Knowledge Integration in Salmon Conservation and Sustainability Planning

TOWARDS EFFECTIVE IMPLEMENTATION OF WILD SALMON POLICY STRATEGY FOUR

Prepared by Julie Gardner, Ph.D., Dovetail Consulting for

Watershed Watch Salmon Society
Watching Out for BC's Wild Salmon

David Suzuki Foundation
SOLUTIONS ARE IN OUR NATURE

PREFACE

Watershed Watch and the David Suzuki Foundation believe that the Wild Pacific Salmon Policy is a significant natural resource policy achievement for Canada, and for Pacific Rim countries as a whole. This federal policy lays the foundation for truly sustainable Pacific salmon management in Canada consistent with the latest conservation science. The success of its implementation should also serve as a model for sustainable, ecosystem-based natural resource management. The focus on the conservation of salmon diversity is the underlying principle of not just salmon persistence, but for sustainable fisheries in general.

Since the release of the policy in 2005, significant achievements have been made on the first three strategies, which focus on defining what we hope to conserve, and the methods for tracking the status of salmon and salmon habitats. This process has been supported by science, with some integration of traditional knowledge.

Despite the progress on these strategies, significant challenges remain to actually implementing the Wild Salmon Policy. These challenges include a lack of finances and people to support implementation, as well as support for the monitoring efforts required for ongoing management. This paper focuses on the specific challenge of meeting the fourth strategy of the policy, namely, Integrated Strategic Planning, which is a key element to functional implementation of the policy. In other words, when people who care about salmon are working together on sustainable management of wild salmon, a successful outcome is more likely.

With the support of the Gordon and Betty Moore Foundation, the Jim Pattison Foundation, and the Bullitt Foundation we commissioned Dr. Julie Gardner to prepare this paper to help guide integrated planning efforts under the Wild Salmon Policy. Dr. Gardner's work explores fundamental themes of communication, trust, transparency and uncertainty that must be considered and embraced for successful implementation of the policy.

We recognize that the profound shifts in the approach of government and stakeholders necessary to achieve the recommendations of this report require leadership from all sectors and all levels of government. Watershed Watch Salmon Society and the David Suzuki Foundation remain committed to helping those who will help us all in building a sustainable future for wild Pacific salmon in Canada. We hope this paper proves to be useful to them.

Dr. Craig Orr
Executive Director
Watershed Watch Salmon Society

Jeffery Young
Aquatic Biologist
David Suzuki Foundation

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SUMMARY AND RECOMMENDATIONS

The importance of knowledge issues in the implementation of the Wild Salmon Policy

The goal of Fisheries and Oceans Canada's Wild Salmon Policy (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" (DFO 2005 p.8). The policy has not been fully operationalized since its release in 2005. Pressure is mounting as the International Union for Conservation of Nature (IUCN) recently added a number of subpopulations of BC Pacific sockeye salmon to the Red List of Threatened Species and recommended that the federal government "Fully implement and fund Canada's Fisheries and Oceans Wild Salmon Policy immediately" (Rand et al. 2008). The goal of this research is to further implementation of the policy, supporting progress towards a functional WSP meeting its full potential.

Of the six strategies in the policy, Strategy 4 is highly relevant to policy implementation, as this is the stage at which actions get spelled out by local and regional planning committees. This report focuses on Strategy 4, in particular on the importance of, and mechanisms for, integrating knowledge frames in integrated strategic planning. Related issues include: complexity of the salmon conservation planning challenge; limitations of science; under-appreciation of local, traditional and fishermen's knowledge; and impacts of uncertainty and risk. The central research question is:

> How can the WSP strategic planning committees (as established in connection with Strategy 4) best integrate the different sources of knowledge required to carry out strategic planning for implementation of the WSP?[1]

WSP planning requires that certain information be used to generate plans that will sustain "conservation units." The parties involved in planning have interests that lead them to focus on different types of information, and they have different abilities and backgrounds that lead to different "ways of knowing." When diverse ways of knowing meet the complexities and uncertainties of managing salmon, dysfunctional dynamics among stakeholders and government representatives (e.g., lack of trust) can escalate, reducing the potential for consensus and stakeholder buy-in to management measures. Furthermore, the separation of, or even contradiction between, formalized research knowledge and users' knowledge can limit success in achieving long-term sustainability of the fisheries resource, as it neglects information that can significantly contribute to effective ways forward.

The WSP is moving in the right direction by promoting an inclusive and transparent approach to decision-making that acknowledges the importance of science, aboriginal traditional knowledge, and social values. This research aims to contribute to successful implementation of the policy by investigating how people working to collaboratively plan for the conservation and best use of wild salmon can build the necessary confidence in

[1] The research approach was a review of diverse literature, supplemented by interviews to shed light on two examples: the Barkley Sound and Skeena River WSP pilot projects.

information, and develop the ability to communicate across their differences using that information.

Information required by the WSP for Integrated Strategic Planning

Section 2 of the report addresses information required by the WSP for Strategy 4: Integrated Strategic Planning. There are six strategies in all, each of which has a number of "action steps." The strategies are:

1. Standardized monitoring of wild salmon status
2. Assessment of habitat status
3. Inclusion of ecosystem values and monitoring
4. Integrated strategic planning
5. Annual program delivery
6. Performance review.

The WSP strategies are sequential, so according to the policy, Strategies 1-3 are to be implemented before Strategy 4, integrated Strategic Planning, is carried out, and all three of these strategies provide information for Strategy 4. Despite this overall stepwise sequence of strategies, the implementation of various strategies is ongoing and will naturally overlap.

In Strategy 4, the information from the first three strategies is analysed and combined with more information in the planning process. The steps for strategic planning are:

Step 1: Identify planning priorities

Step 2: Identify resource management options and alternative management strategies

Step 3: Establish biological, social, and economic performance indicators

Step 4: Assess the likely impacts of management alternatives

Step 5: Select the preferred management alternative.

The WSP prescribes that a range of information needs be met, and is on a good track in indicating that more than one knowledge frame should come into play. Fisheries and Oceans Canada (DFO) anticipates various sources of knowledge will be drawn upon for WSP implementation in addition to technical/scientific knowledge, highlighting Aboriginal Traditional Knowledge. Nevertheless, the policy dominantly reflects a western science approach, and the integration of diverse knowledge types in WSP implementation will be a challenge.

Knowledge frames relevant to salmon conservation planning

Section 3 sets the scene for addressing this challenge by shifting attention from *what* we (need to) know to *how* we know. *How* we know influences the kind of information that is brought to bear in conservation planning. The different ways that people acquire and communicate knowledge also influence how those involved in planning understand the information; therefore, understanding these differences is important to the success of consensus-seeking approaches.

The report simplifies the array of knowledge frames relevant to salmon conservation planning into the general categories of natural science and social science, and, clustered together, traditional, local, and/or fishermen's knowledge.

Science (natural sciences)

The importance of science to meeting the challenges of salmon conservation is unquestionable. Its many qualities include: it furthers understanding of natural systems; it builds credibility with the parties involved in salmon conservation; and it applies rigorous quality control. But the focus on these assets draws attention away from limitations of the science knowledge frame, which, in the case of salmon conservation planning, include:

- lack of fit between scientific methods and some fisheries management needs;
- proprietary nature of research data;
- overemphasis on quantification to the neglect of information that cannot be quantified;
- overconfidence in the ability to produce unassailable scientific results;
- unconstructive use of science in adversarial settings;
- limitations on the objectivity/neutrality of science;
- limitations on the comprehensiveness and certainty of scientific information.

Traditional and local knowledge

Traditional ecological or indigenous knowledge (TEK) is a cumulative body of knowledge, practice and belief handed down through generations by cultural transmission. Local knowledge is knowledge held by people who have come to know an area by living and/or working in it. TEK can be seen as a special case of local knowledge that, when passed on for generations, becomes TEK (Berkes et al. 2001). Local knowledge includes fishermen's knowledge and the knowledge of other stakeholders in salmon conservation planning such as watershed stewardship groups and members of local government councils. As with science, traditional and local knowledge (TLK) has both benefits and limitations for salmon conservation planning.

Advantages of integrating TLK into salmon conservation planning include: support for collaborative processes; scrutiny of scientific research; provision of a range of fisheries-related information to improve the performance of management; provision of specific, detailed data; aggregation of detailed data to data sets for use by scientists; and attention to ecological complexity.

Limitations on integration of the TLK knowledge frame into the integrated planning process include:

- concerns about accuracy and verification;
- challenges related to standardization and scale;

- concerns related to the holder of the knowledge (e.g., reliability, bias);
- proprietary nature of TLK;
- attachment of traditional knowledge to its context;
- risk of neglecting more significant factors affecting the salmon conservation planning process;
- potential injustice to the holders of TLK.

Social science

There has been little social science research within fisheries management agencies in Canada (Soto 2006) and in salmon research in general as compared to natural science. Disciplines such as economics, sociology, psychology, and political science—the "soft sciences"—are marginalized relative to the disciplines of genetics, molecular biology, climatology, ecology, and oceanography—the "hard sciences." Reasons for neglect of the social science knowledge frame overlap with those causing the underappreciation of TLK, and include the difficulty of quantifying research results. The WSP recognizes the need for information on themes like community economics in planning, but does not explicitly acknowledge the need to tap social science.

Resource management approaches calling for integration of knowledge frames

Three approaches to wild salmon conservation and sustainability central to the WSP are highlighted because of their direct relevance to the integration of knowledge frames: collaboration/consensus processes, the precautionary approach, and ecosystem-based management. Ways that each of these drive and benefit from knowledge integration are explained in the report. As well, post-normal science is introduced because of its potential to act as an integrative knowledge frame that might transcend the distinctions between ways of knowing. (Post-normal science recognizes the influence of values on research, embraces uncertainty, and involves non-scientists.)

Need for reorientation around knowledge frames in the WSP

The analysis of knowledge frames suggests the need for a general reorientation of two implicit assumptions of the WSP:

- The policy needs to more fully acknowledge that knowledge frames outside of natural science are more than just "values," and that natural science is not value-free;
- The policy needs to more fully acknowledge that knowledge about salmon stocks, habitat, and ecosystems is local as well as scientific, and that social and economic considerations require science as well as local knowledge.

Integrating knowledge in WSP planning

Section 4 proceeds to more detailed prescriptions for integrating knowledge in WSP planning. It asserts that those involved in integrated strategic planning need to recognize the limitations of the various frames of knowledge while eliciting from each "way of knowing" the information and wisdom required to meet the challenges of salmon conservation. But integrating knowledge frames is difficult and practical guidance is scarce. In this section, suggestions and principles gleaned from the literature are put forward, and examples from the Barkley Sound and Skeena Watershed experiences are offered where available. Connections to specific parts of the WSP are also made where relevant.

A summary and the results of this analysis are presented below in the form of recommendations, under seven general themes.

Recommendations: Priorities for integrating ways of knowing into salmon conservation planning

1. Recognizing different knowledge frames

Fundamental to integrating knowledge frames is the need to recognize that various ways of knowing exist and to respect the value of each without placing them in a hierarchy. Options for blending and/or sequencing attention to the different types of knowledge should be considered. Since science is currently the dominant knowledge frame in salmon conservation planning, special efforts may be needed to carefully draw in traditional and local knowledge, and to encourage multidisciplinary perspectives.

Bring to light and respect ways of knowing:

Encourage all parties involved to recognize that there are different kinds of knowledge, which are equally legitimate. The WSP is on the right track: "All parties should respect the others' opinions and processes, and work towards consensus" (DFO 2005 p. 28). Principled, structured consensus processes as prescribed by the WSP should be able to avoid a hierarchy of knowledge types. The "Knowledgeable Persons Panel" to be convened in connection with Strategy 3 (Ecosystem values and monitoring) (Nelitz et al. 2008 p. 16), demonstrates DFO's openness to various ways of knowing.

Give knowledge frames equal status:

Rather than seeing science as superior, participants should view all knowledge fields as containing valuable expertise. The WSP progresses from an early emphasis on science, in Strategies 1 and 2, to increasing emphasis on participant knowledge and values in Strategies 3 and 4. It is risky to delay attention to the principle of inclusion this way because the science phase associated with the earlier strategies is permeated with subjective framing assumptions that should be informed by the parties on the planning committees.

Blend and/or sequence application of knowledge bases as appropriate:

Not all knowledge sources need to be brought to bear in a multi-party process at every turn. Sometimes traditional and local knowledge can be pulled into a science framework; in other cases some issues are best addressed through science or TLK independently; and in still other areas there is overlap that calls for harmonizing of the various types of knowledge. This flexible approach should help the WSP planning process integrate knowledge types appropriately.

Take care in integrating traditional and local knowledge into science:

Tap methods for bringing traditional and local knowledge into a science frame where appropriate but avoid validating only those non-scientific knowledge claims that conform to the scientific model.

Encourage multidisciplinary perspectives and include social science:

Multidisciplinary approaches are necessary to support salmon conservation planning for a number of reasons, yet the WSP is not configured to encourage multidisciplinary approaches early enough in the planning process. Its delayed attention to knowledge from outside the natural sciences (i.e., only in the latter stages of planning) is unwise. The capacity to fill the social science gap does not exist within DFO at present, and the department should prepare to access social science expertise efficiently. That said, parties other than DFO might adequately fill the gap.

Recognize self-interest as a type of information:

Overt expression of self-interests can productively enrich the deliberative process, leading to a solution that serves the common good. It also helps participants work out for themselves what they want and need, and to become understood and respected for what they want and need.

2. Determining what information is needed

The methods and mechanisms for bringing information—including science—into consensus processes are as important as the content or meaning of the information. To pave the way for integration of knowledge bases, even before information collection begins, collaboration should determine priority information needs, through problem definition and objective setting. Priorities may be usefully reflected in agreed-upon indicators. Collaborative definition of criteria and standards for assessing the validity of information can also help with integration of information later in the process.

Collaborate on information needs early:

Questions mutually framed by stakeholders are an essential foundation for an effective process, and even science questions should arise from the parties involved rather than from government agencies or from "the data." Scientific inquiries are most useful if the parties involved have the opportunity to help frame the issues being examined.

Start with clear problem definition and objectives:

The process of determining what information is needed by a multi-party planning process should start with collaboration on the definition of the problem, priorities, and/or objectives, and it is laudatory that "Interim Guidance for the Development of Strategic Plans" under the WSP recognizes the importance of taking adequate time to identify planning priorities at the outset; however, the WSP risks front-loading the process with scientific assessments before planning priorities are set by the parties involved. While the "inclusiveness" key attribute stated in Strategy 4 calls for all parties to have the opportunity to participate throughout the development of plans (including input to the articulation of objectives), the process is actually well along with the implementation of Strategies 1 to 3 by the time the planning committees are convened. Whether participants will be willing to establish objectives "consistent with the WSP objectives and principles" remains to be seen.

Agree on indicators:

Stakeholder involvement in determining indicators can help to build agreement and acceptance between fishermen, researchers, management authorities, and other users by making possible a shared knowledge base, which is a solid foundation for plan development and implementation. Indicators can be scientifically valid while reflecting the perspective of users. The WSP is on the right track in following inclusive approaches to the identification of indicators, recognizing the importance of local and First Nations knowledge.

Establish criteria for research/information:

Attention should be paid to shared means of assessing information brought to and/or used by the consensus process. Ways that the validity of information from different knowledge frames can be assessed include extended peer review, joint agreement on standards and value premises, society-wide agreement on guidelines, and validation of local, traditional, or fishermen's information.

3. Collecting and processing information

Database design and data collection make up a large, specialized field beyond the scope of this study. Some key directions in this area relevant to the integration of knowledge bases for salmon conservation planning are nevertheless provided.

Collaborate in the assembly and use of information—throughout:

Collaboration is important at every stage in the development of shared knowledge, including data gathering, research and database design. For the strategies of the WSP that precede integrated strategic planning, the need to assemble information from multiple sources is recognized, but DFO is mainly portrayed as the collector of the information rather than as a collaborator in a shared information collection system. The policy does, however, indicate intentions towards a collaborative approach. The best way forward would be to explore joint systems, rather than expecting other parties to join in a DFO-led system.

Consider participatory research:

Participatory research, or "participatory action research", is an approach that engages local people in research projects that aim for results of interest to the study area residents or resource users. Its methods could be applied to information gathering processes for integrated strategic planning.

Link sources of technical knowledge to the multi-party process:

The establishment of technical committees or research initiatives that are intentionally separated from the multi-party committee can add value to collaborative processes, but there are risks involved in having them overly distanced from those engaged in the planning task—e.g., committee structures cannot be relied on to incorporate or transmit local, traditional, and fishermen's knowledge. Ways of counterbalancing the risks while taking advantage of what technical committees have to offer include clear definition of the technical committee's role, questioning of technical committee findings, membership linkages between the technical and planning committees, direction of the technical committee by the planning committee, and tailoring of technical committee results.

4. Providing access to information

Another basic requirement for the integration of knowledge from different frames is that that all participants have equitable, timely, and thorough access to information.

Ensure transparency and equity in access to information:

At all stages of the process, from data gathering to database design, modelling and clarification of assumptions used in models, transparency and equity in access to information is important to the success of collaborative processes. The WSP recognizes transparency as a key attribute of integrated strategic planning, stating: “Information considered in making recommendations should be publicly available and communicated in a timely manner” (DFO 2005 p. 28). On practical as well as ethical grounds, it is particularly important to share information from existing data collection programs (e.g., fish tagging) with the communities where the information is collected. Equitable access also includes timely release of information to all parties simultaneously. The Pacific Fisheries Resource Conservation Council (2006) recommended the establishment of effective and formal partnerships to ensure that data required to implement the habitat and ecosystem components of the WSP are accessible.

Disseminate information to process participants:

A general principle for effective collaborative resource management is to spend sufficient time in sharing data about management issues. If all parties are exposed to the same information and allowed time to digest it and discuss it with their constituents, there is a higher likelihood of consensus, and a better chance of a collective and complete understanding of the resource (Pinkerton 1989, 1996).

5. Addressing uncertainty

Areas of high uncertainty need to be distinguished from areas of lower uncertainty—where there is scientific consensus. Uncertainty can be put in the context of what is known relative to what is not known, and can otherwise be described in terms that non-experts can understand. Attention to uncertainty calls for risk management, acknowledging that uncertainty persists regardless of the quality of scientific advice (Irvine 2008). Collaborative and transparent processes need to acknowledge different conceptualizations of risk and enable participants to share the risk assessment role.

Don’t expect uncertainty to be eliminated:

A caution associated with the drive to analyze uncertainty and risk is that it can lead to over-quantification and become an end in itself. The results of even the highest quality, most thorough research do not guarantee a stop to arguments about data. Addressing uncertainty may not prevent arguments about numbers, but it can make the debates more informed, and more open to the array of information that can be drawn from different knowledge frames.

Put what is known in the context of what is not known:

Multi-party processes should not ask scientists for certainty; rather they should encourage scientists in their duty to candidly provide the best information possible, which includes acknowledgement of what we know and what we do not know. Effectively implemented, the WSP can provide a vehicle to drive more disciplined thinking about information and assessment of it, by clarifying for participants in the planning process the levels of uncertainty and limits to achieving certainty.

Disclose scientific assumptions:

Scientists have an obligation to become more transparent in their communications, making their assumptions and values visible. At the same time, participants in planning committees need to be encouraged to see as clearly as possible the different assumptions that underlie the science presented to them.

Describe uncertainty:

WSP Strategy 4 requires that the documentation of short- and long-term benefits must "explicitly consider uncertainties in not only the scientific information, but also in the economic and social information that decision makers use" (DFO 2005 p. 24). Describing the blurry line between certainty and uncertainty is necessary, though difficult. An array of tools is available, from technical to informal.

Share the risk assessment role:

While expert science may be necessary for the rigorous assessment of risk, it is insufficient on its own, so it is essential to include broader perspectives. The WSP recognizes that scientists and non-scientists should share in the role of risk assessment. Strategy 4 recognizes that the determination of risk tolerance must involve various parties, but does not specify involvement in other aspects of risk analysis.

Acknowledge differing perceptions of risk:

Differing perceptions of risk lead to differing weighting of problems, and can lead to differing conceptualization of issues and heightened differences in solution preferences. The WSP is realistic in its acknowledgement of different perceptions of risk. It appropriately emphasizes "constructive dialogue" to resolve the differences of opinion that will occur between individuals and interest groups about the "best" alternative because of their different priorities and tolerance to risk.

6. Improving communication across knowledge frames

Difficulties associated with combining information from sources with different knowledge frames include "variation in the contexts, tools, training, and technological resources" that shape observations and interpretations, as well as variation in the "mechanisms they use to record, check, and present the results of those observations" (McGoodwin et al. 2000 p. 251). Good communication can help to cross the gulf that these multiple differences create.

Build capacity for participants to discuss different types of information:

The best stakeholder processes improve the capacity of all participants to learn from different kinds of knowledge and communicate across different perspectives (Adler et al. 2003). Local residents and resource users generally have greater capacity than scientists for some aspects of salmon conservation planning, such as the ability to draw on detailed ecological knowledge, while capacity may have to be built in their ability to understand and work with technical information. Education for all participants on how to work toward consensus leads to more effective collaboration.

Communicate science/technical information clearly:

Disseminating scientific information from Strategies 1, 2, and 3 (e.g., about conservation unit status) in a clear and meaningful way to the parties engaged in planning is a challenge facing the implementation of the WSP (Nelitz et al. 2008). Advice as to how scientific information can be made understandable to parties with other knowledge frames includes: learn by doing; make presentations clear and simple; present data in a form that suits the audience; and avoid communicating excessive information. Communications must be also clear in language related to planning and collaboration.

Communicate traditional and local knowledge information clearly:

Fishermen, community groups, Native peoples, and others have to communicate information in an understandable way if they want it to be considered in the consensus process, just as scientists do. The need for particular attention to First Nation knowledge is recognized in the WSP requirement to incorporate aboriginal traditional knowledge (ATK). Consideration of ATK calls for the utmost respect, often with protocols explaining how the knowledge can be collected, communicated, stored, and applied.

Include storytelling:

An area of communication that has received increasing academic attention over the past decade is storytelling, particularly in the field of planning. A multi-party group that openly listens to stories can allow participants to speak in their own voice and comfortably communicate knowledge from frames other than science. Storytelling by scientists and technical experts can provide important context and help people understand the assumptions and values that are embedded in models and findings. Quantitative techniques are emerging for the analysis of stories, or “narratives.”

Make space for face-to-face communication:

When the parties in a planning committee do not understand each other they have a remedy: they can discuss their differences in understandings. Face-to-face communication is critical to building understanding across knowledge frames, and is particularly important for communicating local and traditional knowledge, which is less often written (Wilson 2003). Bilateral discussions can be helpful, but each party should have the opportunity to convey its views directly to the parties that are not involved in the bilateral process.

Use deliberative inquiry:

A means for making the most of the time spent in face-to-face communications that is growing in popularity is the deliberative inquiry process (DIP). DIPs aim to provide a safe environment for respectful engagement on difficult public policy issues, allowing opportunities for laypeople to challenge expert assertions and other information with mutual respect, recognizing that adequate time needs to be provided to consider and discuss the information.

7. Using structured approaches for applying knowledge

Shared analytical methods—or “decision support tools”—have much to offer in integrating knowledge frames. While these tools typically require expertise in their application, they can provide a strong foundation for communication among parties with different ways of knowing. As in the case of science in general, however, the power, accuracy, and status of these tools among other modes of information sharing should not be overestimated.

Collaborate in developing the analytical approach:

Decision support tools are important to the processing of information assembled in earlier stages of integrated strategic planning. The WSP describes a structured process that first establishes specific objectives and priorities, and secondly allows the biological, social, and economic consequences of different conservation measures and activities to be considered and weighed in an open and transparent way (DFO 2005). In Step 3 of the integrated strategic planning process the WSP prescribes a suitably collaborative way of filling in the detail of the analytical approach: “input from First Nations and other participants in the planning process will be used to develop an evaluation framework for comparing the management alternatives” (DFO 2005 p. 46).

Consider a range of decision support tools, including simple ones:

Simulation of predicted outcomes of various alternatives can help planning participants cope with the complexity of the salmon conservation challenge, although the projections of change themselves typically require expert input, as recognized in the WSP. In Step 4 of integrated strategic planning, the likely impacts of management alternatives are to be assessed to provide a set of predicted outcomes, and “DFO will play a lead role in providing or obtaining these predictions from appropriate technical experts” (DFO 2005 p. 46). A more inclusive approach is suggested in the Interim Guidance for the Development of Strategic Plans: “In other cases, reliance may need to be placed on the expert judgments of DFO staff, *First Nations and other participants in the planning process*” (Fraser 2007 p. 18 emphasis added).

Carefully time the introduction of structured decision-making tools:

While structured decision-making tools provide a solid basis for analysis, both the type of decision-making tool and the timing of its adoption should be tailored to the evolution of the multi-party committee process (Sigurdson pers comm. 2008).

Don’t over-estimate the power of models:

It has to be kept in mind that models do not have perfect predictive capacity. Properly designed decision-support tools can take into account the quality of the available data and corresponding level of uncertainty, rather than assuming a higher level of certainty than can be realistically achieved within the capacity of the process.

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ACRONYMS

AAROM	Aboriginal Aquatic Resources and Ocean Management (a DFO program)
ATK	aboriginal traditional knowledge
CJFAS	Canadian Journal of Fisheries and Aquatic Sciences
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CU	conservation unit
DIP	deliberative inquiry process, or deliberative and inclusive process
DFO	Fisheries and Oceans Canada
EBM	ecosystem-based management
ENGOs	environmental non-governmental organizations
IUCN	International Union for Conservation of Nature
ISDF	Integrated Salmon Dialogue Forum
KPP	Knowledgeable Persons Panel
NMFS	US National Marine Fisheries Service
PFRCC	Pacific Fisheries Resource Conservation Council
PSARC	Pacific Scientific Advice Review Committee
TEK	traditional ecological knowledge
TLK	traditional, local and/or fishermen's knowledge
WCVI AMB	West Coast Vancouver Island Aquatic Management Board
WSP	Wild Salmon Policy

1 THE IMPORTANCE OF KNOWLEDGE ISSUES IN THE IMPLEMENTATION OF THE WILD SALMON POLICY

1.1 Goal: Advancing the implementation of the WSP

The goal of Fisheries and Oceans Canada's Wild Salmon Policy (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" (DFO 2005 p.8). The policy has not been fully operationalized since its release in 2005. Progress has been made working out how to implement the policy, focusing on the first three of six strategies, but on-the-ground implementation of planning for salmon conservation and sustainability has not advanced past the start-up of a few pilot projects.[2] Pressure for speedier implementation is mounting as the International Union for Conservation of Nature (IUCN) recently added a number of subpopulations of BC Pacific sockeye salmon to the Red List of Threatened Species and recommended that the federal government "Fully implement and fund Canada's Fisheries and Oceans Wild Salmon Policy immediately" (Rand et al. 2008). The goal of this research is to further implementation of the policy, supporting progress towards a functional WSP meeting its full potential.

Of the six strategies in the WSP, Strategy 4, Integrated Strategic Planning, is highly relevant to implementation, as this is the stage at which actions get spelled out by local and regional planning committees. Strategy 4 is the focus of this report.

> The purpose of Strategy 4 is to develop long-term strategic plans for CUs [conservation units] and groups of CUs and their habitat subject to common risk factors. These plans will account for their biological status and provide recommendations on salmon conservation that reflect the interests of people at local and regional levels (DFO 2005 p. 24).

The "new integrated planning structure" called for in Strategy 4 is collaborative and consensus-oriented. After Fisheries and Oceans Canada (DFO) consultations with First Nations,

> It is suggested that local planning committees for sub-regions need to be established that can bring together all local First Nations governments, harvesters, community interests, local and regional government and other stakeholders to link with more localized projects important to local areas … and assemble, assess and analyze information and seek local consensus.
> In addition, the various interests involved in local planning will need to be brought together region-wide to confirm overall support and resolve any inconsistencies between local plans (DFO 2005 p. 27).

This report explains why integrated strategic planning depends on the integration of knowledge (different types, from different sources), and suggests ways that knowledge

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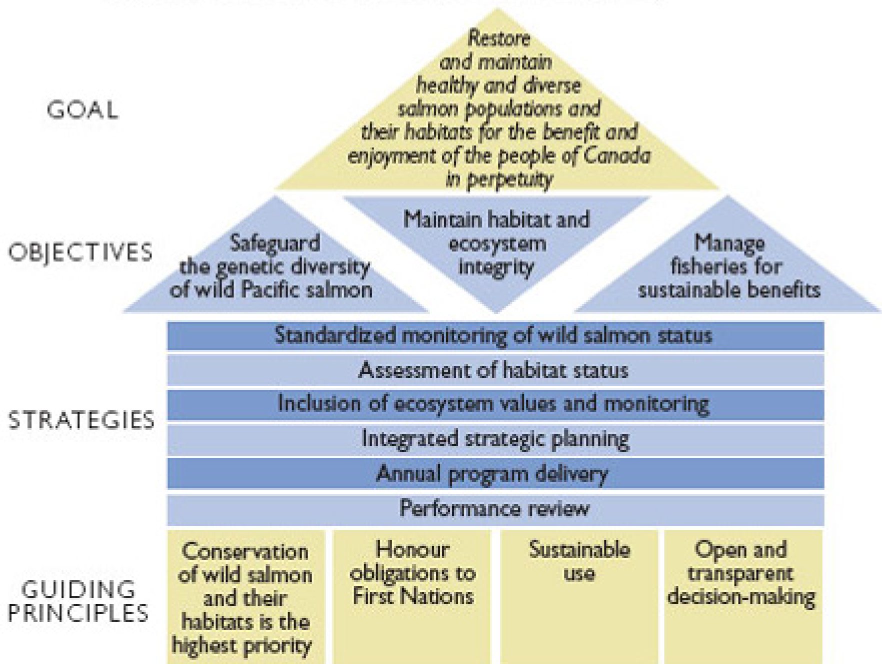
[2] Nelitz et al. (2008 p. 9) concluded that, as of late 2007, "In general, DFO is still engaged in strategic implementation of the policy; on-the-ground implementation has yet to begin." Their assessment still holds true: more papers have been produced (and peer-reviewed) that detail how the various strategies will be implemented (e.g., identification of habitat indicators), but no region or area specific plans for salmon conservation and sustainability have yet been produced under the policy.

can be integrated in multi-party consensus processes such as those prescribed in Strategy 4. Related issues explored in the research include: complexity of the salmon conservation planning challenge, limitations of science, underappreciation of different ways of knowing, and impacts of uncertainty and risk. The central research question is:

> How can the WSP strategic planning committees best integrate the different sources of knowledge required to carry out strategic planning for implementation of the WSP?

An overview of the WSP's goals, objectives, strategies, and guiding principles is provided in the following figure (DFO 2005 p. 8). A detailed description of Strategy 4 is provided in Section 2.2.

Figure 1 Overview of the Wild Pacific Salmon Policy



1.2 Rationale: The need to attend to knowledge issues

WSP planning requires that certain information be used to generate plans that will sustain conservation units (CUs). The parties involved in planning have interests that lead them to focus on different types of information, and they have different abilities and backgrounds that lead to different "ways of knowing." The challenge that stakeholders put to each other: "How do you know?" takes on a literal and critical meaning in settings that strive for the cooperative involvement of many parties (Wilson 2003 p. 270). When diverse ways of knowing meet the complexities and uncertainties of managing salmon, salmon habitat, and ecosystems, dysfunctional dynamics among stakeholders and government representatives can escalate. The potential for consensus is compromised by misunderstanding, miscommunication, doubt, scepticism, loss of confidence and trust, and conflict—even confrontation. In the end, the possibility of creating the best possible plans is compromised. Escalated dysfunction and compromised success can be avoided if variations in ways of knowing are mutually acknowledged and understood.

Traditional fisheries research approaches to informing management have had limited success in achieving the objective of long-term sustainability of the fisheries resource base. Part of the problem is the separation of, or even contradiction between, formalized research knowledge and users' knowledge (Degnbol 2003). At worst, a failure to use all available sources of knowledge can be a significant contributor to fisheries collapses (Charles 2001). In his observation of the causes of the cod collapse on the East Coast, Dobbs (2000 p. 9) concluded that we need to "reconcile the various ways we see the natural world to produce a more nuanced, inclusive, and dynamic perspective."

When a process accommodates the different ways we see the world and even celebrates the differences, it not only generates the best possible solutions, but improves our knowledge of the environmental and social systems of which salmon are a part. This is not just about *more* knowledge; it is about the cumulative and synergistic benefits of *combining* knowledge systems (Hughes et al. 2005). The WSP is moving in this direction by promoting an inclusive and transparent approach to decision-making that acknowledges the importance of science, aboriginal traditional knowledge, and social values.

This research aims to help the policy progress further by investigating how people working to collaboratively plan for the conservation and best use of wild salmon can build the necessary confidence in information, and develop the ability to communicate across their differences using that information. It draws on literature asserting that we must pay attention to *whose* knowledge is being brought to bear, *what* the knowledge is (including how it can be verified), *how* the knowledge is acquired, and *how* the knowledge is communicated. This who, what, and how of knowledge can be summarized as "different ways of knowing," or "epistemological differences" (McGoodwin et al. 2000, Adler and Birkhoff 2003, Wilson 2003). In this research, the short form "knowledge frames" is intended to mean the same thing.

1.3 Focus: The integration of knowledge frames in multi-stakeholder processes

The focus is on the integration of information from different knowledge frames into a process that produces strategic plans "that reflect the interests of people at local and regional levels." The interface between science/scientists and the stakeholder/government group of information users, their own knowledge base, and their values is key.

Questions of interest about use and communication of information from different knowledge frames in multi-stakeholder processes include:

- What do the participants in integrated strategic planning need in order to effectively receive, understand, judge, and use information in strategic planning?
- How is uncertainty expressed, understood, and coped with?
- What is the role of science in informing multi-party processes? How is it integrated into the collaborative process?
- How is local knowledge used in connection with science and other data?

- What does it take for people to trust and agree on information, as a foundation for planning?

Themes relevant to but only partially addressed or unexplored in this research include the following:

- in-season decision-making, and harvest allocation;
- governance/institutional arrangements and planning scales;
- buy-in to the WSP/level of support;
- capacity for implementation;
- public involvement;
- the depth and breadth of aboriginal traditional knowledge (ATK) or traditional ecological knowledge (TEK);
- power, authority, and responsibilities;
- the cultural/social context of knowledge;
- technical approaches to information acquisition and sharing;
- the arts as an additional knowledge frame.

See the appendix for a brief explanation of the above themes.

1.4 Approach: Literature scan and BC examples

The main research approach was a review of diverse literature, supplemented by interviews to shed light on two examples in the report: the Barkley Sound and Skeena River WSP pilot projects.

Cross-disciplinary literature scan

The analysis of knowledge frames relevant to salmon planning in Section 3 is based in a broad scan of diverse literature, including workshop proceedings, reports, books, and journal publications in fields ranging from fisheries management to policy analysis, risk assessment, and philosophy of science.

Within the area of fisheries, the literature was mainly from a harvest perspective rather than an enhancement perspective (i.e., there is much experience of collaboration on the production and habitat restoration side but that literature is less referenced here). Also relevant but virtually untapped in this research are literatures on planning, ecosystem-based management, First Nations ecological/traditional knowledge, and collaboration.

The ideas for integrating knowledge in WSP planning set out in Section 4 were generated from the literature and then, as far as possible, illustrated with examples from two places in BC with extensive experience of multi-party planning relevant to salmon.

Interviews

Unstructured interviews were undertaken with 10 people, primarily to flesh out information on the examples, although a few were related more to the general themes of the research.

Barkley Sound and Skeena River examples

To illustrate ways of integrating knowledge, the research looks at past experience and current directions in processes related to the Skeena River and Barkley Sound.

The Skeena River and Barkley Sound are both pilot project areas for the implementation of the WSP, and new multi-party initiatives are underway to this end. Both areas also have past experience of multi-party fisheries management efforts.

Three phases of experience are drawn upon for the Skeena River example. The first is that of the Skeena Watershed Committee, which operated from 1992 to 1997; the history and analysis of this process can be found in Sigurdson et al. (2008) and Pinkerton (1996). The purpose of the Skeena Watershed Committee according to the memorandum of understanding under which it was established was “to foster communication and cooperation among the parties in order to conserve, protect, and rebuild the salmonid resources of the Skeena Watershed” (Sigurdson et al. 2008 p. 3). In 2009, efforts are underway to establish a new “Skeena Watershed Congress” as a successor to the Committee. Feeding into this initiative are the results of a scientific review of the salmon fisheries by the Skeena Independent Science Panel, which reported its findings to the Canadian Department of Fisheries and Oceans and the British Columbia Ministry of the Environment in May 2008 (Walters et al. 2008).

Barkley Sound also has been subject to layers of multi-party planning relevant to salmon over the years. One is the region-wide West Coast Vancouver Island Aquatic Management Board (WCVI AMB), which was evaluated by Pinkerton et al. in 2005. A recent initiative of the WCVI AMB is the production of a draft report on a West Coast of Vancouver Island/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy (AMB 2006), which was not driven by the WSP. The AMB is also supporting the new Barkley Sound WSP pilot. This has the working name, Barkley Sound Integrated Planning Process, which has four governments on the Steering Committee (Canada, BC, Nuu-chah-nulth and Alberni Regional District). Its geographical area is Area 23 Barkley Sound /Alberni Inlet. Prior to the WSP pilot there had been established an Area 23 harvest advisory committee, which was originally called the Barkley/Alberni Round Table.

In both cases there are various resource plans completed or underway such as water use plans and species recovery plans.

2 INFORMATION REQUIRED BY THE WSP FOR INTEGRATED STRATEGIC PLANNING

The WSP prescribes that a range of information needs be met, and indicates that more than one knowledge frame should come into play. After summarizing Strategy 4 of the WSP—the focus of this report—this section looks at how the authors of the WSP intended integrated strategic planning to be informed.

2.1 Overview of Strategy 4: Integrated Strategic Planning

2.1.1 Strategy 4 among the 6 strategies of the WSP

The WSP strategies are sequential, so according to the policy, Strategies 1-3 are to be implemented before Strategy 4, integrated strategic planning, is carried out. And Strategy 3 (ecosystem values) somewhat depends on the completion of Strategies 1 and 2 (Nelitz et al. 2008). The two that follow—annual program delivery and performance review—are not addressed in this research. Despite this overall stepwise sequence of strategies, the implementation of various strategies is ongoing and will naturally overlap.

Each strategy has action steps. The themes explored in this research are most relevant to the second action step of Strategy 4, "Design and implement a fully integrated strategic planning process for salmon conservation."

Table 1: WSP strategies and action steps

Table 1 **WSP strategies and action steps**

Strategy	Action steps
1. Standardized monitoring of wild salmon status	• Identify Conservation Units • Develop criteria to assess CUs and identify benchmarks to represent biological status • Monitor and assess status of CUs
2. Assessment of habitat status	• Document habitat characteristics within CUs • Select indicators and develop benchmarks for habitat assessment • Monitor and assess habitat status • Establish linkages to develop an integrated data system for watershed management
3. Inclusion of ecosystem values and monitoring	• Identify indicators to monitor status of freshwater ecosystems • Integrate climate and ocean information into annual salmon management processes
4. Integrated strategic planning	• Implement an interim process for management of priority CUs • Design and implement a fully integrated strategic planning process for salmon conservation
5. Annual program delivery	• Assess the status of Conservation Units and populations • Plan and conduct annual fisheries • Plan and implement annual habitat management activities • Plan and implement annual enhancement activities
6. Performance review	• Conduct post-season review of annual workplans • Conduct regular reviews of the success of the WSP

2.1.2 *Five-step planning procedure within Strategy 4*

> The range of information that will need to be processed and the complex and sometimes controversial nature of the issues involved calls for a formal, structured and open procedure to be used in developing strategic plans (DFO 2005 p. 45).

According to the WSP, the structured procedure breaks down decision-making into a logical and manageable sequence of five steps to be followed by local and regional planning committees. Appendix 2 of the policy provides details on the planning procedure (DFO 2005). The following summary also draws on a PowerPoint presentation from the March 2008 Wild Salmon Policy Forum (DFO 2008a).

Step 1: Identify planning priorities

This step defines the planning problem, issues, and priorities, drawing on an overview report provided by DFO. Nelitz (pers. comm. 2008) notes that this step has to include a definition of what it is that is being "integrated" in integrated planning. The product of Step 1 is a list of specific key priorities that are to be addressed in the development of integrated salmon management plans.

Step 2: Identify resource management options and alternative management strategies

The product of this step is a number of alternative strategies that reflect a realistic range of approaches to addressing the management priorities for each planning unit.

Step 3: Establish biological, social, and economic performance indicators

The aim here is to produce a credible, broadly accepted, management assessment framework that captures and reflects all significant biological, social, and economic considerations.

Step 4: Assess the likely impacts of management alternatives

In Step 4, a set of predicted outcomes for each alternative management strategy is generated, as a result of evaluating the alternative management strategies identified in Step 2 using the performance indicators developed in Step 3. The policy's Principle 3 is relevant, as it prescribes weighing the biological, social and economic impacts of fishing and other activities. The consequences of the different strategies for various time periods are to be projected for comparison.

Step 5: Select the preferred management alternative

The products of Step 5 are: compromise solutions that resolve differences of opinion over alternatives and consensus recommendations for the planning unit; activities and management actions to be undertaken over a medium- to long-term timeframe; explicit biological targets to be achieved for individual CUs and groups of CUs; and, where appropriate, anticipated timeframes for rebuilding. This step involves making tradeoffs among different biological, social, and economic indicators.

2.2 Results sought through Strategy 4

To reiterate, the purpose of Strategy 4 is:

> to develop long-term strategic plans for CUs and groups of CUs and their habitat subject to common risk factors. These plans will account for their biological status and provide recommendations on salmon conservation that reflect the interests of people at local and regional levels (DFO 2005 p. 24).

Long-term strategic plans for CUs will “guide fisheries and other activities in specific geographic areas affecting the CUs” (DFO 2005 p. 27).

A careful reading of Strategy 4 derives the following expected outcomes and outputs.

Outcomes

The integrated strategic planning process has to (DFO 2005 p. 24):

- “as a minimum,” result in plans that are capable of maintaining and restoring all CUs above their established lower benchmarks with an acceptable degree of certainty within a defined time frame;
- fully address the conservation of Pacific salmon (safeguard the genetic diversity of wild salmon, maintain the integrity of their habitat and ecosystem);
- result in fisheries that are managed for sustainable benefits;
- meet the federal government’s obligations to First Nations;
- consider the needs of other Canadians.

These strategic plans will also:

- inform the development of annual fishery management, habitat, and enhancement plans (DFO 2005). “The annual status of the CU in relation to these [spawner] targets will guide the development of harvest management plans in the integrated planning process (DFO 2005 p. 11)”;
- be more than fishing plans: “This broad focus in planning will better integrate habitat and resource management activities with harvest management strategies and result in improved decisions in all areas (Fraser 2007 p. 10)”;
- form the basis for ongoing dialogue with First Nations governments, provincial, territorial and local governments and other private parties whose support and cooperation is essential to sustain Pacific salmon in Canada (DFO 2005).

Outputs

The strategic plans need to provide long-term targets, resource management actions, timeframes, and priorities. Specifically the plans are intended to:

- specify long-term biological targets for CUs and groups of CUs that ensure conservation and sustainable use;
- identify recommended resource management actions to protect or restore Pacific salmon, their habitats, and ecosystems in order to achieve these targets (address the causes of any declines);
- establish timeframes and priorities for actions (identify the resource management actions necessary to remedy declines where possible).

WSP emphasis on ecosystem-based management and the precautionary approach

Ecosystem-based management (EBM) and the precautionary approach are both strongly endorsed by the WSP. The contents of the policy calling attention to these priorities are highlighted in Section 3.5. Both have implications for integration of knowledge frames, which are also discussed in that section.

2.3 Information to be considered in strategic planning according to the WSP

> Developing integrated strategic plans for individual CUs and groups of CUs will need extensive detailed information on the status of wild salmon, their habitat, and ecosystem[s] to be brought together and collated with information on fisheries and watershed activities. In addition, broad-based input on possible management actions and their potential impacts will need to be received, considered and discussed in an organized way to arrive at reasoned and informed management decisions (DFO 2005 p. 45).

The three strategies and associated action steps that precede Strategy 4 all provide information for integrated strategic planning. This information is analysed and combined with more information in the planning process. Statements in the WSP (DFO 2005) that indicate the types of information to be incorporated in integrated strategic planning include the following:

- Use as a starting point measures taken by federal, provincial and territorial governments to protect First Nation salmon fisheries;
- Integrate information from Strategies 1, 2, and 3 on the status of CUs, their habitat and the ecosystem (and consider risks to wild salmon as summarized in the status assessment of the CU);
- Cover all stages of Pacific salmon life history;
- Weigh the biological, social, and economic impacts of fishing and other activities:

  > Principle 3, Sustainable Use:
  > Resource management decisions will consider biological, social, and economic consequences, reflect best science including Aboriginal Traditional Knowledge (ATK), and maintain the potential for future generations to meet their needs and aspirations.
  > Social, economic, and biological considerations will inform decisions on salmon, their habitats, and their ecosystems consistent with the priorities assigned to Principles 1 [Conservation] and 2 [Honour obligations to First Nations]. Conservation decisions cannot be based solely on biological information. The maintenance of biodiversity and healthy ecosystems must be considered in the context of human needs for use now and in the future. Decisions will not be taken without regard to their cost or social consequences (DFO 2005 p. 9).

- Document short- and long-term costs and benefits.

More details on the types and sources of information to be applied at each stage of the planning process are included in Table 2, in the following section.

2.4 WSP/DFO directions for use of technical/scientific knowledge as compared to other sources of information

Nelitz et al. produced a progress report on implementation of Strategies 1 to 3 as of late 2007 (their Table 1 p. 11-18). The following table, focused on sources of information for the implementation of each of the policy's strategies, is based mainly on that report as well as the WSP itself and Fraser 2007. The table roughly sorts information into two categories. One is information that would come from technical experts and/or scientists. This information is expected to be generated (or has already been) by or under the direction of the WSP Implementation Team. DFO staff or technical experts and consultants from outside the department could be involved. The second category is information that would come from First Nations, stakeholders, and/or the public, including ATK and local knowledge.

Table 2: Overview of the sources of information for implementation of the first four strategies of the WSP

Strategy	Expert/technical/scientific knowledge	First Nations and/or stakeholder knowledge
1 Wild salmon status CUs	A stock-assessment framework will detail the process by which existing data and information for a CU are gathered/collated and used to identify priority CUs. (Nelitz et al. 2008 p. 11). "For each CU, a statistically based and cost effective monitoring plan will be designed and will build on existing programs and local partnerships" (DFO 2005 p. 19).	CUs were drafted by DFO in 2006-07 and First Nations and stakeholders were consulted on the draft (DFO 2008b). "We did incorporate a lot of local and some traditional knowledge in the definition of CUs—they corrected us many times during consultations on draft lists" (Irvine pers. comm. 2008). An interactive website will enable the public to interact with data for each CU and rank CUs with their own ranking of objectives (Nelitz et al. 2008 p. 11). Development of monitoring guidelines and protocols will likely involve First Nations input (Nelitz et al. 2008 p. 12).
2 Assessment of habitat status	"Habitat data gathered from many sources within and outside DFO will be linked and made more accessible for habitat planning…" (DFO 2005 p. 20).	"Information from multiple sources will be assembled by DFO … Government agencies, First Nations governments, watershed planning processes and stewardship groups will be asked to provide advice on … indicators for their watersheds, based on local knowledge and information on the kinds of data that are available" (DFO 2005 p. 21). DFO is testing an interactive database to "compile quantitative data and expert opinion for watersheds across the region … allows for watershed prioritization based on subjective information from DFO staff and local stakeholders …" (Nelitz et al. 2008 p. 13).

		DFO is looking into governance models for collaborative monitoring across organizations (Nelitz et al. 2008 p. 14).
3 Inclusion of ecosystem values and monitoring	A white paper is being developed by DFO to identify ecosystem objectives and values, identify how to achieve these objectives and identify indicators (Nelitz et al. 2008). “The Department will use existing data and expert advice to identify key indicators … of the current and potential state of lake and stream ecosystems …” (DFO 2005 p. 23).	In 2006-07 DFO consulted the public and First Nations on incorporating ecosystem values (DFO 2008b). A Knowledgeable Persons Panel will be convened out of a workshop to review the white paper. It will generate a draft Ecosystem Assessment Framework for wider consultation and eventually liaise with regional representatives (Nelitz et al. 2008 p. 16).
4 Strategic planning	“Different sections and areas [of the plan] will need to be written by technical experts or consultants retained for specific purposes” (Fraser 2007 p. 14).	Strategy 4 emphasizes inclusiveness, transparency, consultation with First Nations (as attributes of effective planning processes), and involvement of other governments. The multi-party planning committees will include, or have opportunities for input from, all parties that are affected by a planning outcome (DFO 2005).

Because the focus of this research is on Strategy 4, the following table goes into more detail on the types of knowledge expected to be applied in each step within this strategy.

Table 3: Overview of the sources of information for implementation of the steps within Strategy 4 of the WSP

Step 1: Identify planning priorities	“As a starting point for planning, DFO staff will provide an overview report that identifies the CUs exploited by fisheries within each planning unit and give summary information on their biological status (Red, Amber or Green). Key habitat and ecosystem constraints or threats to individual CUs will also be summarized by watershed. For CUs in the Red zone more detailed reports will also be provided as they become available. …[These] will … be	“[Detailed reports for CUs in the Red zone] will consider and incorporate ATK, where available” (DFO 2005 p. 45). The planning participants will “receive and consider information from the Department, First Nations and other sources on the current biological status of the conservation unit(s) within the planning unit and the key habitat and ecosystem constraints or threats that they currently face. This then needs to be brought together with cultural, social and economic information provided by First Nations, fishery stakeholders and others involved in the planning process. … priorities for the planning unit are left to the judgment of the

	subject to peer review through PSARC"[3] (DFO 2005 p. 45).	participants in the planning process based upon local knowledge and both regional and local considerations." [as long as rebuilding of Red zone conservation units—i.e., below lower benchmarks—are included] (Fraser 2007 p. 15).
Step 2: Identify resource management options and alternative management strategies	"At this step … it will also be important to begin quantifying the intended effects of the different tactics" (Fraser 2007 p. 16).	"Several alternative management strategies will be developed in consultation with First Nations and other participants in the planning process" (DFO 2005 p. 45).
Step 3: Establish biological, social, and economic performance indicators	Implies that the evaluation framework will be established by DFO, with input.	"Input from First Nations and other participants in the planning process will be used to develop an evaluation framework for comparing the management alternatives … This will require First Nations and others to identify explicit, measurable performance indicators…" (DFO 2005 p. 46) "either independently or with advice from departmental advisors" (Fraser 2007 p. 17).
Step 4: Assess the likely impacts of management alternatives	"DFO will play a lead role in providing or obtaining these predictions from appropriate technical experts. For some planning units, computer simulations models may be available to assist, but in other cases is will be necessary to rely on expert opinion" (DFO 2005 p. 46).	"In other cases, reliance may need to be placed on the expert judgments of DFO staff, *First Nations and other participants in the planning process*" (Fraser 2007 p. 18 emphasis added).
Step 5: Select the preferred management alternative		"The goal will be to use constructive dialogue among First Nations and others involved in the planning process to resolve [differences of opinion], find compromise solutions and to develop consensus recommendations…" (DFO 2005 p. 46).

3 KNOWLEDGE FRAMES RELEVANT TO SALMON CONSERVATION PLANNING

> …[M]ost groups have a 'predominant' way of knowing things, a shared prism through which group members take in and give out information. This way of

[3] Pacific Scientific Advice Review Committee

> knowing may be institutionalized in laws, rules, and protocols or it may simply be ‘the way we do things around here’ (Adler and Birkhoff 2003).

This section shifts attention from *what* we (need to) know to *how* we know. *How* we know influences the kind of information that is applied to conservation planning, and, at least as important in consensus-seeking approaches, it influences the way we understand the information.

The parties on the local or regional committees responsible for integrated strategic planning for salmon conservation will variously “know” via experience, training, observation, scientific research, data collection, oral tradition, etc. The information brought to the planning process, whether by the parties themselves or external players, is based in these different ways of knowing—or knowledge frames.

This section explores knowledge frames relevant to salmon conservation planning simplified into the general categories of natural and social science, and traditional, local, and fishermen’s knowledge (TLK). Arguments for appreciation of the different knowledge frames are presented, and limitations and/or issues of “underappreciation” are explored. TLK is then compared to scientific knowledge—although various hazards of this exercise are recognized. Finally, four approaches relevant to implementation of the WSP that call for integration of knowledge frames are outlined: collaboration and consensus processes, the precautionary approach, ecosystem-based management, and post-normal science.

3.1 Natural science

Relative to other knowledge frames, natural science (biology, ecology, oceanography, etc.) receives extra credence in the area of fisheries management, and it is emphasized in the WSP. While science is typically the realm of universities, research institutions, and government science bodies, an observer of the debates about salmon aquaculture in BC points out that anyone can use the scientific method, and as long as the findings of their work meet the rigorous criteria required by the scientific method then they are, by definition, a “scientific” result (Hume 2008). Increasingly, a range of players in fisheries have technical and scientific sophistication and access to science based in research that they have directed or undertaken. These include industry players, environmental organizations, stewardship groups (such as streamkeepers), and First Nations. Just as non-scientists can hold rigorous scientific information in addition to opinions, scientists can hold opinions that vary in the rigour of their connection to technical data.

The relevance of science to salmon conservation planning and the limitations of the science knowledge frame are explored here.

3.1.1 Relevance of science

> Science is a way of not fooling yourself.
> \- Commonly attributed to Richard Feynman

The vital role of science in meeting the challenges of salmon conservation is unquestionable. What follows is a sampling of the qualities it brings.

Furthering understanding of natural systems: Science protocols permit representations of natural resource conditions and trends that further our understanding of cause-effect relationships and the consequences of management decisions (Burchfield 2001 p. 237). More specifically to the WSP, "This knowledge can be used to help provide a rationale for deciding upon appropriate environmental indicators, monitoring locations and sampling frequencies, or methods for analysing environmental data" (Nelitz et al. 2008 p. 24). In the area of ecosystem-based management, integral to the WSP, science is of limited relevance to identifying valued ecosystem components, but it provides a basis for understanding the complex web of interactions among human activities and these components (Nelitz et al. 2008).

Credibility with parties involved in salmon conservation: Scientific information carries an influential weight among most participants in multi-party planning processes because of the rigorous standards that guide its reporting (Burchfield 2001). Strong, quantitative data can provide a firm foundation for planning and management and help reduce speculation and varying interpretations of information, as the Skeena Independent Science Panel emphasized with respect to policy-making about steelhead (Walters et al. 2008). More broadly, legitimacy of institutions in democratic governance depends in part on the way that research-based science provides objective validity. The quantitative methods of the natural sciences are a convenient means of providing transparent answers that account for the source of the knowledge and respond to the "how do you know that?" question (Wilson 2003). Thus, a clear foundation of science for salmon conservation plans can smooth the path for the implementation of the plans.

Rigorous quality control: Rules of the scientific method, including hypothesis testing, statistical analysis, etc., provide a shared basis for the evaluation of the results of scientific research. Various processes provide the opportunity for review of research results to ensure they are reliable and unbiased. For example, to ensure that "good science" was brought to the development of the WSP, and because the policy advanced the science informing management decisions in its orientation around a new management unit (CUs), measures were taken to ensure that the science was well founded (Irvine 2008). In addition to having reputable government scientists play key roles, science-based workshops were held with participants from outside BC, and non-government scientists and university academics participated throughout the development of the policy. Formal peer review was also used—e.g., in the methodology that identified CUs (Irvine 2008). Key documents setting direction for Strategies 1 to 3 of the WSP will also be subject to peer review (Nelitz et al. 2008). For DFO science, the peer review process is the Pacific Scientific Advice Review Committee (PSARC)[4].

3.1.2 Limitations of the science knowledge frame in salmon conservation planning

> The concept of "decisions based on sound science" is predicated upon the presumptions that science is a neutral body of knowledge immune from value judgements, science can predict with certainty and clarity what will happen in the

[4] For information on PSARC go to http://www.pac.dfo-mpo.gc.ca/sci/psarc/whatis_e.htm

> physical world, and policymaking is a rational process. None of these is true (Karl et al. 2007).

This report does not question the fundamental utility and appropriateness of applying science to salmon conservation planning. It does not mean to suggest that the intellectual development that comes with the understanding of scientific methods should be ignored—a risk that can stem from an emphasis on other ways of knowing (Widdowson and Howard 2006). Rather, outlining the limitations of science here illuminates reasons why science should not be presumed to be the only or the "best" knowledge frame applied to the salmon conservation planning task. The issue of the predominance of science leading to underappreciation of traditional and local knowledge is explored in Section 3.3.4.

Lack of fit between scientific methods and some fisheries management needs

Effective execution of scientific research typically requires long time frames—e.g., to gather data over repeated natural resource cycles. Yet the time available for decision-making in fisheries is usually too short to allow for such rigorous gathering of evidence. Outcomes can include scientific results with low reliability (wide confidence intervals), or the delaying of decision-making while the wheels of research turn. This uncertainty[5] is out of sync with the assumption of predictability behind management-oriented fisheries research; i.e., that predictable targets can be achieved by implementing technical measures or regulatory measures such as catch or effort quotas (Degnbol 2003).

Spatial scales of science can also be mismatched with management needs. Some fisheries science methods reflect large-scale ways of conceptualizing the marine environment and managing the fisheries resource—e.g., focusing on aggregated stocks. This can seriously compromise the ability of fisheries science to address the reality of the substructure of fisheries stocks (Soto 2006).

Another flaw in scientific method with regard to informing management is the possibility of a Type 2 error. In conventional approaches to hypothesis testing, the existence of a trend or change in a population can only be accepted if there is sufficient evidence to reject the presumption that there is no trend (the null hypothesis). This approach is intended to protect an investigator against making a Type 1 error, which involves rejecting a null hypothesis when it is, in fact, true. However, compelling evidence against a null hypothesis is often difficult to muster given the high levels of environmental variability. This situation thus establishes the possibility of rejecting a phenomenon that is real and perhaps important in the management setting—a Type 2 error. The precautionary approach aims in part to reduce the possibility of a Type 2 error. Bayesian inference is an alternative to hypothesis testing that also seeks to alleviate related issues (see Section 4.5.3).

Proprietary nature of research data

Researchers invest in the collection of data sometimes at great expense, and career advancement often depends on the publication of the results of data analysis. Accordingly, they are highly reluctant to share data from their research programs prior to

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[5] Other dimensions of uncertainty are explored below.

publication. Because the publication process can be lengthy and multiple publications can result from the same data set, the raw data may not be made available for years. Even data gathered by government agencies are often not widely released.

Overemphasis on quantification

There is a school of thought in fisheries management that follows the dictum, “If you can’t measure it, it doesn’t exist” (Tautz, pers. comm. 2008). This attachment to the quantitative aspect of natural science is widespread outside of fisheries as well, with Albert Einstein often quoted as having cautioned “Not everything that can be counted counts, and not everything that counts can be counted.” The drawbacks of not heeding Einstein’s advice include:

- Overemphasis on quantification overplays quantitative techniques to the extent of excluding other tools and sources of information—e.g., often rejecting the relatively unorganized, mostly qualitative information that fishermen can provide as “anecdotal” (Dobbs 2000);
- Overemphasis on quantification can be overly preoccupied with statistical methods: “the ‘numerical’ approach of current resource economics and marine biology, emphasizing linear relationships and states of equilibrium, fails to account for the chaotic aspects of many fisheries” (Palsson 1995 p. 91-2);
- Overemphasis on quantification singles out incompleteness of scientific information as the main impediment to good management, while other challenges to conservation may be more serious. For example, Holtby lists challenges for the Fraser River, “in order of increasing intractability, fisheries (mixed-stock), other water and land-use (people), end of cheap energy and climate change” (in Gallaugher et al. 2006 p. 71-73).

Overconfidence in the ability to produce unassailable scientific results

It is often assumed that players outside of the scientific community should accept the results of scientific research as valid and credible. Indeed, for government to “manage,” resource users such as fishermen essentially have to give their consent, and this consent is contingent on the users’ faith in the information on which the management decisions are based (Wilson 2003, Pinkerton 1989). Yet non-scientists increasingly have the ability to assess technical information. If they doubt its accuracy they might not adhere to regulations, possibly in a very public way—as in the case of fishermen who carry out “demonstration fisheries.” Another outcome of doubt on the part of the users is pressing of charges against the government—e.g., as Cheam First Nation members took DFO to court for actions taken to protect sockeye stocks. They appealed their conviction for fishing during a closure in part based on a claim that DFO’s conservation measures lacked a scientific basis and that the policy of “stock rebuilding” is not specific enough (Chouinard 2008).

At worst, the attempt to build a quantitative argument to convince users of the wisdom of a regulation or even the value of a management alternative becomes a downward spiral of knowing more and more about less and less, as Dobbs concluded with respect to the East Coast cod collapse:

> Challenged constantly by fishermen who often saw things differently [about the health and size of the stocks] and in particular by a highly vocal sector of the industry adverse to restraint, NMFS [National Marine Fisheries Service] had to

> steer its limited resources into producing the most narrowly focused, ambiguity-free, statistically defensive numbers possible. Magnuson's council process thus transformed NMFS increasingly into a number-crunching machine that elevated math, statistical analysis, and single-species stock assessments far above wider biological inquires…. [this resulted in] defensive, dry, indigestible, math-driven, statistical science that alienated fishermen and excluded their knowledge (Dobbs 2000 p. 91).

Unconstructive use of science in adversarial settings

Research results will always be "debatable." Healthy debate among academics is key to scientific progress, so it is virtually assumed that even results published in the most respected journals will be questioned, and tested in subsequent research. However, when detailed, technical debate from the "combat biology world of science" (e.g., over the relevance of alternative data sets) enters the resource decision-making forum, it can stifle progress (Tautz, pers. comm. 2008). Opponents in confrontational processes pick and choose scientific claims in the opportunistic pursuit of self-interest, diverging rather than converging on "the facts of the matter." In highly adversarial situations, rather than being the focus for building credibility, science can be marginalized as deeply contentious debates minimize its value for informing decisions (Karl et al. 2007). A review of the Skeena Watershed Committee experience concluded that, "Although science was viewed as a way to unite the sectors in terms of problem solving and despite a developing trend to make decisions based on the results of the research, there were concerns that the science could be manipulated to suit policy needs" (Sigurdson et al. 2008 p. 4).

A common reaction is to seek to eliminate the scope for such nefarious intent by producing unassailable research results. The "catch" is that more science does not reliably build the confidence and buy-in on the part of resource users that the agencies sponsoring the research wish to instill. If the parties involved in making choices about management do not feel respected and do not understand each other—leading to a lack of trust—more and better numbers may help but will not be enough of a foundation for progress towards consensus.

Limitations on the objectivity/neutrality of science

Even though science, like all areas of human activity, is naturally influenced by values the general belief is that scientists can be honest brokers of policy options, provide unbiased scientific information, impartially advise on effects of choices, etc. (Lackey 2007, Irvine 2008). It is also widely held that scientists should not advocate values by expressing personal policy preferences connected with scientific information. Yet many observers have come to question the clarity (and even the appropriateness) of the boundaries between science and society, policy and politics. A sampling of views on the blurring of these boundaries follows:

- In the context of ecosystem-based management and the realm of policy issues and their implementation, scientists are not as naïve as they are accused of being, and "no one can know better than scientists how to get the best results and the most mileage out of science" (Browman et al. 2005 p. 242);
- "Claims by scientists to objective scientific knowledge of the condition of fish stocks are extremely hard to establish and, in fact, rarely made" (Wilson 2003 p. 271-2);

- "Subjective framing assumptions permeate the science in a complex and pervasive fashion" (Stirling 2001);
- The perspectives scientists bring into decision-making fora may be influenced by their own ethics, concerns, and interests. Statements that come under the guise of science but are implicitly biased by the scientists' values confuse issues, undermine the credibility of the underlying science, and exacerbate conflicts (Jones 2002);
- "Science has always been affected by its context, particularly politics. Nonetheless, the image portrayed of science used for fisheries management emphasizes the formal, the ideal and depicts truth in numeric form" (Hall-Arber 2003 Comment on Holm).

Two mechanisms for reducing the potential influences on science that render it less objective are to ensure autonomy and to practice peer review.

Autonomy of science:

The objectivity of scientists may be called into question with respect to who funds their research. If their research involves collaboration with parties in the management milieu, claims of preserving independence, or of avoiding conflict of interest, may be weakened (Ravetz 2004). The solution typically put forward is to distance researchers from government and fisheries organizations into institutions that are at least semi-autonomous (e.g., McGoodwin et al. 2000). Related issues were debated in the *Canadian Journal of Fisheries and Aquatic Sciences* (CJFAS) in 1997. Hutchings et al. (1997 p. 1198) called for the formation of "a politically independent organization of fisheries scientists" outside of DFO because the consolidation of fisheries research into DFO had "permitted, intentionally or unintentionally, a suppression of scientific uncertainty and a failure to document comprehensively legitimate differences in scientific opinion." Responses from DFO employees (Doubleday et al.) and a university fisheries scientist (Healy) disagreed.[6] This principle of separating scientists from those involved in planning or decision-making is reflected at the scale of the multi-party planning committees such as those prescribed by the WSP. Processes of this sort often establish technical/scientific committees/working groups, or research initiatives, that are directed by, but arms length from the parties at the planning table.[7]

Review of scientific results:

The 1997 debate in CJFAS also questioned the reliability of the peer review process for stock assessment in maintaining objectivity and transparency. Critics (Hutchings et al.) acknowledged that "the present stock assessment review process is more open to non-DFO employees than in the past" but that the "integration of outsiders" in the process still was not adequate. This was because assessment documents are not written in a form readily accessible to non-scientists and the opportunity for comment can be limited to

[6] An indicator of continuing belief in the need to separate science from government agencies was a recent request for proposals from Environment Canada to "explore alternative means of strengthening the independence of [the Committee on the Status of Endangered Wildlife in Canada] COSEWIC [including an] evaluation of the current means by which the Secretariat is able to provide support to COSEWIC that is arms-length from government." The request implies that the aim is to ensure that the COSEWIC assessment process is independent and transparent, and that each member of COSEWIC can, as provided for in the legislation, exercise his or her discretion in an independent manner. A role of COSEWIC as an advisory body is to ensure that species will continue to be assessed using the best available scientific and aboriginal traditional knowledge.

[7] See section 4.3.3 for pros and cons of technical committees.

open meetings rather than based on circulation of assessment documents prior to the meeting (Hutchings et al. 1997 Reply). More generally, because the scientific review process depends on commitment, and because it can be influenced by powers controlling the process (e.g., restricting the release of selected results) "quality in science is in fact a very delicate cultural product" (Ravetz 2004 p. 356).

In any case, the fact of peer review, even that connected with most-respected journals, does not lead to conclusions that are unassailable by laypeople and scientists alike. Commentary from an observer of the sea lice and salmon farming controversy in BC, Neil Fraser (2008),[8] explains how the findings of an article published in *Science* that links sea lice to declining wild salmon populations were questioned by DFO scientists[9]. Fraser goes on to assess the qualifications of the authors and reviewers involved according to criteria by which researchers are typically judged in academia, such as the number of publications on which they are first authors, the status of the journal in which their research results are published, and the currency and relevance of their research experience and publications. In public forums such as news releases, newspaper editorials, and radio talk shows, other criteria tend to be used for questioning credibility, such as the author's level of formal education and how the research is funded. There has been so much questioning of credentials and research results by so many players around the sea lice issue that Fraser (2008) states, "science [has] become a spectator sport in B.C."

Limitations on the comprehensiveness and certainty of scientific information

Even if scientific research could be relevant to management, reliable, accurate, and objective, it will never provide totally complete information for salmon conservation planning. Bisbal (2006 p. 162) is scathing regarding the state of knowledge for salmon recovery in the Pacific Northwest, calling it "narrow, piecemeal and often ephemeral," with underlying information that is "ambiguous, flawed, or simply nonexistent." Examples of areas of scientific knowledge Bisbal identifies as particularly deficient include the major habitats and resources, food web interactions, river dynamics, population processes, fish distribution and abundance, and migration paths, as well as quantification of habitat losses or effects of major factors on salmon. Charles (2001 p. 218) highlights the fundamental role of the stock-recruitment (or spawner-recruitment) relationship in fishery science, and points out that, "given the fluctuations in, and inherent complexities of, ocean and fish stock dynamics, together with uncertainties in the corresponding data available to scientists," our understanding of the relationship is very weak.

Bisbal (2006 p. 163-164) lists factors that pose practical limits to scientific inquiry and its ability to deliver the knowledge needed for decision-making:

- inability of any scientific framework to yield absolute answers and fully eliminate uncertainty;
- relatively slow pace of the scientific process;
- logistical challenges posed by the extensive spatial and temporal scales in effect;

[8] Professor of Geophysics at the University of Hawaii.
[9] As interviewed in an industry periodical, Northern Aquaculture.

- complex suite of climatic, atmospheric, hydrologic, and oceanographic variables salmon encounter during their lifecycles;
- limited ability to meet the requirements of sample size and replication of treatment and control groups due to the fragile condition and low numbers of individuals in dwindling salmon populations;
- human-driven factors such as intermittent support from political/institutional sources; economic, social, and cultural costs; and erroneous perceptions that the information in hand is sufficient and scientifically adequate.

With regard to the latter, human-driven factors, Nelitz et al. (2008) point out that the greater the rigour expected in scientific methods to complete an action step in the WSP, the greater the level of effort, technical capacity, funding, available data, and/or time required to complete the relevant analysis. While methods of greatest rigour are more scientifically credible and can always be justified, they are not usually implemented because of limits on resources.

In BC, reduced fishing effort has meant even less reliable information on which to base fisheries management—especially in-season. When fisheries are closed, data are not being generated and estimates of escapement become even more approximate, increasing the uncertainty of information. Such a large volume of information has been lost that most values are now the result of multiple estimations (Riddell 2007).

In short, society expects a level of certainty and predictability about fish stocks that simply does not exist when it comes to salmon (Gordon Ennis in Gallaugher et al. 2006). While the size of fish stocks (in biomass of numbers) may be the most obvious source of uncertainty for fisheries users and managers, the area of uncertainty that the fisheries science literature usually focuses on involves stock-recruitment relationships (both randomness/process uncertainty and parameter/state uncertainty) (Charles 2001 p. 203). There is uncertainty around:

- observations (“nothing in a fishery can be measured perfectly”);
- models—due to observation uncertainty, random fluctuations, and structural uncertainty;
- estimation—due to lack of experience over time, unknown states of nature, and the existence of random fluctuations;
- basic ignorance about the nature of the fishery system including key aspects such as species structure, fleet structure, spatial complexity, fish-fish interactions, or technological change (Charles 2001).

Berkes et al. (2001) point out that uncertainty also stems from implementation error.

Another source of uncertainty that will continue to grow is climate change impacts on ocean conditions and river temperatures, which will make fisheries increasingly difficult to predict (Riddell 2007). While climate change models exist, downscaling them to local levels further increases uncertainty.

Opinions differ over whether, in theory, it is possible to complete the knowledge base for salmon management and how much effort should be invested to this end. The executive director of the Pacific Fisheries Resource Conservation Council commented in a public workshop, “We are never going to get the number right” (Gordon Ennis in Gallaugher et al. 2006 p. 34). Knudsen and Doyle (2006), writing for the Salmon 2100 Project, are more optimistic. They call for significantly advancing the scientific and technical basis for salmon harvest and habitat management as an “aggressive action” required for salmon populations from California to southern BC to be sustainably harvestable—“If we are to have salmon populations abundant enough to support fisheries, given the multitude of factors impinging on them, we must move the technology of salmon predictions and management into a new paradigm of accurate assessment and precise exploitation” (Knudsen and Doyle 2006 p. 315). They believe that improved knowledge can support a scientifically accurate, dependable management system with precision that will rival or exceed weather forecasting. The authors argue for a stronger role for scientists in decision-making about salmon, including a high-level science advisory panel.

Conversely, Dose (2006 p. 257), in the same volume, argues strongly that scientific uncertainty (and the need for more data) has been overemphasized as a factor in the challenge of “saving salmon”—rather, “credible science” exists but “is not being used to save salmon.” He asserts that the range of possibilities for saving salmon should be considered in the social and economic arena rather than making science the primary forum for decision-making. He calls for a more ecologically based approach rather than continuing reliance on “technofixes” as well as two other “pillars”: a societal commitment and conscientious implementation of specific actions. These comments draw the social science knowledge frame to attention.

Writing more generally about natural resource management policy and decision-making, Karl et al. (2007 p.22) emphasize that because environmental problems are so complex, and decisions are unavoidably based on a range of values along with the interests of stakeholder groups, “decisions based on sound science must integrate social science, natural science, and stakeholder concerns.”

3.2 Social science

Social science has much to contribute to salmon conservation planning but this field of science is underemphasized in the WSP as well as in fisheries management in general.

3.2.1 Relevance of social science

In the Salmon 2100 Project Lackey argues that, in the context of risks to salmon in the Pacific Northwest and southern BC, we know basically what wild salmon runs need for recovery from a technical perspective; i.e., the closer the habitat is to its natural condition the better (Lackey et al. 2006, Lackey pers. comm. 2008). The core policy drivers needing attention—rules of commerce, increasing scarcity of resources, growth in regional population, and individual and collective preferences—are not ones that the natural sciences are best suited to (Lach et al. 2006). Therefore, increasing the role of science and technology in recovery efforts amounts to little more than buying time. The challenge boils down to what are people willing to trade off to achieve some level of recovery, since salmon want the same things humans want—the same areas to live, the same water (Lackey pers. comm. 2008).

While the policy drivers in BC outside of the southwest may differ from those applying in the heavily populated part of the province, socio-economic considerations are still key to making trade-offs in salmon conservation planning. Strategy 4's integrated strategic planning process recognizes this need in calling for socio-economic factors to be considered in the step of designing a management assessment framework that captures and reflects all significant biological, social, and economic considerations. Similarly, Principle 3 of the WSP, sustainable use, prescribes the consideration of social and economic consequences of resource management decisions in addition to biological ones and explicitly recognizes that conservation decisions cannot be based solely on biological information (DFO 2005).

Other reasons social science is relevant to the implementation of the WSP include:

- Social scientists are relatively familiar with the dynamic of inshore fisheries and local fisheries terminologies and technologies (McGoodwin et al. 2000);
- Social scientists have expertise in the integration of local and fishermen's knowledge into fisheries management (Soto 2006);
- Social and economic information is relevant to identification of ecosystem values in ecosystem-based management (see Section 3.5.3);
- Some parties at the planning tables will call for their interests to be expressed in social and economic indicators.

3.2.2 Underappreciation of social science

The term "science" tends to mean natural science unless social science is specified—including in the term's usage in this report. There has been little social science research within fisheries management agencies in Canada (Soto 2006)[10] and in salmon research in general as compared to natural science. Disciplines such as economics, sociology, psychology and political science—the "soft sciences"—are marginalized relative to the disciplines of genetics, molecular biology, climatology, ecology, and oceanography—the "hard sciences."

Reasons for neglect of the social science knowledge frame overlap with those causing the underappreciation of TLK, and include the great difficulty of quantifying research results. Economists and other social scientists regularly use quantitative techniques to present data, which tends to be taken seriously; "Otherwise, the information is dismissed as 'anecdotal' and ultimately unfit or at least unusable for application in decision-making or policy development" (Hall-Arber 2003 comment on Holm).

The discrimination against social science, together with increasing specialization among professional scientists (and the need to manage large amounts of information in complex areas such as fisheries management), leads to tunnel vision, storage of knowledge under unconnected accounts, and barriers of understanding between scientific communities (Bisbal 2006, Degnbol et al. 2006). While specialization enables conceptual sophistication and analytical depth in a particular area, it limits knowledge about tools outside the area of specialization and the free exchange of perspectives that could lead to new management tools (Degnbol et al. 2006).

[10] Soto (2006) notes that change, while slow, is now evident, with social aspects of fisheries increasingly being addressed.

Social scientists' techniques, protocols, and standards—the methods through which they deal with validity and reliability—are legitimate and need to be appreciated by natural scientists in order to bridge the gap between the natural sciences and the social sciences. An explicit acknowledgement and discussion of social science could demonstrate how qualitative and quantitative methods can complement each other, and lead to the integration of sources of knowledge and experiences analysed in qualitative terms with quantitative data (Bisbal 2006, Pinkerton 2003 Comment on Holm). This could open the doors to cross-disciplinary advice for salmon conservation planning and capitalize on the opportunities that social science offers.

3.3 Aboriginal, local, and fishermen's knowledge

This section first explains the terms aboriginal traditional knowledge, local knowledge and fishermen's knowledge. This suite of knowledge frames is then explored in terms of relevance and limitations with respect to salmon conservation planning, in a blended knowledge frame category: traditional and local knowledge (TLK). Problems of underappreciation of TLK are also described.

3.3.1 Working definitions of "aboriginal traditional knowledge," "local knowledge," and "fishermen's knowledge"

Aboriginal traditional knowledge (ATK)—the term used in the WSP—is also used interchangeably with indigenous knowledge, traditional knowledge, or traditional ecological knowledge (TEK), although an author using one of the terms exclusively might distinguish its meaning from the other two versions.[11] The WSP (DFO 2005 p. 38) defines ATK as follows:

> …includes, but is not limited to, the knowledge Aboriginal peoples have accumulated about wildlife species and their environment. Much of this knowledge has accumulated over many generations.

TEK or indigenous knowledge, also known as traditional knowledge (TK):

- is about the relationship of living beings (including humans) with one another and with their environment—it does not separate people from nature;
- may pertain to biology and ecology (e.g., fish stocks and aquatic ecosystems);
- can also be about resource management systems and institutional organization;
- is a cumulative body of knowledge, practice and belief, handed down through generations by cultural transmission;
- is dynamic, building on experience and evolving by adapting to changes (Charles 2001, Berkes et al. 2001, Bielawski 1996).

TEK can be seen as a special case of local knowledge, that, when handed down for generations, becomes TEK (Berkes et al. 2001). A Government of the Northwest Territories Traditional Knowledge Working Group explained that traditional knowledge

[11] Nadasdy (2003) cautions that these terms often have no counterparts in the language of aboriginal peoples and thus should not be assumed to refer to agreed-upon realities.

is more than just information that aboriginal peoples have about the land and animals—it has roots based firmly in the landscape and a land-based life experience of thousands of years, and it offers "a view of the world, aspirations, and an avenue to 'truth,' different from those held by non-aboriginal people" (Government of the Northwest Territories 1991 p. 11).

Local knowledge is that held by people who have come to know an area by living and/or working in it, and is sometimes called local ecological knowledge (LEK). It includes fishermen's knowledge, which may be referred to as fishermen's ecological knowledge (FEK), as well as the knowledge of community-based stewardship groups, local government councils, outdoor recreationists and others. This knowledge can be about a wide range of things: habitat and threats to habitat, ecology, fish behaviour, catch trends, climate and weather, technology, business, illegal activities, international trade, etc. It includes knowledge developed over long time periods as well as recent knowledge, such as that acquired through fishing in recent years (Charles 2001).

FEK is generally thought of in two ways: first, as knowledge held by laypeople and produced in an ongoing way, in the context in which they live and work; and second, as an end product of a research project on the first type of knowledge, in which it has been collected, refined, and transformed in the hands of researchers (Holm 2003). A third type of local knowledge is held by laypeople who have tapped scientific methods—usually inventory and monitoring—to inform themselves and others about themes related to stewardship or advocacy goals. Streamkeeper groups, for example, may have data about hydrology and riparian habitat that they have collected over the years. Watershed stewards have commissioned consultant studies of watershed ecology. Some stewardship groups focus on the intertidal zone.[12] Others monitor marine ecosystems and species, from eelgrass to cetaceans.[13]

This research addresses traditional, aboriginal, local, and fishermen's knowledge in one category for most purposes, as traditional and local knowledge—TLK. See Table 4 in section 3.4.2 for more characteristics of TLK.

3.3.2 Relevance of traditional and local knowledge (TLK)

> TEK researchers argue that TEK represents at least a critical supplement to "normal" scientific research, and perhaps an equal, alternative paradigm upon which to base science and management (Neis and Felt 2000 p. 13).

This research looks at TLK as a knowledge frame co-equal with science, rather than as a supplement, but does not go so far as to investigate TLK as an alternative paradigm for science and management.

The WSP calls for ATK to be incorporated in at least two instances:

- Principle 3. Sustainable Use:
  Resource management decisions will consider biological, social, and economic

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[12] E.g., the Georgia Strait Alliance Straitkeepers program has been carrying out intertidal quadrat studies for over a decade. http://www.georgiastrait.org/?q=node/616

[13] E.g., the Strawberry Isle Research Society conducts primary research and monitoring of various marine ecosystems in Clayoquot Sound. http://www.strawberryisle.org/

consequences, reflect best science including Aboriginal Traditional Knowledge … (DFO 2005 p. 9);

- For CUs in the Red zone more detailed reports will also be provided as they become available. These detailed reports will consider and incorporate ATK, where available ... (DFO 2005 p. 45).

Advantages of integrating TLK into salmon conservation planning include the following.

Support for collaborative processes: Increasing attention to the many strong bases of local knowledge has the potential to improve the interaction between fishers, communities, scientists, and managers (Charles 2001).

Scrutiny of scientific research: Input of local knowledge provided by non-scientists enriches the production of conventional scientific knowledge by scrutinizing the scientific research (Irvine 2008).

Provision of a range of fisheries-related information to improve the performance of management: Fishermen "can provide information about distributions of fish over time and space within a given year, including local abundances, changes in migrations, etc. While such information does not necessarily translate into a comprehensive estimate of overall stock abundance, it can be valuable input for scientists and managers" (Charles 2001 p. 330). Furthermore, "While fishermen cannot be expected to do better than science on issues that science targets, they will often have knowledge on issues that science—because it must be specialized—does not target" (Holm 2003).

Provision of specific, detailed data: TLK is more useful than knowledge produced by science in some ways because it is based on more detailed information and more continuous observation than is usually available from research-based sources (Wilson 2003). The fine temporal and spatial scale of fishermen's knowledge often exceeds that found in science. Commitment by fishermen to contribute to data gathering and analysis, especially during the fishing season, thus enables better management by producing good data. For example, it can provide data specific enough to enable traditional practices to continue unimpeded—i.e., meeting governments' need for assurance of conservation (Pinkerton 1989). As fisheries management focuses increasingly at finer temporal and spatial scales (e.g., CUs), TLK becomes even more relevant to salmon conservation planning. Practical knowledge at this scale can better allow for contingency and fluctuations in the ecosystem, and work with the reality of chaotic, unpredictable, fisheries systems (Palsson 1995). The data gathered by community-based stewardship groups, focused on habitat and ecosystem health, can play a similar role on the watershed side of the fishery system—filling in information at a fine scale.

Aggregation to data sets for use by scientists: Fishermen's knowledge can, at least in theory, be collected and aggregated to construct a larger scale, regional and intersectoral analysis of the dynamics of particular fisheries and marine ecosystems—which can approximate the scales typically associated with fisheries science (Neis and Felt 2000, McGoodwin et al. 2000).

Attention to ecological complexity: The reasons why integration of knowledge frames is important to ecosystem-based management are further outlined in Section 3.5.3. Generally, local people and resource users have perspectives more congruous with ecological complexity than does scientific research—emphasizing the importance of habitat over population dynamics, and regarding fisheries as systems in which small perturbations may have substantial future consequences (Wilson 2003 citing Smith 1990, Berkes 1993 and Pinkerton 1989).

3.3.3 Limitations on integration of the TLK knowledge frame

Limitations on integration of the TLK knowledge frame range from concerns related to its lack of congruence with scientific norms to broader ethical issues related to the integration intent.

Concerns about accuracy and verification

Because TLK is transmitted orally rather than in writing, it can be subject to problems with recall, and can be difficult to verify (McGoodwin et al. 2000). While TLK undergoes a form of peer review via cultural processes, this is not transparent to those beyond the community/culture/group. Widdowson and Howard (2002) criticize the use of traditional knowledge in forums such as environmental impact assessment because they say it lacks criteria and standards by which it can be evaluated. They liken unquestioning acceptance of traditional knowledge to the emperor with no clothes.[14]

Holm describes the disparaging perception of fishermen's knowledge often held by commentators who come from a scientific perspective:

> … raw fishermen's knowledge comes in the form of a mixed bag of knowledge items; a huge pile where a few nuggets of genuine insights and well-tested truths are entangled in a wide variety of beliefs, speculations, rumours, misunderstandings, lies, hopes, ideas, exaggerations, superstitions, and anecdotes. The basic problem becomes one of untangling the good stuff from the bad… (Holm 2003).

Challenges related to standardization and scale

TLK data are highly complex and usually are not standardized in terms of temporal scale, territorial coverage, technology, effort, and expertise, and are therefore difficult to compile into empirical information that matches reliability of scientific data (McGoodwin et al. 2000). The methods employed in collecting/aggregating local knowledge are not always clearly reported (Davis and Wagner 2003, Widdowson and Howard 2002).

Local knowledge may be relatively easily integrated with salmon planning/management at a fine scale—specific to a locale and time—but is more difficult to amalgamate and apply at broader temporal and spatial scales.

Concerns related to the holder of the knowledge

Fishermen's knowledge varies according to many factors including the holder's role in the fishery system, the technology employed, their experience, what part of the fish

[14] See Widdowson and Howard (2006) for an explanation of this critique and note their reference to published responses to their earlier work on the topic. Authors of the responses include Marc G. Stevenson, Fikret Berkes and Thomas Henley. The published debate was picked up by The *Globe and Mail* newspaper in 1997 (reference also in Widdowson and Howard (2006)).

population's life cycle they are in contact with and the extent it is politicized (i.e., reflects the "position of an individual or a group within a polarized political field") (Holm 2003). Some holders of TLK may be regarded as more "expert" than others, yet it is not clear how local experts are identified in TLK research (Davis and Wagner 2003). As well, bias can stem from the connection between TLK and the interest of the holder of the knowledge, posing difficulty in discerning opinion from empirical knowledge (Soto 2006 citing Johannes 1993).

Proprietary nature of TLK

Aboriginal groups retain proprietary rights to TEK, and cultural norms or First Nations governments may prevent the sharing of TEK. Local knowledge held by fishermen is often not willingly shared because of its importance to future harvesting success.

Attachment of traditional knowledge to its context

There is a lack of categories for data collection that match both aboriginal and scientific worldviews, so research using traditional knowledge tends to extract aboriginal knowledge from its context so that it matches categories of information determined by scientists (Bielawski 1996). This suits the needs of science but loses meaning of the aboriginal knowledge, which is "both context-embedded and implies correct, spiritually based relationships with the environment" (Nadasdy 2003 p. 132). The process of distilling and incorporating the experiences of First Nations people into the language and institutional structures of modern resource management inevitably distorts those experiences (Nadasdy 2003).

Risk of neglecting more significant factors affecting the salmon conservation planning process

With the aim in mind of integrating knowledge frames to further the implementation of the WSP, "relevance" of TLK in this discussion is judged in practical terms, focusing on integration that could occur within the processes laid out in the WSP, particularly Strategy 4. It does not consider the political and cultural context for WSP implementation, and lack of attention to these dimensions may mean that issues pivotal to the success of collaboration with First Nations in resource management are not addressed (Nadasdy 2003)[15].

Potential injustice to the holders of TLK

There are significant attributes of traditional/aboriginal knowledge that are not attended to when the focus is on integrating ATK with other knowledge frames,[16] some of which could be compromised through integration efforts and would be best appreciated through

[15] The important theme of power relationships is beyond the scope of this research but highly relevant to the challenge of integrating knowledge frames in salmon conservation planning. The reader is referred to authors who explore how knowledge is bound together with issues of social power and relationships among stakeholders, such as Pinkerton (1989, 1996, 2003, 2005), Abrams (2000), Wilson (2003), Neis and Felt (2000), Palsson (1995), Nader (1996), Nadasdy (2003) and Soto (2006). See especially Nadasdy (2003) chapter 3, "The Politics of TEK: Power and the Integration of Knowledge."

[16] Nadasdy goes so far as to argue that the notion of systems of knowledge itself may be misguided—the assumption that knowledge exists in discrete epistemological systems may not be accurate (2003).

fundamental changes in resource management regimes (Nadasdy 2003). While this research stops short of examining different approaches to salmon conservation planning that would do justice to traditional/aboriginal knowledge (e.g., embedding management in First Nation communities or turning over responsibility to First Nations governments), it does not support the mere skimming-off of indigenous empirical insights, to be inserted into science-driven frameworks (Scott 1996).

3.3.4 Underappreciation of TLK

TLK tends to be underappreciated in fisheries management because of its lack of consistency within the norms of the science frame. Key differences, as summarized in the next section, include that TLK is tacit rather than discursive, and it uses different rules and norms to determine validity (Neis and Felt 2000, Palsson 1995). In her Ph.D. thesis, Soto (2006) critically analyses this tendency. Samples of critiques by Soto and other authors follow:

- Holders of TLK are assumed to be “locked up in a particular natural or cultural world, driven by genetic makeup, ecological context, superstitious beliefs, or local concerns.” Scientists, by contrast, are assumed to be “objective explorers of reality, proceeding by rational methods and detached observations” (Palsson 1995 p. 87);
- “There are many examples where lay people’s findings have been proven to be valid, and experts have had to change their original standpoints. Hence, there also seems to be reason for lay people to mistrust science, and science itself fosters this mistrust by failing to recognize the public and other stakeholders as knowledgeable actors who can deal with complexities and uncertainties” (Lidskog 2008 p. 71);
- “Scientific information easily passes the entry exam for quality control, since it must, by definition, be information that has been systematically collected, organized and reviewed. …What is missing all too often is critical reflection on whether the information should be accorded special status or if it is even relevant.” Interests and values that are expressed in terms other than the quantified language of science can inadvertently be outweighed by technically driven characterizations (Burchfield 2001);
- Fisheries managers have dismissed (though less so over time) fishermen’s knowledge because of the assumption that it is biased by the motivation to increase catch-quota allocations. “The assumption that commercial fishers behave like predators leading inevitably to the ‘tragedy of the commons’ is rife within fisheries management…” (Soto 2006 p. 120).

Underappreciation of TLK in relation to the science frame in fisheries management leads to the following impacts:

- TLK is not used or it is treated with suspicion;
- TLK is used in limited ways relative to its potential applications;
- Particular kinds of TLK are ignored because they do not fit within current procedures in fisheries science and management;
- TLK is ignored because it is social knowledge, and social dimensions of fisheries management tend to be neglected (Soto 2006).

To reiterate, the point is not to do away with science in salmon conservation planning; it is to acknowledge the relevance of forms of knowledge that could help close the information gap, especially when combined with technical knowledge (Kearney et al. 2007).

3.4 Comparing TLK to technical/scientific knowledge

A comparison of TLK to science helps set the context for challenges and ways forward in integration. Nonetheless, the hazards of a dualistic perspective are explained here before putting forward a comparative table listing some characteristics of TLK and science.

3.4.1 Some pitfalls of contrasting TLK with science

As this report pursues the integration of knowledge frames in wild salmon conservation, the risks of highlighting distinctions between the frames are somewhat self-evident. Wilson (2003) and Soto (2006) caution against the oversimplification of fisheries knowledge into two cultures on the following grounds:

- *Obscures qualities distinct to different frames:* Qualities and values of traditional aboriginal knowledge are obscured when this knowledge frame is lumped with other forms of local knowledge. The same can be said of fishermen's knowledge;
- *Can denigrate TLK:* Stereotyping the two knowledge frames into two ideal types often tends to denigrate local knowledge while idealizing scientific knowledge;
- *Hides variation within each:* Simplifying into two categories can hide the fact that there are multiple viewpoints within each knowledge frame; there are various cultures and standards of validity within each; and there are important exceptions to the generalizations about each. Thus, generalizations may obscure the actual range of characteristics and quality of both TLK and science "on the ground." For example, while Table 4 indicates that TLK is tacit and qualitative, most of the information kept in fishermen's logs is tangible and measurable while other knowledge they gain from experience is not written down, and all this knowledge is intuitively meshed (Dobbs 2000);
- *Underplays similarities:* Rigid categories reduce recognition of similarities between TLK and science: e.g., scientists and others both hold only a partial understanding of reality; both have their own specialized terminology; both evaluate facts in terms of their source; both depend on observations; both make deductions based on premises and deliberately verify these in relation to experience; and both present "facts" about which the presenter holds many different levels of certainty, from their own direct experience to something that is generally accepted as true without reflection (Wilson 2003, Scott 1996);
- *Draws attention away from other important dynamics:* There are important reasons why different stakeholders are saying different things, and why communications are distorted, other than differences in the way the parties in a process understand things. These can include the way interactions are structured and differences based in culture (e.g., class or cultural differences between rural and urban dwellers). Such differences can also prevent the effective raising of arguments that, if and when raised, would be mutually understood.

3.4.2 Characteristics of TLK compared to technical/scientific knowledge

> … enhancing dialogue between resource users and scientists and managers and creating new and better knowledge require understanding *how* knowledge is

made within each of the different knowledge traditions (McGoodwin et al. 2000 p. 260).

With the pitfalls of contrasting TLK with science in mind, Table 4 compares TLK to technical/scientific knowledge, from a number of authors' perspectives.

Table 4: Characteristics of TLK (including aboriginal, local, and fishermen's knowledge) compared to scientific knowledge (Sources: Adler and Birkhoff 2003, Degnbol 2003, Holm 2003, McGoodwin et al. 2000, Nadasdy 2003, Neis and Felt 2000, Palsson 1995, Wilson 2003, Bielawski 1996)

Characteristic	Traditional and local knowledge	Scientists' knowledge
Knowledge	• an aspect of broad cultural processes embedded in complex networks of social relations, values, and practices	• abstract product of the human intellect
Basis	• experience • the land/seascape • a land/sea-based way of life of thousands of years (for traditional/aboriginal) • spiritual teachings	• theory • Western/European philosophies • empirical, based on evidence • involves some practical knowledge obtained in the course of engagement and experimentation
Explicitness	• tacit • intuitive • much of it is nested in a web of implicit, unspoken relationships	• discursive • shared • expressed
Accumulation	• result of situated learning, culturally shared • socially restricted in some cultural groups	• bodies of codified learnings built up using scientific logic
Expression	• narrative • transmitted orally	• textual • written records
Nature of observations	• observations by people in direct engagement with everyday tasks and contact with the environment (often over generations)	• observations dictated by research protocols • specialized technologies and training to go beyond visual inspection
Processing	• direct and immediate experience, accumulated over time	• data processed according to approved methodologies
Standardization	• data are highly complex and not standardized in terms of temporal scale, territorial coverage, technology, effort,	• normalized, standardized consistent with professional standards and expertise • variations related to subcultures

	etc.	(e.g., institute-to-institute, lab-to-lab)
Transferability	• local in that the experience is shaped by a unique place • location specific; often cannot be generalized to other places	• transferable • not attached to a specific context
Replicability	• often not replicable • sometimes formulated in general terms	• following rules of hypothesis testing, experimentation • replicable
Level of detail	• detailed	• relatively general
Temporal scale	• intensive sampling over extended periods	• less frequent observations
Spatial scale	• fine spatial scale	• large-scale averaging
Attention to uncertainty, variability, forecasting	• questions basic assumptions • may claim knowledge of the ecosystem is too imperfect for making reliable forecasts • learning by doing	• reference to uncertainty in margin of error associated with analyses and predictions • emphasizing linear relationships and states of equilibrium, less able to deal with variability and respond to changes in the ecosystem
Peer review	• poorly understood peer review process	• peer review part of a larger process of professionalization
Qualitative vs. quantitative	• qualitative • non-quantitative	• quantitative • numerical, statistical analysis
Field of science	• studied by social scientists	• realm of natural science
Worldview	• holistic • traditional/indigenous/aboriginal does not separate people from nature • humans in reciprocal relationship with animals	• reductionist • compartmentalized • separates people from nature • humans superior to animals
Perspective on fish	• stock structures are complex aggregates of localized sub-populations • concerned with local abundance • respect for fish as individual beings	• assumes large-scale, homogeneous stock systems • fish regarded in aggregate as stocks • respect for fish as part of genetic diversity

Alder and Birkhoff have undertaken a similar analysis, shown in the following table, in which knowledge from “here” is their term for TLK and knowledge from “away” is parallel to scientific knowledge.

Table 5: Knowledge from "here" compared to knowledge from "away" (Adler and Birkhoff 2003)

Knowledge from "here"	Knowledge from "away"
• slow knowledge	• fast knowledge
• cultural information	• scientific information
• lay people	• experts
• observations of particular locales	• broad statistical patterns
• holistic thinking	• disciplinary thinking
• information that starts with certain values in mind	• information that seeks to be value-neutral
• oral traditions	• written histories
• informal insights	• formal studies
• single situations	• universal patterns
• lore, stories, narratives, and anecdotes	• data, figures, measurements, and statistics

3.5 Resource management approaches calling for integration of knowledge frames

Three approaches to wild salmon conservation and sustainability central to the WSP are highlighted here because of their direct relevance to the integration of knowledge frames: collaboration/consensus processes, the precautionary approach, and ecosystem-based management. Ways that each of these drive and benefit from knowledge integration are explained. As well, post-normal science is introduced because of its potential to act as an integrative knowledge frame that might transcend the distinctions between ways of knowing.

3.5.1 Collaboration/consensus processes

The WSP calls for decision-making through an inclusive process rather than predetermined rules in part because rules cannot anticipate and adequately address the diversity of problems and eventualities that will be encountered due to the complexity of salmon and salmon habitat management (DFO 2005). An inclusive, collaborative process creates the opportunity for a range of relevant knowledge to be brought to bear on the complex challenges facing salmon conservation. Such processes are increasingly being seen as "the best way to link the substance of science to decisions that must be made regarding environmental policy" in situations of inherent uncertainty stemming from the complexity of natural systems (Karl et al. 2007 p. 24).

The central value of integrating knowledge bases via collaboration is spelled out in an essay about “a new environmental movement” as follows:

> [A] striking difference between collaborative conservation and its predecessors [“technocracy”] is its emphasis on integrating local and scientific expertise. … Collaboratives embrace the importance of scientific knowledge and expertise, but at the same time seek to expand the concept of expertise beyond bureaucratic and organized interest expertise. Collaboratives are also less certain that scientific information can or should be insulated from the political arbitration of conflicting values. Explicit attempts are made to integrate scientific knowledge and technical expertise with local knowledge … [This] approach … opens up traditional science to new ways of knowing, and perhaps new understandings about how complex ecosystems function. It also creates a greater sense of community investment in efforts to protect nature, as it validates the importance of local stories and talents, which rarely command the prestige of knowledge produced at remote universities and research centers (Brick and Weber 2001).

While the promise of a collaborative approach is strong, the consensus process can be difficult. The WSP concedes that reaching consensus on a preferred management alternative and management actions will not always be possible due to differences of *opinion*. The possibility of failure to reach consensus should not then be exacerbated by differences of *understanding*. Reasons that the parties involved may not understand each other include different ways of knowing, and the lack of a common information base that parties involved in salmon planning can use with confidence (Sigurdson and Stuart 2007 in Nelitz et al. 2008, Grumbine 1994). Attention to the former can help resolve the latter. The blending of different ways of knowing is thus part of the challenge as well as being part of the opportunity.

3.5.2 The precautionary approach

The WSP (DFO 2005 p. 15) states “Precautionary approaches are now widely applied in fisheries management and the protection of marine ecosystems.” It explains that the precautionary approach acknowledges uncertainty in information and future impacts, and the need for decision-making in the absence of full information. It also implies a reversal in the burden of proof and the need for longer-term outlooks in conservation of resources.

Precautionary measures aim to cope with the uncertainty that is integral to fisheries management by reducing risk (Berkes et al. 2001, Charles 2001). But rather than accepting uncertainty as part of management, the initial international response to the precautionary approach was to internalize uncertainty into research by quantifying it and associating probabilities of various outcomes with the predicted effects of management measures. The more fundamental shift was then to change the objectives of management “from targeting production, with optimization being the core concept, to emphasizing conservation and risk management, with precaution being the core concept” (Degnbol 2003 p. 39-40). This risk avoidance approach addresses danger zones of different intensity rather than a single threshold or maximum limit. The WSP approach is consistent with this conservation and risk management orientation, as it commits to the use of precaution specifically in terms of setting benchmarks:

> …the introduction of a lower benchmark (Strategy 1) is a significant precautionary step in the conservation of Pacific salmon. In determining the value of the benchmark, all sources of uncertainty in assessment of the CU must be determined (for estimation of the buffer) … Where assessment information is highly uncertain, more precautionary lower benchmarks will be defined (DFO 2005 p. 15).

Because the precautionary approach is a less exact science than conventional fisheries science was thought to be, the approach "must be characterized by process, transparency, participation, agreement, documentation, feedback, accountability, evaluation, and responsiveness" (Berkes et al. 2001 p. 24). Again, the integration of knowledge frames is consistent with this letting go of exclusive reliance on science and a shift to participatory management processes.

3.5.3 Ecosystem-based management

A fisheries management shift over the 1990s followed concerns about overexploitation and environmental degradation, calling into question the effectiveness of conventional management. The focus moved away from production toward conservation and away from individual species at a single broad scale, towards multi-species stock analyses and ecosystem-based management at multiple scales (Hughes et al. 2005, Berkes et al. 2001). The WSP reflects this new management approach:

> There has been an increasing awareness that past management of large fisheries and 'stocks' has failed to adequately protect or recognize the value of diversity in Pacific salmon. … Biologists are learning more about the genetic diversity of wild salmon, the impact of climate on survival, and the relationship of salmon to their habitat and surrounding ecosystems. … The *Oceans Act* calls for integrated resource management and an ecosystem perspective (DFO 2005 p. 5).

Objective 2 of the WSP is to maintain habitat and ecosystem integrity: "Identifying, protecting, restoring and rehabilitating aquatic habitats are critical to maintaining their integrity and sustaining ecosystems" (DFO 2005 p. 13); and Strategy 3 is about inclusion of ecosystem values and monitoring.

Both of the approaches to salmon conservation planning discussed above—collaboration and the precautionary approach—are partially driven by the complexity of salmon ecosystems and the resulting uncertainty. Characterizing/predicting ecosystem structure and function are inherently difficult (Browman et al. 2005). Recognizing the limits of science in this context points towards an appreciation of the knowledge held by fishermen (Berkes et al. 2001). Given that much scientific effort is still committed to single stock models, fishermen's observations of ecological processes are particularly important (Holm 2003). The combination of different knowledge systems can contribute to building understanding of resource and ecosystem dynamics to support ecosystem resilience (Hughes et al. 2005).

A theme issue of *Marine Ecology Progress* (Browman et al. 2005) was dedicated to exploring the politics and socio-economics of ecosystem-based management (EBM) of marine resources, recognizing how inextricable and complex the linkages are between science and societal forces in implementing an ecosystem-based approach. This reflects the strong connection of values and political-socio-economic considerations to EBM. Lackey (2007) asserts that ecosystem health is a value-driven policy construct often "passed off as science to unsuspecting policy makers and the public." And Grumbine 1994 p. 28) incorporates values into his working definition of EBM: "Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework towards the general goal of protecting native ecosystem integrity over the long term."

Values are particularly central to the determination of ecosystem objectives and ecosystem indicators—as called for by the WSP. This again implies the need for collaboration, since in most cases the social goals and values that should influence the definition of ecosystem objectives are not clear, or at least not clear enough to articulate as specific, measurable objectives (Nelitz et al. 2008).

One further argument for inclusion of knowledge systems beyond science in the EBM approach is that local scales are where people connect with ecosystems, to the extent that "local-scale EBM is often a bottom-up (stakeholder driven) effort to create a forum for communication between management agencies, scientists, and the community" (Heiman and Wendt 2008). Results of public meetings hosted by the Pacific Fisheries Resource Conservation Council on Vancouver Island are consistent with this reasoning. Issues of importance about wild salmon populations included salmon ecosystems, and community members expressed a desire to be involved in whole ecosystem management of resources through an integrated, "common sense" approach to stewardship driven by First Nations, municipal, corporate, and community groups (Johannes 2006). Likewise, the EBM perspective is appealing to First Nations, who know their home rivers and have a responsibility for stewardship of the watersheds in their territories (Weinstein 2007). ATK has a head start over science on an integrated, ecosystem-based perspective because it does not separate people from nature (Bielawski 1996).

Writing in 1994, Grumbine recognized that implementation of ecosystem management through dialogue and cooperation at local and regional levels will be quite different from management imposed bureaucratically, and he pondered whether "experts" (as opposed to holders of TLK) are capable of playing less powerful roles in decision-making.

3.5.4 Post-normal science—an integrative knowledge frame?

In the context of debates around the justification for marine protected areas, Jones (2002) asserts that scientists may appropriately make statements based on personal, ethical judgments as long as these are explicit and separate from statements based in scientific evidence. He points out that this role is characteristic of what is called "post-normal science." Post-normal science addresses some of the limitations of conventional science. It may increase acceptance of ways of approaching science that include skills, practices, and networks as legitimate forms of knowledge in addition to mental representations and theories (Holm, 2003). Such acceptance could facilitate the integration of knowledge frames. A leading author on post-normal science, Ravetz (1999, 2004), says that it:

- addresses issues where facts are uncertain, values in dispute, stakes high and decisions urgent;

- is precautionary, usually concerned with reacting to the unintended harmful effects of progress, focusing on sustainability;
- works with knowledge in the public rather than private sphere, including communities;
- lies at the contested interfaces of science and policy;
- does not require the elimination of uncertainty in the generation of quality results—instead, manages uncertainty skillfully;
- seeks understanding of, rather than assuming isolation from, the synergies of the complex interactions of the natural world with social, economic and political realities;
- encourages the democratization of expertise via scrutiny of scientific reports by an 'extended peer community';
- recognizes decision stakes;
- takes scientific inquiry from artificially controlled conditions to address problem-solving in its societal and cultural milieu.

Post-normal science accords local knowledge special importance because this contextualized knowledge is often highly relevant to action (Lidskog 2008). It draws in knowledge of local circumstances important to environmental problems as well as political and social dimensions of scientific practice. Scientists, instead of providing facts, provide testimonies.

But Lidskog (2008) cautions that post-normal science does not entirely level the playing field for the various frames of knowledge. He points out that science is still in "the driver's seat," and others may only evaluate and correct it as they judge its quality and relevance. Irvine (2008) critiques post-normal science from almost the opposite direction, stating that the process it describes goes so far beyond science as to make the term a misnomer. He reflects that many of the lessons learned in generating the WSP "illustrate elements advocated by proponents of what has been called post-normal science." He then questions the specific terminology, stating that the interdisciplinary approach it advocates: "is not science per se, but policy making, or perhaps decision making." He asserts that the assimilation, interpretation, and recommendations arising from the scientific process are important, but are not science. Converging with Lidskog's critique, Irvine observes that "Scientific knowledge is required, but so are other types of knowledge."

3.6 Adjusting assumptions about the roles of different knowledge frames in the WSP

Section 2.4 showed that DFO anticipates various sources of knowledge will be used in WSP implementation in addition to technical/scientific knowledge. Yet the policy predominantly reflects a western science approach. Nelitz et al. (2008 p. 19) note that "knowledge type" is a challenge facing the implementation of the policy in that "there is great uncertainty about how to bring in Traditional Knowledge in a meaningful way." Before looking in detail at how different knowledge frames may be integrated into WSP planning in Section 4 of this report, two suggestions are made here for a general reorientation of the policy's assumptions about knowledge frames.

Unrealistic separation of science from values

The policy needs to more fully acknowledge that knowledge frames outside of natural science are more than just "values," and that natural science is not value-free.

The WSP is on the right track in recognizing that:

> Making the best decisions on salmon conservation cannot be done by scientists or other technical specialists alone. While choices must certainly be informed by scientific and technical information, the best decisions will ultimately reflect public values (DFO 2005 p. 14).

This statement appropriately supports the application of different knowledge frames to the salmon conservation challenge. Yet the preceding analysis raises a caution about the statement: it should not be taken to imply that the scientific/technical information is value-free, nor that the other knowledge to be brought to bear on policy implementation is all "values." Stakeholders representing "public values" in the planning committees—like scientists and technical specialists—will have relevant and reliable information that needs to be integrated into the salmon conservation planning process.

Nelitz et al. (2008 p. 9) advise in a different direction, calling for an even clearer distinction between science and values to increase the chance of successful policy implementation. They observe that the WSP Strategies:

> …involve a mix of science (objectivity) and social values (subjectivity). Strategies 1, 2, and 3 are focused on accurately representing the current state of scientific knowledge and collecting the appropriate data to represent this understanding. … In contrast, Strategies 4, 5 and 6 are focused on designing and implementing a process for … making decisions … that reflect society's value for Pacific salmon. A distinction between science and values is important so that these aspects are clear to all participants…

The research reported in Sections 3.1 to 3.5 suggests that the objectivity of science can be overplayed, at the cost of underappreciating other knowledge frames (the "current state" of knowledge comprises local and traditional knowledge as well as scientific knowledge) and compromising the level of integration necessary for consensus. In particular, it would be inappropriate to undo the interconnection of values and science explicit in Strategy 3: Inclusion of ecosystem values and monitoring. The policy is on the right track in acknowledging that values are central to ecosystem-based management.

Oversimplification of knowledge sources for various strategies and steps

The policy needs to more fully acknowledge that knowledge about salmon stocks, habitat, and ecosystems is local as well as scientific, and that social and economic considerations require science as well as local knowledge.

Section 2.4, on WSP/DFO directions for use of technical/scientific knowledge as compared to other sources of information, indicates that most of the WSP strategies, and the steps within Strategy 4 (integrated strategic planning), call for input from sources other than technical specialists. Nevertheless, there is a transition from emphasizing knowledge "from away" through the first three strategies, to knowledge "from here" in Strategy 4. Nelitz et al. (2008 p. 9) summarize the focus of Strategies 1, 2, and 3 as follows:

Strategy 1. Scientific understanding of salmon populations

Strategy 2. Scientific understanding of salmon habitats

Strategy 3. Scientific understanding of marine, terrestrial, and freshwater ecosystems deriving benefits from salmon.

In contrast, Strategies 4-6 are focused on "designing and implementing a process for using those data."

Yet it is in Strategy 4 that local interests become engaged, and it is also here that social and economic considerations are expected to be drawn into the process. The foregoing analysis of knowledge frames relevant to salmon conservation planning strongly suggests that Strategies 1 to 3 (as well as 4) should be informed by TLK, and that Strategy 4 (or whatever earlier steps could be used to incorporate social and economic information) should tap the social sciences as well as TLK. Social sciences also have relevance to Strategies 1-3; for example, in the design of collaborative monitoring systems.

4 INTEGRATING KNOWLEDGE IN WSP PLANNING

> The best stakeholder processes do not privilege one way of knowing above others. They welcome all modes of inquiry and analysis to the table and integrate information that makes sense culturally, scientifically, economically, and politically (Adler and Birkhoff 2003 p. 7).

> Once the proper spirit is achieved in pooling expert and "experiential" knowledge, remarkably rich versions of environmental processes become possible (Cormick et al. 1996 p.64).

Those involved in integrated strategic planning need to recognize the limitations of the various frames of knowledge while eliciting from each way of knowing the information and wisdom required to meet the challenges of salmon conservation. But integrating knowledge frames is difficult and practical guidance is scarce. Here, suggestions and principles gleaned from the literature are put forward, and examples from the Barkley Sound and Skeena Watershed experiences are offered where available. Connections to specific parts of the WSP are also made where relevant, often in relation to statements assembled in Table 2: Overview of the sources of information for implementation of the first four strategies of the WSP. The WSP implies the need to integrate knowledge frames, though not as explicitly as does the draft WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy. That strategy lists "Integrating scientific, traditional, local, and other knowledge and values" as a specific cooperation and integration need (AMB 2006 p. 15).

The analysis in this section tackles the central research question of the report:

> How can the WSP strategic-planning committees best integrate the different sources of knowledge required to carry out strategic planning for implementation of the WSP?

Seven areas of endeavour relevant to consensus processes are discussed in terms of how they can support the integration of knowledge frames in integrated strategic planning for salmon conservation. Within each area the following recommendations and principles are developed:

1. **Recognizing different knowledge frames**
    - Bring to light and respect ways of knowing;
    - Give knowledge frames equal status;
    - Blend and/or sequence application of knowledge bases as appropriate;
    - Take care in integrating traditional and local knowledge into science;
    - Encourage multidisciplinary perspectives and include social science;
    - Recognize self-interest as a type of information.
2. **Determining what information is needed**
    - Collaborate on information needs early;
    - Start with clear problem definition and objectives;
    - Agree on indicators;
    - Establish criteria for research/information.
3. **Collecting and processing information**
    - Cooperate in the assembly and use of information—throughout;
    - Consider participatory research;
    - Link sources of technical knowledge to the multi-party process.
4. **Providing access to information**
    - Ensure transparency and equity in access to information;
    - Disseminate information to process participants.
5. **Addressing uncertainty**
    - Don't expect uncertainty to be eliminated;
    - Put what is known in the context of what is not known;
    - Disclose scientific assumptions;
    - Describe uncertainty;
    - Share the risk assessment role;
    - Acknowledge differing perceptions of risk.
6. **Improving communication across knowledge frames**
    - Build capacity for participants to discuss different types of information;
    - Communicate science/technical information clearly;
    - Communicate traditional and local knowledge information clearly;
    - Include storytelling;
    - Make space for face-to-face communication;
    - Use deliberative inquiry.
7. **Using structured approaches for applying knowledge**
    - Collaborate in developing the analytical approach;
    - Consider a range of decision support tools, including simple ones;
    - Carefully time the introduction of structured decision-making tools;
    - Don't overestimate the power of models.

4.1 Recognizing different knowledge frames

Prerequisites for integrating knowledge frames include recognition that various ways of knowing exist and respect for the value of each. General options for blending and/or sequencing attention to the different types of knowledge should be considered. Since science is currently the dominant knowledge frame in salmon conservation planning, special efforts may be needed to carefully draw in traditional and local knowledge, and to encourage multidisciplinary perspectives. Another source of knowledge that can be undervalued includes the expressed self-interests of participants.

4.1.1 Bring to light and respect ways of knowing

The first step towards integrating knowledge frames is simple and challenging, obvious and subtle: those involved have to acknowledge that there are different kinds of knowledge that are equally legitimate. Disagreements over resource management challenges are often related to differences in how different people and groups think or "know the truth"—differences that are exacerbated because they are often invisible (Adler and Birkhoff 2003). Ignorance of the differences leads to misunderstandings and perceived divergences, which in turn hinder discussions. Wilson (2003 p. 273-4), in his review of the literature on the dynamics behind the East Coast cod collapse explains this ignorance-based misunderstanding as the "two cultures theory of fisheries knowledge," in which scientists and fishermen both feel that their "side" uses "common sense" while the other does not, and members of each culture find the knowledge claims of the other to be incoherent.

The WSP (DFO 2005 p. 28) acknowledges the need for respect, stating "All parties should respect the others' opinions and processes, and work towards consensus." This is consistent with one of nine principles for consensus set out by Cormick et al. (1996 p. 68): "Acceptance of the diverse values, interests, and knowledge of the parties involved in the consensus process is essential."

There are no blunt tools for developing respect, trust, and effective communication, and the integration process requires considerable care (Charles 2001). Nevertheless, a simple starting point is to explicitly recognize that there are different ways of knowing and different modes of communicating important facts and ideas, and that it is not acceptable to trivialize one kind of knowledge while putting another on a pedestal. Adler and Birkhoff (2003 p. 10-13) go further, to a type of affirmative action, in recommending that the participants in the process be asked, "'How can we give opportunity, credence, and value to the ways of knowing that are not predominant?'" The AMB has acted in this manner, playing the role of promoter and legitimizer of local knowledge use in management decisions (Pinkerton et al. 2005). Facilitation of the Skeena Watershed Committee also made space for local knowledge, giving respect and weight to contributions made by First Nations because their experiences and attachment to the land gave them a particular understanding of the area. First Nations representatives brought to the process valuable, qualitative information on factors such as migration timing and other processes. Similarly, fishermen's reports of declining steelhead in the system were heeded despite there being a shortage of scientific data that could make this case beyond a specific part of the watershed (Tautz, pers. comm. 2008).

Principled, structured consensus processes as prescribed by the WSP should be able to avoid a hierarchy of knowledge types, "accessing science, traditional and local knowledge as complementary and interactive sources of wisdom, not mutually exclusive" (Palsson 1995 p. 94). The "Knowledgeable Persons Panel" to be convened in connection with Strategy 3 (Ecosystem values and monitoring) (Nelitz et al. 2008 p. 16), is a good demonstration of DFO's openness to the various "sources of wisdom." The Knowledgeable Persons Panel (KPP) was conceived at a consultation workshop on Strategy 3 as a mechanism for involvement in ecosystem monitoring. The KPP would work with regional teams that would provide localized knowledge. It would share knowledge and experience (i.e., science direction) with the regional teams; provide focus and consistency to discussions within and among regions; and collate advice from the regions (Hoffman 2007). According to the workshop report (Abrams et al. 2006) the purpose of the proposed panel is to make use of people who know the subject matter, to serve as institutional memory and context providers, and to minimize wheel spinning. It was proposed to be composed of people with a mixture of different knowledge and experience pertaining to ecosystem values and establishing assessment frameworks. Some members would also bring knowledge and experience on how best to involve First Nations in discussions.

4.1.2 Give knowledge frames equal status

> [Environmental researchers are more like artists than oracles—they make decisions on] relevant facts; on the boundaries between what we know and don't know; and on what we care about. … if we interpret science as something other than this artful endeavour, if we sense that it offers true direction, that its elegance takes priority over other forms of knowing, we can be misled, disappointed, and ultimately suspicious of our most trusted partner in solving human problems (Burchfield 2001 p. 237).

Trust more important than numbers:

Frequently, the common sense remedy for "arguing about numbers" is to get more and better data. For example, the Skeena Independent Science Panel (2008) calls for the acquisition of reliable information—"better hard data"—on the abundance of steelhead because "Nothing breeds controversy faster than weak or nonexistent data." Yet achieving perfect information on most themes related to salmon planning is unrealistic, and even the most robust quantitative analyses can be debated.[17] An alternative perspective is that arguing about numbers is an indicator of other issues, from the inevitable uncertainties in understanding the salmon ecosystem to a lack of trust among the parties. Integrating the extensive knowledge of resource users and local people is essential not only to informing the salmon conservation planning process but to laying the groundwork for constructive use of the science that is available—turning data from ammunition into a piece of a large puzzle. Rather than agreement on numbers as the foundation for trust, trust is the foundation for agreement on numbers. Rather than science being seen as superior, different knowledge fields are all viewed as containing valuable expertise (Lidskog 2008). Meeting the challenge of making decisions and dealing with differences in the face of uncertainty and risk requires sharing of information between sectors and blending together science and local knowledge: "While

[17] See section 3.1.2 for more commentary on overconfidence in the ability to produce unassailable scientific results and unconstructive use of science in adversarial settings.

science can support decision-making, decisions involve more than science" (Sigurdson et al. 2008 p. 4).

Tendency to prioritize science over TLK:

Science tends to receive priority ranking either through an overall emphasis on science or through delaying incorporation of other knowledge frames until late in the process. A participant who represented the province in the Skeena processes observed that too much confidence has been placed in science as a way of dealing with the issues of fisheries management in the watershed, and that other tools need more emphasis—"science is just part of the picture in the Skeena" (Tautz, pers. comm. 2008). Another participant, with a sport-fishing background, criticized the Skeena Independent Science Panel for failing to include information on steelhead based in past experience, such as the disadvantages of radio tagging (confidential communication).

The Skeena Independent Science Panel recommended that a new Science Committee should be open to using traditional ecological knowledge (Walters et al. 2008), and the purpose of the panel itself was "to ensure the best available science and Traditional Ecological Knowledge is available to provide an agreed technical base for management planning" (Walters et al. 2008 Appendix A). Yet the panel was criticized for lack of attention to such knowledge, including the following commentary:

> What is "Traditional Ecological Knowledge"? If I were to offer up written observation made by the anglers who put Skeena steelhead on the map in the 1950s and 60s would anyone pay attention? Is anyone interested in the fact there were once very catchable numbers of steelhead at the outlet of Morice Lake in late August or that there were schools of dozens and even hundreds of steelhead swimming around the lower bays of Sustut and Johanson lakes in mid-September? Would anyone like to speak with the Guide Outfitter who once had a bear hunting camp at the outlet of Sicintine Lake because bears gathered there to feed on spawning coho? How about Kluatantan? [Years ago] there were those who related stories of fishing for steelhead and coho at the Kluyaz Lake outlet early in their hunting season. There are Tourism BC promotional pictures of steelhead caught from the Kispiox in August and I have personal friends who have records of huge steelhead caught on annual trips to the Suskwa River 45 years ago when they could only make the long trip from Prince George before school started. If biodiversity is of any significance at all relative to steelhead, not to mention things other than fish, it is serious stuff to fail to include at least passing acknowledgement of what has already been compromised or lost (confidential commentary on results of the Skeena Independent Science Review).

Shifting from an expert-led to a bottom-up approach:

The WSP progresses from an early emphasis on science in Strategies 1 and 2 to increasing emphasis on participant knowledge and values in Strategies 3 and 4. It is risky to delay attention to the principle of inclusion this way because the science phase associated with the earlier strategies is permeated with subjective framing assumptions that should be informed by the parties on the planning committees.

> Divergent public interests and values cannot therefore be adequately addressed by 'bolting on' inclusive deliberation at the end of an expert-led process … The relationship between expertise and wider public deliberation needs to be far more multifaceted, directly engaged and symmetrical (Stirling 2001 p. 71).

One way to achieve symmetry, in addition to integrating knowledge frames from the beginning, is to strive for representation of parties with people who have the different types of knowledge. Another is to consider also a "bottom-up" stance that uses science for guidance where appropriate and valuable rather than being wedded to a "top-down" approach that seeks and/or relies on comprehensive scientific information (Jones 2002). The role of scientists can even be explicitly limited in ground rules for the multi-stakeholder process that specify the roles that scientists will and will not be expected to play (Karl et al. 2007).

In processes leading up to the current Barkley Sound WSP pilot, the "Alberni Round Table" shifted the multi-party governance focus from one that relied on expert knowledge to one that integrated local and expert knowledge. This integration is supported by the evolution of a Joint Technical Working Group under the AAROM[18] program into a Barkley Sound Technical Working Group in which First Nations continue to be key players (Luedke 2008 workshop presentation). In this watershed-based process participants realized that their vested interests in the resource could best be served by working together on shared issues (e.g., impacts of logging on fish habitat). Another way that local knowledge was given credence was via in-season conference calls in which local users were welcome to report on their observations of what was happening in the streams, etc., which could then be correlated with expected run size. Looking ahead in the WSP pilot process, one of its convenors anticipates that no single party should be able to claim it is the only source of information on a given topic:

> Traditional and local knowledge has to come into the process and be valued alongside DFO's knowledge and blended if the needs of the people are going to be dealt with in a collaborative process. Up until now DFO has built their knowledge on what their science and research has told them and they have to realize that other types of knowledge have to come in as well (Beaith pers. comm. 2008).

The draft WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy identifies two information priorities related to local knowledge. One is to pilot an existing local knowledge mapping initiative by applying it to a salmon-related subject, and the other is to expand the breadth of local knowledge being collected as part of a salmon stock health project. This latter would include local knowledge about aspects of salmon and their habitat including migratory routes, feeding grounds, linkages with other species, etc.

4.1.3 Blend and/or sequence application of knowledge bases as appropriate

Nelitz et al. (2008 p. 15) state that a challenge in implementing the second action step of Strategy 2 (Assessment of habitat status) (see Table 1) is "gaining local knowledge about a watershed" (e.g., restoration priorities are typically determined using expert opinion and data from DFO science, habitat, NGOs, FNs, etc.). They point out the need for a transparent and consistent process for integrating quantitative and qualitative data. Table 6 lays out a few general ways of integrating the application of different knowledge frames. It suggests that not all knowledge sources need to be brought to bear in a multi-party process at every turn. Rather, "Different knowledge fields may to various degrees

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be seen as relevant when approaching a specific issue...” (Lidskog 2008 p. 81). Various factors will determine whether, for example, both science and local knowledge need to apply at a particular stage in the planning process.[19] Sometimes traditional and local knowledge can be pulled into a science framework; in other cases some issues are best addressed through science or TLK independently; and in still other areas there is overlap which calls for harmonizing of the various types of knowledge. British Columbia’s Forest Science program worked through its approach to research prioritization to arrive at this kind of “compromise,” moving away from assumptions that First Nations-driven projects consistently had to fit into a science framework (Tautz, pers. comm. 2008).

Table 6: Ways of bringing different knowledge frames to bear (summarized from Adler and Birkhoff 2003 p. 9)

Types of stakeholder process outcomes	Ways of bringing knowledge frames together
Co-existent knowledges	Different strands of knowledge are acknowledged—neither explanation of how the world works is privileged over the other.
Complementary knowledges	Different strands of knowledge stand on their own (e.g., are applied to different tasks/issues).
Integrated knowledges	Different strands of knowledge fully complement each other (i.e., come to the same conclusions).
Adaptive knowledges	Different kinds of knowledge are treated as “tentative” and processes are set up to continually collect information that might in turn change the project itself.
Knowledge compromises	Different kinds of knowledge are used in part. No one source of knowledge is predominant. Stakeholders agree to tradeoffs, exchanges, or bargains.

4.1.4 Take care in integrating traditional and local knowledge into science

Fisheries managers regularly tap the vast knowledge held by the fishing community—for example, anglers often have better knowledge than fisheries biologists (Tautz, pers. comm. 2008), and commercial fishermen are a vital source of data for in-season management (see Section 3.3.2). And as the capacity for scientific research grows within some user groups, integration across knowledge frames is less necessary in some cases. For example, the Skeena Fisheries Commission[20] publishes in peer-reviewed journals to end arguments as to the accuracy of their data (Duiven 2008 workshop presentation). Volunteer streamkeeper and watershed stewardship groups often engage in rigorous research projects, learning from consultants they hire for some projects, and from volunteers with scientific backgrounds who contribute to research design.

[19] An important factor beyond the scope of this report is that of scale. Local knowledge is most easily tapped and applied at the local scale, and “scaling-up” information from the local level to broader planning contexts can be challenging.

[20] Skeena Fisheries Commission member nations are the First Nations with traditional territory in the Skeena drainage and the adjacent north coast of British Columbia. http://skeenafisheries.ca/resources.htm

Nevertheless, it is often necessary to draw local, traditional and fishermen's knowledge that has not followed scientific research conventions into a science framework. Despite the arguments presented above for equal weighting with science, building other forms of knowledge into science is likely better than not linking the sources of knowledge at all—a reported failing of the Skeena Watershed Committee process (Sigurdson et al. 2008).

Ways that traditional and local knowledge can be added to information in a science frame include:

- Use scientific minds to provide a probability forecast and community input to provide another part of that picture (Dalmer pers. comm. 2008);
- Start with quantitative data, as at a fish-counting fence, and build other sources of knowledge onto that—e.g., from anglers: "Take prior knowledge and build in other sources beyond the quantitative piece to give a picture of the world that crosses disciplines" (Tautz, pers. comm. 2008);
- Encourage improvements to model designs and predictive tools by user groups—e.g., the First Nations' knowledge of the timing of the fisheries "could fit into a spreadsheet if it felt right and the results were right" (Tautz, pers. comm. 2008);
- Use local knowledge provided by non-scientists to scrutinize the scientific research; e.g., DFO provided opportunities for comment and debate throughout WSP development (Irvine 2008). Those who provide the local knowledge, which is contextual and case-specific, can thus be regarded as an "extended peer community" (Lidskog 2008);
- Researchers can aggregate data from local and traditional sources to produce regional and intersectoral analyses of the dynamics of particular fisheries and marine ecosystems that can approximate the scales associated with much science (McGoodwin et al. 2000);
- Knowledge claims from local users, fishermen, and First Nations can be treated as hypotheses, to be validated or rejected using the scientific method (Holm 2003).

A strong caution from Holm (2003) regarding approaches such as those listed above is that they "force" fishermen's knowledge to fit within a scientific practice and dis-embed it from the cultural, social, and political contexts in which it originates. This approach risks validating only those of the non-scientific knowledge claims that conform to the scientific model. This resonates with a First Nation perspective expressed at an Integrated Salmon Discussion Forum (ISDF) workshop: that First Nations have had to capitulate to using numbers because in a world of shrinking resources it comes down to shares—and shares are determined through quantitative techniques.

For more suggestions on the integration of TLK, see Section 4.6.3 on the communication of TLK.

4.1.5 Encourage multidisciplinary perspectives and include social science

Multidisciplinary approaches are necessary to support salmon conservation planning for a number of reasons (McGoodwin et al. 2000). They can:

- engage a wider range of interests;
- help make science more relevant;
- bring essential information to the planning task;

- encourage cross-disciplinary work, possibly calling on scientists to “rethink their assumptions, values, and ambitions, and the way they speak to each other” (Degnbol et al. 2006 p. 542);
- “provide a composite picture that blends scientific and nonscientific knowledge and data” (Bisbal 2006 p. 170);
- help restore trust between the parties involved (Bisbal 2006).

Successful adoption of multidisciplinary approaches depends on the involvement of a certain kind of individual—perhaps a management specialist—who has the ability to bridge cultural, procedural, and disciplinary boundaries. Ideally, they are trained in management disciplines, have the skills of recognizing appropriate areas of specialized knowledge, and can bring their skills to bear in a coordinated manner to the multidimensional problems at hand (Degnbol et al. 2006).

The WSP is not configured to encourage multidisciplinary approaches early enough in the planning process. Its first strategies, on salmon stocks and habitat, are firmly based in the natural sciences. Strategy 3, on ecosystem values, begins to recognize relevance of other knowledge frames. Within Strategy 4, integrated strategic planning, and social and economic considerations are again brought in at the end rather than coming together with the natural science information through multiple iterations. The planning participants are to “receive and consider information … on the current biological status of the conservation unit(s) within the planning unit and the key habitat and ecosystem constraints or threats that they currently face,” which is then supposed to be “brought together with cultural, social, and economic information provided by First Nations, fishery stakeholders, and others involved in the planning process” (Fraser 2007 p. 15). This attention to knowledge from outside the natural sciences in the closing stages of planning is too little, too late.

Even if the scope is restricted to fields of knowledge that can be quantified, such as economics, the WSP is relatively silent on this side of the equation. The capacity to fill this gap does not exist within DFO at present, and the department should prepare to access social science expertise efficiently. That said, parties other than DFO might adequately fill the gap, as the Skeena example demonstrates. In the current Skeena planning process, the need for information beyond the natural sciences is recognized and non-DFO parties are filling the gap. NGOs have commissioned, through the Pacific Salmon Foundation, a technical analysis of socioeconomic aspects of Skeena commercial and recreational salmon harvest regimes to inform the watershed process (Skeena Salmon Review Terms of Reference [21]).

Beaith, a coordinator of the Barkley Sound process, acknowledged that the background study that DFO has underway to inform the planning process will not provide the socio-economic information that will be required (pers. comm. 2008). He does not, however, see this as a drawback, because the needs of the parties involved should drive the pursuit of the necessary information rather than DFO, which has a relatively narrow focus. Indeed, recognition in the WSP that socio-economic information is needed, together with DFO’s lack of capacity to provide the information, provides leverage for the engagement of a range of specialists who may better address the interests of the stakeholders. For

[21] http://www.skeenawild.org/resources/archive/isrp-terms-of-reference/

example, the fate of the Robertson Creek Hatchery will be key—it will need science, economic, and social expertise applied to the impacts.

4.1.6 Recognize self-interest as a type of information

Information from most sources, including science, can be used in the opportunistic pursuit of self-interest (Wilson 2003), and several of the tools for integrating knowledge frames covered in this section aim to counter tendencies towards this negative dynamic. This is not to say, however, that conflict or assertions of self-interest are to be avoided. Conflict that stems from the expressed interests of participants is not necessarily a negative; rather, it can productively enrich the deliberative process (Abelson et al. 2003). Working from explicit self-interest, participants can use the consensus-seeking process as a form of deal-making in which "I work with you, for my own narrow self-interest, to help you find a form of your narrow self-interest that costs me less or gives me greater gain." This way a solution that serves the common good can be found; i.e., an outcome in which each party is better off than in the status quo. In the process, expression of self-interests also helps participants work out for themselves what they want and need, and to become understood and respected for what they want and need (Mansbridge 2007).

Key to achieving this positive outcome is a discussion setting that puts participants on equal footing, is respectful and non-manipulative, where the expression of interests is overt rather than buried or disguised by arguments on pseudo-objective matters. A process mechanism that illuminates how the claims of the stakeholders are framed in discussions that reflect their perspectives and economic interests would enhance meaningful cooperation (Wilson 2003).

4.2 Determining what information is needed

The methods and mechanisms for bringing information—including science—into consensus processes are as important as the content or meaning of the information. To pave the way for integration of knowledge bases, even before information collection begins, collaboration should determine priority information needs through problem definition and objective setting. Priorities may be usefully reflected in agreed-upon indicators. Collaborative definition of criteria and standards for assessing the validity of information can also help with integration of information later in the process.

4.2.1 Collaborate on information needs early

A simple starting point is to collaborate on defining information needs early. Questions mutually framed by stakeholders are an essential foundation for an effective process (Adler and Birkhoff 2003). Karl et al. (2007) recommend a "joint fact-finding process" that generates "technical questions that need to be answered given the goals of the process and interests of the parties" at an early scoping stage. Burchfield (2001) argues that even science questions should arise from the parties involved rather than from government agencies or "the data." This was not the case when research began in the Skeena Watershed through initiatives under Canada's Green Plan before the parties in the committee had decided on their information needs. Lack of attention to key questions from the user's perspective meant that the information was not as useful as it might have been in informing the group's discussion of the issues it was struggling to deal with (Sigurdson pers. comm. 2008). Ideally, identification of information needs is a two-way street: there is a role for technical people to frame questions they see as important from a scientific point of view, but there has to be an interconnection with the people who will be using the information and will also have pressing questions that need answers. See section 4.3.3 for related ideas on linking sources of technical knowledge to the multi-party process.

4.2.2 Start with clear problem definition and objectives

Complex resource management challenges like salmon conservation planning require a decision-making framework that is built on objectives and values set by multiple stakeholders, including performance measures for decisions (McDaniels et al. 2006). Moreover, since problem identification is at the core of all planning, the engagement of the parties involved is critical (Burchfield 2001). Accordingly, determining what information is needed by a multi-party planning process should start with collaboration on the definition of the problem, priorities, and/or objectives. Different knowledge frames may lead to different problem definitions, all of which reveal issues and aspirations of participants; so multiple problem definitions should be an option (Adler and Birkhoff 2003).

Contrary to the above advice, many public sector planning models front-load the process with scientific assessments, and this can be problematic for meaningful multi-party participation: "If researchers decide what must be measured, they also, by default, are deciding what must be important" (Burchfield 2001 p. 238). This is a risk in WSP implementation. Even though planning priorities are, appropriately, to be set through "the judgment of the participants in the planning process based upon local knowledge and both regional and local considerations" (Fraser 2007 p. 15), this occurs after much of the basic information gathering is complete. The planning committees are to be provided at the outset with an information package on biological, habitat, and ecosystem aspects of the conservation unit(s) within their planning unit, and members of the committees may have had little influence (if any) on the collection of this information, even though it will have been drawn from a variety of sources. While the "inclusiveness" key attribute stated in Strategy 4 calls for all parties to have the opportunity to participate throughout the development of plans, including input into the articulation of objectives, the process will be well along in the implementation of Strategies 1 to 3 by the time the planning committees are convened.

Nevertheless, it is laudatory that "Interim Guidance for the Development of Strategic Plans" recognizes the importance of taking adequate time to identify planning priorities at the outset: "[Given] the wide range of often competing interests in the salmon resource, and a long history of conflict this first step is essential for building trust between the participants and establishing reasonable dialogue and interest based discussion on how to move forward" (Fraser 2007 p. 16).

While the ecosystem overview to be provided to Barkley Sound participants by DFO will not have been guided by the specific parties that come together to plan, participatory priority setting in the Barkley WSP pilot got a head start in another process. The AMB used the WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy to ask people of the area with interests in the salmon resource the three most important things needing attention. The strategy summarizes the needs identified by those involved in wild salmon renewal, and outlines their suggested priorities for meeting those needs (AMB 2006).[22] Another consultation around priorities is planned to be more specific to the WSP process and to involve more stakeholders.

Whether participants in planning processes will be willing to establish objectives "consistent with the WSP objectives and principles" remains to be seen.[23] Fundamentally, WSP-style fisheries management aims to sustain a diversity of stocks. The stock-specific approach was also the one taken by the Skeena Watershed Committee. The precautionary orientation of this approach lowers the emphasis on economic objectives (which had a higher profile in the maximum sustained yield approach). Stock-specific management also requires more data, and the data should be "closely tied to clearly identified management goals" (Pinkerton 1996). Berkes et al. argue that there is an alternative,[24] less data-intensive approach, which has perhaps even closer ties to clear objectives. They recommend:

> … an approach that is based on the view that even when a biological assessment is not affordable, there are usually viable alternatives. A great deal can be achieved with organization, planning and stakeholder participation: a Management Objective Driven (MOD) approach. The most rational initial focus appears to be what the stakeholders want out of the fishery; that is, the management objectives (Berkes et al. 2001 p. 40).

4.2.3 Agree on indicators

Stakeholder involvement in determining indicators can help build agreement between fishers, researchers, management authorities, and other users by making possible a shared knowledge base, which is a solid foundation for plan development and implementation (Degnbol 2003). The selection of indicators of change is value-laden, and changing the indices or their relative importance can lead to non-trivial differences in conclusions (Gray 1989). Nevertheless, indicators can be scientifically valid while reflecting the perspective of users. Indicators meeting both these priorities, ideally, work in a formal research context, make sense to stakeholders by reflecting features which correspond to stakeholders' understanding of the resource system, are relevant to management by indicating direction of action and responding to management measures, function across

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[22] The themes include inventory/stock assessment, protection of salmon and salmon habitat, salmon production, habitat restoration and harvesting.

[23] The biological objectives of the WSP are to safeguard the genetic diversity of wild salmon and maintain the integrity of their habitat and ecosystem. The social and economic objectives are to manage fisheries for sustainable benefits.

[24] "It has become almost doctrinal for managers to believe that little can be done until a stock has been assessed and management reference points chosen on the basis of that assessment. In that approach, which we describe as Stock Assessment Driven (SAD), management depends on monitoring the status through ongoing or periodic assessment" (Berkes et al. 2001 p.40).

scales, are observable on a sustained basis (affordable), and are observable by stakeholders (directly or via transparency in the observation process) (Degnbol 2003). Habitat and ecosystem indicators driven by Strategies 2 and 3 of the WSP could be developed, and/or assessed and improved, in relation to these attributes.

The WSP is on the right track when it states, in connection with Strategy 2 (Assessment of habitat status and monitoring), “Government agencies, First Nations governments, watershed planning processes and stewardship groups will be asked to provide advice on … indicators for their watersheds, based on local knowledge and information on the kinds of data that are available” (DFO 2005 p. 21). Surprisingly, there is less explicit reference to collaboration on ecosystem indicators in the policy, despite their clear connection to human values. The policy states, “The Department will use existing data and expert advice to identify key indicators … of the current and potential state of lake and stream ecosystems …” (DFO 2005 p. 23). This orientation appears to be changing, however, as the department consulted the public and First Nations on the incorporation of ecosystem values in 2006-07 (DFO 2008b), and has the intention to convene a “Knowledgeable Persons Panel” to generate a draft Ecosystem Assessment Framework for wider consultation (see Section 4.1.1). There are also plans to eventually liaise with regional representatives—presumably including integrated strategic planning committees (Nelitz et al. 2008).

When the WSP comes to indicators for assessing the performance of management alternatives, in Step 3 of the integrated strategic planning process, a fully collaborative approach to the generation of indicators is envisaged, in which “First Nations and others [are] to identify explicit, measurable performance indicators…” (DFO 2005 p. 46) “either independently or with advice from departmental advisors” (Fraser 2007 p. 17).

4.2.4 Establish criteria for research/information

Local knowledge is commonly presumed to be unreliable, and checking its accuracy is difficult because it does not follow an explicit set of established standards such as those for scientific research. At the same time, in the enclosed world of science, it is assumed that only colleagues can fully assess the quality and significance of the products of scientific research. Yet every type of knowledge has standards of quality that can be examined, debated, or shaped (Adler and Birkhoff 2003). The differences should not lead to abandoning quality control, because without attention to shared means of assessing information a consensus process can degenerate to accepting the lowest common denominator of agreement, producing vague, general principles that are subject to multiple interpretations and difficult to implement (Abrams 2000).

Ways that the validity of information from different knowledge frames can be assessed include the following.

Ongoing oversight:

As the research is undertaken, those involved can ensure credibility by consistently checking in with the parties at the planning table (Karl et al. 2007). Methods for staying in touch with the stakeholder constituencies should also be implemented.

Extended peer review:

This approach, associated with post-normal science (see section 3.5.4), requires that traditional, restrictive criteria of quality be revised and quality is a matter of "a process of common discovery of creative solutions to complex situations" (Ravetz 2004 p. 356). The approach to quality assurance extends the peer community beyond research colleagues to involve all those concerned with the policy process (Ravetz 2004). This approach relies on mutual learning: it requires respect and appreciation of the perspectives and commitments of other parties in the extended peer community, who bring to the process "extended facts," including local knowledge, far beyond the peer-reviewed published literature (Ravetz 2004). This "community" can be the parties involved in a consensus process, who subject all information—scientific, technical traditional, cultural or local—to respectful questioning about validity, accuracy, authenticity, and reliability (Adler and Birkhoff 2003).

Pinkerton (1989 p. 13) points out that fishermen "have enough knowledge to realize how incomplete government data is, to understand when their own data contradicts government's analysis, and to question the validity and/or reliability of decisions based on it." Stakeholders in the Skeena process are aware of their ability to appraise scientific results. At a meeting to initiate the new forum (April 11, 2008 Skeena Watershed Information Session), a First Nations representative stated "We have the ability to say whether [the report of the Independent Scientific Review Panel] agrees with what we know on the ground." And a commercial sector representative suggested that the science used by the panel will have to be checked, or at least that there may be disagreement with its results.

Joint agreement on standards and value premises:

At the beginning of a collaborative venture participants can seek agreement on how to collect, process and share information. This includes jointly establishing criteria and standards for data quantity and quality, information collection, processing, and dissemination to ensure high-quality research and decision-making (Abrams 2000). Along these lines, DFO is appropriately looking to the development of monitoring guidelines and protocols with First Nations input in implementing the WSP (Nelitz et al. 2008). "Quality assurance, quality control" has received considerable attention with respect to volunteer monitoring initiatives, recognizing the need for rigour in data collection by environmental/community stewardship groups.

Karl et al. (2006) recommend that methods for dealing with conflicting data and interpretations of facts and forecasts should be determined at the scoping stage in a collaborative process. Guidelines may also be designed in the form of principles rather than at the procedural or technical level. Barbara Gray, in her classic text on collaboration (1989 p. 253-4), asserts that disputes over the accuracy of technical information "cannot be resolved at the technical level but are rooted in the value premises embedded in each piece of research." She concludes, "Collaborative designs, then, must include some bases for the parties to explore the common value premises against which they would like technical assessments to be judged."

Society-wide agreement on guidelines:

Bisbal (2006 p. 167-8) prescribes an ambitious approach in which guidelines to compile a credible body of evidence that illuminates what is known, and not known, about salmon are agreed on at a societal level. He says formally established, independent advisory teams should take on this daunting task, and regularly reexamine new information and experience and assess the validity of long-standing principles and the status of knowledge. These teams or panels should "strive for a pluralistic representation of recognized experts on diverse relevant disciplines" insulated from policy setting, political pressures, and agency control.

Validation of local, traditional, or fishermen's information:

Local ecological knowledge can be collected, refined, and transformed into scientifically reliable and valid data in the hands of researchers. This research can establish "procedures for discriminating between different types of lay knowledge: That which is acceptable as valid knowledge and thus can be admitted to the land of science and that which is not and must remain outside" (Holm 2003). Procedures to "clean up" the potentially valid information include focusing on the appropriate selection of informants, use of procedures for selecting what type of knowledge it is appropriate to extract from given informants, and de-selecting knowledge that is particularly vulnerable to interest distortions (Holm 2003). Even as he reviews these methods, however, Holm suggests that they discriminate against non-scientific knowledge, and points out that there is a lack of well-proven, agreed-upon procedures for mining valid data, using scientific relevance criteria (Holm 2003).

4.3 Collecting and processing information

Database design and data collection is a large, specialized field beyond the scope of this study. Here, a sampling of ideas in this area relevant to the integration of knowledge bases for salmon conservation planning is provided.

4.3.1 Collaborate in the assembly and use of information—throughout

In their report on the implementation of the WSP, Nelitz et al. (2008 p. 24) point out that "the process of bringing scientific information to decision-makers requires significant integration between scientists collecting raw data and decision-makers relying on that information." Such integration can be achieved by working together on various aspects of information gaps, research questions, data collection, data analysis, interpretation, and use—a process described as "joint fact-finding" by Karl et al. (2007) and McKinney (2001).

While cooperation takes some effort, it has multiple benefits, including (Adler and Birkhoff 2003, Karl et al. 2007, Cormick et al. 1996, Pinkerton 1996):

- a better-informed process;
- accessibility to all forms of knowledge by all stakeholders;
- a common understanding of the situation shared by participants;
- more faith in the resulting jointly owned knowledge;

- more openness among the parties involved;
- increased mutual understanding and trust.

Cormick et al. (1996) point out that mutual sharing of information and insights about circumstances is especially important in cross-cultural settings, where there is much to learn about styles of communication, customs, and distinctive worldviews. They further explain:

> … cooperative approaches to handling information needs can eliminate the expensive process of pitting experts against each other. Abandoning "adversarial science" allows all parties to develop a more sophisticated and shared appreciation of technical issues (Cormick et al. 1996 p.63).

The need to assemble information from multiple sources is recognized for the strategies of the WSP that precede integrated strategic planning, but DFO is portrayed as the collector of the information rather than as a collaborator in a shared information-collection system. The policy does, however, indicate intentions towards a collaborative approach: "Monitoring plans will build on existing programs and local partnerships" (DFO 2005 p. 19), and the department is looking into governance models for collaborative monitoring across organizations (Nelitz et al. 2008).

Collaboration at all stages:

Cooperation is important at every stage in the development of shared knowledge:

- *Determination of information needs* (discussed above in section 4.2);
- *Identification of research methods:* The parties involved should explore the benefits and disadvantages of relevant methods of information-gathering and analysis (Karl et al. 2007);
- *Research/data gathering:* Wilson (2003) explains how communications among stakeholders become distorted (e.g., different ways of knowing, lack of objectivity in science, difficulty in making tacit knowledge explicit) and urges the design of institutional rules to reduce distortion. One method is collaboration in research to gather the necessary information. Charles (2001) and McGoodwin et al. (2000) also emphasize the need for collaborative, interdisciplinary research projects with the participation of those most familiar with, and attached to, the fish resources and their environment;
- *Database design:* At a 2008 Integrated Salmon Discussion Forum workshop it was argued that even the design of the architecture of a new system for consolidating data should be a participatory process, since user groups have much to contribute and their involvement will help build shared accountability and responsibility;
- *Developing the analytical approach* (discussed below in section 4.7.1).

Lack of cooperation in information-gathering was a factor in the collapse of cod on the East Coast, where opinions of fishermen and scientists regarding fish populations only met in the consideration of the agency/scientists' population estimates—too late for convergence or reconciliation (Dobbs 2000). The Skeena Watershed Council had a similar experience. In a debate over the harvest rate plan in 1995, "Government's failure to provide to the [commercial] fleet more complete data on the run size, and on how the harvest rate model worked, allowed resentment to build in the fleet. …In other words, joint data production, sharing, and interpretation had not progressed as far as some players thought, and this backfired on the process" (Pinkerton 1996).

Practicality of collaboration in information gathering:

The challenge of cooperative approaches to data-gathering and processing should not be overestimated. While the vast majority of research is done within government and universities, and resource users are not often involved in determining research priorities, there is increasing recognition that "(a) fishers have a base of useful knowledge which is continually updated through direct experience at sea, and (b) support for management is enhanced if fishers are involved in dealing with the information available" (Charles 2001 p. 134). Fishermen, NGOs, and the private sector have had increasing involvement and importance in research while that of international agencies and governments has shrunk, in relative terms (with universities staying the same) (Charles 2001).

Furthermore, shared data collection is justified by the "bottom line" of limited budgets. All parties recognize that DFO cannot improve on the precision and accuracy of fisheries data on its own. At the watershed level, the capacity of DFO for data collection can be supplemented by the involvement of local volunteers and fishermen (Pinkerton 1996). The BC Watershed-based Fish Sustainability Planning (WFSP) framework recognizes an array of sources of information:

> Expertise for WFSP may come from government agencies, utility and forest companies, consultants, or others. Some WFSP participants may have the resources to hire specialists to work on their behalf. … In some watershed planning units, government specialists may carry out the technical tasks. Where government resources are limited, WFSP participants may be able to provide resources for carrying out the technical tasks, or obtain additional resources … (BC Ministry of Fisheries et al. 2006 p. 30-31).

In ocean fisheries such as groundfish and herring there is already a tremendous amount of collaboration: "People are working together, and they are buying into the fact that they are in it together and are taking advantage of each other's strengths" (Al Cass in Gallaugher et al. 2006 p. 55). Many collaborative research programs have been longstanding successes, with tagging studies being the most common form of collaborative fisheries research (Wilson 2003). Communication of data to government by fishermen during the fishing season is a "daily and essential component of management which would be virtually impossible without this help" (Pinkerton 1989 p. 23).

Emphasis on a joint approach:

Nelitz et al. (2008 p. 12) point out that working with other groups will be essential for successful implementation of the WSP, but that "Engaging First Nations, ENGOs,[25] and community groups to participate in monitoring programs that satisfy WSP needs will be a challenge, particularly when groups have pre-existing programs that are tailored to meeting their own specific needs." The solution may be to explore joint systems, rather than expecting other parties to join in a DFO-led system. There are precursors for this approach. For example, the Skeena Fisheries Commission and DFO share a common electronic data system. Because it is a joint system, neither party is consistently in the position of asking for or giving data to the other party. The Northwest Indian Fisheries Commission also has a joint Washington State-Tribes fisheries database, which combines two sets of catch numbers. It is based on a protocol for data-sharing that includes

[25] Environmental, non-government organizations

standards. This arrangement, which also includes an agreed-upon model and collaboration on stock assessments, means that time is not wasted arguing about which party has the correct forecast. Instead, the joint State-Tribes work has the space to focus on appropriate assumptions. Washington or the Tribes may raise issues related to monitoring, etc. based on their own evaluations (e.g., use of indicators or conversion factors), and verification is done in dialogue (Mike Grayum 2008 workshop presentation).

4.3.2 Consider participatory research

Participatory research and participatory action research are approaches that engage local people in research projects that aim for results of interest to the study-area residents or resource users.[26] While participatory research is often emphasized in connection with small-scale fisheries and/or developing countries (e.g., Berkes 2001, Pomeroy and Rivera-Guieb 2006), it is not restricted to that context. For example, Bielawski (1996) recommends it for integrating indigenous knowledge with science in the Northwest Territories. And BC's prescription for fish sustainability planning at the watershed level suggests this approach without naming it, in recognizing that some technical tasks for fish sustainability planning at the watershed level can be carried out by non-specialists; e.g., collation of existing information, documentation of local and traditional knowledge, inventory work, and mapping (BC Ministry of Fisheries et al. 2006). Community-based stewardship groups are often well-suited to this work. Bielawski (1996) maintains that the approach can do more justice to indigenous knowledge than the alternative of "extracting bits of knowledge" from it for use in science.

Participatory research in the fisheries context has been described by Pomeroy and Rivera-Guieb in an IDRC handbook (2006), and by Bielawski (1996). According to these two authors, participatory research is characterized by:

- a cyclical process that includes research design, gathering information, analysing data, and taking action;
- community control over the process, from setting the research agenda through consultant selection to budgeting;
- community ownership and control of research products and their use;
- moving away from dependence on scientific information provided by outside professionals to local knowledge and skills by relying on the capability of community adults as trainee researchers, teachers, writers, and project advisors;
- a commitment to a group dynamic and consensual process of decision-making.

Some guidelines for participatory research from Pomeroy and Rivera-Guieb (2006, Box 7.6) are:

- Set objectives first so that the most appropriate tools can be selected;
- Build on previous information gathered. The results of each tool can be used to generate new ideas;

[26] Participatory action research typically emphasizes empowerment of those involved and a clear focus on change resulting from the research. The term *participatory research* may include participatory action research but also research that is more "top-down" and less targeted to specific actions.

- Cross-check and probe to ensure reliability of information;
- Analyse and validate on the spot;
- Avoid collecting information that is not necessary;
- Avoid bias;
- Acknowledge the value of indigenous knowledge, skills, and practice; [Bielawski would place these knowledge, skills, and practices at the centre of the research process.]
- Be creative.

Table 7: Conventional versus Participatory Research (Box 7.3 in Pomeroy and Rivera-Guieb 2006)

	Conventional research	Participatory research
Purpose	To collect information for diagnosis, planning, and evaluation	To empower local people to initiate action
Goals of approach	Predetermined, highly specified	Evolving, in flux
Approach	Objective, standardized, uniform approach, blueprint to test hypothesis, linear	Flexible, diverse, local adaptation, change encouraged, iterative
Modes of operation	Extractive, distance from subject, focus on information generation	Empower, participatory, focus on human growth
Focus of decision-making	External, centralized	Local people, with or without facilitator
Methods/techniques	Highly structured focus, precision of measurement, statistical analysis	Open-ended, visual interactive, sorting, scoring, ranking, drawing
Role of researcher/facilitator	Controller, manipulator, expert, dominant, objective	Catalyst, facilitator, visible initially, later invisible
Role of local people	Sample, targets, respondent passive, reactive	Generators of knowledge, participants active, creative
Ownership of results	Results owned and controlled by outsiders, who may limit access by others	Results owned by local people, new knowledge resides in people
Output	Reports, publications, possible policy change	Enhanced local action and capacity, local learning, cumulative effect on policy change, results may not be recorded

4.3.3 Link sources of technical knowledge to the multi-party process

Governance structures for integrated strategic planning are beyond the scope of this research. Nevertheless, the technical committee arrangement is so ubiquitous in cooperative resource management processes that its implications for the integration of knowledge frames deserve attention. The establishment of technical committees or research initiatives intentionally separated from the multi-party committee is the antithesis of participatory research and somewhat contrary to the integration of knowledge bases. Yet some separation of research activities from planning/decision-making activities is justified—on practical terms as well as to preserve "a transparent institutional space for objective knowledge to be protected and grow" (Wilson 2003. p. 276). In this report, the need to keep research separate in the service of objectivity is considered to be less pressing than is usually understood, taking into account the many ways in which scientific and technical information can be biased and the high value of other knowledge bases that tends to be downplayed because of their assumed lack of objectivity.

Various principles and priorities to make the most of technical committees are set out below. Many of these would also apply to tapping expertise via individual experts retained by a multi-stakeholder group and via expert studies commissioned by a group.

The potential of technical committees:

Technical committees or research projects that are undertaken by outside experts who are not on the planning committees offer several opportunities. They can bring more information to bear, with high standards of reliability, while saving the planning group from spending unnecessary time working through technical detail. Experts can contribute through these committees without having to sit at the planning table, where they might dominate discussions or intimidate those who would bring information from other knowledge bases into the mix. Pinkerton (1989 p. 27) asserts, "Co-management operates best where external support can be recruited (university, non-government scientists, credible organizations) and where external forums of discussion (e.g., technical committees) including more than fishermen and government members can be involved in co-management concerns."

The potential of technical committees is recognized in the Barkley Sound and Skeena Watershed processes. The draft WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy lists as a priority the continuing development of the DFO-Nuu-chah-nulth Joint Technical Working Group as a cooperative forum for technical staff and researchers working in the area (AMB 2006). And a commercial fishing representative at a Skeena Watershed information session stated that a benefit of the Skeena Watershed Committee was "having the science brought to us—that we could then ground-truth." The new Skeena Congress is envisioned to have at its core a technical working group that will include scientists with various backgrounds (Knox pers. comm. 2008). A "Skeena Science Committee" was recommended by the Skeena Independent Science Panel to ensure information needs for WSP implementation are met (Walters et al. 2008).

The risks of technical committees:

Risks of having technical committees or research efforts overly distanced from those engaged in the planning task are recognized in the literature and demonstrated in experience. In reviewing the experience of the Skeena Watershed Committee, concerns were expressed over a lack of connection between scientific research on salmon stocks (financed by Green Plan funding) and the needs of the committee. Practical questions were not addressed in lieu of more academic and complex scientific questions, causing difficulties for the committee's deliberations—participants voiced concerns such as "Why are we wasting all this money on this research if it's not helping us?" (Sigurdson et al. 2008; Sigurdson, pers. comm. 2008). Committee structures cannot be relied on to incorporate or transmit local, traditional and fishermen's knowledge, and cannot substitute for direct input from these other knowledge frames (Soto 2006). The research undertakings of committees or inquiries usually do not iteratively work into discussions among planning committee members; instead the science is held apart, as if it could be tarnished by contact with the deliberations of the consensus process. The Skeena Science Panel's rationale for its recommended Skeena Science Committee reflects this assumption of the supremacy of scientific information, in that it puts forward the Science Committee as a solution to the problem of "selective and deliberate misuse of scientific information by Skeena interest groups." The panel advised that, rather than promoting their own interests, user group representatives on the science committee "must hold themselves to the highest scientific standards in all deliberations, free from politics and special interests" (Walters et al. 2008 p. 84-5).

Making technical committees work:

Ways of counterbalancing the above risks while taking advantage of what technical committees, etc., have to offer include the following:[27]

Clear definition of technical committee role: The responsibilities of the technical committee should be carefully defined by the planning committee. For example, in the case of Watershed-based Fish Sustainability Planning, it is expected that the (optional) watershed technical committee would develop a watershed profile, identify management options, and identify monitoring and assessment options (BC Ministry of Fisheries et al. 2006 p. 30-31). The Skeena technical working group could be tasked with bringing to the new Skeena Watershed Congress knowledge of the implications of potential decisions put forward by the Congress—e.g., making clear the implications of the tradeoffs between protecting a weak stock and allowing certain harvest rates (Knox pers. comm. 2008). The Joint Technical Working Group put forward in the draft WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy is expected to produce a strategy or decision-rules that address weak stocks within conservation units, especially in relation to First Nations' domestic needs (AMB 2006).

Technical committee members with credibility in the constituencies of the parties at the planning table: There must be scientists (or other experts) around the technical table in which each member of the multi-party planning table has confidence (Sigurdson pers. comm. 2008). This way, the stakeholder representatives will have a route to understanding the advice from the technical committee and will have the confidence to share this knowledge with their constituents. This positive relationship, ideally built on common worldviews, smoothes the transfer of technical committee findings into the work of the planning table. It also allows the process of interaction between the technical committee and the planning committee to extend beyond the multi-party process itself, into the communities of interest beyond the planning table.

[27] See also section 4.2.1, which relates to the timing of bringing technical information into a multi-stakeholder process.

Questioning of technical committee findings: There should be ongoing opportunities for committee interaction, including face-to-face communication. The Skeena Independent Science Panel recommended that "Members of the community and user groups should have access to the Skeena Science Committee for the purpose of asking questions, sharing experiences, suggesting analyses, and receiving opinions on the quality and use of technical information" (Walters et al. 2008 p. 85). The results of the Joint Technical Working Group recommended in the draft WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy are expected to be reviewed by Round Tables, the AMB, Uu-a-thluk, and government agencies (AMB 2006 p. 18). Ideally, the authors of technical reports should also "be part of the ongoing conversation about the implications of their findings…" (Karl et al. 2007).

Membership linkages between the technical and planning committees: As envisaged for the Skeena process, the scientists on the technical committee can be drawn from the same organizations/agencies that are represented in the planning committee. In some cases there may be reason to tap expertise from outside the area. In others it might be reasonable to have a sub-set of technical committee members sit on the planning committee (e.g., in a liaison role).

Broad definition of "technical": Members of technical groups do not all have to be scientists. Usually they will be specialists or experts, including scientists, with clear credentials such as their university education or their position in an organization, but the parties involved may also recognize the qualifications of people with less formal credentials. The draft WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy says that the Joint Technical Working Group "can include knowledgeable local people, academics, or others with technical contributions" (AMB 2006 p. 18).

Direction of the technical committee by the planning committee: As discussed earlier, it is critical for the users of knowledge to be closely involved in determining what information needs to be gathered and analysed. The members of the planning committee, rather than the scientists on the technical committee, should drive the process. An example is the technical committees that serve the member tribes of the Northwest Indian Fisheries Commission and the State of Washington in fisheries management: while the technical committees operate separately from the policy-makers, the committees are closely directed by the policy-makers (Grayum 2008 pers comm.).

Tailoring technical committee results: In the end, it is up to the planning committee to make what it will of technical committee findings. Results can be built on and/or distilled to a form that suits the needs of process participants. A coordinator of the Barkley Sound pilot WSP project explains what might transpire following delivery of the ecosystem overview by DFO in the integrated planning process:

> DFO's WSP is starting this off with the ecosystem overview, but there is early recognition that we have to find a way to make the process work and make it real for people in implementing the integrated planning process. Once DFO has delivered the discussion paper we will probably reduce it from the 50-100 page version to one with the information that is most useful and relevant. We will create visuals, explain what we know now and what the gaps are, and distil the document into something people can easily understand. To determine how we will do this the organizations on the planning committee will take key

> components of the overview to the people who need to work with it and ask them what they need to see to make it useful. Commercial fishermen understand things differently from First Nations, and the Regional District is technically savvy but their interests are further away from salmon than those of people in DFO—so you have to tailor the information in a different direction for everybody to make it functional. Their producing a discussion paper from DFO's perspective is fine, but we cannot as an integrated process take that as the gold standard (Beaith pers. comm. 2008).

4.4 Providing access to information

Another basic requirement for the integration of knowledge from different frames is that information needs to be accessible in a transparent and equitable fashion, and relevant information needs to be effectively disseminated to process participants.

4.4.1 Ensure transparency and equity in access to information

Transparency in consensus-based planning is critical, particularly when a process has uncertain outcomes. Followed at all stages of the process, from data gathering to database design, modelling, clarification of assumptions used in models, etc., this principle is a significant asset to a consensus process:

- Access to information allows stakeholders to be properly informed so as to be able to participate fully (Berkes et al. 2001);
- Transparent and justifiable information provides users with the rationale for prescriptions flowing from the results of the planning process (Wilson 2003);
- Beyond the process itself, equitable access to a range of information, knowledge, and perspectives is key to promoting understanding of and respect for ecosystems, communities, and interconnections (WCVI AMB 2008);
- Free sharing of information builds trust and reduces suspicions of negative intent (Abrams 2000).

The draft WCVI/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy identifies a number of information needs, some of which clearly reflect a priority on accessibility (AMB 2006):

- In order to improve coordination and effectiveness of salmonid renewal activities, better access to and management of information is necessary;
- Information held by the federal and provincial governments should be easier to access and available alongside other information about the WCVI area;
- Local knowledge needs to be collected in a reliable way, made accessible, and used in decisions.

The WSP recognizes transparency as a key attribute of integrated strategic planning, stating, "Information considered in making recommendations should be publicly available and communicated in a timely manner" (DFO 2005 p. 28). This is consistent with a federal guideline that "Departments should make publicly accessible, on an ongoing basis, all scientific findings and analysis underlying decisions, and demonstrate how the science was taken into account in the decision making or policy formulation"

(Government of Canada 2000 p. 10). Some would put a finer point on the requirement for information to be made available in a "timely" or "ongoing" manner, arguing that it should be released to those involved in the process at the same time as it is presented to the agency that sponsored the research, so that there is no opportunity for bureaucratic or political influence on the data received (Hutchings et al. 1997). An explicit agreement on access to information could set out such provisions. The parties could agree on "full disclosure" with rules to handle materials containing proprietary information (Cormick et al. 1996).

On practical as well as ethical grounds, it is particularly important to share information from existing data collection programs (e.g., fish tagging) with the communities where the information is collected. More broadly, any data collected in partnership (e.g., DFO, First Nations, non-government organizations) should be put into a common data system that is fully shared. A way of ensuring transparency would be to subject the data system to an annual review (Brian Riddell in Gallaugher et al. 2006).

Technical approaches to information acquisition and sharing are beyond the scope of this research. Nevertheless, the importance of integration of data-holding entities is acknowledged. For example, the Pacific Fisheries Resource Conservation Council (PFRCC) recommended the establishment of effective and formal partnerships to ensure that data required to implement the habitat and ecosystem components of the WSP are accessible, emphasizing that the province is the main holder of broad-based data sets (PFRCC). The Fraser Salmon Watersheds Program is building a web-based site that will enable the dissemination of information and allow tracking of events and processes connected with a strategic plan (Saunders pers. comm. 2008). This tool could be emulated by DFO for WSP implementation. Another example is an integrated, geo-referenced database and a linked document database produced by the WCVI AMB.[28] An evaluation of the AMB identified this internet-accessible, marine-oriented atlas as one of the board's most substantial measures of progress toward integrated management.

One means of ensuring equitable access to information in situations of conflict or where trust is lacking is to provide intervener funding so that all parties can afford to hire experts or pay for data that would otherwise be out of their reach—thus "bridging the expertise gap" (Cormick et al. 1996).

4.4.2 Disseminate information to process participants

A general principle for successful collaborative resource management is to spend sufficient time sharing data about management issues: "The best stakeholder processes ensure that both kinds of information—technical and local, scientific and cultural, lay and expert—are accessible to everyone involved" (Adler and Birkhoff 2003 p. 7). If all parties are exposed to the same information and allowed time to digest it, ponder the long-term implications, and discuss it with their constituents, there is a higher likelihood of consensus, and a better chance of a collective and complete understanding of the resource (Pinkerton 1989, 1996).

[28] Accessible through the AMB web page: www.westcoastaquatic.ca

Instances have been reported in connection with the Skeena watershed experience in which information sharing was inadequate. First, dissatisfaction on the part of the commercial sector with the Skeena Watershed Committee's harvest rate plan in 1995 was partly a result of insufficient resources having been spent on information production and dissemination. It could have been made clearer how the harvest rate-based fishing plan worked in-season, and how it related to the test index (Pinkerton 1996). Second, the Skeena Independent Science Panel (Walters et al. 2008 p. 82) reported that in some situations "government agency staff were not exchanging or using information in the most appropriate and timely manner, which led to mistrust, misinterpretation of data, and poorly defined and differing interpretations of management objectives." While they emphasized inter-agency dynamics, they stated that the two main agencies involved (DFO and BC Ministry of Environment) link strongly with their "constituents" and that the agencies are less responsive to participants who do not share their interests. This tendency to align along interest areas constrains open debate and causes other problems.

4.5 Addressing uncertainty

Areas of high uncertainty need to be distinguished from areas of lower uncertainty—where there is scientific consensus. Uncertainty can be put in the context of what is known relative to what is not known and described in terms that non-experts can understand. Attention to uncertainty calls for risk management: "We need to acknowledge uncertainty persists regardless of the quality of scientific advice, and accept that it will influence how we manage risk" (Irvine 2008). Collaborative and transparent processes need to acknowledge different conceptualizations of risk and enable participants to share the risk assessment role.

4.5.1 Don't expect uncertainty to be eliminated

A caution associated with the drive to analyse uncertainty and risk is that it can lead to overquantification and become an end in itself. At a certain point, "We shouldn't be afraid to say 'there's some uncertainty but this is as good as it gets'" (Tautz, pers. comm. 2008).

Some anticipated an end to "arguing about data" through the provision of the results of the Skeena Independent Science Panel (Peacock 2008 workshop presentation). Yet the results of even the highest quality, most thorough research do not guarantee a stop to arguments about data. Scientific uncertainty and the diversity of scientific opinion can be exploited by the various interests to legitimize their own options (Healey 1997) regardless of the size of the body of evidence. This is partly connected with the high levels of uncertainty that are bound to persist on multiple aspects of complex, dynamic ecosystems, but is also due to inadequacies in the way uncertainty is handled in multi-party processes. For example, adversarial processes tend to pit scientists with different interpretations of the same data against each other, "thereby canceling out what they have to say" (Karl et al. 2007).

Addressing uncertainty may not prevent arguments about numbers, but it can make the debates more informed, and more open to the array of information that can be drawn from different knowledge frames. Ensuring that decision-making processes adequately consider the level of scientific uncertainty may even be more important than determining how to undertake research that is rigorous enough, given that "natural resource decision making occurs in spite of having imperfect or incomplete scientific information" (Nelitz et al. 2008 p. 9).

4.5.2 Put what is known in the context of what is not known

The Institute of Critical Thinking at Sonoma State University states that it is essential for scientists to be "fair-minded, intellectually responsible scientific thinkers," and this requires the attribute of "Intellectual humility—knowledge of ignorance, sensitivity to what you know and what you do not know. It implies being aware of your biases, prejudices, self-deceptive tendencies and the limitations of your viewpoint" (Paul and Elder 2003 p. 22). Multi-party processes should not ask scientists for certainty; rather, they should encourage scientists in their duty to candidly provide the best information possible, which includes acknowledgement of what is known and not known (Sigurdson et al. 2008). Others break this prescription down into smaller categories: (1) what we know, (2) what we do not know, (3) what we need to know, (4) what we should expect to be known vs. what we cannot know, (5) what we can estimate and how well, and (6) what can we control (Bisbal 2006 citing Bierbaum 2002, Riddell in Gallaugher et al. 2006).

Government of Canada (2000 p. 9) "Principles and guidelines for the effective use of science and technology advice in government decision making" include:

- Scientists and science advisors should ensure that scientific uncertainty is explicitly identified in scientific results and is communicated directly in plain language to decision-makers;
- Decision-makers should ensure that scientific uncertainty is given appropriate weight in decisions;
- Starting well before decisions are made, scientists, science advisors and decision-makers should communicate to stakeholders and the public the degree and nature of scientific uncertainty and risks, as well as the risk-management approach to be used in reaching decisions.

Effectively implemented, the WSP can provide a vehicle to drive more disciplined thinking about information and assessment of it, clarifying to participants in the planning process levels of uncertainty and limits to achieving certainty. The Skeena Independent Science Panel recognized the importance of this opportunity in its recommendation for a Skeena Science Committee:

> Not only must the Science Committee report what it knows, but also what it does not know with confidence. The latter uncertainties are important for everyone to understand—decision makers, users, the public, and other scientists. Those uncertainties reflect limits to the knowledge and awareness of them will help ensure that the data are used properly (Walters et al. 2008 p. 85-86).

4.5.3 Disclose scientific assumptions

One way that science lives with uncertainty is to make assumptions. Various scientific traditions, disciplines, and even research groups make different assumptions. Different, but equally "reasonable," framing assumptions routinely lead to variations in the results of quantitative analysis, including risk assessment (Stirling 2001), yet these assumptions often lie buried in methodology that is not explicit about them (Hutchings et al. 1997).

User groups are typically invited to explain the interests behind their observations and conclusions while scientists are not. Like stakeholder interests, scientists' rationales for hypotheses, parameters, and assumptions should have to be made explicit: "If conclusions of research depend on assumptions within the minds of researchers, then why not allow those assumptions to be tested within the mix of ideals and desires of collaborative groups?" (Burchfield 2001 p. 242). Lidskog (2008 p. 71) asserts that science has an obligation to "become more reflexive and transparent, making its own assumptions and values visible."

Participants in planning committees need to be encouraged to see as clearly as possible the different assumptions that underlie the science presented to them (McGoodwin et al. 2000). Understanding assumptions does not necessarily require technical know-how. For example, a criticism of the Skeena Independent Science Review was that the analysis assumed one conservation unit for summer run steelhead, and, partially on this basis, determined that the steelhead do not pose a conservation problem. The Northern Rivers Conservation Trust reported that "those concerned with steelhead were outraged" by that rationale (Vermillion 2008).

Modern science is based on hypothesis testing, and the rationale for the selection of a particular hypothesis over its alternatives is perhaps the most fundamental framing assumption. Bayesian inference is a technique that accepts that it is insufficient to single out one hypothesis in the study of natural systems, because many natural systems, and even the behaviour of individual fish stocks, can be so complex that a simple statement of rejecting or accepting one idea about them is insufficient. Preikshot (2008 p. 19) explains that "in a Bayesian approach probabilities of a given hypothesis being true are calculated, implying a suite of ecosystem states rather than an either/or state".

4.5.4 Describe uncertainty

WSP Strategy 4 requires that the documentation of short- and long-term benefits must "explicitly consider uncertainties in not only the scientific information, but also in the economic and social information that decision makers use" (DFO 2005 p. 24). Describing the blurry line between certainty and uncertainty is necessary, though difficult (Sigurdson et al. 2008). An array of tools is sampled here, from technical to informal and general to specific:

- Use terms that do not exaggerate the level of certainty that can be attained. Making this point by going to an extreme, it was suggested at a meeting of the Integrated Salmon Discussion Forum that "pari-mutuel handicapping" would be a more appropriate term than "prediction" concerning forecasts of salmon runs;
- Work towards an assessment framework that includes improving understanding—even quantifying—the basis of uncertainty (Brian Riddell in Gallaugher et al. 2006);
- Quantify and make explicit the variability associated with model parameters and variables used in analysis, including providing confidence intervals (Hutchings et al. 1997);

- Explain the risks in choosing confidence limits, including the risk of being overselective and rejecting correlations that are probably real, or being overly sensitive, accepting correlations that are probably accidental (Ravetz 2004);
- Be clear about how preliminary the provided data are—early data may aid discussion in a timely manner (Cowichan Fisheries Round Table terms of reference, February 18, 2008).

It was noted earlier that overemphasis on analyzing uncertainty and risk can lead to over-quantification and become an end in itself. Another challenge posed in striving to describe uncertainty is that the technical language involved in communicating uncertainty (confidence intervals etc.) is contrary to plain-language communication. Managers and laypeople tend to look for "a silver bullet," simplicity (e.g., fewer hypotheses) and distilled information rather than much data. It thus behooves non-scientists involved in the salmon conservation planning process to take the time to listen to, and build their capacity for understanding the technical language of uncertainty (see Section 4.6 on improving communication).

4.5.5 Share the risk assessment role

Traditionally, risk management has been a science-centred activity, in which "experts establish the probability and magnitude of the hazards, other experts evaluate the benefits and costs of various options, and then political priorities are invoked to choose the best option" (Lidskog 2008 p. 72). But there are drawbacks to approaches that use only science, not least of which is that they leave out stakeholders who should have a say as to how risks are anlaysed because they will be experiencing the impacts of risks. Expert-based, scientific approaches to risk assessment tend to assume a complete range of possible outcomes are analysed as to their probabilities, while some possibilities may not be included due to ignorance, and some probabilities may not be quantifiable. As well, much subjectivity is involved in framing assumptions about boundaries, definitions, weighting of effects, and distribution of impacts. Therefore, while expert science may be necessary for the rigorous assessment of risk, it is insufficient on its own, so it is essential to include broader perspectives (Stirling 2001). Especially in situations of deep uncertainty, "dogmatic science" has to give way to open-ended dialogue in which participants learn to respect the others' approaches, so that there can be a creative process of resolution (Ravetz 2004 p. 354).

Early in the development of the WSP, it was "assumed that scientists were best able to assess risks to wild salmon and advise policy-makers on how to manage and conserve salmon" (Irvine 2008). Increasingly, policy development became interdisciplinary: DFO's Policy Branch joined Science Branch in leading policy development; public inclusion continued; and the governance model shifted from technocratic to transparent. The Department recognized that scientists and non-scientists should share in the role of risk assessment (Irvine 2008).

In Step 4 of the strategic planning process recommended in the WSP, the likely impacts of management alternatives are evaluated using performance measures. The policy states that the predictions resulting from the evaluation process "will need to reflect the uncertainties and risks associated with each management alternative" (DFO 2005 p. 46). It recognizes that the determination of risk tolerance must involve various parties, but does not specify involvement in other aspects of risk analysis. It is reasonable to assume that experts will be relied on to interpret the risks associated with particular strategies and their outcomes (Irvine 2008). Most of the text in the WSP focused on risk relates to CUs:

> In determining the value of the benchmark, all sources of uncertainty in assessment of the CU must be determined (for estimation of the buffer) and the Department and advisors must determine a risk tolerance to be applied in a risk management framework. Where assessment information is highly uncertain, more precautionary lower benchmarks will be defined (DFO 2005 p. 15).
>
> [The lower benchmark between Amber and Red] will be determined on a case-by-case basis, and depend on available information, and the risk tolerance applied. The determination of the risk tolerance to apply is a value judgement that requires consultation with First Nations and others affected by this choice (DFO 2005 p. 17).

4.5.6 Acknowledge differing perceptions of risk

Differing perceptions of risk are a key obstacle to successful collaboration and are often at the heart of environmental disputes (Gray 1989). They lead to differing weighting of problems, and they can lead to differing conceptualization of issues and heightened differences in solution preferences. Moreover, the parties involved often do not accept one another's ways of looking at risks. Scientists and those they advise adopt a technical view of the issues and base risk management on predictions of the probability of certain hazards. "Lay" views on risk management are based more in experience and focus on extreme possibilities rather than on statistical averages.

The authors of the WSP found that non-scientists have different perceptions of risk than scientists, but their views are not homogenous. For example, ENGOs and First Nations argue for the protection of maximum amounts of diversity while fishing interests find it less necessary to maximize the protection of diversity, and are more likely to support additional enhancement to cope with loss of biodiversity (Irvine 2008). When conservation is a high priority and a precautionary approach is being taken, resource harvesters have a heightened interest in decreasing uncertainty and risk. For example, in the case of the Skeena Watershed Committee, "the commercial sector found benefits in the promise of funded watershed projects and improved data collection to make conservation measures more flexible" (Pinkerton 1996).

The WSP is realistic in acknowledging different perceptions of risk and it appropriately emphasizes "constructive dialogue," as demonstrated in the excerpt below:

> It is anticipated that differences of opinion will occur between individuals and interest groups about the 'best' alternative because of their different priorities and tolerances to risks. The goal will be to use constructive dialogue among First Nations and others involved in the planning process to resolve these differences, find compromise solutions and to develop consensus recommendations wherever possible for each planning unit (DFO 2005 p. 46).

4.6 Improving communication across knowledge frames

Difficulties associated with combining information from sources with different knowledge frames include "variation in the contexts, tools, training, and technological resources" that shape observations and interpretations, as well as variation in the "mechanisms they use to record, check, and present the results of those observations" (McGoodwin et al. 2000 p. 251). Good communication can help to cross the gulf that these multiple differences create. Ways that communication in integrated strategic planning can be enhanced include building the capacity of the participants, clear communication of information from different knowledge frames, storytelling and face-to-face deliberation, particularly through deliberative inquiry.

4.6.1 Build capacity for participants to discuss different types of information

Local residents and resource users generally have greater capacity than scientists for some aspects of salmon conservation planning, such as the ability to work with communities and to draw on detailed ecological knowledge. Where capacity may have to be built is in their facility to understand and work with technical information. General ways in which technical capacity can be built include:

- regular opportunities to hear scientists, critically scrutinize the results of scientific research and debate research results (McGoodwin et al. 2000);
- training that targets improved understanding of the kind of technical information that will be used regularly;
- ensuring that each party in the planning committee has within it, or at its disposal, qualified scientists or other competent technical people—so that "your scientists can talk to our scientists" (Barnes 2008 workshop presentation).

Capacity building should not focus exclusively on helping non-scientists understand science: "The best stakeholder processes improve the capacity of all participants to learn from different kinds of knowledge" (Adler and Birkhoff 2003 p. 7). Indeed, Pinkerton recommends: "An investment in education about the resource and risks to the resource, as well as education about how to work toward consensus, is necessary and critical to the success of the process" (Pinkerton 1996).

A convener of the Barkley Sound WSP pilot recognizes that the various types of knowledge brought to the process will be in different formats. He anticipates the need for a team of people who have the ability to understand things from different perspectives from the beginning of the process: "Ultimately the whole table will have to learn to communicate across perspectives but before that we will need a group of people with the skill sets and resources to bring the information together in a way that helps this move forward—e.g., individuals with experience from both DFO and First Nations who can explain technical information in a way that others can understand" (Beaith pers. comm. 2008).

4.6.2 Communicate science/technical information clearly

Participants in integrated strategic planning will be called on to use science from Strategies 1, 2, and 3, and in turn, to pass on their advice to decision-makers. Nelitz et al. (2008) point out that integration in WSP implementation would be facilitated by determining which scientific linkages need to be represented to decision-makers (through data) and in what form. They caution that disseminating scientific information (e.g., about CU status) in a clear and meaningful way to the public and other interested parties is a challenge facing the implementation of the WSP. The following comment by a First Nations representative reinforces this observation:

> … the reality of the fishery is that when it comes to the aboriginal community, the employees at DFO need to communicate across legal, cultural and social divides—a gulf (Ernie Crey in Gallaugher et al. 2006 p. 63).

Lessons can be taken from the experience of the Skeena Watershed Committee process, in which scientific results were not always effectively communicated to non-scientists. A review of that process concluded that the science must be expressed in ways that people can understand, relate to, and use (Sigurdson et al. 2008 p. 6). The effectiveness of the communication of science becomes fundamental to its ultimate value—its meaning must be made clear in the context of people whose lives are going to be affected (Tautz, pers. comm. 2008). The Independent Science Panel acknowledged this requirement in stating that the recommended Skeena Science Committee must communicate its results in both technical and non-technical manners to reach the appropriate audiences (Walters et al. 2008 p. 85).

Communication is another large field of expertise beyond the scope of this report; however, a sampling of advice as to how scientific information can be made understandable to parties with other knowledge frames includes:

- *Learn by doing:* e.g., "Choose one or two main information needs (for example, stock health and ecosystem monitoring/indicators) and produce a way of communicating the information that enables a layperson to easily understand and act on the information" (AMB 2006 p. 11-12);
- *Make presentations clear and simple:* "Without dumbing things down, keep presentations as simple and clear as possible" (Adler and Birkhoff 2003 p. 10-13). Presenting information in small, "bite-sized" chunks can help;
- *Present data in a form that suits the audience needing that information:* Different audiences should be provided with technical information in different forms and levels of detail; e.g., only scientists would be interested in raw data sets; stakeholder and community groups need highly aggregated data in sources such as graphics, maps, and indicators (Nelitz et al. 2008);
- *Make the distinction between technical information and scientific opinion clear:* Scientists have an obligation to communicate when they are offering opinions, even if they are "expert" or "informed." These opinions should be distinguished from relatively incontrovertible technical data or research results, or they can be misconstrued by those receiving the information who do not have the background required to make the distinction on their own;
- *Avoid communicating excessive information:* "When a huge pool of information on a particular issue, specifically a contentious one, is made available without proper interpretation and integration, it tempts interested parties to selectively adopt preferred portions of the record to provide the necessary scientific backing for their policy stance. …

the noise level obscures otherwise observable effects" (Bisbal 2006 p. 162). Note, however, the risk in following this advice—i.e., that transparency and equity of access to information could be compromised. If selective release of information is likely to compromise transparency and equity, the process should err in the direction of providing too much information.

Some scientists are naturally better communicators than others, especially outside their home territory of technical reports and journals. Other sections have suggested matching the expert to the setting—e.g., ensuring there are technical committee members who hold the confidence of planning table members, or building scientific capacity into stakeholder organizations. Another approach is for scientists to seek training in communication from organizations such as the US-based Communication Partnership for Science and the Sea.[29]

There is another type of technical information—or "jargon"—distinct from the natural science of salmon in the context of WSP implementation: the language of planning and collaboration. Communications must be clear in this area too. Definitions should be provided and care taken not to use terms like co-management, collaborative management, and collaboration interchangeably (unless they have been defined as synonyms).

4.6.3 Communicate traditional and local knowledge clearly

The need for particular attention to First Nations knowledge is recognized in the WSP requirement to incorporate ATK. The field of ATK is broad and cannot be encapsulated in this report. Consideration of ATK calls for the utmost respect, often with protocols explaining how the knowledge can be collected, communicated, stored, and applied. This section only touches on the need for traditional and/or local knowledge to be communicated to participants in the planning process in a way that helps those who see the world through other knowledge frames to understand it.

Stakeholders such as fishermen, community groups and native peoples are obliged to communicate information that they want to be considered in the consensus process in an understandable way, just as scientists do: "Without violating matters that are sacred, and without talking down to outsiders, it is critical that context, history, and backgrounds are explained in ways that do not leave things inexplicably mysterious" (Adler and Birkhoff 2003 p. 10-13). Specific approaches are worth exploring, as demonstrated by the WCVI AMB. The board has investigated various ways of promoting communication between parties with different values, perspectives, and worldviews. Acting in the role of "culture broker" it:

- made a successful proposal to develop a CD-ROM and poster of Nuu-chah-nulth and English words and information about over 25 sea creatures;
- included diverse information and views on aquatic creatures and management on the AMB website;
- brings Nuu-chah-nulth communities' concerns to the board; e.g., commercial herring harvest, ecosystem approach, merging of scientific and local knowledge;

[29] Go to http://www.compassonline.org/about/staff.asp for more information.

- distributes material at board meetings explaining Nuu-chah-nulth perspectives on resource issues (Pinkerton et al. 2005 p. 13).

4.6.4 Include storytelling

An area of communication that has received increasing academic attention over the past decade is storytelling, particularly in the field of planning. Sandercock (2003) suggests that to be stronger in their policy advocate role, that planners, social scientists, government planning agencies, and their consultants need to learn how to convey information in storytelling modes. She says they can be entertaining in the communication of their work without compromising the integrity of the science. Snowden, writing about strategic planning for organizations while in the employment of IBM (1999), described "story" as "an ancient skill whose value we are starting to rediscover." He maintains that storytelling can help us understand the current situation, and prepare for possible futures and for action. As a degree of analysis is introduced in compiling anecdotes and carefully constructing a story, storytelling can create purposeful and goal-directed activity, as well as convey complex meaning. Snowden states that the use of the story tool is especially appropriate in the face of increasing uncertainty. Quantitative techniques have been developed for drawing knowledge from multiple stories, also referred to as narratives.

A multi-party group that openly listens to stories can allow participants to speak in their own voice and comfortably communicate knowledge from frames other than science. Adler and Birkhoff propose:

> Stories are the single most accessible way for human beings to communicate in groups. Often local or cultural knowledge is located in stories. For scientists and technical experts, telling stories can provide important context and help people understand the assumptions and values that are embedded in models and findings (Adler and Birkhoff 2003 p. 10-13).

The advantage of storytelling has been mentioned in discussions at the Integrated Salmon Dialogue forum:

> The goal is to develop the trust and confidence necessary to have one sector advocating on behalf of another's programs. When each understood the other's story sufficiently and was comfortable telling it confidently to the public ...then real change would begin happening...change that can foster building a new future for the salmon fisheries (ISDF meeting summary 2008).

4.6.5 Make space for face-to-face communication

Often the time consumed in the meetings required for consensus processes is regarded as a serious drawback. Yet investment of time in face-to-face communication is critical to building understanding and respect for differences across knowledge frames (Cormick et al. 1996). Conveners of both the Skeena and the Barkley WSP pilot processes recognize this:

> [The Barkley process] has to be collaborative, transparent and open from the beginning. It's the right way to do it—heading towards EBM. It's difficult,

> challenging and time-consuming, but the appropriate way to do business. When there were lots of fish and resources you could get away without it, but not now (Beaith pers. comm. 2008).

> To some degree the participants [in the Skeena Watershed Congress] at least need to understand how the limit and target reference points are being developed by working with people like the technical working group—if everybody's in the room and can ask questions of the scientists, then they can have an open discussion and work through "that's not what they meant" so everyone can understand it on the same level and remove the bias and different interpretations of how the reference points were arrived at (Knox pers. comm. 2008).

Conversing together is perhaps the ultimate, albeit the most simple, way of achieving the integration of knowledge across different ways of knowing. When the parties in a planning committee do not understand each other they have a remedy: they can discuss their differences in understandings. Discussion is particularly important for communicating local and traditional knowledge, which is less often written down and is therefore tacit until spoken aloud (Wilson 2003). Frequency of contact between the participants in a planning process can also help to build trust, which in turn enhances learning and problem-solving ability (Pinkerton 2003).

A representative of the Northwest Indian Fisheries Commission related lessons on the importance of face-to-face communication, reporting the necessity for the parties involved in Washington fisheries management to hear one another's interests expressed directly. Misunderstandings arose when the State met with the Tribes and other constituencies separately and attempted to convey the interests of the different participants, as the State unintentionally misrepresented what they had heard (Grayum 2008 pers. comm.). This does not imply that bilateral communications between governments should not happen—the WSP fully acknowledges the necessity for DFO to work with First Nations one-to-one as well as within consensus-building processes. It does mean that DFO cannot reliably play the role of conveying First Nation interests and recommendations to other parties. A corollary is that First Nations and other resource users may need the opportunity to share knowledge in a caucus-type format, at times independent of government managers.

Experience of the Skeena Watershed Committee also points to the value of face-to-face communication:

> Over time the various parties developed a better understanding of where each one was coming from and what they needed from the process. The participants challenged each other, and the conversations were often tense and difficult; yet the conversations were almost always respectful of each person's right to be there and say what they honestly felt they had to say. The posing of questions provided the mechanism for moving the process forward and allowed for an effective and meaningful exchange of knowledge. A trust was developed that kept people at the table with a commitment to be part of the solution (Sigurdson et al. 2008 p. 4).

4.6.6 Use deliberative inquiry

A means for making the most of the time spent in face-to-face communications that is growing in popularity[30] is the deliberative inquiry process, or deliberative and inclusive process (DIP). DIPs aim to provide a safe environment for respectful engagement on difficult public policy issues. They allow for challenging experts' assertions and other information, with mutual respect, recognizing that adequate time needs to be provided to consider and discuss the information (Abelson et al. 2003). The approach does not shy away from bringing technical and/or scientific information to laypeople (e.g., nanotechnology—see Anon 2007).

In deliberative inquiry processes:

- Participants share a commitment to the resolution of problems through public reasoning and dialogue aimed at mutual understanding (Abrams pers. comm. 2008);
- It is assumed that laypeople have the ability to critically evaluate, contest, and renegotiate the boundaries of expert knowledge, and to create alternative meanings (Lidskog 2008);
- There is an emphasis on acquiring and considering information for the purposes of reaching some considered judgement on an issue (Abelson et al.);
- Through iterative dialogue participants can evaluate and re-evaluate their opinions in light of different perspectives and new evidence (Abrams pers. comm. 2008);
- Systematic, transparent exploration of the priorities and value judgments associated with different perspectives is encouraged (Stirling 2001);
- Risk communication can be a vehicle for mutual learning where all involved parties influence each other, leading to a changed and broader understanding (Lidskog 2008);
- Value is given to reflective and focused conversations (Abrams pers. comm. 2008).

Deliberative inquiry or deliberative democracy techniques are applied to controversial issues often having an ethical aspect such as those related to medical research and genetic modification, and often focus on the impacts of technology (Stirling 2001). They can, however, pertain to other matters of public interest such as environmental legislation (Fleck 2007). Fleck (2007 p. 24) puts forward as suitable subject matter for democratic deliberation the question of "How clean must the air and water be?" Deliberation is an appropriate approach because there is no scientifically objective answer to the question (although much scientific information would be pertinent), and tradeoffs would have to be made among a number of options (e.g., acceptable environmental quality, higher taxes or product costs, and loss of jobs). The W. Maurice Young Centre for Applied Ethics at UBC recently hosted a public deliberation event with members of the general public on the issue of sequencing of the salmon genome—a value-laden, but technical issue (Dr. Kieran O'Doherty pers. comm. 2008)[31]. The US-based Kettering Foundation specializes in the study, promotion, and facilitation of deliberative forums on public policy.[32]

While most DIPs assume the non-scientist/non-technical participants are citizens (often randomly selected), some have applied the approach in a multi-stakeholder context—

[30] A not-for-profit organization, the Canadian Community for Dialogue and Deliberation, was incorporated in 2006. http://www.c2d2.ca

[31] Go to www.salmongenetalk.com for more information.

[32] Go to http://www.kettering.org/ for more information.

such as in the UK in connection with impacts of a genetically modified crop (Stirling 2001). The characteristics of DIPs listed above could easily be applied to the consensus process of the multi-party committees doing WSP integrated strategic planning.

4.7 Using structured approaches for applying knowledge

This section provides a brief overview of the place for decision support tools in integrating knowledge frames. While these tools typically require expertise in their application, they can provide a strong foundation for communication among parties with different ways of knowing. As in the case of science in general, however, the power, accuracy and status of these tools among other modes of information sharing should not be overestimated.

4.7.1 Collaborate in developing the analytical approach

As mentioned earlier, effective integration of knowledge is sustained by collaboration at every stage, from design of databases to data collection through structuring models to generation of results. Shared analytical tools—or "decision support tools"—are important to the processing of information assembled in earlier stages of integrated strategic planning. The WSP has adopted what Charles (2001) calls the "management procedure" approach to risk management. In this approach, all parties have to agree on how computations will be made and what data are required, to come up with decision rules based on predicted performance estimates from projections into the future (Charles 2001). The projections are typically in the form of consequences or impacts of different options, which can then be assessed collaboratively. The WSP describes this approach as a structured process that first establishes specific objectives and priorities, and secondly allows the biological, social, and economic consequences of different conservation measures and activities to be considered and weighed in an open and transparent way (DFO 2005).

In Step 3 of the integrated strategic planning process the WSP prescribes a suitably collaborative way of filling in the detail of the analytical approach: "input from First Nations and other participants in the planning process will be used to develop an evaluation framework for comparing the management alternatives" (DFO 2005 p. 46).

4.7.2 Consider a range of decision support tools, including simple ones

Tools for comparison of alternatives can range from simple tables to sophisticated computer models and are not mutually exclusive. "Consequence tables" lay out the outcomes of various options in relation to objectives. Models provide a simplified representation of reality that can be descriptive or predictive. Knudsen and Doyle (2006 p. 311) include "advanced and timely information management and modeling" as one of five "simultaneous, aggressive actions" required to support salmon management decisions in order for salmon populations in southern BC to be sustainably harvestable. Dialogue about salmon conservation in BC has been following similar lines: "…visual displays and computer simulation models [e.g., projecting fisheries populations and catches through time, given various uncertainties in the natural systems] can start conversations about what scenarios are acceptable to which user groups or stakeholders" (Carrie Holt in Gallaugher et al. 2006 p. 107).

Simulation of predicted outcomes can help planning participants cope with the complexity of the salmon conservation challenge, although the projections of change themselves typically require expert input, as recognized in the WSP. In Step 4 of integrated strategic planning, the likely impacts of management alternatives are to be assessed to provide a set of predicted outcomes, and "DFO will play a lead role in providing or obtaining these predictions from appropriate technical experts" (DFO 2005 p. 46). The policy states that for some planning units, computer simulation models may be available to assist, while in other cases is will be necessary to rely on expert opinion. A more inclusive approach is suggested in the Interim Guidance for the Development of Strategic Plans: "In other cases, reliance may need to be placed on the expert judgments of DFO staff, *First Nations and other participants in the planning process*" (Fraser 2007 p. 18 emphasis added). Nelitz et al. (2008) see an opportunity in the implementation of the WSP via links with other watershed prioritization systems/decision support tools.[33]

In the case of the Skeena Watershed Committee, working together on a "harvest rate" computer model developed by DFO and the Province of BC was an important tool for responding to parties' concerns and drawing the science and other sectors more closely together (Pinkerton 1996, Sigurdson et al. 2008). The model, which was carefully explained to the user groups, helped evaluate the implications of different time and area management strategies and gear type options, usefully facilitating conversations about choices and consequences.

> [The sectors could measure the model's outputs] in relation to their own experiential knowledge and judgments. It enabled people to get more 'hands on' and turn something that was too big and shapeless to be dealt with effectively into something more manageable and discrete. In that sense it empowered people to participate in the conversation in different and more effective ways (Sigurdson et al. 2008 p. 4).

An early step in the Barkley Sound WSP pilot is expected to be "tool development," including the development of a structured decision-making approach and a model. The model and analysis will simulate 19 sockeye stocks into the future, apply different escapement strategies, and compare expected performance (DFO 2008a).

4.7.3 Carefully time the introduction of structured decision-making tools

While structured decision-making tools provide a solid basis for analysis, if introduced to a process too early they can have a negative influence. When members of a group are not sufficiently accustomed to working together, bringing in an unfamiliar framework for discussion is premature, and can derail discussions that might otherwise build consensus. Thus both the type of decision-making tool and the timing of its adoption should be tailored to the evolution of the multi-party committee process (Sigurdson, pers. com. 2008).

[33] E.g., Environmental Process Modernization Plan (EPMP)/risk management framework, Ministry of Environment Watershed Evaluation Tool, Nature Conservancy Canada's watershed threats assessment tool.

4.7.4 Don’t over-estimate the power of models

Models do not have perfect predictive capacity. In 1995, the model used by the Skeena Watershed Committee underestimated the run size while the in-river test fishery overestimated it, leading the commercial sector to dispute the committee’s harvest rate plan (Pinkerton 2006). Nevertheless, the model helped participants understand processes and connections, providing a good tool for examining alternatives.

Properly designed decision-support tools can take into account the quality of the available data and corresponding level of uncertainty, rather than assuming a higher level of certainty than can be realistically achieved given the capacity of the process. As discussed above, this uncertainty should be explained to stakeholders. Expectations of the performance of models can be managed at a more general level as well. For example, the BC Pacific Salmon Forum is currently sponsoring the development of two predictive models to “explain the role of sea lice in the lives of farmed and wild salmon,” and the research manager does not promise that the models will be able to make accurate enough predictions for government policy-makers to rely on:

> I think we will be able to piece together more of the jigsaw than we’ve ever done before but it’s doubtful we will have a silver bullet. My hope is that the Forum can produce recommendations that are ‘science informed’ but I doubt that the science will be sufficiently exact to provide definitive direction. At the very least we’ll be able to make some conclusions about the level of risk (O’Riordan in BC Pacific Salmon Forum 2008).

REFERENCES

Literature

Anon. 2007. Enough talk already: Governments should act on researchers' attempts to engage the public over nanotechnology. Editorial in Nature 448, 5: 1-2

Abelson, Julia, Pierre-Gerlier Forest, John Eyles, Patricia Smith, Elisabeth Martin, and Francois-Pierre Gauvin. 2003. "Deliberations about deliberative methods: issues in the design and evaluation of public participation processes." Social Science & Medicine 57: 239–251

Abrams, Peter, Julie Gardner and David L. Peterson. 2006. Workshop to Design a Public Consultation Process on Implementing the Wild Salmon Policy Strategy 3: The Inclusion of Ecosystem Values and Monitoring into Wild Pacific Salmon Management, March 23 - 24, 2006, Richmond, BC Workshop report, Prepared for the Department of Fisheries and Oceans

Abrams, Peter. 2000. Overcoming obstacles to implementing community-based collaborative governance of natural resources: The case of Clayoquot Sound Central Region Board. Thesis submitted for the Master of Resource Management degree. Vancouver: Simon Fraser University

Adler, Peter S. and Juliana E. Birkhoff. 2003. Building Trust: When Knowledge From "Here" Meets Knowledge From "Away". Portland, Oregon: The National Policy Consensus Center
http://www.policyconsensus.org/publications/reports/docs/BuildingTrust.pdf

Aquatic Management Board (AMB). 2006. West Coast of Vancouver Island/Nuu-chah-nulth Ha-ha-houlthee Wild Salmon Strategy. Draft report. Port Alberni: AMB
http://www.westcoastaquatic.ca/Draft%20WCVI%20Wild%20Salmon%20Strategy%2001%20Feb%2006.pdf

Aquatic Management Board (AMB). 2008. AMB Homepage www.westcoastaquatic.ca

BC Ministry of Fisheries; BC Ministry of Environment, Lands and Parks; and Fisheries and Oceans Canada. 2001. Watershed-based Fish Sustainability Planning: Conserving BC fish populations and their habitat: A guidebook for participants. Victoria: Province of BC

BC Pacific Salmon Forum. 2008. Forum Focus: Newsletter of the BC Pacific Salmon Forum 3, 2 (June)

Berkes, Fikret, Robin Mahon, Patrick McConney, Richard Pollnac and Robert Pomeroy. 2001. Managing Small-scale Fisheries: Alternative Directions and Methods. IDRC, Ottawa

Bielawski, Ellen. 1996. Inuit Indigenous Knowledge and Science in the Arctic, pp. 216-227 in Laura Nader (ed) Naked science: anthropological inquiry into boundaries, power and knowledge. New York and London: Routledge

Bisbal, Gustavo A. 2006. Learning to decide and deciding to learn: conduits to wild salmon in 2100? pp. 151-173 in Robert T. Lackey, Denise H. Lach and Sally L. Duncan (eds). Salmon 2100: The future of Wild Pacific Salmon. Bethesda, Maryland: American Fisheries Society

Brick, Philip and Edward P. Weber. 2001. Will rain follow the plow? Unearthing a new environmental movement. pp. 15-24 in Brick, Philip, Donald Snow and Sarah Van De Wetering (eds). Across the Great Divide: Explorations in Collaborative Conservation and the American West. Washington, D.C.: Island Press

Browman Howard I. and Konstantinos I. Stergiou. 2005. Politics and socio-economics of ecosystem-based management of marine resources Theme Section in Marine Ecology Progress Series. 300:241-296
http://www.int-res.com/articles/meps_oa/m300p241.pdf

Burchfield, Jim. 2001. Finding science's voice in the forest. pp. 236-243 in Brick, Philip, Donald Snow and Sarah Van De Wetering (eds). Across the Great Divide: Explorations in Collaborative Conservation and the American West. Washington, D.C.: Island Press

Charles, Anthony. 2001. Sustainable Fishery Systems. Fish and Aquatic Resources Series 5. Oxford, UK: Blackwell Science

Chouinard, Mike. 2008. Cheam lose fish appeals. Chilliwack Times

Cormick, Gerald, Norman Dale, Paul Emond, S. Glenn Sigurdson and Barry D. Stuart. 1996. Ottawa, Ontario: National round Table on the Environment and the Economy

Cowichan Fisheries Round Table terms of reference, February 18, 2008

Davis, Anthony and John R. Wagner. 2003. *Who* knows? On the importance of identifying "Experts" when researching Local Ecological Knowledge. Human Ecology, 31(3): 463-489

Degnbol, Poul. 2003. Science and the user perspective: The gap co-management must address. pp. 31-49 in The Fisheries Co-Management Experience: Accomplishments, Challenges, and Prospects, eds. D. C.Wilson, J. Nielsen, and P. Degnbol. Dordrecht: Kluwer Academic Publishers

Degnbol, Poul, Henrik Gislason, Susan Hanna, Svein Jentoft, Jesper Raakjær Nielsen, Sten Sverdrup-Jensen and Douglas Clyde Wilson. 2006. Painting the floor with a hammer: Technical fixes in fisheries management. Marine Policy 30 (2006): 534–543

Dobbs, David. 2000. The Great Gulf: Fishermen, Scientists, and the Struggle to Revive the World's Greatest Fishery. Washington, D.C, Covelo, California: Island Press/Shearwater Book

Dose, Jeffrey J. 2006. Commitment, Strategy, Action: The three pillars of wild salmon recovery. pp. 233-259 in Robert T. Lackey, Denise H. Lach and Sally L. Duncan (eds). Salmon 2100: The future of Wild Pacific Salmon. Bethesda, Maryland: American Fisheries Society

Doubleday, William G., D.B. Atkinson and J. Baird. 1997. Comment: Scientific inquiry and fish stock assessment in the Canadian Department of Fisheries and Oceans. Can. J. Fish. Aquat. Sci. 54: 1422-1426

Fisheries and Oceans Canada (DFO). 2005. Canada's Policy for Conservation of Wild Pacific Salmon. Vancouver: Fisheries and Oceans Canada http://www-comm.pac.dfo-mpo.gc.ca/publications/wsp/default_e.htm

Fisheries and Oceans Canada (DFO). March 2008a. Canada's Policy for conservation of Wild Pacific Salmon: Integrated Strategic Planning. PowerPoint presentation at Wild Salmon Policy Forum, March 2008, Richmond, B.C. http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/wsp/wsp_forum_March_2008_e.html

Fisheries and Oceans Canada (DFO). March 2008b. Fisheries and Oceans Canada Pacific Region Implementation Plan 2006-2010, Report on Progress as of March 2008

Fleck, Leonard M. 2007. "Can We Trust 'Democratic Deliberation'?" Hastings Center Report 37 (4): 22-25

Fraser, G. Alex. 2007. Interim Guidance for the Development of Strategic Plans under Canada's Policy for the Conservation of Wild Pacific Salmon. Discussion Paper. Prepared for Fisheries and Oceans Canada, Fisheries Management Branch, Pacific Region

Fraser, Neil. 2008. A Canadian Tragedy. Essay circulated by web. Honolulu, Hawaii November 12, 2008

Gallaugher, Patricia, Jennifer Penikett and Laurie Wood. 2006. Speaking for the salmon town hall meeting: Getting the missing fish story straight: Part II A ten-year retrospective on Fraser sockeye salmon, Proceedings. Burnaby: Simon Fraser University

Government of Canada. 2000. A framework for science and technology advice: Principles and guidelines for the effective use of science and technology advice in government decision making http://strategis.gc.ca/S-Tinfo

Government of the Northwest Territories, Traditional Knowledge Working Group. 1991. Report of the Traditional Knowledge Working Group. Yellowknife: Department of Culture and Communications, Government of the Northwest Territories

Gray, Barbara. 1989. Collaborating: Finding common ground for multiparty problems. San Francisco: Jossey-Bass Publishers

Grumbine, R. Edward. 1994. What Is Ecosystem Management? Conservation Biology, Vol. 8, No. 1. (Mar., 1994), pp. 27-38 http://links.jstor.org/sici?sici=0888-8892%28199403%298%3A1%3C27%3AWIEM%3E2.0.CO%3B2-E

Hall-Arber, Madeleine. 2003. It's pretty fishy … : Commentary on Holm. MAST / Maritime Studies 2(1): 42-44

Healey, M.C. 1997. Comment: The interplay of policy, politics, and science. Can. J. Fish. Aquat. Sci. 54: 1427-1429

Heiman, Kimberly and Dean Wendt. 2008. Connecting the many scales of marine EBM. Marine Ecosystems and Management. 1(2) http://depts.washington.edu/meam/Heiman-Wendt.pdf

Hoffman, Chris. 2007. Department of Fisheries and Oceans Fall 2006 Consultations Summary of Comment. Prepared for the Department of Fisheries and Oceans

Holm, Petter. 2003. Crossing the Border: On the Relationship Between Science and Fishermen's Knowledge in a Resource Management Context. MAST/Maritime Studies 2(1): 5–34

Hughes, Terence P., David R. Bellwood, Carl Folke, Robert S. Steneck and James Wilson. 2005. New paradigms for supporting the resilience of marine ecosystems. Trends in Ecology and Evolution, 20(7): 380-386

Hume, Stephen. 2008. Science is a method; it does not insist on a credential. Vancouver Sun A15 June 25, 2008

Hutchings, Jeffrey A., Carl Walters, and Richard L. Haedrich. 1997. Is scientific inquiry incompatible with government information control? Can. J. Fish. Aquat. Sci. 54: 1198-1210

Hutchings, Jeffrey A., Carl Walters, and Richard L. Haedrich. 1997. Reply: Scientific inquiry and fish stock assessment in the Canadian Department of Fisheries and Oceans, and Reply: The interplay of policy, politics, and science. Can. J. Fish. Aquat. Sci. 54: 1430-1431

Integrated Salmon Discussion Forum (ISDF). 2008. May 2nd 2008 meeting summary

Irvine, J.R. 2008 In Press. The successful completion of scientific public policy: lessons learned while developing Canada's Wild Salmon Policy. Environ. Sci. Policy, doi:10.1016/j.envsci.2008.09.007

Johannes, Mark R.S. 2006. What's Happening to Wild Salmon in Your Community? What the Council Heard: Vancouver Island Public Meetings. Vancouver: Pacific Fisheries Resource Conservation Council

Jones, Peter J.S. 2002. Marine protected area strategies: issues, divergences and the search for middle ground Reviews in Fish Biology and Fisheries 11: 197–216

Karl, Herman a., Lawrence E. Susskind and Katherine H. Wallace. 2007. A dialogues not a Diatribe: Effective integration of science and policy through joint fact finding. Environment 49(1): 20-34

Kearney, John, Fikret Berkes, Anthony Charles, Evelyn Pinkerton, Melanie Weber. 2007. The Role of Participatory Governance and Community-Based Management in Integrated Coastal and Ocean Management in Canada. Coastal Management 35:79-104 http://dx.doi.org/10.1080/10.1080/08920750600970511

Knudsen, E. Eric and Eric G. Doyle. 2006. Science and technology are essential for sustaining salmon populations and their ecosystems. pp. 311-332 in Robert T. Lackey, Denise H. Lach and Sally L. Duncan (eds). Salmon 2100: The future of Wild Pacific Salmon. Bethesda, Maryland: American Fisheries Society

Lach, Denise H., Sally L. Duncan and Robert T. Lackey. 2006. Can we get there from here? Salmon in the 21st century. pp. 597-617 in Robert T. Lackey, Denise H. Lach and Sally L. Duncan (eds). Salmon 2100: The future of Wild Pacific Salmon. Bethesda, Maryland: American Fisheries Society

Lackey, Robert T., Denise H. Lach and Sally L. Duncan, editors. 2006. Salmon 2100: The future of Wild Pacific Salmon. Bethesda, Maryland: American Fisheries Society

Lackey, Robert T. 2007. Science, scientists, and policy advocacy. Conservation Biology. 21(1): 12-17
http://oregonstate.edu/dept/fw/lackey/RecentPublications.html

Lidskog, Rolf. 2008. Scientised citizens and democratised science. Re-assessing the expert-lay divide. Risk Research. 11(1): 69-86
http://dx.doi.org/10.1080/13669870701521636

Mansbridge, Jane 2007. Self-interest in deliberation. Kettering Review. 25(1): 62-72

McDaniels, Timothy, Holly Longstaff and Hadi Dowlatabadi. 2006. A value-based framework for risk management decisions involving multiple scales: a salmon aquaculture example. Environmental Science and Policy 9: 423-438

McGoodwin, Barbara Neis and Lawrence Felt. 2000. Integrating Fishery People and Their Knowledge into Fisheries Science and Resource Management. pp. 248-264 in Neis, B., and L. Felt (eds). Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management, St. John’s: ISER Books

McKinney, Matthew J. 2001. What do we mean by consensus? Some defining principles. pp. 33-41 in Brick, Philip, Donald Snow and Sarah Van De Wetering (eds). Across the Great Divide: Explorations in Collaborative Conservation and the American West. Washington, D.C.: Island Press

Nadasdy, Paul. 2003. Hunters and bureaucrats: power, knowledge, and aboriginal-stat relations in the southwest Yukon. Vancouver: UBC Press

Nader, Laura (ed). 1996. Naked science: anthropological inquiry into boundaries, power and knowledge. New York and London: Routledge

Neis, B., and L. Felt. (eds). 2000. Introduction. pp. 11-24 in Finding Our Sea Legs: Linking Fishery People and Their Knowledge with Science and Management, St. John’s: ISER Books

Nelitz, Marc, Carol Murray and Katherine Wieckowski. 2008. ESSA Technologies Ltd. Returning Salmon: Integrated Planning and the Wild Salmon Policy in B.C. Vancouver: David Suzuki Foundation

Palsson, G. 1995. Learning by Fishing: Practical Science and Scientific Practice. pp. 85-96 in Property Rights in a Social and Ecological Context: Case Studies and Design Applications. S. Hanna and Mohan Munasinghe (eds). Stockholm, Sweden and Washington, D.C.: The Beijer International Institute of Ecological Economics and The World Bank

Pacific Fisheries Resource Conservation Council. 2006. Advisory: Implementing the habitat and ecosystem components of DFO’s Wild Salmon Policy. Vancouver: Pacific Fisheries Resource Conservation Council

Paul, Richard and Linda Elder 2003 (copyright 2006). A Miniature Guide for students and faculty to Scientific Thinking. Sonoma, California: The Foundation for Critical

Thinking
http://www.criticalthinking.org/files/ScientificThinking-DC.pdf

Pinkerton, Evelyn (ed). 1989. Co-operative Management of Local Fisheries: New Directions for Improved Management and Community Development. Vancouver: UBC Press

Pinkerton, Evelyn. 1996. The Contribution of Watershed-Based Multi-Party Co-Management Agreements to Dispute Resolution: The Skeena Watershed Committee. Environments 23(2): 51–68

Pinkerton, Evelyn W. 2003. Bridging the Equality of Embeddedness: Commentary on Holm. MAST/Maritime Studies 2(1): 39-41

Pinkerton, Evelyn. 2003. Toward Specificity in Complexity: Understanding co-management from a social science perspective. in Douglas Clyde Wilson, Jesper Raakjaer Nielsen and Poul Degnbol (eds). The Fisheries Co-management Experience: Accomplishments, Challenges and Prospects. Dordrecht, Boston, London: Kluwer Academic Publishers

Pinkerton, Evelyn, Anita Bedo and Arhur Hansen. 2005. Final evaluation Report: West Coast Vancouver Island Aquatic Management Board
http://www.westcoastaquatic.ca/AMBFinalEvaluation22March05.pdf

Pomeroy, Robert S. and Rebecca Rivera-Guieb. 2006. Fishery Co-management: A Practical Handbook, CAB International in association with the International Development Research Centre, Ottawa, ON
http://www.idrc.ca/openebooks/184-1/

Preikshot, Dave B. 2008. Computer modeling of marine ecosystems: Applications to Pacific salmon management and research. Vancouver: Pacific Fisheries Resource Conservation Council

Rand, Pete, Mart Gross and Guido Rahr. 2008. One-quarter of world’s sockeye salmon face extinction: International Union for the Conservation of Nature adds Pacific sockeye to Global Red List of Threatened Species. Most endangered runs in British Columbia. Press Release. October 6, 2008. Links to Full report, Red list summary page and Executive summary of IUCN sockeye assessment:
http://www.stateofthesalmon.org/iucn

Ravetz, J., 1999.What is post-normal science? Futures 31: 647–654

Ravetz, J., 2004. The post-normal science of precaution. Futures 36: 347–357

Riddell, Brian. 2007. Why can’t we get it right? in Fraser Sockeye Salmon: Moving from Talk to Action: Proceedings. Patricia Gallaugher and Laurie Wood (eds.). Burnaby: Continuing Studies in Science, Simon Fraser University
http://www.sfu.ca/cstudies/science/salmon.htm

Sandercock, Leonie. 2003. Out of the closet: The importance of stories and storytelling in planning practice. Planning Theory and Practice. 4 (1): 11-28

Scott, Colin. 1996. Science for the West, Myth for the rest? The case of James Bay Cree Knowledge Construction. in Laura Nader (ed). Naked science: anthropological inquiry into boundaries, power and knowledge. New York and London: Routledge

Sigurdson, Glenn, Barry Stuart and Patricia Gallaugher. 2008. Summary of the Skeena Watershed Committee Debriefing Session, February 2008, Terrace, BC

Snowden, D. 1999. The paradox of story: Simplicity and complexity in strategy. Scenario and Strategy Planning. 1(5): 16-20. November

Soto, Cristina. 2006. Socio-cultural Barriers to Applying Fishers' Knowledge in Fisheries Management: An Evaluation of the Literature Cases. Ph.D. thesis. Burnaby: Simon Fraser University, School of Resource and Environmental Management http://www.rem.sfu.ca/pdf/CSoto.pdf

Stirling, Andy. 2001. Inclusive deliberation and scientific expertise: precaution, diversity and transparency in the governance of risk. PLA Notes. 40: 66-71

Vermillion, Jeff. 2008. Skeena River Update. Northern Rivers Conservation Trust E-Newsletter. June 2008

Walters, C.J., J.A. Lichatowich, R.M. Peterman and J.D. Reynolds. 2008. Report of the Skeena Independent Science Panel. A report to the Canadian Department of Fisheries and Oceans and the British Columbia Ministry of the Environment

Weinstein, Martin S. 2007. Design Possibilities For A Regional Resource Management Board For The Implementation Of The Wild Salmon Policy Within The MTTC First Nations' Territories: Discussion Paper prepared for: The Watershed Watch Salmon Society, Coquitlam, BC

Widdowson, Frances and Albert Howard. 2002. The Aboriginal industry's new clothes. Policy Options, March 2002. p. 30-34

Widdowson, Frances and Albert Howard. 2006. Aboriginal "Traditional Knowledge" and Canadian public policy: Ten years of listening to the silence. Presentation for the Annual Meeting of the Canadian Political Science Association, York University, Toronto, June 1-3, 2006

Wilson, Douglas Clyde. 2003. Fisheries Co-Management and the Knowledge Base for Management Decisions. pp. 264-279 in The Fisheries Co-Management Experience: Accomplishments, Challenges, and Prospects, eds. D. C.Wilson, J. Nielsen, and P. Degnbol, 265–279. Dordrecht: Kluwer Academic Publishers

Personal communications and unpublished presentations

Interviews

The following people were interviewed in 2008 for this research:

Abrams, Peter. facilitator, Dovetail Consulting, Vancouver

Beaith, Brad [in 2008] coordinator for the WSP, West Coast Vancouver Island Aquatic Management Board

Dalmer, Denise. Executive Director, West Coast Vancouver Island Aquatic Management Board

Grayum, Mike. Executive Director, Northwest Indian Fisheries Commission, Olympia, Washington

Irvine, Jim. Research Scientist, Fisheries and Oceans Canada, Salmon and Freshwater Ecosystems, Pacific Biological Station, Nanaimo, British Columbia

Knox, Greg. Executive Director, SkeenaWild Conservation Trust, and [in 2008] Secretariat Skeena Watershed Congress

Lackey, Robert. US Department of Fisheries and Wildlife, Oregon State University, and US EPA, Corvallis, Oregon

Nelitz, Mark. Systems Ecologist, ESSA Technologies Ltd., Vancouver

O'Doherty, Kieran. W. Maurice Young Centre for Applied Ethics, University of British Columbia

Sigurdson, Glenn. Principal, The CSE Group, Vancouver

Art Tautz, Science Advisor, Ministry of Environment, Vancouver

Workshop presentations (unpublished)

Barnes, Chris. Skeena Fisheries Commission, speaking at the Skeena Watershed Information Session, April 2008, Terrace

Duiven, Mark. Skeena Fisheries Commission, speaking at the Skeena Watershed Information Session, April 2008, Terrace

Luedke, Wilf. DFO, speaking at the Integrated Salmon Dialogue Forum workshop, November 2008, Vancouver

Peacock, Dave. DFO, speaking at the Skeena Watershed Information Session of April 2008, Terrace

APPENDIX: THEMES RELEVANT TO, BUT ONLY PARTIALLY ADDRESSED OR UNEXPLORED IN THIS RESEARCH

In-season decision-making, and harvest allocation:

These are detailed areas of decision-making that involve a limited array of stakeholders compared to the parties expected to engage in integrated strategic planning. As well, they are not as long term or comprehensive as the planning called for in Strategy 4.

Governance/Institutional arrangements and planning scales:

Various research initiatives re underway on governance structures for the implementation of the WSP. The research for this report looks at aspects of communication between knowledge frames, but it does not include attention to many aspects of communication related to governance such as inter-agency communication.

Buy-in to the WSP/level of support:

This report does not assume full support for the WSP from stakeholders and governments. Neither does it address the themes of focus with attention to potential lack of buy-in to the policy from various stakeholders or governments.

Capacity for implementation:

Capacity of DFO and other parties to implement the WSP is a key challenge but this research does not explore its implications.

Public involvement:

There is an array of topics related to keeping the public informed about integrated planning and WSP implementation. For example, the WSP approach requires that current salmon planning processes be opened up to greater public involvement and facilitation of public understanding of final management decisions. These are not explored in this report.

Aboriginal traditional knowledge (ATK) or traditional ecological knowledge (TEK):

This research addresses the field of ATK/TEK to the extent that it is a special case of local knowledge. This field is so large and complex that this research essentially could be repeated with ATK as the focus.

Power, authority and responsibilities:

These themes are central to collaborative approaches to integrated planning, and issues around decision-making authority are one of the challenges facing the implementation of the WSP (Nelitz et al. 2008). The various parties in the WSP planning committees will have different mandates, or no legal mandates. Recognizing that First Nations are not stakeholders, WSP implementation is to be founded on bilateral consultations between Governments and First Nations (including accommodation of interests where rights or title may be adversely affected). And the key attribute of “transparency” in Strategy 4 states: “Responsibility for final decision-making and linkages between the various parts of the planning structure should be clearly described and agreed upon” (DFO 2005 p. 28). While recognizing that power is a central part of the knowledge context, the scope of this research could not do justice to issues of social power and relationships among stakeholders. Publications and reports by Pinkerton (1989, 1996, 2003, 2005), Abrams (2000), Wilson (2003), Neis and Felt (2000), Palsson (1995), Nader (1996), Nadasdy (2003) and Soto (2006) are part of a wide body of writing that explores how knowledge is bound together with issues of social power and relationships among stakeholders.

The cultural/social context of knowledge:

Like power and authority, cultural and social, cultural, and historical factors are important contexts affecting the way knowledge is generated (McGoodwin et al. 2000). The factors range from gender to disciplines, professions, ethnicity, locales (e.g., urban-rural) and class distinctions. Again, this is a large topic beyond the scope of this research. It is deeply and extensively analysed by Soto (2006) who explores in a Ph.D. thesis "a key idea reflected in a wide range of literature in the social sciences: that knowledge is generated within and reflects a social context. It is embedded within a greater cultural system and its institutions" (Soto 2006 p. 40).

Technical approaches to information acquisition and sharing:

This research does highlight the importance of transparency, communication and cooperation in information gathering and sharing; however it does not delve into the detailed, usually technical aspects of monitoring programs, database design, harmonization of data repositories and information systems. Nor does it include communication among scientists or experts, as the focus is on the interplay of those knowledge frames with others.

The arts as an additional knowledge frame:

It is quite likely that "the arts" could play a useful role in salmon conservation planning. Their potential was recognized in the program of the 2008 meeting of the Science and Management of Protected Areas Association (SAMPAA), and some participants in that event argued that "arts" should be added to the name of the organization: "SAAMPAA." Otherwise, this research encountered virtually no attention to the arts as a frame of knowledge in connection with fisheries management, so it is not developed as a theme in this report.