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The successful completion of scientific public policy: lessons learned while developing Canada's Wild Salmon Policy

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ABSTRACT

Canada's Wild Salmon Policy gives Canadians the opportunity to make informed decisions about the amount of habitat, ecosystem, and salmon diversity to protect, in order to provide salmon with the potential to adapt and survive in a changing environment. Valuable lessons learned during the completion of this recent landmark conservation policy include: (1) there must be an express need for major new policies and decision makers should be receptive to proposed changes; (2) resource and expertise allocation should be realistic to ensure successful and timely policy completion; (3) science-based policies must be based on good science; (4) environmental policies require input from multiple disciplines—biological consequences are only one element that politicians and decision-makers need to consider; (5) since there will always be uncertainty, and different perspectives on the level of risk that various stakeholders are willing to accept, a precautionary approach is appropriate; (6) to be effective, communication should be open and transparent; and finally (7) it is important to think beyond policy completion—how will the policy be implemented? Documenting these lessons should assist others, thereby resulting in more efficient completion of science-based policies.

1. Introduction

The integration of science and policy is one of the biggest challenges in the policy-making process (Quevauviller et al., 2005). This is partly the result of changing views on the role of science and scientists in policy development. Traditionally, scientists provided relevant expertise to policy makers and managers as the need arose, but few were active participants in the policy-making process. Recently, however, scientists have been encouraged to become much more active in management and decision-making processes (Steel et al., 2004; Pielke, 2007). Initiatives to reform science policy are ongoing within many democratic nations (OECD, 2006).

A public policy is a course of action adopted by a government to achieve a desired goal that is in the best interests of members of society. While frameworks for the incorporation of science in public policy have been developed (Office of Science and Technology, 2000; Industry Canada, 2000; NERC, 2005; SINAPSE, 2007; Sullivan et al., 2006), documentation is often not readily accessible and few appear to have been peer reviewed. Scientists and others involved in policy-making need practical advice on how to better integrate scientific and non-scientific information in science-based public policy.

The Government of Canada released its policy for the Conservation of Wild Pacific Salmon in June 2005 (DFO, 2005). Finally completed after 6 years of drafting, consultation, debate, review, and re-drafting, the Wild Salmon Policy (WSP) is transforming Pacific salmon management and assessment in Canada. The policy began as a local initiative by a small group of concerned scientists and other staff within the

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Canadian Department of Fisheries and Oceans (DFO), and evolved to become a national initiative involving not only government scientists and policy makers, but also stakeholders, academics, interested members of the public, and First Nations (i.e. Aboriginal Canadians who are neither Inuit nor Métis) representatives.

The overarching goal of the WSP is to restore and maintain healthy and diverse salmon populations and their habitat for the benefit and enjoyment of the people of Canada in perpetuity (DFO, 2005). This goal is to be achieved by fulfilling three objectives: safeguard genetic diversity, maintain habitat and ecosystem integrity, and manage fisheries for sustainable benefits. In addition, decisions and activities are guided by four principles: wild salmon conservation is the highest priority, honour obligations to First Nations, sustainable use, and open and transparent decision-making. The policy is being implemented though six strategies, each of which consists of specific action steps (Fig. 1).

Documenting valuable lessons learned during the policy's development will help others working on science-based public policies. The primary goal of this paper is to present these lessons—I do this by summarizing major steps during the policy's development. This also accomplishes the second goal of the paper, which is to describe the WSP. To improve the value of providing these lessons to others working at the science policy interface, I link the lessons to relevant natural and social science literature.

2. Lesson 1—the policy must be needed and decision makers must be receptive to proposed changes

Recognition that overexploitation threatened many of the world's fisheries helped stimulate a new global conservation ethic beginning in the 1980s. The United Nations Convention on the Law of the Sea adopted in 1982 provided an international framework for the development and use of global marine resources (United Nations, 1982). In 1992, Canada was the first industrialized nation to ratify the UN Convention on Biological Diversity (United Nations, 1992), which ultimately committed 168 countries to develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations. Canada released its own Biodiversity Strategy in 1995 (Environment Canada, 1995), and in 1996 passed the federal Oceans Act (Department of Justice, 1996), both of which included commitments to manage ecosystems with a view to conserving biological diversity. Canada's Species at Risk Act, passed in 2003, allowed for the protection of salmon and other species below the taxonomic species level (Irvine et al., 2005).

A turning point for DFO and the way they manage Pacific salmon occurred in 1998. The release that year of the paper "A New Direction for Canada's Pacific Salmon Fisheries" (DFO, 1998) launched a process to clarify the future direction for the management of Pacific salmon by establishing clear principles and articulating operational policies. This new direction helped to create an environment among senior decision makers that was receptive to major changes. This paper set out a broad policy framework, under which specific operational policies and guidelines for managing Pacific salmon were to be developed. The first principle in the New Directions document stated that conservation of Pacific salmon stocks was DFO's primary objective and would take precedence in managing the resource. The New Directions paper catalyzed the development of four influential policies: Salmon Allocation (DFO, 1999), Improved Decision Making (DFO, 2000), Selective Fishing (DFO, 2001), as well as the 2005 Wild Salmon Policy (DFO, 2005).

When the first official draft Wild Salmon Policy was publicly released in March 2000, following work over ~18 months, it was not only a time of increasing awareness of the importance of biodiversity, it was also a time when there were widespread

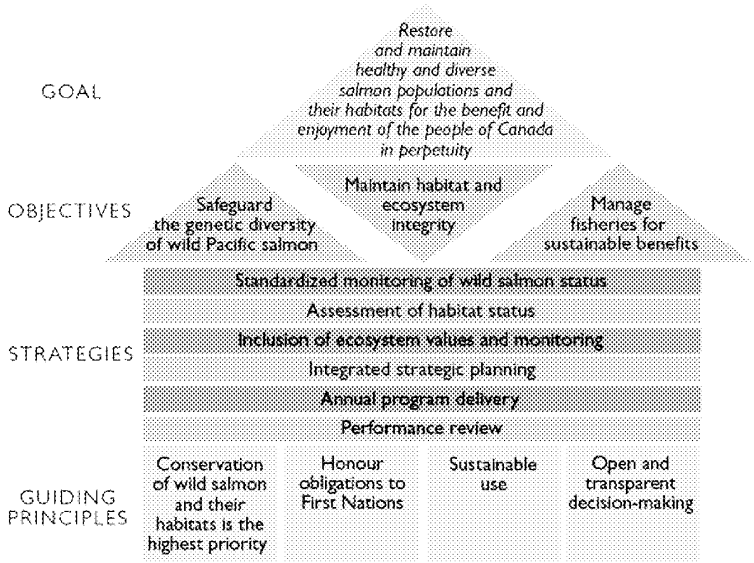

Fig. 1 – Overview of Canada's Policy for the Conservation of Wild Pacific Salmon (from DFO, 2005).

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concerns about the status of populations of wild salmon. A 1996 study for the American Fisheries Society identified more than 8000 natural spawning streams by salmon species in British Columbia and the Yukon (Slaney et al., 1996). Salmon were extirpated in 1.4% of these streams and assessed as at risk of extirpation in another 8%.

In summary, when work on the WSP began, there was widespread recognition of the need for stronger policy direction on the conservation of Pacific salmon. Proposed objectives for the policy were clearly articulated early in its development, and decision makers were receptive for recommendations for significant change.

3. Lesson 2—apply principles of project management including realistic estimates of resources and expertise

Developing a major policy is akin to managing a complex project; numerous sources of information on project management are available (e.g. Frigenti and Comninos, 2002). Although the field of project management continues to evolve, the management of relationships, resources, costs, and risks have been significant components of risk management for over a decade (Crawford et al., 2006). Following the definition and justification of needs and objectives (Lesson 1), and before a decision on policy development is made, a realistic estimate of the resources and expertise required is necessary. Assuming that anticipated benefits justify policy development proceeding, a schedule should be established and the policy developed.

Ecological policy issues tend to be complex and contentious with considerable uncertainty (Lackey, 2007), and the WSP was no exception. Our first draft policy that was publicly released in 2000 included a statement that DFO expected to finalise the policy later that year, yet the policy was not completed for another 5 years. It is clear that we initially did not have a realistic impression of the magnitude of the task we were undertaking.

Planning for adequate resources requires an accurate appreciation of the magnitude of the task, both in terms of the amount of time, but also the particular expertise. Scientific public policy requires input from multiple disciplines, not only during the formulation of the policy, but also during its implementation. Although DFO staff from the science, management, and policy sectors were given flexibility in their work plans and schedules, few were assigned to the policy, which caused some delays. The commitment and involvement of people with appropriate skills needs to be secured. Analogous to a competent project manager, a skilled champion can assist when major policies are being developed. In the case of the WSP, a very senior champion with a background in fisheries management assigned to the project during its final stages helped steer it through the government system and it was ultimately endorsed by senior officials.

4. Lesson 3—good scientific advice requires good science

Canadian Pacific salmon management has evolved during the last 50 years from the management of large stock aggregates to increasingly selective fisheries (Hyatt and Riddell, 2000; Irvine and Fraser, 2008). The WSP further advances the science that informs management decisions—salmon will now be managed and assessed as biologically based Conservation Units (CUs), each of which is a group of wild salmon living in an area that is sufficiently isolated from other wild salmon such that if the salmon in the area were to become extirpated, it is unlikely that area would be recolonized naturally in an acceptable period of time (e.g. a human life-time). Since this change was based on scientific advice, it was essential that the science be well founded. Reputable government scientists played key roles throughout the development of the policy.

A potential concern with public science (i.e. science conducted by government scientists) is its independence from political interference. To alleviate potential concerns, and to receive input on the developing policy in its early stages, we held three science-based workshops with participants from other Canadian regions and the U.S. Pacific Northwest. Non-government scientists and university academics participated throughout the development of the policy, including multi-stakeholder dialogue sessions during the final 6 months of policy development, when all participants were able to contribute to the drafting of the final policy. After the policy was finalised, the Pacific Fisheries Resource Conservation Council, an independent body established to provide advice on conservation and environmental sustainability of Pacific salmon, published several reports advising on aspects of WSP implementation (e.g. Nelitz et al., 2006). Up-to-date genetic and environmental information was incorporated in the peer-reviewed methodology that identified Conservation Units (Holtby and Ciruna, 2007).

Good public science needs the support of governments and adequate resources. Widespread evidence demonstrates that without adequate resources, expected program performance standards can decline, eroding public confidence. In the U.S., recognition of the benefits realised by government supporting broad scientific research led to major funding initiatives such as the National Science Foundation (Bush, 1945). Perceived erosion of public science financial support in Britain undermined the credibility of the science advice provided by the public sector during the bovine spongiform encephalopathy (BSE) crisis in the mid-1990s. This precipitated a change in how advice was provided and emphasized the need for enhanced support of public science expertise (House of Commons Science and Technology Committee, 2006). In Canada, eroding public confidence in scientific advice in regulatory frameworks resulted in a new drug review process in the Health Protection Branch of Health Canada in the late 1990s (Science Advisory Board, 2000) that led to recommendations on adequate resources for Canadian public science, as well as enhanced transparency in process, a broad communications strategy, and international exchange of scientific information.

5. Lesson 4—recognize that environmental consequences are only one element to consider when making decisions

Early WSP development followed a technocratic model (Millstone et al., 2004), which assumed that scientists were best

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able to assess risks to wild salmon and advise policy makers on how to manage and conserve salmon. The 2000 draft and a 2002 revision produced following an ambitious round of information sessions and consultations with stakeholders, interested members of the public, and First Nations, while credible scientific documents, did not deal with social and economic issues. Addressing socio-economic considerations was a major task not anticipated initially that required expertise from outside DFO's Science Branch. Commencing in 2002, policy development was led jointly by the Science and Policy Branches of DFO. From this point on, fishery scientists attempted to assess risks in a socially neutral way, while resource managers and social scientists were tasked with accounting for other legitimate social and economic factors that needed to be traded off against risks to wild salmon. As policy development became increasingly interdisciplinary with additional public inclusion, unbeknownst to us it ultimately resembled the transparent governance model proposed by Millstone et al. (2004) and further developed by Renn (2008). In the transparent model, scientists and non-scientists share in the traditionally scientific role of risk assessment and non-scientific role of risk management.

The WSP seeks to conserve salmon diversity by protecting CUs, their habitats, and their ecosystems. But how much diversity to protect? As we developed the policy, some critics were adamant that the policy should be prescriptive, and that it should specify how much diversity the government would commit to protecting. We disagreed. Ecological consequences are only one element to weigh when making decisions about complex environmental issues. Since societal views that dictate particular prescriptive approaches can change quickly, prescriptive environmental policies can quickly become out-of-date.

WSP Strategies 1–3 respectively provide scientific information on the state of the fish populations, their habitats, and ecosystems (Fig. 1, DFO, 2005). Upper and lower benchmarks delimit red, amber, and green status zones for fish populations (and may also be used to delimit habitat and ecosystem status zones). The benchmark between amber and green zones identifies whether harvests are less than or greater than the level expected to provide the maximum sustainable catch of the CU. CUs in the amber zone are at a low risk of extinction, but there is lost production. CUs in the green zone are biologically secure and desirable from an ecosystem perspective because of the quantity of marine-origin nutrients they bring back to their watersheds.

We deliberately chose to use the term benchmarks rather than reference points (e.g. limit and target), because these points are often associated with societal values, and we agreed with Lackey (2004) that science should strive to be policy-neutral. To allow fishery and habitat managers the opportunity to react proactively, the CU benchmark between amber and red zones is at a precautionary level with a high enough abundance, that there is a substantial buffer between it and when the CU might be considered at risk of extinction by the Committee on the Status of Endangered Wildlife in Canada or Canada's Species at Risk Act (Irvine et al., 2005).

The biological status of a CU may result in specific restrictions being proposed (e.g. fishery closures), but social and economic considerations also need to be considered before major changes are recommended. WSP Strategy 4 (Fig. 1) integrates the scientific information from the previous three strategies with appropriate social and economic information to develop long-term strategic plans consistent with the goal and objectives of the policy. Plans consider risks to wild salmon, their habitats and ecosystems, and weigh the biological, social, and economic consequences of fishing and other activities. The government will honour its legal obligation to consult with First Nations, and these consultations will be complemented with input from harvesters, community interests, local and regional governments and other stakeholders. The policy proposes a structured five-step procedure to assist in strategic planning: (1) identify planning priorities; (2) identify resource management options and alternative management strategies; (3) establish biological, social, and economic performance indicators; (4) assess the likely impacts of management alternatives; and (5) select the preferred management alternative. The amount of diversity to protect will be determined using a risk management approach that considers more than just biological information.

Elkington (1998) was the first to identify the triple bottom line for sustainability: economic prosperity, environmental quality, and social justice. The WSP is aligned along these three pillars of sustainability. Policy objectives include managing fisheries for sustainable benefits (economic prosperity), protecting genetic diversity and habitat and ecosystem integrity (environmental quality), while the overarching goal and second principle highlight the intent to conserve wild salmon for the benefit and enjoyment of Canadians while honouring obligations to First Nations (social justice) (Fig. 1).

6. Lesson 5—acknowledge uncertainty and manage risk

Environmental science can be predictive, but inevitably there is uncertainty. In addition to scientific uncertainty, which may reflect a lack of agreement among competing scientific understandings rather than a lack of understanding (Sarewitz, 2004), there is uncertainty about the consequences of various policy options. We need to acknowledge uncertainty persists regardless of the quality of scientific advice, and accept that it will influence how we manage risk.

Different stakeholders have different perspectives on the level of biological and socio-economic risk they find acceptable. WSP Strategy 4 incorporates objectives and values articulated by stakeholders relevant to multiple scales of governance, essential for complex multi-scaled systems (McDaniels et al., 2006). To manage risk when making resource management decisions, McDaniels et al. identify the need to characterize: (1) the multiple levels where regulatory decisions arise and linkages among them; (2) the means and ends objectives of the stakeholders; and (3) performance measures for decisions as a basis for assessment and evaluation.

The WSP commits DFO to using a precautionary approach to mange risk for wild salmon. The 1995 UN Agreement (United Nations, 1995) obligated Canada to apply the precautionary approach to conservation and fisheries management, and the 1996 Oceans Act (Department of Justice, 1996) included a commitment to manage marine ecosystems based on this

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approach. Specific guidance on the application of precaution is provided by Privy Council Office (2003): (1) the precautionary approach is a legitimate decision-making approach within risk management; (2) decisions should be guided by society's chosen level of protection against risk; (3) sound scientific information must be the basis for applying precaution; (4) mechanisms for re-evaluating the basis for decisions should exist; and (5) there should be a high degree of transparency, clear accountability, and meaningful public involvement.

The lower benchmark (between amber and red zones) illustrates the use of precaution in the conservation of wild salmon in Canada. All sources of uncertainty, including those associated with data and harvest management controls, are considered when identifying the buffer between this benchmark and the level at which the CU might be considered at risk of endangerment.

7. Lesson 6—maintain effective, transparent, and open communication recognising the need for significant public inclusion

Open and transparent decision-making is one of the guiding principles of the WSP (Fig. 1). According to the Canadian Framework (Industry Canada, 2000), "transparency implies an articulation in plain language of how decisions are reached, the presentation of policies in open fora, and public access to the findings and advice of scientists as early as possible. Openness implies early and ongoing consultation with stakeholder groups, as well as public discourse, to ensure that public concerns are considered in making decisions on science-based issues."

Communication needs to flow between those working on policy development and senior government officials and politicians. In democratic governments, this is particularly true near election times when a loss of political good will could mean that a policy is not finished or implemented. It is important to keep senior staff, politicians, and the media well informed. It is also important to communicate with working level staff so the policy achieves acceptance internally.

An extended peer community can enrich the production of scientific knowledge by providing local knowledge that is contextual and case-specific (Lidskog, 2008). We tried to provide opportunities for comment and debate throughout policy development, and to be inclusive in who participated. Following release of the first major draft policy in 2000, we consulted with 28 stakeholder organizations, held 16 community fora/open houses, received 43 written submissions and 110 response forms, and coordinated information sessions in 9 First Nations communities (Irvine and Fraser, 2008). We made ourselves available for bi-lateral briefings when requested. Major comments we considered while writing a major new draft released in December 2004 included: (1) general support for conserving genetic diversity, (2) questions about what level of diversity to conserve, (3) concerns for a more inclusive ecosystem approach, (4) the need to consider impacts on fisheries and human communities, and (5) more details required on implementation. We posted the 2004 draft policy on the DFO web-site and circulated it by e-mail and/or regular mail to various stakeholders, First Nations representatives, and other levels of government.

During 2005, we modified our approach for receiving input. We had found that our approach of travelling around the region giving similar messages to different groups of people, while a useful way of communicating information, did not always allow participants sufficient opportunity to provide significant input. We therefore chose to bring together people with disparate views and work through drafts of the developing policy together. We encouraged individuals to attend successive workshops so that we could learn and develop as a group. Following a multi-interest dialogue forum held on 2–3 March 2005 that included representatives of sport and commercial fishing, environmental organizations, interested public, First Nations, and other levels of government, we again revised the policy, distributed copies and posted it to the DFO website. We held a final forum specifically for First Nations on 29 April 2005 and a final multi-interest forum on 30 April 2005. Changes between the March and April drafts of the policy were reviewed at these latter fora when further, final input was solicited. During 2005 alone we received and reviewed 246 electronic and written submissions. Many comments resulted in changes to the policy, and we documented and responded as often as practicable to comments that did not result in changes.

I only report a few of the more significant changes made in response to input during the final 6 months here. Many of these resulted from discussions with First Nations who have a special relationship with salmon in British Columbia and the Yukon. A new Principle 2 was added (Resource management processes and decisions will honour Canada's obligations to First Nations). We modified Principle 3 to reflect that Aboriginal Traditional Knowledge would inform resource management decisions as part of best science. We expanded Strategy 4 to include references to First Nations governments and changed the description of the proposed planning structure to indicate DFO recognized that the provisions for participation of First Nations needed to respect their individual governance structures. To help make the policy understandable to the public, we minimised the use of scientific and bureaucratic jargon, and defined terms when necessary.

A common understanding of important terminology was necessary to understand implications of the policy. Three important terms that we reviewed with workshop participants before finalising definitions of were "wild salmon", "conservation", and "sustainable use". We recognised that a "continuum of wildness" exists for salmon. For instance, some people consider wild salmon to be only those living and spawning in the wild that have had no influence from cultivation in their ancestry. Others argue that wild salmon include those raised in hatcheries that are released as juveniles but spawn naturally. We defined wild salmon as those that "had spent their entire life cycle in the wild and originated from parents that were also produced by natural spawning and continuously lived in the wild." We required wild salmon to complete more than one full generation in the wild, in order to safeguard against potential adverse effects resulting from artificial culture. Conservation and sustainable use were separate guiding principles in the policy. Conservation was defined as "the protection, maintenance, and rehabilitation of genetic diversity, species, and ecosystems to sustain biodiversity and the continuance of evolutionary

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and natural production processes." Sustainable use was "the use of biological resources in a way and at a rate that does not lead to their long term decline, thereby maintaining the potential for future generations to meet their needs and aspirations." These definitions identified the primacy of conservation over use, and separated issues associated with constraints on use from allocation issues. The intent of the WSP is to protect the biological foundation of wild Pacific salmon in order to provide long-term sustainable use.

Effective, transparent, and open communication helped establish credibility for DFO staff working on the policy. The final policy released in June 2005 did not please everyone. We had not made all the changes that were requested of us. However, by doing our best to ensure communication was open and transparent, we built up trust among stakeholders ranging from fishers to preservationists, particularly during the final stages of policy development. By June 2005, the majority of people we had been working with were satisfied with the policy and keen to see it released so that we could move towards policy implementation.

8. Lesson 7—plan for the future, especially policy implementation

Many public policies probably end up on the shelves of government employees with little impact on society. Because of the far-reaching implication of the WSP across many sectors of society, we included a section in it on implementation where we described the integrated strategic planning process in considerable detail. We identified an interim process in Strategy 4 to manage priority CUs, as well as preliminary features for a new planning structure.

We made two commitments to the future in Strategy 6. First, we agreed to conduct post-season reviews of annual workplans. Second, and more significantly, we committed to having regular independent reviews of how well the WSP was achieving its goals and objectives. Depending on results from the first independent review to be held during the first 5 years of the policy's adoption, policy implementation procedures could be revised to address shortcomings that might be reducing its effectiveness.

Many of the project management approaches identified in Lesson 2 are also relevant to policy implementation. However, uncertainty about the specifics of implementing a non-prescriptive science based policy make it difficult to estimate and secure resources. As with policy development, having a champion of appropriate influence will improve the likelihood of success. Communication is very important; although we are at a relatively early stage since the policy's release, we have held numerous information sessions with various stakeholder, First Nations, and community groups as well as several follow-up multi-stakeholder dialogue sessions to receive input on policy implementation.

9. Discussion

In this paper I documented major lessons the writing team learned while completing Canada's policy to conserve wild Pacific salmon. While these lessons now seem largely to be common sense, and some have been stated elsewhere (e.g. Industry Canada, 2000), we would have benefited by knowing them when we started our work. In summary, it makes no sense to develop policies if they are not needed and senior officials are not receptive to change. If policy objectives cannot be clearly articulated early on, the policy is probably not needed, or at least needs to be better thought out. Resource and expertise allocation should be realistic to ensure successful and timely policy completion. To ensure that environmental policies are based on good science, due diligence procedures should be followed, especially peer input and review. Environmental policies require input from multiple disciplines; politicians and decision-makers need to hear from a broader community than scientists. Social and economic considerations entwine within environmental issues and need to be carefully considered. Since there will always be uncertainty, and different perspectives on the level of risk that various stakeholders are willing to accept, a collaborative and precautionary approach is an appropriate way to manage risk. To be effective, communication early on among participants should be mutual, open, and transparent. An extended peer community including non-scientists needs to be involved throughout policy development. Finally, it is important to think beyond policy completion—how will the policy be implemented?

Many of the lessons we learned illustrate elements advocated by proponents of what has been called post-normal science (e.g. Funtowicz and Ravetz, 2003; Ravetz, 2004). Post-normal science is a precautionary approach that addresses environmental issues where facts are uncertain, values in dispute, stakes high, and decisions urgent (Ravetz, 1999). It welcomes the input of local knowledge provided by non-scientists to enrich the production of more traditional scientific knowledge (Lidskog, 2008). An extended peer community serves a vital role by scrutinizing scientific research and providing necessary local contextual knowledge. However, while in agreement with the process described by these authors, the use of the term post-normal science is problematic to me. The usual outcome of the interdisciplinary approach advocated by Funtowica and Ravetz and others, and supported by myself, is not science *per se*, but policy making, or perhaps decision making. Scientific knowledge is required, but so are other types of knowledge. Science is evolving to fulfill expectations of it when dealing with complex environmental issues. However, in the end, it is the assimilation, interpretation, and recommendations arising from this process that are most important. This may be post-normal, but it is not science.

Much has been written recently about policy advocacy among scientists (e.g. Lackey, 2007; Pielke, 2007; Scott et al., 2007). Pielke discusses how scientists have choices in the role they play in policy development. When there is a lack of consensus on major issues, and high uncertainty about the effects of various options, scientists may choose to be issue advocates, or honest brokers of policy options who provide information but do not make decisions. Scott and his co-authors describe a continuum of policy advocacy for conservation biologists and conclude that scientists should "strive to report it [policy relevant science] in value-neutral language, to state clearly the policy implications of the

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findings, and to be vigorous in their efforts to bring that information to the attention of decision makers and all interested parties." Lackey cautions scientists that when they advocate personal policy preferences, they need to clarify to others that they are playing the role of policy advocate, rather than a policy-neutral scientist.

We scientists working on Canada's Policy for Conservation of Wild Pacific Salmon (DFO, 2005) were clearly advocates of the policy. We genuinely believed that society should take measures to protect diversity of salmon, their habitats, and ecosystems. Diversity provides salmon with the potential to adapt to future pressures and changes in climate, fishing, and habitat, and increases their likelihood for survival in the longer term. We argued that protecting diversity is a type of insurance that is key to the continuance of healthy populations of wild salmon and therefore the ecological processes that depend on them and the cultural, social, and economic benefits drawn from them. These views, although articulated by us, were generally shared by those who participated in the development of the policy (i.e. stakeholders, First Nations, public). Where differences in opinion were common, were in values—how much diversity to protect, and what appropriate levels of risk are. Here we as natural scientists were careful not to be advocates. As the policy (and its authors) matured, and we increasingly recognised that environmental effects are only one factor that decision makers need to consider, we became honest brokers of policy options (*sensu* Pielke, 2007). Scientists should provide informed opinions about plausible consequences of actions or inactions, and monitoring effects of choices (Oreskes, 2004), but should exercise great care to play appropriate and clearly defined roles (Lackey, 2004). Understanding the anthropogenic drivers of changes to diversity, and the societal impacts of response strategies should be left to social scientists (van den Hove, 2007).

Various ways to bridge science and policy in environmental matters have been explored (Pohl, 2008). In Canada, the Council of Science and Technology Advisors (CSTA) was established in 1998 to provide the Government with external expert advice on science and technology issues. Building on work in the USA, UK and elsewhere, the resulting SAGE Report (CSTA, 1999) identified six principles, each with guidelines, to ensure that government decisions are informed by sound scientific advice: (1) early identification of issues; (2) inclusiveness; (3) sound science and science advice; (4) uncertainty and risk; (5) transparency and openness; and (6) review. In 2000, the Government of Canada adopted these principles in its Framework for Science and Technology Advice (Industry Canada, 2000). Although the CSTA was recently replaced by the Science, Technology and Innovation Council, this framework continues to provide a benchmark against which to test the robustness of science and technology advisory processes. Lessons learned while developing the WSP validate many of the principles in the framework.

To ensure that science-based policies have a solid science foundation, due diligence procedures need to be followed, including peer review. The US science-policy system has many independent non-government organizations providing checks and balances to government, as well as advisory bodies within government. For instance, the Union of Concerned Scientists (2004) has raised concerns of political interference on scientific advice, and provided recommendations on restoring scientific integrity in U.S. government policymaking. European science advice structures and methodologies exhibit considerable national differences, yet show common principles of good practice including: openness and transparency; independence; and cooperation between advisory bodies (SINAPSE, 2007); and increasing engagement of stakeholder groups and public in the advisory process (Glynn et al., 2003). As a result of the BSE crisis, guidelines developed in the UK are regularly updated to provide scientific advice in departments as well as advisory bodies (Office of Science and Technology, 2000, 2005). A review of the publicly funded science and technology community in Australia (Stocker, 1997) led to: improvements in science advisory structures; better coordination to ensure consistency and quality of science advice; improved timeliness and broader opinion in advisory processes; and maintenance and increase in public confidence in the overall science advisory process. These examples illustrate an increasing awareness of the value of incorporating non-scientific information in science-based policy development.

Much has been written recently about public inclusion in scientific policy development and risk assessment (e.g. Irwin and Michael, 2003; Ravetz, 2004; Lidskog, 2008; Renn, 2008). We found that non-scientists have different perceptions of risk than scientists, but their views are not homogenous. This was illustrated in the central debate of "how much salmon diversity to protect". Environmental representatives and most First Nations generally argued for the protection of maximum amounts of diversity, while most fishing (recreational and commercial) representatives felt that it was less necessary to protect maximal diversity and supported the concept of additional enhancement (e.g. hatcheries) in the event of losses of diversity. Within this debate, science played a pivotal role in providing realistic interpretations of the risks associated with particular conservation strategies and the most likely outcomes.

First Nations representatives, stakeholders, and the public all contributed valuable knowledge. Our approach of holding successive professionally facilitated workshops with significant participant overlap allowed an increased understanding of others' views and values, and led to a greater degree of consensus than we anticipated. Information exchange was only one benefit—we developed respect for, and learned from each other. This approach required a significant effort, but was well worth it. The successful completion of the science-based public WSP depended on input from an extended peer community consisting not only of other scientists and resource managers, but also of stakeholders, environmental enGOs, interested members of the general public, and First Nations.

The valuable role of First Nations representatives in the development of our policy deserves special comment. Aboriginal communities have coexisted with Pacific salmon for many generations, and many continue to rely on salmon, not only for food, but also as a central component of their culture. First Nations representatives contributed three types of important information—local contextual knowledge generally specific to the area where they lived, a holistic understanding of the role of salmon in the ecosystem and vice versa, as well as a deeper form of traditional knowledge and wisdom (Turner et al., 2000). Figuring out how to incorporate the latter in the modern science world remains a significant challenge.

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Canada's WSP is an example of the successful integration of science and policy that is paying dividends. The policy has and will continue to change the management and assessment of Canadian Pacific salmon, their habitat, and ecosystems. Salmon are now managed and assessed on the basis of Conservation Units, which recognize the importance of diversity. Continued implementation of the policy will result in an increasingly ecosystem-based approach to fisheries and habitat management. The WSP required cooperation among disciplines, and significant public inclusion; these are also important in policy implementation. The policy has been used as a template for a developing policy on Atlantic salmon from Canada's east coast, and has helped guide the development of various science-based conservation policies for non-salmon from Canada's Pacific coast. The lessons presented in this paper should aid the development of future science-based policies internationally as well as in Canada.

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