantifiable metrics must be identified, with benchmarks established for each, thus providing a toolkit for multidimensional assessment (Figure 32).

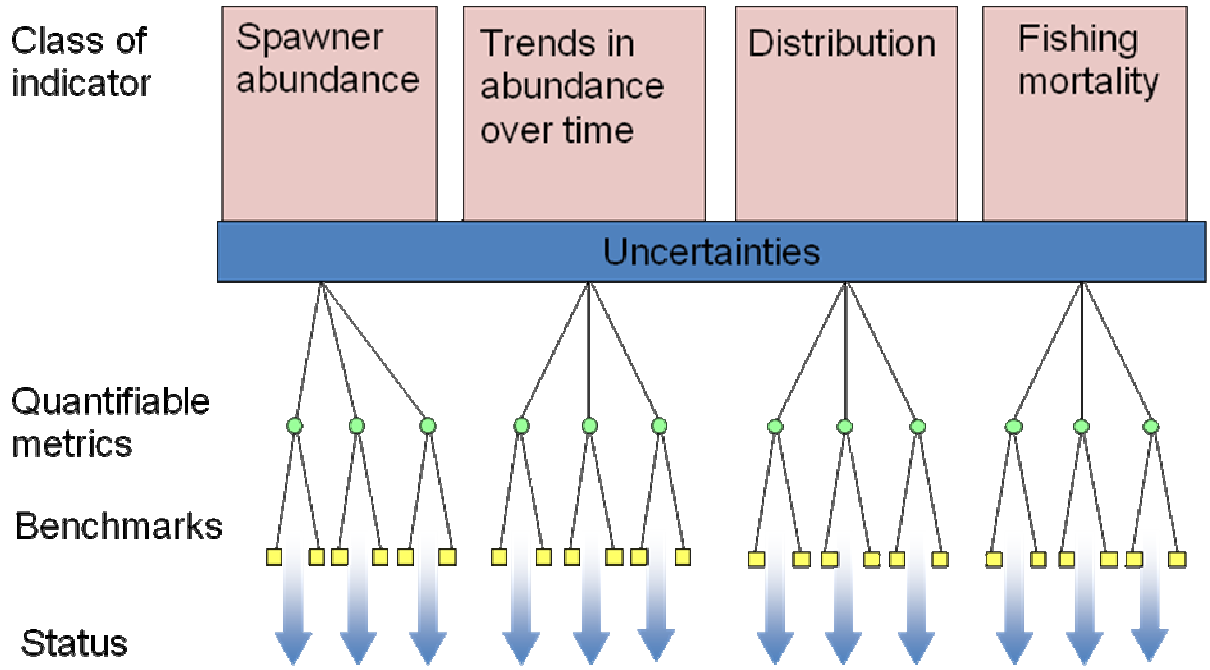


Figure 32. Assessing status of conservation units under Canada's Wild Salmon Policy

A candidate list of metrics and benchmarks has now been drawn from the literature. Holt reviewed some of the potential candidates, noting that the choice and application of these metrics will depend in each case on what information is available for the conservation unit. Criteria must also be established to allow evaluation of potential benchmarks, which will be done by using a simulation model. As required under the WSP, different levels of uncertainty in data and harvest management will be factored into the simulation model to evaluate the performance of different candidates under a wide range of conditions. For the lower benchmark of abundance, for example, the model would assess how well candidate benchmarks perform against criteria such as the probability of specific recovery or extirpation outcomes, taking into account various levels of uncertainty.

Initial simulations show that some benchmarks are more robust in the face of uncertainty, Holt noted. The choice of specific benchmarks will depend on risk tolerance and this simulation model can therefore serve as a tool to evaluate risk.

Challenges will include assessing spawner distribution across a CU, given little previous experience and theoretical backing to provide guidance. Combining information from a multi-dimensional assessment into a single status rating raises questions of how to prioritize potentially conflicting values. How to account for cases where there are limited or no data for some metrics will pose further challenges. A possible solution is to use a matrix that compensates for increased uncertainty by increasing precaution.

Summarizing key points, Holt noted the Wild Salmon Policy requires biological assessment of abundance and distribution of salmon within CUs. Four classes of indicators will be used to denote abundance, trends in abundance, distribution and fishing mortality relative to productivity. Candidate metrics and

benchmarks must be identified for each category, with evaluation of benchmarks in a simulation model that explicitly incorporates uncertainties, and risk tolerance to be identified by fisheries management.

Discussion

Q: Are the benchmarks based on mathematical spawner-recruit relationships?

- Holt: No. Some of those being considered are driven by spawner-recruit relationships but we don't have those for many CUs so we are looking at other options, such as assessing the capacity of freshwater systems. Other classes of indicators (trends and distribution) would not be based on stock-recruit relationships.

Q: In the U.S. it would be difficult to get something useful based on the data available.

- Holt: We are also evaluating the quality of data available relative to risk.

Q: Is target escapement set by this process or is that separate?

- Holt: Target escapement will be a separate management objective. This is solely for biological assessment.

Q: I applaud the work on the Wild Salmon Policy, but unfortunately it doesn't always influence fishing plans. When you talk about supporting biological diversity, it's hard to see how you're doing that. Not one commercial fish has been listed since SARA (Species at Risk Act) was established, so it's not working. I support the Wild Salmon Policy but it is lacking the funding needed for implementation.

Q: What proportion of identified CUs has some usable metrics for this sort of analysis?

- Holt: Most of them will have information to address at least some aspects, but very few will have enough information to be able to use all of those metrics. The key is how best to combine available information where we have big blanks.

Q: In the context of the Wild Salmon Policy, how do you see moving away from managing stock complexes to single-stock management, for example on the Fraser?

- Holt: The Fraser will be a challenge, given the large number of CUs and management groups. We will have to be creative in how we manage to support the recovery of depleted CUs.

Bayesian decision analysis for rebuilding a depleted salmon population & retrospective evaluations of assessment criteria for conservation status

Randall Peterman, Simon Fraser University

This presentation will discuss two Master's theses, Peterman said. The first illustrates the use of Bayesian decision analysis to evaluate recovery options and inform tradeoffs between economic and ecological benefits. The second evaluates criteria for assessing stock status and shows that some commonly-used criteria are not very reliable.

There have been many hypotheses explaining the decline of Cultus Lake sockeye, he noted, including overfishing, pre-spawn mortality and marine survival. A key issue in recovery efforts is that this stock represents a very small portion of a very large aggregate of economically-important stocks.

A study was undertaken to find harvest strategies that would meet the Cultus recovery objectives while quantifying tradeoffs between salmon recovery and the economic value of harvests. Management objectives were to rebuild Cultus Lake sockeye to above 20,000 spawners in 20 years, while maximizing the economic value of harvests as long as the recovery objective was met. Bayesian methods were used to

do risk assessment, evaluating alternative options for achieving these management objectives while taking uncertainties into account. The analysis looked at the relationship between different harvest rule options and Cultus sockeye abundance, recognizing that as the latter grows, it would be possible to adjust harvest rates and rules.

A "tree" model of decision components illustrates that each management option leads to a whole suite of possible outcomes, Peterman explained. The key uncertainty is the relationship between spawner abundance and smolts, since the underlying relationship is unclear. So you fit a model that could take on any of those shapes and represent this on a decision tree as alternative states of nature in terms of the spawner-to-smolt relationship. Each of those states is then weighted by probability. Other sources of uncertainty include marine survival and the difference between actual and target harvest, so a range of possible values for both factors are similarly addressed in two further "branch" levels in the decision tree. The outcome for each possible scenario is then expressed in terms of the two management objectives (probability of recovery to 20,000 spawners by year 20 and annual average economic value of catch). The results of this analysis showed that many harvest rules met the recovery objective, and identified which of these would maximize harvest value.

A key point is that this approach also permitted estimation of the tradeoffs between the two variables. If the objective was a 90% chance of achieving the recovery targets, it would require acceptance of very low harvest. If a higher probability of not saving this stock was acceptable, you could quantify the resulting increase expected in harvest value (Figure 33). The usefulness of this tool is that it allows tradeoffs to be explicitly quantified to aid decisions, he noted.

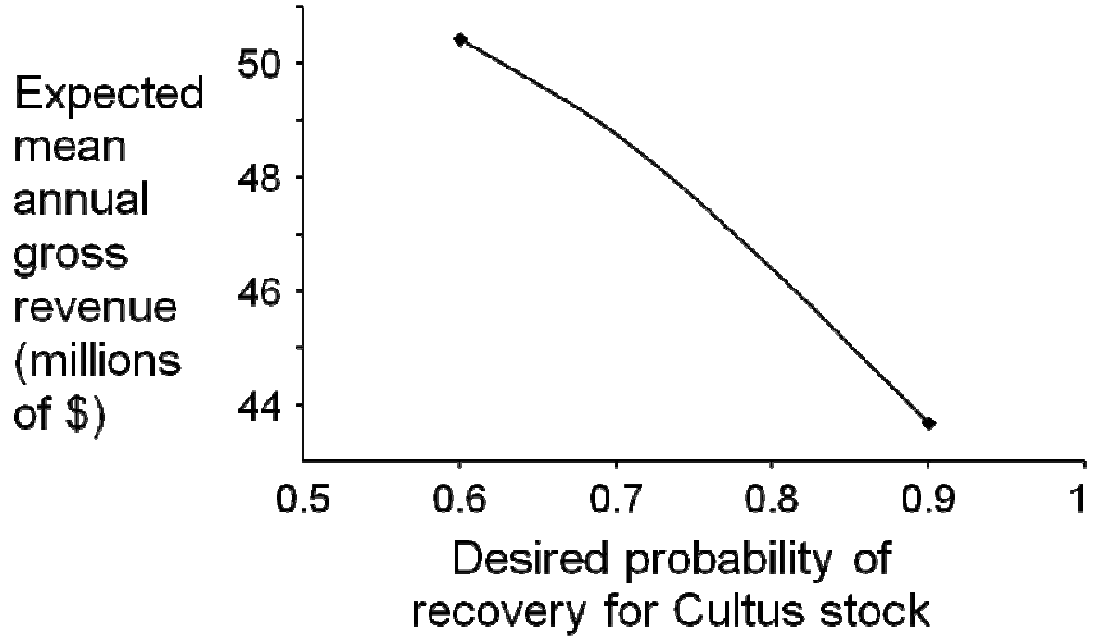


Figure 33. Trade-offs between the probability of recovery and harvest value; Pestes et al. 2008, Conservation Biology 22:351

The second study evaluated criteria used to assess conservation status, Peterman continued. This work looked at which measures of declining abundance were most reliable in correctly predicting whether salmon populations were truly declining in the face of high population variability over time. Available measures include short- and long-term, log-transformed or not, smoothed or not, and combinations of these. Any time series shows salmon abundance is highly variable over time, so the challenge is to identify a metric that takes into account that high level of variation without being fooled by it.

Retrospective analysis was used to compare each of the 22 decline criteria, using long-term spawner data for 18 Fraser River sockeye stocks to see how frequently estimated declines would have correctly matched true declines. Predictions were tallied under four categories: the number of correct predictions of

"declining" or "not declining" (i.e. true positive and true negative), along with the number of false positives and false negatives. These outcomes were then combined, using a method common in assessing medical diagnostics called an ROC curve, to provide a single rating for each of the criteria. This showed which predictions were most frequently correct and which were less reliable.

Since harvest rates present a potential confounding factor, a sensitivity analysis was performed, comparing results for pre-1995 data against post-1995 years when harvest declined. The results showed a very similar ranking for the criteria. One commonly-used criterion (IUCN-A) performed poorly, and was not even in the top five.

The results of this analysis showed that the most reliable criteria were based on long-term comparisons of spawner abundance with measures of extent of decline compared to a historical baseline, Peterman said. Features of those criteria that performed well included: percentage decline since the maximum of the first five years (smoothed with four-year moving averages); ratio of mean abundance in current generation to mean of first generation in data series (smoothed); overlapping or non-overlapping moving windows; and annual rate of decline in abundance over the entire time series (smoothed).

The key message is that such criteria should be evaluated before they are used to assess the status of wild salmon populations. Future work should include looking beyond retrospective analysis and doing simulations to further analyze reliability.

Discussion

Q: Did the evaluation of options for Cultus sockeye consider upstream harvest and other stocks that may be driving fishery management changes? How would those factor in?

- Peterman: Upstream harvest was not considered as an option. The values of actual commercial harvest were way lower than the estimates given to the Minister. The analysis did not take into account other populations of concern. When harvest was reduced, it allowed other populations to recover, so there was less economic tradeoff than had been assumed.

Q: There are issues with the quality of the estimates in the early parts of the time series. When there are order of magnitude differences, it may be better to be categorical instead.

- Peterman: The data were long-term and very clean. The main point is that if you're going to use these metrics, you should simulate how they will perform instead of assuming that they will correctly reflect declines. The study also split the data to compare results for all data against those for high quality data. Reliability values went up with better-quality data
- Holt: We are using long- and short-term trends for the Wild Salmon Policy. Some historical baselines may be less sensitive to uncertainties in the data.

Q: Cultus was an exceptional example in terms of data quality. Where there is a lack of information, would a CU be placed in a red zone? How do you address such uncertainty?

- Holt: First you need to identify benchmarks that are robust in relation to marine survival. A second strategy is using the matrix described where status is weighted towards red when there is more uncertainty.

Q: I'm from the headwaters of the Yukon. Some of the reports from Alaska show salmon status as healthy, but in terms of returns to the headwaters, status is not healthy. We started seeing a decline of large salmon 10 years ago and have had no fishing for the last three years at all. How do we close the whole river with SARA or COSEWIC (Committee on the Status of Endangered Wildlife in Canada)? Would it apply across the border if we applied to SARA for a listing?

- Holt: I can't speak on those issues, but information about changes in size at age would be incorporated into our assessments.

Q: Are the attributes of criteria that perform best contingent on the shape of the decline? Is there a difference in performance when there is a nice linear decline vs. a catastrophic drop?

- Peterman: The pattern of decline can change. We found benefits with long-term criteria compared to short-term ones.

Q: At what point is the decline calculated? What was the standard for whether a decline took place?

- Peterman: Actual decline was determined based on all subsequent years from when the criterion was evaluated, using three thresholds of conservation concern (30%, 50% and 70%).

Q: Did some criteria perform better in one direction or were they consistently biased in one direction?

- Peterman: The analysis didn't look at how it was biased. It looked at how the criterion did across all populations and all years.

Q: Regarding problems with past stock assessment data, will we need different quality information going forward to implement the Wild Salmon Policy properly and if so, what is being done? Is DFO looking at whether to use tools like Peterman's?

- Holt: One of the outputs of our program is a list of indicators that could be useful and also advice on where data is missing, so that we can prioritize which classes of indicators will be most important and what data and monitoring should be prioritized.

Q: There must be many CUs with substantial natural spawning of hatchery-origin fish.

- Holt: Populations with significant hatchery influence won't be included as Wild Salmon Policy CUs, though it's not clear where to draw the line.

Panel: Community and economic incentives and other strategies to promote sustainability

Recreating sustainable fisheries in the Skeena watershed

Greg Taylor, SkeenaWild Conservation Trust

The Skeena watershed includes 29 salmon CUs, of which Babine sockeye is by far the largest, with its artificially-enhanced spawning channel. Other stocks are not doing as well, Taylor noted. Five are identified as being of serious concern, six are stocks of concern and 17 have insufficient data.

Some stocks are being harvested well above the recommended exploitation rate, he noted, though it was not always this way. There was sustainable fisheries management on the Skeena between 1500 BC and the late 1800s, with a large, robust First Nations fishery harvesting upwards of 750,000 fish. To be sustainable, there had to be a sustainable regime that allowed fish to pass through and that protected biodiversity. In trying to restore sustainability, therefore, it is important to understand key principles of traditional governance and management:

- Fishing rights and access were recognized as property, for example with traditional family fishing sites (efforts are now underway to establish quotas and defined shares)
- Sustainable fishing practices
- Conservation for future generations
- Economic exchange based on reciprocity (sharing of wealth)

- Strict and transparent enforcement of rules (current efforts on the Fraser are trying to replicate the traditional model of a Feast Hall)

Taylor described a change from robust, sustainable management to a situation of crisis, with steadily-declining salmon harvests over the past century. In the early 1900s, every tributary had a traditional weir, but early managers deemed these as threats to conservation. Managers responded to the loss of distribution and biodiversity with technological fixes such as enhancement. While an enhanced stock can handle a 70 percent exploitation rate, natural stocks that co-migrate with them can't handle such levels. Managers have therefore viewed fisheries management as a tradeoff between economic benefits and biodiversity. They are trying to serve two masters, Taylor said. But the result of trying to manage this tradeoff is that as total abundance rises, exploitation rates go up, irrespective of the impacts on biodiversity.

In 1990 and 1991, weekly harvest rates were distributed over the different runs. But in 1992, harvests were moved forward to avoid coho and steelhead concerns, with the result that fisheries ended up hitting Wet'suwet'en stocks harder. In 2008, fisheries were shifted again to protect those stocks and are now threatening others instead.

There is another way, Taylor said, that is not based on this false premise. Economic benefits can be achieved in different ways, and looking to the past can help us move forward. The Skeena Fisheries Commission is employing traditional terminal methods, with many examples now of upstream dip net and beach seine fisheries. The new Skeena commercial fishery reconnects with the past. Conservation, biodiversity and ecological integrity are paramount in all management decisions because houses, groups and their associated territories are for all time. Fisheries are consistent with traditional ecological knowledge and peer-reviewed science and are allocated, monitored and controlled through traditional law. Taylor described several examples of up-stream, terminal and lake and in-stream fisheries (Figure 34), noting that fish quality can deteriorate in the higher reaches, but that all fish caught are still marketable.

In 2008, revenues of $1.3 million were derived from these fisheries, in an area with very high unemployment and low incomes. Costs and overheads are also lower than for ocean fisheries. This income goes directly to local communities, so the fishery is a major economic provider as well as a way to protect biodiversity. In total, these fisheries employed 45% of the harvesters, while representing 20% of total catch from the Skeena.

In terms of how to move forward, Skeena First Nations have come together and formed the Skeena Watershed Selective Harvesters Association. Under the current management regime, they can only access fish identified as surplus to traditional allocations, so the association is seeking defined access to grow this selective fishery. Efforts are also underway to certify all sockeye products under the Skeena Wild mark as selectively harvested in "fair trade" fisheries. Additional value can be developed through marketing or product development (e.g. organic labeling). The association is also working to identify opportunities to invest in infrastructure and processing, in order to return a greater share of market value to local communities.

Taylor closed by expressing appreciation to First Nations and others who have worked through the Skeena Fisheries Commission to develop this model over the past 20 years.

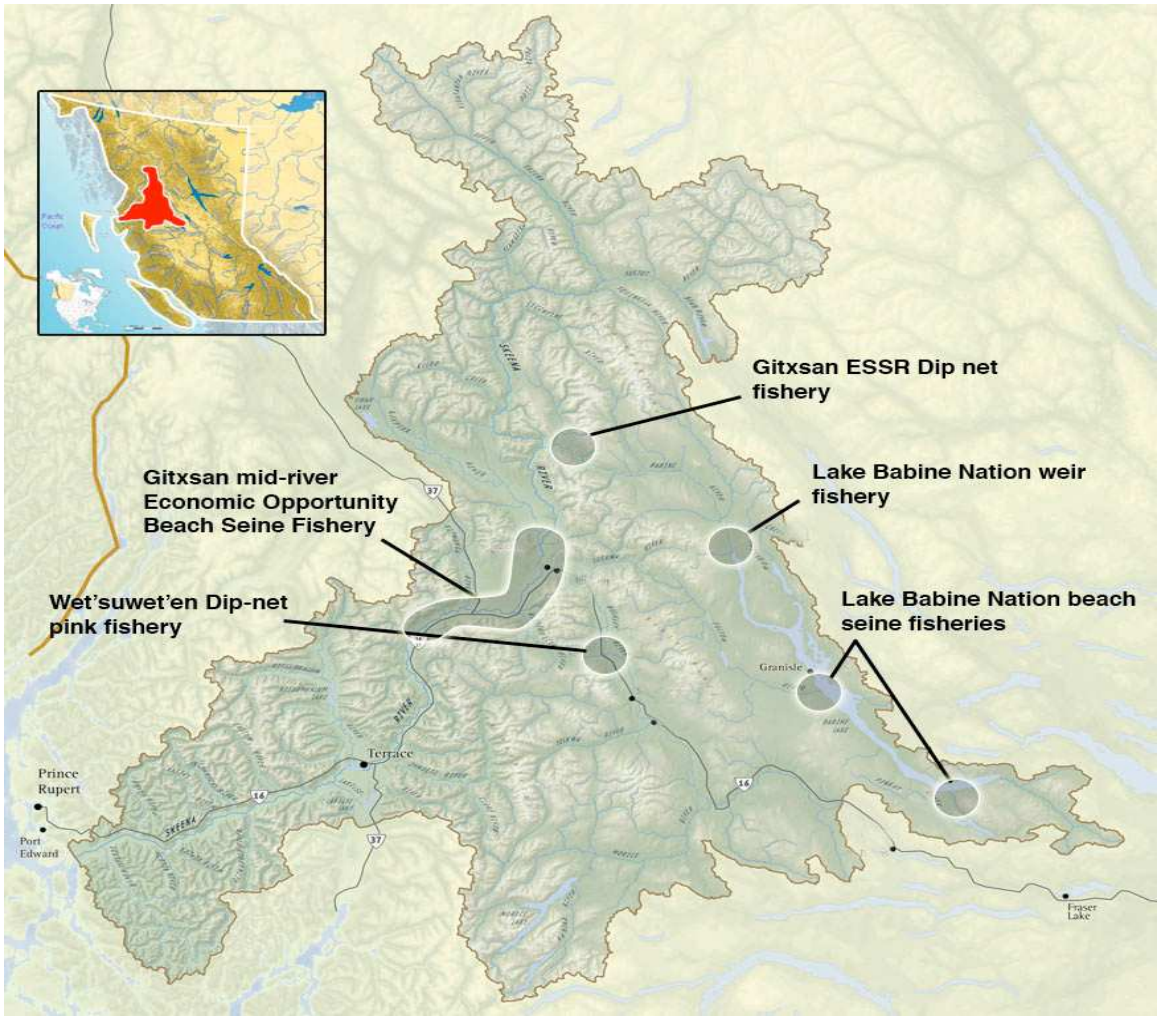


Figure 34. Locations of some terminal fisheries in the Skeena watershed

Several problems with management of the salmon fishery on Sakhalin Island

Vladimir Tabunkov,Fisheries Assocation of Sakhalin

Tabunkov explained that his organization represents the interests of fishermen, and that despite the increase in fish abundance, there are still concerns. The modern way of managing involves science, natural and artificial production and regulation of human harvest and marketing. It is impossible to address all facets of a complex system, he added, so his talk would focus on those most important to fishermen.

To understand reforms in the fishery, it is necessary to go back in history. In Communist times, management was centralized. There were no laws but strict quotas regulated by rules of fishing, science and harvest plans. The monopoly rested with collective farms assigned permanent leases, with processing in government plants. Inadequate processing capacity was a serious limiting factor, with coordination challenges and bottlenecks at the plants.

River ecosystems were subject to very intense human activity, such as forestry, oil and gas development, coal mines and agriculture. Many salmon spawning grounds were lost, leading to a serious decrease in

abundance. In the early 1990s, the environmental situation started to improve under *Perestroika* and government efforts, and also because the economy was falling apart. Forestry and coal mining disappeared, along with most agriculture, and oil and gas exploration virtually ceased. The environmental situation improved dramatically and, starting in the 1990s, salmon abundance started to increase. The primary native species is pink salmon, with most fishing in the eastern part of Sakhalin Island. This period coincided with federal fishery reform, with the introduction of quotas and a requirement to listen to science advice in defining permissible catch values.

It is now understood that this was a very inefficient system, with too much bureaucracy, he continued. Especially when government projected high salmon returns, it could take 15 days to several months to get a decision from Moscow. Meanwhile, fishing was on hold, so large numbers of fish were reaching the spawning grounds. People came to understand that there was something fundamentally wrong with the system of quotas.

This led to a grassroots movement that proposed reforms to the agencies responsible for fisheries. From them on, Tabunkov said, our voice was heard and the federal quota system became defunct. Scientists and a fisheries commission now make decisions locally. This system is much better than the old one, but not perfect. Decisions are still too slow. Now we talk about forecast values instead of quotas, but it's still the same thing and the bureaucratic process still takes 5 to 10 days, with consequential delays for fisheries.

To manage fisheries, the Sakhalin coastline was divided into fishery areas, each assigned to a fishing company for 20 years. It is in the companies' interest to operate sustainably and to preserve habitat. There is also increasing desire to rely on hatcheries. Hatcheries existed under the old regimes. In 1992, 15 federal hatcheries released a total of 900 million fish. In the post-Soviet era, more hatcheries were established but these were not federal hatcheries, so the federal contributions declined. A decree assigned specific river areas to the hatcheries and they also got the right to conduct commercial fishing. Since then, many companies decided it was a good idea to build their own hatcheries. The number of hatcheries increased by factor of two or three, but output declined to 750 million juveniles. There were no scientists involved and they all focused on chum.

Hatcheries in eastern Sakhalin are harming our natural systems and native pink production, Tabunkov said. The hatchery chum salmon were everywhere and the pinks had no more spawning grounds. So a new law was introduced regulating companies' rights to get involved in commercial fishing. There is a plan to allocate 23 more licenses for 23 new hatcheries yet to be built. Regarding the efficiency of hatchery operations, he said there is no tagging of hatchery fish and genetic research leaves much to be desired. When you compare the number of hatchery fish and fluctuations in abundance, you can't say there is a direct correlation between the two.

Another major issue is how to regulate the numbers caught. The criteria used are based on the number of spawners. The value is based on ocean catches up to the estuaries. You can't fish in the estuaries but you can make it difficult for fish to get upstream—some rivers are 100% blocked (Figure 35, left). The more fish caught in the ocean, the fewer that can reach spawning grounds upstream. Though we continue to use this method, we are not happy about this practice, he said, suggesting corruption is a factor contributing to unsustainable policies. Last year several spawning grounds were only filled to one-third of their capacity so the fish commission started to develop new rules, which have now gone to the federal fisheries agency and will hopefully be adopted.

Figure 35. Issues with regulating fisheries on Sakhalin Island: blocking rivers (left), poaching (right)

Another issue is poaching (Figure 35, right), which started to increase in the 1990s due to the economic rewards. The poachers are just looking for fish roe, and fighting these people requires getting the police involved. The harm done by poachers is hard to estimate, but we guess it is about 20% of all salmon caught, he said. The reason is the lack of legislation and the quota system still in place. A fishing company will do anything to get the allowed number of fish, regardless of the ecological consequences, and if appropriate authorities don't get involved, there will be major devastation.There is a federal policy stating that fishing companies should process and market fish domestically and if possible locally. Thanks to the Wild Salmon Center, we are now looking at certification criteria. The fishing community applauds this approach, which we hope will offer opportunity for a better future.

First steps of salmonid monitoring in Sakhalin

Anatoly Semenchenko, Sakhalin Salmon Initiative

The goal of this initiative is to move away from monitoring commercial fisheries to monitoring of whole river ecosystems, Semenchenko said. As a non-profit, it is easier for us to interact with the various players and the focus is on designing down-to-earth criteria. Objectives of our monitoring are to not just look at salmon that have commercial value, he added, but to describe the entire ecosystem. The more indicators, the better we can describe the ecosystem.

Three rivers covered by this initiative are located in the Aniva Gulf region, including two rivers that are virtually identical and a third one, the Taranay, which is much larger. The Taranay has a small hatchery producing some pink and chum.

Sensors monitor temperatures in the river throughout the year. Water temperatures in the Naicha River are considerably lower. Both basins have virtually no environmental concerns. Other activities include GIS mapping and biological analysis of samples collected in a downstream rotary trap. Juvenile counts, dive surveys and spawning ground surveys are also used to provide data (Figure 36). Semenchenko presented a series of slides illustrating some of the data provided and then summed up the results of monitoring research in 2008, including collection of hydrological and meteorological data for the three test rivers.

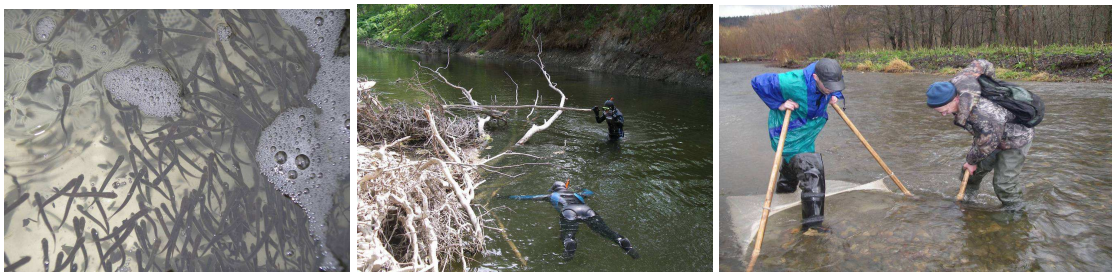


Figure 36. Juvenile counts (left), snorkeling surveys (center), spawning ground surveys (right)

Fifteen fish species live in or enter the river to spawn, with pink salmon as the most abundant. Masu salmon also spawn in all three rivers, but no evidence was found of Sakhalin taimen spawning grounds or juveniles. The number of pink spawners ranged from 220,000 to 391,000. Masu numbers ranged from 1,000 to 10,000 and they occupied about one-quarter of all spawning areas. Salmonid abundance in Aniva Gulf rivers is high, with commercial catch averaging close to 20 million individuals. Biological differences were observed for pink salmon over the course of the spawning migration period. Threats include a growing sport fishery for masu salmon, Semenchenko said. In 2008, about 1,000 were caught in the Kura River, compared to about 100–140 spawners.

Importance of wild & hatchery-reared salmon in commercial pink & chum stocks in Sakhalin-Kuril region

Alexander Kaev, Sakhalin Research Institute of Fisheries and Oceanography

This region releases some 280 million pinks and 270 million chum from 33 hatcheries, Kaev said.

Chum harvests have been increasing but the relationship between releases and catch is ambiguous: the relationship is negative in some areas and positive in others (Figure 37). Such contradictions may be related to plant efficiency, indirect economic impacts and the occurrence of wild chum salmon in 1970s catches. However, the chum salmon rearing program resulted in catch increases in the last 10 years, due to better fry survival. The proportion of hatchery stocks in catch is about 90 percent. In recent years, that has increased despite the improved state of some wild chum populations.

For pinks, at first glance catches appear to have been higher where there were high numbers of hatchery releases, in the southern part of eastern Sakhalin and Iturup Island. But natural pink production is also highest in these same areas. Since the 1980s, pink catches increased in all areas. The relative increase in catches was lower in areas with increased hatchery culture. When the mean number of hatchery and wild fry were compared to adult returns for these generations, in all cases large returns coincided with high returns of wild fry. This comparison showed that declines or increases in catches depended in changes in abundance for naturally-produced fish for all areas in the region, even in areas where hatchery fry represented 40 percent of all fish. The declining trend in pink escapement to spawning grounds in recent years is therefore alarming. From 2002 to 2008, escapement declined from 3.9 to 2.6 million.

Summing up, Kaev said that in light of expected deterioration of salmon marine habitat, measures will have to be developed to maintain the fishery. The chum salmon fishery could be maintained based on further development of hatchery rearing. However, to support the pink salmon fishery, improving spawning conditions are a very important factor.

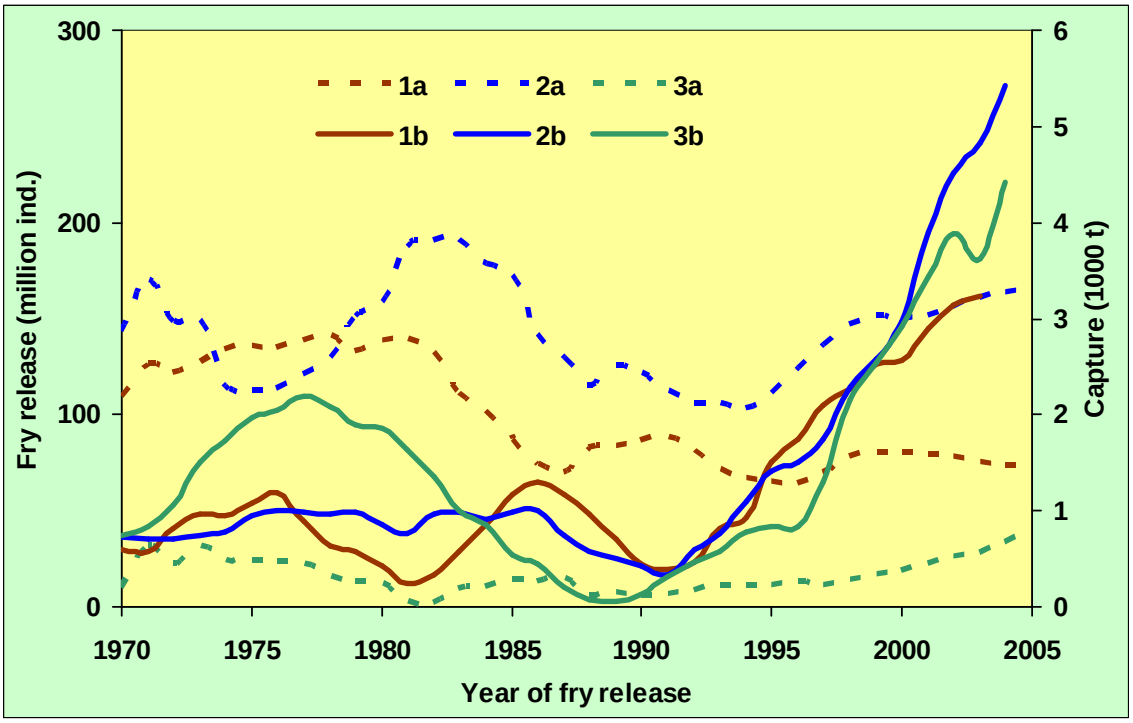


Figure 37. Dynamics of fry release (a) and subsequent catch (b) of chum salmon: 1) southwestern Sakhalin, 2) eastern Sakhalin, and 3) Iturup Island

Discussion

Q: For Iturup fisheries, in recent years commercial chum catch has increased. Is this due to increased fishing effort or increased abundance?

- Kaev: For chum, we have a very clear situation. This is due to hatchery improvements and more wild fish. The pink situation is not as clear. Harvest has increased in all regions. We think this is because abundance is up and also because the size of each individual has increased, but we don't know how much is due to the influence of hatcheries.

Q: You've illustrated threats and a potential disaster for the fishery in Sakhalin due to poaching etc. So why are pinks doing so well?

- Tabunkov: This is a very good question: Of course not everything is bad. Pink abundance has been growing to 2007 and it indicates this fish can survive under huge fishing pressures. But there are a large number of rivers where we can demonstrate that they don't reach the spawning grounds. The picture about poaching is very typical. It happens in hard-to-reach places. Pinks are doing very well in the southern region, where measures are enforced to protect them. The fishermen themselves protect them. It must be stressed that fishery reforms mean there are far fewer inspectors now, so a lot more work is needed to monitor and protect fish.

Q: You said that 90 percent of chum in southern Sakhalin are from hatchery sources and only 10 percent are wild. These data would suggest that the wild population has collapsed. How did you arrive at those numbers?

- Kaev: These are the statistical data that we have from southern Sakhalin. Wild chum are only found in a few rivers there.

Q: Over the last few days, we've heard about wild salmon policies being adopted around the Pacific Rim that involve efforts to limit impacts of hatcheries on wild stocks. Are such policies also necessary for Russia and might they be implemented?

- Tabunkov: We don't have legislation like that yet but I do think we need it. We would also like closer cooperation with people elsewhere who work on salmon legislation. Our fishermen would like to see that, but our people are not in charge.

Q: What is being done to compare different monitoring techniques?

- Semenchenko: There are several ways to describe this system. We are developing new methods and trying to look at the whole system. We don't just focus on salmon, but for example we research hydrological parameters that actually reflect the status of salmon habitat.

Q: It's great to see in-river fisheries being re-developed on the Skeena. The campaign to remove traditional weirs in the early 1900s had more to do with allocating fish to emerging commercial fisheries. Is there also interest in marketing, given that the price for pinks has been so low in recent years? Is most used for domestic consumption or is it marketed elsewhere?

- Taylor: Pink is not a primary component of catch, though there is a small pink harvest in Moricetown. It commands good prices. Smoked products are produced at a roadside facility that is a popular tourist attraction. But the ability to market is affected by inconsistent supply.

Q: It wasn't clear whether the in-river Skeena management regime was aspirational or fully in place. Can you also comment on challenges in getting provincial and federal governance lined up with traditional approaches?

- Taylor: This was developed and has been evolving since 1992. Local DFO (federal fisheries) staff has been great but there are challenges. Higher-ranking officials see the mixed-stock ocean fishery as the only thing with economic benefit. We are trying to work with agencies to demonstrate that we can achieve more economic benefits by catching fish at different places, while protecting biodiversity.

Q: What is the impact of MSC certification and what are the challenges? Is the Russian government supportive?

- Tabunkov: The primary evaluation included a list of barriers to achieving sustainable fishing. One of the first problems is the impact of hatcheries and administrative issues. Of course, we need a certain number of measures to fulfill those demands, but when we do that we can achieve sustainable fisheries. It depends on how quickly the local and federal government will respond to our proposals. The work is very preliminary at this point, but our administration is supportive.

Q: I want to compliment you on incorporating traditional knowledge into your plans for the Skeena. We need to do more of this.

Q: What about quality of in-river fish and marketability?

- Taylor: Certainly it's a different product and requires different markets as it moves upstream. But roe quality also increases. There are challenges, but they are surmountable. Every fish caught was sold to market. It may not command the same price as a fish on the coast, but there is no boat or fuel cost, so the returns to fishermen are equal, if not better. In the mixed-stock fishery, many of the boats come from the south, so the money goes south with them, whereas these earnings stay in local communities. But this is all for nothing if we don't protect habitat and we are now facing some major challenges currently with new pipelines and other major projects.
- Loring: In addition to protecting habitat, it's also about how to protect the culture and knowledge of the people. When we do a traditional harvest, it allows full participation by the whole community, including children, who learn important lessons about taking care of these things.
- Taylor: It was very rewarding to see the effect on individuals who got involved in the fishery, and who had been on suicide watch just one winter previously.

Afternoon plenary

Bringing the Future into Focus

Fran Ulmer & Greg Bock, plenary co-chairs

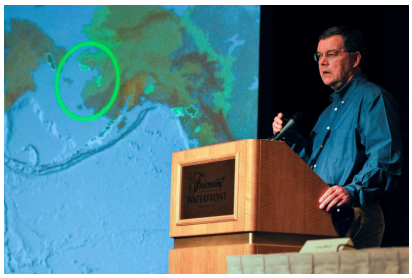
Salmon Strongholds and network principles

Introduction: Block noted that many see the idea of protecting core centers of abundance and diversity at different scales across the Pacific Rim as a foundational piece of a salmon conservation strategy. A salmon stronghold is defined as a geographical unit that meets biological criteria of abundance and diversity (run timing and life history), habitat quality, and other biological attributes important to sustaining viable wild Pacific salmon populations throughout their range. It may refer to a watershed, multiple watersheds or other defined spatial units where populations are strong and diverse and where the habitat has high intrinsic potential to support a particular species or suite of species.

A network of strongholds provides sufficient habitat and sustains ecological processes necessary for persistence of target species. Such a network is extensive enough to maintain the variability necessary to stimulate needed evolutionary changes, to support widely dispersed populations that are less likely to be affected by the same disturbance, and to support populations large enough to be self-sustaining. In tackling the challenge of how to balance social and commercial interests, Block further noted, the importance of involving people who work and interact with all the different interests on the ground.

A potential process for establishing a network of salmon strongholds

Gordon Reeves, US Forest Service, Pacific Northwest Research station



Basic concepts must be established in creating a network of salmon strongholds, Reeves said. The network must be comprehensive enough to capture the biological features we want to protect and maintain, but also as efficient as possible in terms of seeking to meet the conservation goals in as economical an area as possible. Selected sites must complement each other in order to meet overall conservations goals, instead of working at cross purposes. Flexibility must be built in to allow choices among a number of sites to reach the conservation goals. Some parts of the network (strongholds) would be deemed essential and irreplaceable in meeting conservation goals.

With many interests already working towards conservation, this concept can provide a valuable unifying framework. The salmon conservation network is a subset of all salmon basins, and the strongholds are a subset of that network.

Marxan is a decision-support system for systematic conservation planning that was designed to help develop biodiversity reserves, and is used by many conservation organizations. It uses an iterative decision-support process and looks at all possible options to determine the most efficient solutions for network design problems. Combined with data on salmon abundance from the Pacific Salmon Conservation Assessment database, Marxan can help minimize total network cost, while considering suitability, spatial configuration and species abundance and diversity.

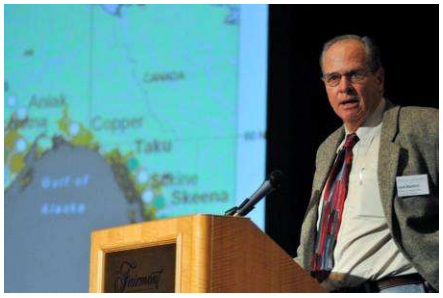
Suitability will be influenced by the level of impact: areas with higher impacts will entail higher costs than pristine areas, Reeves noted. A map reflecting relative costs for watersheds around the Pacific Rim showed that western U.S. states and Japan had the highest proportion of high-cost watersheds, while Russia and Alaska had the most low-cost watersheds.

He illustrated the use of Marxan to identify irreplaceable salmon strongholds needed to conserve existing abundance and diversity in each eco-region. Using the model to identify the "cream of the cream" in each eco-region (80 percent conservation level) resulted in only a few highly irreplaceable watersheds such as those in western Alaska and Kamchatka. After "locking in" these watersheds into a potential network, Marxan was iteratively run at the 50% goal level. The highly irreplaceable areas at the 50% goal level were locked in, and re-run at the 30% goal levels. The resulting network includes centers of high abundance and diversity (80% goal) as well as being an efficient and representative selection of the diversity of salmon across the Pacific Rim at the 50% and 30% goal levels.

Summarizing, Reeves said Marxan is a potential tool to use in developing a salmon conservation network. Early requirements in such a process include agreement on conservation goals – a way is needed to develop a scientific and political consensus on the goals of this network. Other requirements include improving a common databases and consideration of other factors such as environmental complexity, climate change impacts and economic and social-political aspects. A stronghold strategy must also be part of a more comprehensive long-term strategy, he stressed.

Salmon ecosystem vital signs

Jack Stanford, Flathead Lake Biological Station



If salmon strongholds are created, a system will be needed to measure how they work, Stanford said. Salmon ecosystems must be quantified by routine monitoring, with rigorous statistics and adaptive models that demonstrate trends and allow comparison to patterns at unaltered reference sites. Vital signs include sustained returns of sufficient spawners, density and growth of juveniles, habitat connectivity and productivity, hydrology, temperature patterns, productive and biodiverse food webs, high salmonid biodiversity, minimal water pollution and no cultured stocks.

Stanford's research uses remote imaging tools that provide fine-scale information to develop a Pacific Rim-wide Landsat database with measurable habitat values. River reaches with the highest habitat complexity tend to have the highest salmon productivity, he noted. These metrics are related to on-the-ground proxies of salmon productivity obtained from the SaRON suite of watershed sites being monitored around the Pacific Rim.

A range of metrics permits ranking of rivers around the Pacific Rim in terms of their physical complexity. The next step is conducting analysis of stock abundance to determine coherence with what the stocks are doing, he explained. The database allows users to pull up rank maps based on various features or to drill down and look upstream and at sub-basins. This provides a systematic and unbiased way to compare one river to another. This analysis also shows that rivers in the far north will provide good salmon habitat as climate warms (Figure 38).

Questions include the ability to link fine- and coarse-scale data, Stanford said. The percentage abiotic (cobble and water) scales best with the Landsat data, followed by the number of nodes of separation and confluence in floodplain reaches. These measures appear to give good coherence with SaRON data on average density of salmonid juveniles. However, rivers heavily influenced by glacial outwash have biological signals that don't fit as well with the most complex habitat.

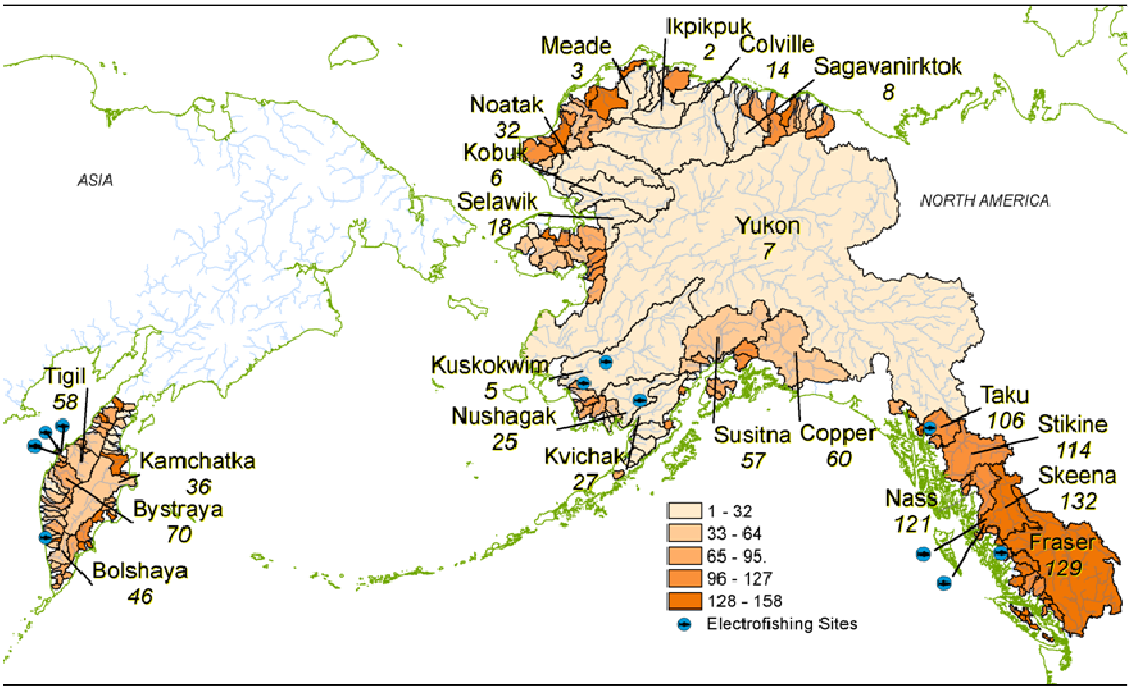


Figure 38. Ranking rivers of the Pacific Rim by physical complexity (Luck, M., N. Maumanee, J. Kimball, J. Stanford, M. Lorang, D. Whited, Flathead Lake Biological Station)

Use of spatially-explicit models of Asian salmonids for their conservation planning

Michio Fukushima, National Institute of Environmental Studies

Fukushima discussed the application of these models for two different studies. The first related to Japan's extensive network of dams, some of which were built centuries ago. Spatially-explicit statistical models were used to determine the effects of dams and habitat fragmentation on salmon and other fish and whether those effects could indeed be measured.

The study objectives were to assess if fish species richness was lost due to damming, he said, and the extent of this loss if this was the case. A total of 7,848 fish surveys were used to develop the model; 6,009 had no dam between the survey site and the mouth of the river, while the remaining 1,839 had at least one dam downstream. The model showed that species richness decreased with elevation. Fish species richness was also modeled against geomorphology, climate and human activity, resulting in a map for all of Hokkaido showing predicted differences in species richness. The model can predict species richness under a hypothetical status of no dams as well for the actual dam status. When these are compared, it shows the predicted loss of richness due to damming (Figure 39). The same technique can be used to model predicted distribution of individual species like the predicted loss of masu salmon due to damming.

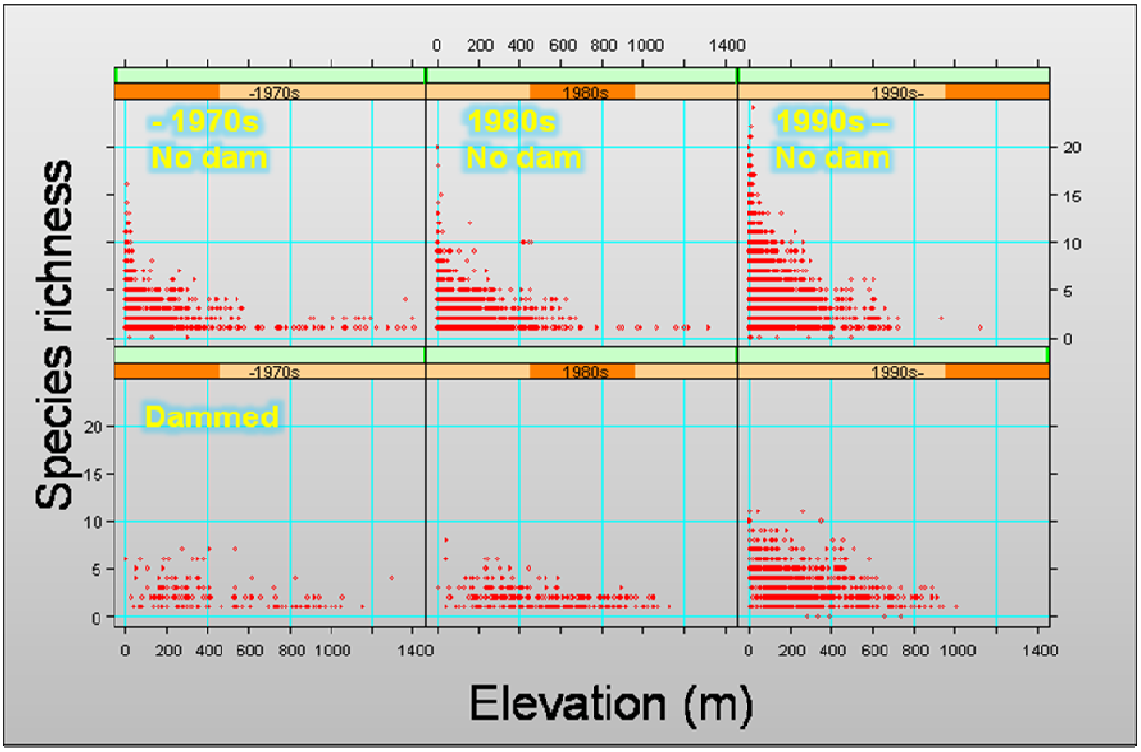


Figure 39. Fish species richness vs. elevation, survey periods, and damming

In a second application, Fukushima said, this kind of model was used to assess the efficacy of protected watersheds in Hokkaido. Hokkaido has 574 watersheds, of which 32 are protected for fish. These were originally designed to protect commercially-important species like masu salmon, but conservation of critically-endangered Sakhalin taimen has become an added objective. So the study sought to determine whether the same set of protected watersheds could effectively conserve two different salmonids with potentially different habitat preferences, and also whether the choice of protected watersheds was consistent with science.

The specific objectives were to rank watersheds based on the probability of fish occurrence and to assess the value of existing protected watersheds based on this ranking. Maps were developed to show where Sakhalin taimen probably exist. When these were compared against the protected areas, little overlap was found between the two, indicating that the protected sites were not successful at protecting this species (Figure 40). However, similar analysis for masu salmon suggests the protected areas are quite effective for protecting this species.

The relative performance of the protected watersheds was also compared to that of other randomly selected rivers. This showed that the protected systems performed slightly better for masu and slightly worse for Sakhalin taimen than the performance of any 32 randomly-chosen rivers. Similar modeling for 35 other fish species showed that the protected rivers provided above average benefits for four other species but below-average benefits for 33 others. This led to the conclusion that masu salmon were effectively protected by the existing system of protected watersheds, Fukushima said, but that endangered Sakhalin taimen were not protected at all.

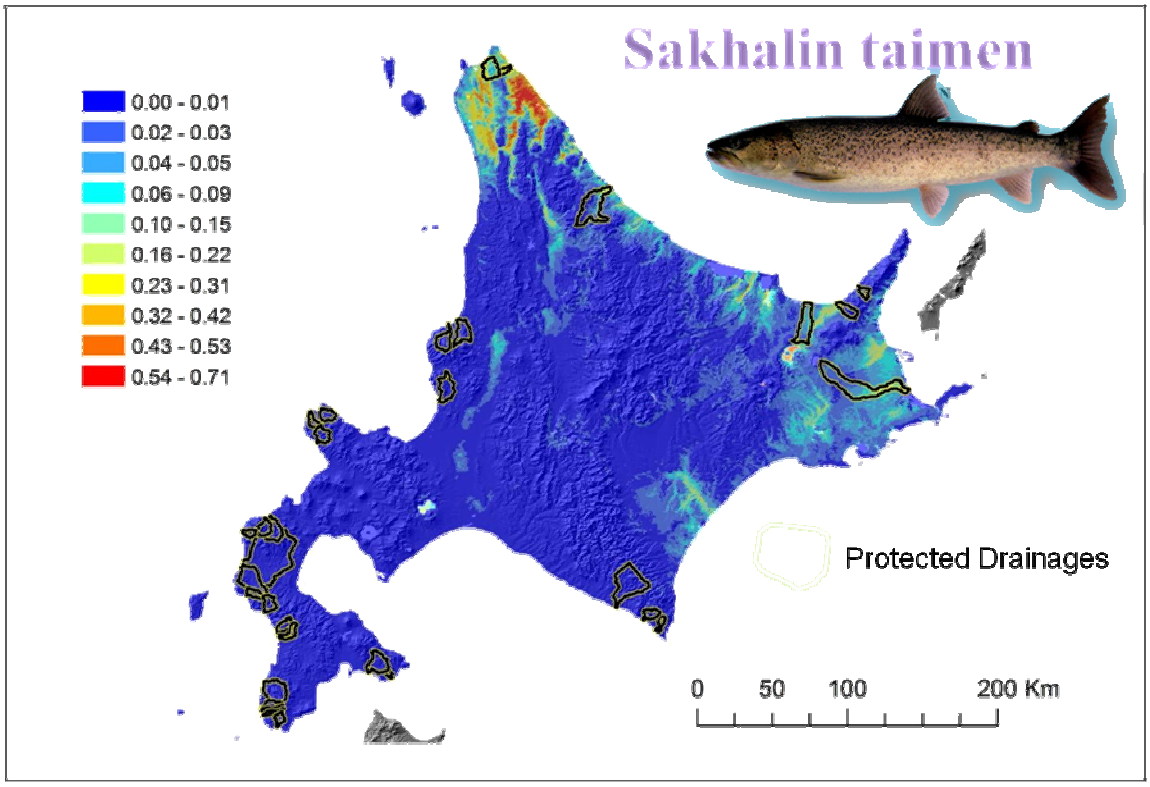


Figure 40. Abundance of Sakhalin taimen in relation to Hokkaido protected areas (outlined)

A Pacific Rim network of salmon strongholds

Guido Rahr. Wild Salmon Center

With much at stake and pressures increasing from climate, harvest and other challenges, it is really important to take the long view, Rahr said. Today, we are seeing important steps in this international conversation about what we need to do. The Pacific Salmon Conservation Assessment has provided a multi-species index that identifies a network of globally-significant salmon ecosystems around the Pacific Rim, in the hope that what happened with Atlantic salmon won't be repeated here. In the past, we have not been proactive, with most of the dollars going to restoring declining systems. This is a losing strategy that we need to change, he stressed. Strategies that react at the eleventh hour are very expensive.

The process of prioritization for identifying strongholds is an iterative one. It will be important to protect regionally-adapted populations in each eco-region and to identify the best places to make early investments, Rahr noted. Even the most productive systems face major challenges today, including mining development in Bristol Bay and poaching in Kamchatka, which has been reported to amount to 55,000 tons per year per river.

The goals of a stronghold strategy include ensuring the long-term health of the most important wild salmon ecosystems across the Northern Pacific Rim. These strongholds would also serve as places to test, demonstrate and exchange new strategies that would be applied more broadly to salmon conservation and management. We need to elevate the status of strongholds as global priorities, Rahr said. Nations and communities need to commit to making wild salmon conservation a primary natural resource management policy in strongholds. We need to accelerate the application of salmon conservation

principles, economic incentives and conservation funding, and to establish a stronghold network to test and share new strategies that support salmon and managers.

Promising developments include Japan work on wild salmon management and sustainable salmon policies in Alaska and Canada, he added. West Coast senators all supported introduction of stronghold legislation in the U.S. last year. Other promising areas include Russian efforts in Kamchatka, Sakhalin and protection of the Kol River, which represents a very important opportunity. The stronghold strategy is not a silver bullet for all the issues and it does not suggest that other rivers aren't important, Rahr concluded, but it's one piece that we have to get right.

Regional strongholds panel

Fran Ulmer, University of Alaska Anchorage

Ulmer introduced the panel by stating that the people who think about salmon aren't necessarily representative of the public and elected officials. If it's an important goal, she asked, what are we going to do about it? The next panel will focus on important next steps.

R.J. Kopchak, Ecotrust

Management is a cognitive challenge, Kopchak said. It can't be done by any one person or interest group. The way we deal with resource management, with jurisdictions and borders, decisions must be made in a fractured environment. So we've drawn a line around a number of major watersheds and tried to better understand them. We're trying to join what we're doing terrestrially to what is being done in the marine environment, with a headwaters-to-ocean strategy (H-to-O). Challenges include how to wipe out borders and find common language. We tried to create an electronic elder – a GIS-based electronic database that cuts across boundaries.

Mike Healey, UBC Professor Emeritus

Healy recalled working on a committee that argued for strongholds years ago and applauded current efforts. We really need to take a long-term view of salmon conservation, he said. Focus on climate change and what it will mean for developing a network. In the next few decades, habitat may no longer be suitable for salmon in the southern part of their range. It's a developing reality and something to consider in selecting strongholds in the southern part of the range. Look for places that might remain suitable despite changes in temperature and hydrology or run the risk of failure in the south. In the north, salmon are doing quite well and may even do better for a while as things warm up. We need to think about which places will be good locations for conserving salmon in 30 to 50 years. If we don't choose the right places, he added, we won't achieve our objectives. We also need to look at the Arctic, including Alaska's North Slope and the Canadian Arctic. Are there places we should think about conserving early on, given that other interests are "champing at the bit" to exploit Arctic resources? The future is not going to be the same as the past, he concluded. I'm not suggesting we shouldn't continue doing conservation, but we need to think more explicitly in terms of what is needed in the context of climate change.

Vladimir Belyaev, Russia Federal Fisheries Agency

Two years ago, Belyaev said, we received a request for a fishery at the mouth of a river that feeds into the Arctic. Climate will redistribute salmon. We do need to look at the future, but don't forget about today. The state of salmon differs in different regions. Japan and Korea are also in a particularly difficult situation with wild salmon. How is Russia different? We have no private property on rivers and coastlines, so it is easy for the federal government to designate protected areas and national parks. But when we speak about creating these, we must understand that these cannot exist separately from fishing and from the people who live around these areas. Salmon conservation is first about human relations, he said. Salmon has to do with fishermen, scientists, Aboriginal people, legislators, bureaucrats, etc. All these people are connected. It's important to think about whether your country has legislation that facilitates designation of protected areas. At a meeting last year where opposing viewpoints were expressed, we had to find a compromise. Even owners of different fisheries have different ideas about

what is needed. In the last year we have advanced a lot, and I disagree that it is as bad as has been described. Criticism is a favorite pastime and is not always objective, he said. We need to create harmonious relations among different players and with other interests such as mining to ensure that if there are impacts, they are minimal. We need to cooperate and move in the right direction.

Tim Bristol, Trout Unlimited

I'm a salesman, not a scientist, Bristol began. Is salmon a game changer? Maybe, but we have a lot of work to do. The real question is how to wield the tools we have in the best way possible. Strongholds provide a way to deal in a "fun" way with things that can be depressing. There are efforts to conserve chunks of land in Alaska. These can be grassroots concepts that bring disparate people together. We're doing that in the Tongas for forests and doing eco-regional assessment for SE Alaska. It's a long battle but people are opening up to these concepts. It's important to reframe it as a place where you can make a living *and* still pass it on to your children. In the Bristol Bay watershed, where there is a mine proposal, various interests were brought together to look at promoting a salmon stronghold. We need to reach political decision makers and the people whose livelihoods depend on salmon, and to explain to the public that salmon are worth conserving. This can lead to a new way of doing conservation that is about fun, food and many other things as well, he concluded.

Randall Hagenstein, The Nature Conservancy-Alaska

Imagine sitting here in 2059. Under Scenario A, strongholds were identified in 2009 and these remain in relative healthy condition as the last vestiges of healthy ecosystems in Alaska. Now consider Scenario B, he proposed, in which returns remain the same as in 2009, thanks to a focus on productive systems that led to a rising tide floating all boats. In rolling out strongholds, we may talk about identifying one or two watersheds that best capture the diversity. But it doesn't mean we don't also focus on other key watersheds. We need to make the investment in targeted watersheds across the range of salmon, as part of a policy that will lift all boats on the rising tide. Only roughly 50 percent of anadromous habitat in Alaska is currently contained within the Anadromous Rivers Catalogue. Once the remainder are identified and added to the database, a host of laws will come into effect and provide important protection, he noted. One thing we could do is get funding to get the stream nomination process moving, in order to bring the full impact of existing laws to bear. It is an arduous process to document flows and what they are over time. One application submitted over 10 years ago still hasn't been adjudicated. But this is a way to address the need to ensure that every water body has water for salmon, he said.

Discussion

Q: Does it make sense to think strategically about species most adapted to climate change, such as Hood Canal coho that are unusually heat tolerant?

- Healey: That's an example of what we need to start thinking about. Some stocks may be more tolerant of higher temperatures. We also need more work on downscaling global climate models. We may find local pockets that will maintain suitability for longer periods of time, such as streams fed by cooler groundwater. Most of those things aren't being done but we need to start now.

Q: In conserving river flows in the BC interior, we need to get away from the idea of just conserving flow and doing comprehensive water management, including preserving aquifers.

- Hagenstein: Groundwater flows are a very important aspect of what constitutes good habitat. Also think of which places are likely to experience the most dramatic flow regime changes, for example glacier-fed systems that will become snowmelt-fed rivers.
- Kopchak: In the Copper River area, most rivers rely on glaciers. These relate well to salmon strongholds. We need to pay attention and learn more and try to maintain some of the function.

Q: What about the big blue ocean area between all the strongholds? In what year do all the nations recognize the tragedy of the commons and address the hatchery issue?

- Ulmer: The NPAFC is an example of a body created to address part of what you're talking about, for example, high-seas driftnet fishing. We need to recognize the positive, including the ban and enforcement against high-seas fishing. We can make progress once we agree on a common goal. The problem is the lack of consensus on whether hatcheries are good or bad.
- Healey: Thinking forward to climate change impacts, we may have to turn to hatcheries to help deal with those problems. We may be able to continue rearing salmon with cool groundwater if the ocean is still okay. We may also use them as a tool for selecting salmon more likely to cope with the changes. While we need to recognize the problems of simply using them for production, they may also be the last bastion of conservation.

Q: We heard about the need for change in individual human behavior regarding our sense of entitlement and ecological footprint. We need education and an informed public that votes differently.

- Kopchak: We need to change the paradigm and create advocates for change and the only way to do that is to change who knows what. The State of Alaska is too big; the scale that people can relate to is the local watershed level.

Q: This process was started to bring people together to talk about salmon across the Pacific Rim. It's good to see more people here this time but we're still talking about the same things. The only thing that's changed is the sense of urgency. We can research them to death, but what can we start doing to implement?

- Ulmer: Adopt a legislator.
- Belyaev: We often ask what are we to do. Our way forward consists of many steps; each is a sum of many initiatives. We need to work as a family of scientists, managers, legislators and politicians. Then we can talk about the total of our land and creeks. Politicians need to be informed to be on our side. In Russia, wildlife articles are not common in the newspapers. There is a need for the public to understand that they are an important part of the habitat.

Q: I see a real danger in a focus on strongholds, both social and political. You need to bring fish into people's backyards. That's where the political, biological and educational value sits.

Q: There is a metaphor for the network of strongholds from a cities conference. It was about treating the city like a body and bringing it to health through acupuncture – you insert a needle to create a benefit that spreads out. How do you arrange it so that examples are followed?

Q: I really like the idea of looking at our present and our future for 2059. Assuming that all the salmon will be in the north, people will start wondering how salmon that once existed in the south arrived in the north. We know how man migrated, but there are two scenarios that could explain how salmon moved north. One is that southern populations died and northern populations grew more abundant. The other scenario is that southern populations started moving north. It's important to know which of these will actually happen. If the first scenario is correct, we should focus on saving northern populations. If it's the second, then we need to protect the southern ones. To distinguish between these two theories, genetic research will be very important and we will be able to do it in salmon strongholds. There will be new technology by 2059, but genetics today, though not perfect, are still useful.

Q: We all recognize that Bristol Bay is a stronghold; so is Kamchatka. Bristol Bay is facing threats from a very destructive form of mining. We could decide that these are two of the strongholds and go ahead and tell legislators and the governor. Maybe they will listen and make changes. There is an opportunity and we can't wait.

Q: There is biological arrogance at these meetings. In Eastern Oregon, there are fish in Pleistocene lakes where there is nothing else left but sagebrush. Populations have the capacity to adapt and respond to challenges if we don't get in the way. We should just let them get on with it. I put much more faith in these fish to adapt by themselves than in anything we could ever do. I don't think we're smart enough to intervene on that level.

Q: The concern about strongholds and marine protected areas is that if we protect some, it gives society permission to destroy the others. We should try to do a better job of protecting everything and give fish an opportunity to adapt. If we are going to do triage, follow Healey's advice and anticipate the changes.

Q: When you have a complex challenge, you need to think of it as a continuous system of water and salmon. Water will always win. The problems are social, and you need to think of social systems like water.

Q: There is a sense of 'us vs. them' in relating to the public. If we want to educate people we need to make more effort to understand where they're coming from.

Q: I'm from a Yukon community of 300 people. We have to manage people, not the fish.

Closing plenary

Brian Riddell & Rich Lincoln, conference co-chairs

Conference highlights: challenges and opportunities

Mark Angelo, British Columbia Institute of Technology

Commending the organizers, Angelo stressed the benefits of being able to meet with colleagues from around the Pacific Rim. This conference has sought to bring the future into focus, and the challenges are daunting. But there has been a real effort to focus on solutions and on the need to protect wild salmon and their habitat. The presentations covered a range of topics, such as understanding the ocean, the importance of monitoring and the role of wild salmon policies. Presenters highlighted the importance of science and management and how to move from discussion and policy development to being more action-oriented. There is a pressing need for action. Despite the measures taken, the state of salmon has continued to worsen in many areas. Whatever the cause, there is a need for fresh approaches.

Angelo recapped some of the key points and perspectives. In parts of the Pacific Rim where salmon are struggling, there is a need to develop ecosystem-based management that incorporates changing conditions. This won't be easy, as there are large knowledge gaps. Shifts in research include modeling of ecosystems with conditions of natural variability that affect salmon, and the need to identify key aspects of environmental and social values. We need to join science and management to ensure they work together, he added. This is the only way to move from talk to action.

A second challenge is how to give the salmon habitat conservation agenda a more preventative slant instead of doing crisis management. We spend too much time trying to fix development proposals instead of doing better up-front planning. New governance structures and collaborative multi-sectoral processes are needed that work harder to incorporate local values and secure local buy in. We need to build on strengths and protect key areas for salmon and in this regard the establishment of protected areas is a very positive move. We need to manage key watersheds that have exceptions values and to support Jack Williams' call to protect, reconnect and restore. In urban settings, we have been very active in such projects. In addition to restoring salmon values, these efforts have had other important spin-off benefits in terms of education and awareness. In addition, we need to protect rivers that are still in good shape in the face of threats from pollution, dams and excessive water extraction. Key basin areas include the "heart of the Fraser." We have one of the most productive areas right in Vancouver's backyard and there is an urgent need for a collaborative plan to protect this area's values.

The Wild Salmon Center is providing a leadership role and the Pacific Fisheries Resource Conservation Council is now undertaking a review to see how the strongholds concept might be used in Canada to complement existing strategies, with a report due this spring. More research is needed to understand changing patterns and more cooperation is also needed to carry out important ocean research, he continued. As salmon nations, we need to work more closely to address interactions between wild and hatchery fish and to determine how many hatchery fish should be introduced into the wild.

With growing competition for access to water and living space, we must build the case for salmon protection and be more persuasive about the importance of salmon values and biodiversity. The treatment of salmon must be seen as a moral issue, Angelo said, not a minor constraint on resource extraction and other such activities. We have a room full of leaders and great ambassadors for salmon. How do we improve leadership so that more is done to reconnect young people with salmon and to reverse a young generation drifting away from nature? This highlights the importance of political leadership. Throughout the Pacific Rim, there is need to change to sustainability as a guiding concept. This is an onerous undertaking and it is only through making the public more aware of salmon values that realistic salmon goals can be achieved. BC Rivers Day and World Rivers Day provide one way of engaging the public and raising awareness to this end.

Many proposals made here hold hope for the years ahead, Angelo continued. We can't forget the hope that the salmon themselves provide. They are opportunistic, resilient and able to colonize. There is no doubt that their future remains unclear and we have no focused snapshot that gives us certainty about the future. We have to accept that and try to manage around it. When things do come into focus, we hope that salmon will be widely seen as an icon – abundant and contributing to our ecosystems. We hope future generations will be able to see and admire these fish just as we have, he concluded.

Farewell and thanks

Riddell thanked Lincoln and the State of the Salmon staff for their efforts in putting this conference together. He also thanked all the praarticipants. Lincoln expressed appreciation to the Gordon and Betty Moore Foundation and other sponsors, along with volunteers, participants and presenters, expressing the hope that the conference would catalyze actions that go well beyond the salmon management realm and focus on changing human behavior. He also thanked the steering committee, Wild Salmon Center and Ecotrust staff, the State of the Salmon team and his co-chair, noting that the organizers would be producing conference proceedings and sharing copies of the presentations.

Acknowledgements

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The State of the Salmon organizing team consists of Rich Lincoln, Peter Rand, Cathy Kellon, Naomi Molstrom, Sydney Mead, Stephen Lloyd, and Sarah O'Neal.

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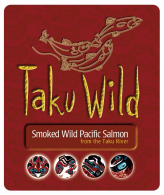
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