Review of the Draft Research and Restoration Plan for Artic-Yukon-Kushkokwim (Western Alaska)Salmon

Committee on Review of Artic-Yukon-Kuskokwim (Western Alaska) Research and Restoration Plan for Salmon

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Committee on Review of Arctic-Yukon-Kuskokwim (Western Alaska)
Research and Restoration Plan for Salmon

Board on Environmental Studies and Toxicology

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Summary

This is the second of two reports prepared by the National Research Council (NRC) Committee on Review of Arctic-Yukon-Kuskokwim (Western Alaska) Research and Restoration Plan for Salmon. The NRC was requested by the Arctic-Yukon-Kuskokwim (AYK) Sustainable Salmon Initiative (SSI) to help it develop a research and restoration plan to understand and reverse declines in salmon populations in the AYK region (Figure 1-1). To respond to that request (detailed statement of task in Chapter 1), this committee described in its first report what a research and restoration plan should contain and how it should be developed. (Appendix A has the summary of that report.) That report described three frameworks as examples for looking at the human-salmon problem. It recommended ways to develop and prioritize research questions based on the frameworks, and it discussed the relationship of restoration to the research. This report evaluates that plan.

The plan is thoughtful and has much to commend it. However, it is longer than it needs to be for clarity, and the long section on salmon life history could be usefully replaced by a section that deals with factors that affect salmon productivity. The commendable principles of the research plan, the criteria for identifying research topics, and the intellectual model that the plan is based on are not well connected to the specific research questions that receive high priority, listed toward the end of the plan. In other words, it is not clear how the AYK SSI arrived at the questions from the principles.

The committee's specific conclusions and recommendations are provided in Chapter 6. In addition to the need for shortening, clarification, and a better explanation of how the research questions were derived from the principles, this committee also recommends the following:

- The relationship between the AYK SSI research and restoration plan and other ongoing research programs in the region should be made clearer, including the degree to which the AYK SSI intends to depend on other programs' information or complement their research.
- Capacity building is well defined in the draft plan, but the plan should provide more specifics on how it plans to build capacity.
- This committee endorses the program's approach of focusing early requests for proposals (RFPs) on retrospective analyses, based on the need to catalog, assemble, and synthesize existing data as an important early step in the program.

- Administration of this, like any, scientific program is a significant undertaking and requires the full attention of a dedicated and qualified individual. Therefore, the AYK SSI should hire a full-time dedicated science director to manage the plan.
- There is insufficient separation between those who write the science plan and the RFPs and evaluate research proposals and the investigators who submit research proposals. As a result, there is some conflict of interest, which needs to be avoided.
- The draft research plan should focus more attention on management tools such as biological escapement goals, because they are critical to managing salmon fisheries and they affect sustainability.
- Metadata for the region contained in the North Pacific Ecosystem Metadatabase should be assessed early in the program.
- The plan does not adequately integrate the concept of local and traditional knowledge throughout the document. Local and traditional knowledge and capacity building, although related and both critical to the plan's success, are distinct, and they should each be clearly communicated with more specifics on how to better integrate them into the plan.

The committee is optimistic about the research and restoration plan and looks forward to seeing it develop important and timely results.

1

Introduction

BACKGROUND

Alaska salmon and freshwater fish have been critical to the survival of the people and wildlife in the Arctic-Yukon-Kuskokwim (AYK) region for thousands of years. Salmon influence the structure of human societies in the region, and humans, through their various activities, affect the lives and numbers of salmon. That relationship, which has lasted for millennia, is more tenuous today, when increased human populations and modern technology and economies make it possible to deplete salmon populations easily.

The AYK region, which encompasses more than 40% of the state (Figure 1-1), includes the Norton Sound region, the watersheds of the Kuskokwim and Yukon rivers within Alaska, and the coast from the Bering Sea to the Arctic Ocean up to the Canadian border. Declines (either natural or human-induced) in the abundance of salmon in the 1990s and early 2000s created hardships for the people and communities that depend heavily on this resource. The reasons for the drop in salmon returns are not well understood, which makes it difficult for fishery managers and scientists to identify appropriate management actions. The factors that caused the declines likely involve aspects of the life cycles of the fish and their environments in freshwater and in saltwater. Human impacts on salmon and their environments—mainly fishing in this region—probably are involved. Higher returns for some AYK salmon species and populations in very recent years are good news for the people of the region and provide opportunities for comparative studies.

STAKEHOLDER GROUPS AND THE AYK SUSTAINABLE SALMON INITIATIVE

In response to salmon declines in the late 1990s, regional organizations joined with state and federal agencies to form a partnership to cooperatively address salmon research and restoration needs. This partnership includes the Association of Village Council Presidents, the Tanana Chiefs Conference, Kawerak, Inc., the Bering Sea Fishermen's Association, the Alaska Department of Fish and Game (ADF&G), the National Marine Fisheries Service (NMFS), the

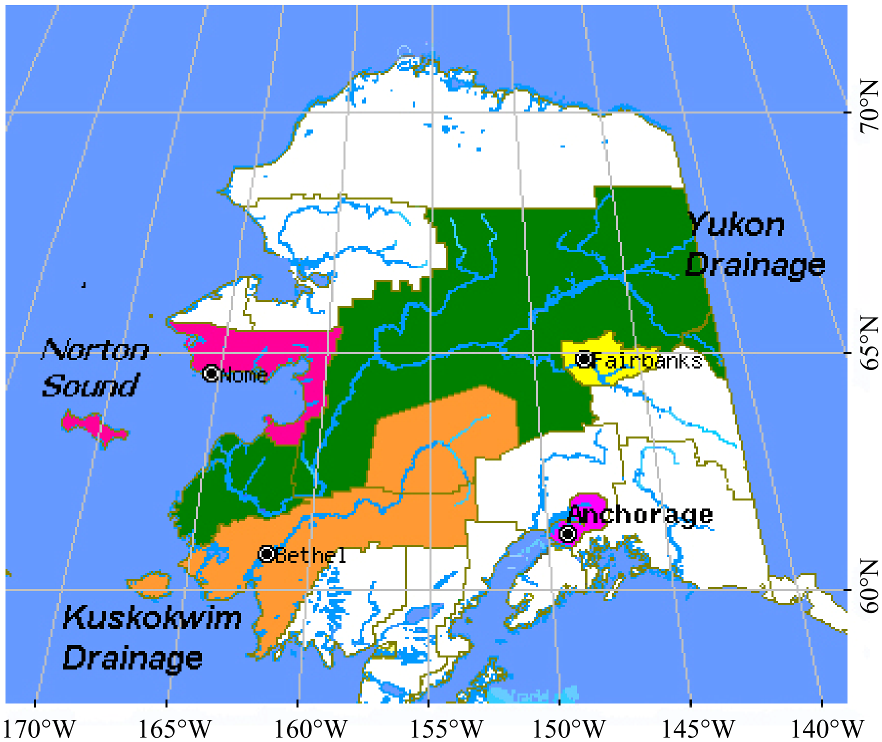

FIGURE 1-1 Map of Alaska, showing the Arctic-Yukon-Kuskokwim region. The region of concern for the purposes of this study includes the Yukon River drainage, the Kuskokwim-Goodnews drainage, and the drainages between Shishmaref in the north and Cape Newenham in the south. The area of study does not include North Slope drainages and the northern part of the Northwestern region drainages. Source: Wolfe 2003. Reprinted by permission of the author.

U.S. Fish and Wildlife Service, plus additional Native, governmental, and nongovernmental (NGO) ex-officio partner institutions.

The AYK Sustainable Salmon Initiative (SSI) was created through a $5M congressional appropriation in 2002 (renewed in 2003), to undertake an expanded research program toward gaining an understanding of the declines of salmon in the region. The AYK region includes more than 100 communities, most of which are strongly dependent on subsistence fishing and hunting. To help ensure that the appropriated funds target high-priority issues, a draft AYK Research and Restoration Plan was developed by the Scientific and Technical Committee (STC) of the AYK SSI (AYK SSI 2005). The AYK SSI was described in this committee's first report (NRC 2005).

THE PRESENT STUDY

To help the AYK SSI prepare the research and restoration plan, the help of the National Research Council (NRC) of the National Academies was requested by the Scientific and Technical Committee of the AYK SSI. The NRC committee's statement of task is in Box 1-1.

The committee held its first meeting September 27-30, 2003. During this meeting, it held public sessions in Bethel, St. Mary's, and Aniak. The committee attended the AYK SSI workshop in Anchorage, November 18-20, 2003. Several committee members and staff also

Box 1-1 NRC Committee Statement of Task

The NRC committee will assist the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative in developing a high-quality, long-range research and restoration (science) plan for the AYK region. The committee will assess the current state of knowledge, describe ongoing research in the region, and identify research questions of greatest relevance to the region. It will outline essential components of a successful, long-term science plan, identify research themes that the science plan should be based on, and identify critical research questions within the research themes. The committee will later review the research and restoration plan drafted by the Scientific and Technical Committee of the AYK SSI.

attended the Tanana Chiefs Conference Natural Resources Coalition in Fairbanks, January 22-23, 2004. The committee held its next meeting February 2-6, 2004, which included public sessions in Nome and Unalakleet.

This is the second of two reports produced by this committee. In its first report (NRC 2005), the committee was charged with providing insights from the AYK SSI workshop, briefings, relevant science plans, published literature, and the committee members' expertise to help the STC avoid difficulties and pitfalls. That report, whose summary is in Appendix A, outlined essential components of a successful, long-term science plan; summarized other existing research plans for the region that are relevant to the AYK region; refined research themes, related to the goals of the AYK SSI, around which the science plan can be organized; and identified critical research questions that should be addressed within research themes. Those themes included physical, biological, social, and economic matters.

After receipt of this committee's first report in August 2004, the AYK SSI submitted its draft research and restoration plan to the committee on June 15, 2005 (AYK SSI 2005). After receipt of the draft plan, the committee met in Anchorage on August 8-11, 2005, including an open session on August 10 during which conversations were held with members of the AYK SSI Scientific and Technical and Steering committees.

This second report reviews the draft research and restoration plan. The NRC committee evaluated the plan in light of concerns, themes, and questions identified throughout the study process, recommends actions that agencies, regional organizations, and universities can take to implement research programs that will address the plan, and assesses the ability of the plan, over time, to help understand the causes of the decline of these stocks and to provide for sustainable salmon management.

REPORT ORGANIZATION

In the next chapter, the committee provides general comments on the draft research and restoration plan. Chapter 3 examines the research framework and how it leads to a road map for a research program, priority-setting, funding decisions, and related matters. Chapter 4 considers capacity building, which is described as very important in the draft research and restoration plan. Chapter 5 looks at specifics of the research plan, including the incorporation of local and traditional knowledge; independent peer review; collaboration with other organizations; leveraging of limited funds, and related matters. Chapter 6 summarizes the committee's conclusions and recommendations.

2

General Comments

The draft research and restoration plan (AYK SSI 2005) is a large (118 pp including 3 appendices) and detailed document that reflects much thought. It has much to commend it. The statement of principles and the background are very clear. The committee members found the readers' guides in the beginning of each chapter to be helpful. Another positive feature is the document's emphasis on and definition of capacity building, and especially that capacity building "will be reflected in the AYK SSI's requests for proposals."

However, the committee judged that the document is much longer than it needs to be. For example, the long section on salmon life history is not needed for a research and restoration plan—it is sufficient to incorporate other descriptions of salmon life history by reference. Anyone qualified to successfully compete for AYK SSI funding should be quite familiar with salmon life history. Figure 3-1, the conceptual framework for the AYK SSI Research and Restoration Plan, is not only sufficient; it is a very good way to express succinctly the underlying concepts that the plan is based on. Reducing the plan's length this way also would allow a clearer description of how the conceptual framework leads to the priority-setting and research questions (discussed in more detail in Chapter 3 of this report).

Because the core of the salmon problem concerns salmon population dynamics, the plan needs a section describing the sources of variability in salmon abundance that are important, e.g., inter-annual variability and longer term fluctuations, illustrated with examples.

Similarly, the plan needs a section on population dynamics that reviews and integrates current concepts on the processes responsible for variations in abundance of salmon. This should include coverage of such items as the stock-recruit relationship, the use of the stock-recruit relationship as the foundation for discovering environmental correlates of mortality and other dynamic rates, the value of separating marine and freshwater sources of mortality, using the spatial scale of analysis as a variable in meta-analyses to discover density-dependent and density-independent environmental correlates of mortality, discussion of the roles of density-dependent and density-independent mortality in generating stability and variability in salmon abundance, and examples of processes that might act on each life stage to regulate population size and produce variability in abundance.

Perhaps the biggest difficulty the committee had with the draft plan is the lack of clear connections between the front sections—the setting forth of principles, criteria, and the intellectual model that the plan is based on—and the back sections—the areas that the RFPs will focus on. In other words, the plan does not transparently describe the process that the AYK SSI used to get from the principles to the research questions. In the next chapter, this report provides an example of how such a connection might be made, focusing on smolt survival.

Finally, several sections lack sufficient specificity to be easily understood. One important example is the relationship between the SSI's research program and the research programs of other organizations. Evidently, the SSI has a vision of how this relationship should evolve. In talking to the authors of the draft plan, it is clear that they have thought at considerable length about how their vision should be implemented. However, it is unclear from the plan itself whether, for example, the SSI will support research that also is being conducted by other programs (e.g., ADF&G) or whether instead its support will be focused elsewhere, relying on those programs to fill in the gaps.

Another, related example concerns the relatively modest amount of money that is available to support the AYK SSI research and restoration plan. The SSI is obviously well aware of that limitation, but just how the program will adapt to it is not clear. The goal of the plan is "By 2012, assemble existing information, gain new information and improve techniques for understanding the trends and causes of variation in salmon abundance and human use of salmon that support sustainable use and restoration through a collaborative and inclusive process." The year 2012 is only seven years away from the date of the draft plan (2005), and many of the processes that influence salmon abundance operate at periods much longer than seven years (e.g., the decadal-scale regime shifts in northeast pacific marine ecosystems described by Francis and Hare {1994}). Also, the large spatial scales involved make it impossible to understand the causes of changes in salmon abundance fully without an immense budget, even given enough time. This is not to say that the activity is ill-founded or should be abandoned. However, it does appear that achieving substantial understanding of the causes of variations in salmon dynamics and productivity in the AYK region is too ambitious to be achieved in seven years with the available budget (although of course some gains in knowledge should be expected), and perhaps the plan should reflect that reality more clearly. In addition, even though funding beyond 2012 has not been secured, the work should lead to a sustainable research infrastructure that could continue the studies beyond 2012 if funding becomes available then. Indeed, it would be quite appropriate for 2012 or any other year to be identified as an interim milestone for the program.

A comparison with research into the abundance of Steller sea lions (*Eumatopias jubatus*) (NRC 2003) is instructive because it illustrates how a problem that initially seemed less complex than the AYK salmon problem remains puzzling even after the expenditure of much more research money than is planned for the AYK SSI science plan. More than $120 million has been spent on that research in the past five years (Dalton 2005), and yet considerable uncertainties remain. And the Steller sea lion problem is in principle more tractable than the salmon problem, because sea lions are not anadromous; only one species—indeed, only some populations of that species—is at issue; there is only small directed take (harvest) of sea lions (ADF&G 2004); and the spatial distribution of sea lions, at least of adults, is much more restricted than that of the five salmon species of importance in the AYK region.

Other comments on the draft plan include the overemphasis on detail at the expense of a broader picture, the mistitling of the glossary (called "Terms of Reference"), and considerable redundancy. More specific comments are provided in the following chapters.

In conclusion, we recommend that the SSI write its plan so that the underlying conceptual model is understandable in the context of past and continuing research, even when that research is being done outside the context of SSI funding. Doing so would clarify the reasons for addressing the current "holes" in the model, and also would serve as a measuring stick for progress.

Because the SSI will have to make difficult decisions about how to allocate funds for the various issues and elements, it also will be helpful for the RFPs to provide information on items such as the expected size of awards; the duration of the award; and key criteria for ranking proposals, such as cost, partnerships in the region, capacity building, and of course the likelihood that the research will produce meaningful results.

3

The Research Framework

IMPLEMENTATION OF RESEARCH FRAMEWORK

In preparing its initial advice to the AYK SSI about developing a research and restoration plan, this committee (NRC 2005) set forth the elements such a plan should contain. Reading the draft plan prepared by the AYK SSI leads this committee to amplify that advice. We begin with a diagram (Figure 3-1) of 11 steps that should be followed to implement the AYK SSI research program, as well as a description of each step and references to pages in the STC document that apply to each step. Reorganization and shortening of the current draft plan to follow these steps and perhaps the inclusion of a diagram that shows the research program framework would improve clarity and reduce confusion about the proper sequence of steps to be followed.

Steps for Implementation

Step 1. Problem Formulation

The first step in any research program is to identify clearly the overarching questions relevant to the program goal. Frequently this is one clearly stated goal with a well-defined set of carefully chosen broad, universal questions. Specific research questions are developed later (Step 5). The purpose of Step 1 is to encourage creative thinking based on concepts used to understand issues in the world. This creative thinking, or problem formulation, is a process of identifying important factors that affect salmon abundance. It is helpful to identify those factors, or *stressors*, and the regime that they operate in. For example, if temperature is a stressor (a factor that affects salmon), then the range and duration of temperature fluctuations is the stressor regime. The stressor also might affect primarily a specific life stage. For example, if sea temperatures over the continental shelf in summer are higher than average, that might not affect adults, but it might affect the marine survival of juveniles. Information for problem formulation should come from published literature, expert opinion, local and traditional knowledge, and the experience and expertise of the researchers.

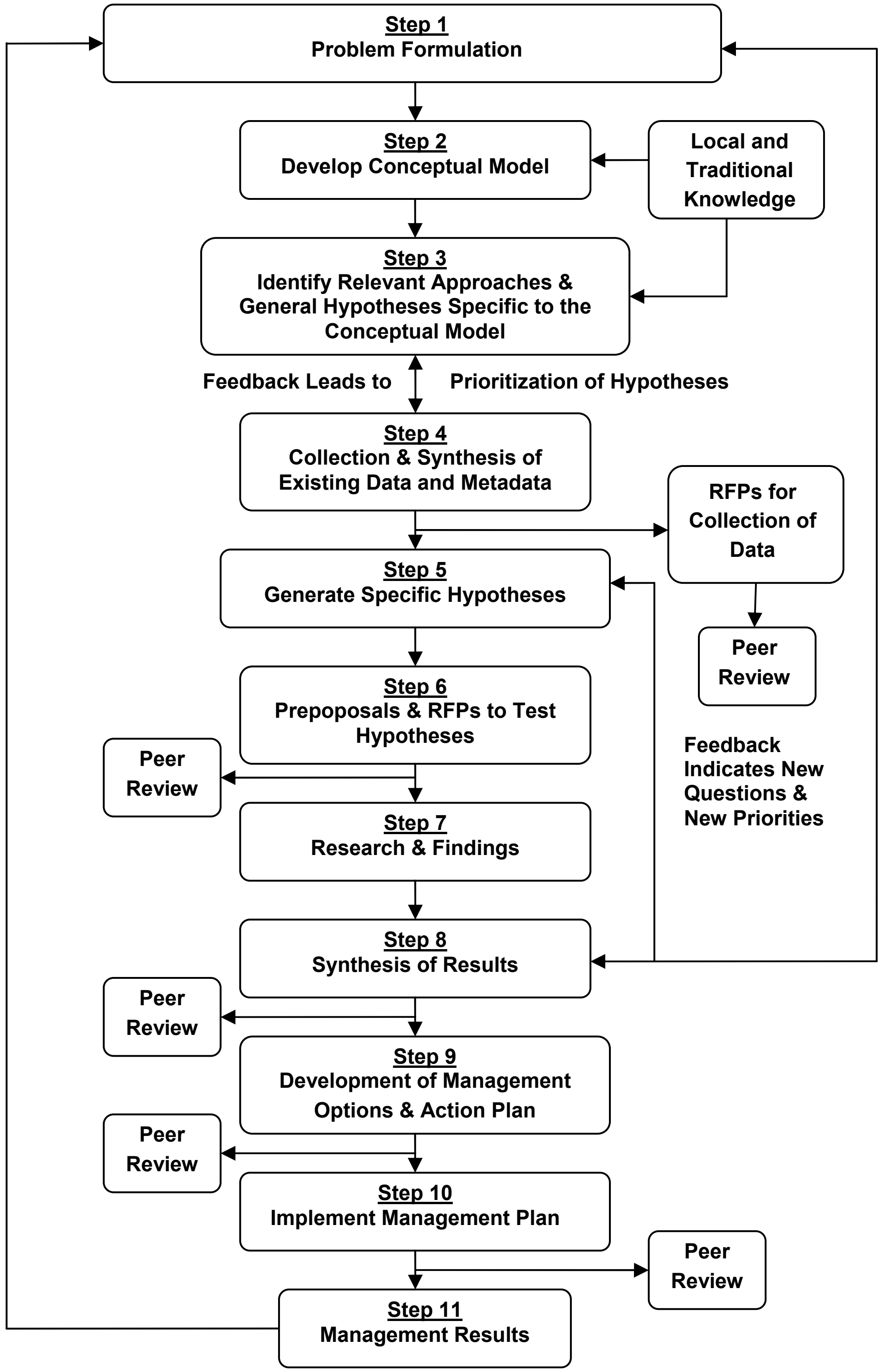

FIGURE 3-1 Numbered sequence of eleven steps that should be followed to develop and implement the AYK SSI research program.

The AYK Salmon Research and Restoration plan was funded because of low salmon returns in the region. Therefore, it makes sense for problem formulation to translate into questions about how the trends and causes of variation in AYK salmon abundance and human use of salmon can be compared and contrasted with trends and causes of variation elsewhere around the world. Any number of factors at global (climate change), international (e.g., chum salmon hatcheries in Japan), regional (e.g., commercial fishing in the Bering Sea), or local (e.g., downriver commercial fishing) scales could contribute to the decline of AYK salmon. As indicated in Figure 3-1 of this report, local and traditional knowledge (LTK) provides important input on local trends and causes of variation at this initial step.

In the draft AYK Salmon Restoration and Research Plan this component appears in the Plan Overview (p. 7, lines 19-22), section 1.2.2 (Goal, p. 11), and section 2.2 (Statement of Research and Restoration Program Goal, p. 36). While the program goal is stated, the plan does not seem to include any clearly stated broad questions that are universal in scope. While some description, definition, and identification of causative factors or stressors and stressor regimes are in the plan's introduction (sections 1.3-1.3.9), the information in these sections is not clearly linked to the problem or overarching questions. We recommend deleting these sections (1.3-1.3.9) from the introduction. As discussed in Chapter 2 of this report, we suggest replacing the sections with others that describe important sources of variability in salmon abundance, and that review and integrate current concepts about the processes responsible for that variability. We also recommend deleting the program completion year of 2012 from the statement of the program goal, as a date should not be a part of problem formulation.

Problem formulation will lead to the development of a conceptual model (Step 2) that describes the problem and links the stressors to the problem, i.e., the resource issue in this case. The conceptual model is an integral component of problem formulation.

Step 2. Development of a Conceptual Model

A conceptual model can often be expressed through a visual representation to incorporate the fundamental problem, stressors, and stressor regimes to render a holistic understanding of the problem and its components. Figure 2.1 in the draft research and restoration plan is a good example of such a visual representation. There are several ways to develop a conceptual model, including expert scientific opinion, local and traditional knowledge (LTK), and workshops led by broad and creative thinkers. This is a natural point to incorporate LTK, and in the case of the AYK plan it is essential, as discussed below. An example of such a conceptual model is the Gulf Ecosystem Monitoring (GEM) model (http://www.evostc.state.ak.us/gem/concept_large.htm). (See also NRC 2002.)

In the draft Salmon Restoration and Research Plan this step appears in section 1.2.5 (Elements of the Conceptual Foundation, p. 1) and section 2.3 (Conceptual Foundation, pp. 36-38, Figure 2.1). It is unclear how the conceptual foundation illustrated in Figure 2.1 is related to the fundamental problem, as well as how this foundation is matched with the priority setting criteria (p. 9 and pp. 65-66).

Step 3. Identification of Relevant Approaches and General Hypotheses Specific to the Conceptual Model

Once the general problem has been formulated and the conceptual foundation has been illustrated, the next step is to identify the relevant approaches and general hypotheses that are specific to explaining and ultimately testing the validity of the conceptual model. These general hypotheses are developed by expert scientific opinion, LTK, and workshops, and offer an explanation for processes that may contribute to the problem or relevant stressors. A general hypothesis for the AYK plan, for example, might be that climate change alters the timing and extent of spring freshwater runoff and that consequently juvenile salmon survival is affected by runoff. In this case, runoff is the stressor variable. The timing and magnitude of the runoff relative to the salmon's life stage constitute the stressor regime.

Relevant approaches (monitoring, process studies, retrospective studies, modeling studies) are described in section 4.6 (Types of Study Approaches, pp. 79-82). We also recommend adding experimental manipulations, especially of management actions, to the list of relevant approaches. Feedback occurs between Step 3 and Step 4 that then leads to prioritization of these hypotheses. In the case of the AYK plan, the prioritization may be facilitated by the use of the nine criteria listed on pages 65 and 66.

Step 4. Collection and Synthesis of Existing Data and Metadata

At this stage of implementing a research plan, an evaluation is needed of what already is known that is pertinent to the problem and what data have already been collected but perhaps not analyzed specifically to address the problem. At this step, existing data are located and identified formally; this collection of information about primary data is known as metadata. In the metadata, the type, accuracy, sampling, availability and other characteristics of the primary information (data) are addressed. All data relevant to the hypotheses must be gathered and evaluated, regardless of institutional source. Traditional knowledge should be included at this stage. These data may be obtained from extant agency programs or through grant and contract mechanisms. For example, development of metadata involves expertise, time, and expense, and will need to be funded through a grant or contract. This may involve RFPs, and, if so, should include peer review. The information in Appendix 2 of the draft plan is the start of a metadatabase on freshwater assessment project data, although no specifics are provided on when, where, and by whom the data were collected, data types (e.g., paper records, computer files), species, data formats, variables, where the data are located, how the data are stored, data condition, quality, and so on. Metadata for this region are available at www.pmel.noaa.gov/np/mdb/index.html.

Without adequate attention to this step, the AYK SSI could spend time and money doing research that already has been done, or gathering information that already has been gathered. The only place in the plan where metadata are specifically mentioned is in sections 4.10 (Communication of Research Results, pp. 88-89), 4.10.1 (Summary of Communication Obligations, p. 90), and 4.11 (Data Management, p. 91). The information presented in Table 4.1 and Table 4.2 is a form of metadata, although it pertains only to similar themes in other research plans and does not specifically address whether or not there are existing data available and the adequacy of these data. Appendix 2 (pp. 110-113) contains a partial list of freshwater salmon assessment projects that currently are collecting data in the AYK region, although there are not enough details to evaluate data availability and adequacy (e.g., species, spatial and temporal coverage) with respect to Step 3. This task will require considerable investment of time and money, although it will provide dividends for research far into the future. As recommended later, the AYK SSI should take the opportunity to work with other organizations that are doing similar work (e.g., the North Pacific Research Board's Alaska Marine Information System and the North Pacific Ecosystem Metadatabase).

Step 5. Generation of Specific Hypotheses

Based on the collection of metadata and evaluation of extant data and knowledge in steps 3 and 4, the next step is to develop hypotheses specific to the problem, and to prioritize them. The method of prioritization can include the potential for important results, the lack of overlap with other programs, and the lack of current funding opportunities for this type of research, among other factors. This step relies on RFPs to encourage scientists to test these hypotheses, prove peer review, and obtain funding through grants and contracts.

Section 4.3 of the draft plan (Setting Research Priorities, pp. 65-77) is directly applicable to this step. In the layout of the draft document, however, the origin of the specific questions outlined in Chapter 3 (pp. 50-61) is unclear, and they would more logically follow rather than precede the description of how these specific questions were prioritized. The gap analysis based on the review of research plans of 10 potential partner organizations plus existing state and federal research programs from the AYK region does not seem to be a thorough and well-executed approach for prioritizing specific hypotheses, especially given that Table 4.1 (pp. 71-72) includes the category "Other programs?" and Appendix 1 (pp. 103-109) contains some organizations that were not included in the gap analysis. This shortcoming in the draft plan was recognized by the AYK SSI, which described the gap analysis "obviously incomplete" (see Note to readers, p. 72). In the present draft, peer reviewers cannot evaluate the gap analysis. Whether the current research plans of these other programs have been or will be successfully implemented or whether they adequately address hypotheses critical to the success of the AYK SSI Salmon Research and Restoration Plan is unknown. A clear statement of specific hypotheses for the AYK plan is buried near the end of the plan in section 4.8 (Restoration Studies, lines 10-14, p. 83), i.e., "Hence the working hypothesis of the Science Plan is that the most likely causes for declines in AYK salmon populations are human harvest in fresh and salt water, mortality factors related to short and long-term climate change such as disease, and competition from hatchery fish in the marine environment." Moving this statement forward in the plan would improve the presentation.

Step 6. Testing of Hypotheses

This step would likely be accomplished through preproposals, RFPs, and external peer review of the resulting proposals (and of course research, Step 7 and a major topic of this whole report). The plan also should include methods for documenting progress on specific proposal objectives and on data management and archiving. This step involves consideration of conflict of interest among the investigators, whether the proposed investigation is of sufficient scope, and incorporation of capacity building, among other matters.

No mention is made of the use of preproposals in the draft plan. Preproposals can be useful to researchers and funders by eliminating time spent in writing and evaluating proposals that do not match program goals. Preproposals should be short enough not to impose an undue burden on their authors or on the AYK SSI. Section 4.3.4 briefly describes guidelines for RFPs, and states that "In future drafts a summary of components of the RFP and an overview of the proposal review process will be provided here." Because this section of the draft was not yet complete, the NRC committee could not review this part of the plan. A sample of a complete RFP that was provided to the NRC committee by the STC at the August 8-11 meeting in Anchorage, Alaska, meets most of our recommendations; it is thoughtful and well written. We recommend that an NSF- or NIH-type process be used in preparation, review, and selection of the proposals. Consideration should be given to an NSF-type proposal format and solicitation.

By the above recommendation, the committee means that RFPs should be widely disseminated to the general scientific community throughout the United States, and beyond if appropriate. The RFPs should require structured elements in proposals, such as broader impacts of the work and inclusion of LTK, among others. There should be anonymous, independent peer review of the proposals, which should include a mechanism to avoid conflicts of interest. If funds permit, establishment of a panel of outside, independent experts to evaluate proposals would be helpful. There should be a ranking procedure for the results of the peer review, and rules for final selection that are established and made public before the process begins.

Section 4.10 (Communication of Research Results, pp. 87-90) outlines approaches for documenting progress, and section 4.11 (Data Management, p. 91) briefly describes data management and archival.

Step 7. Research and Findings

This step is the core of the program, and its elements are discussed throughout this report.

Step 8. Synthesis of Results

Because there will be results from numerous projects, it is important that they be evaluated and synthesized in a holistic manner relevant to the problem and program goals. An important step would be periodic evaluation of results as mentioned in section 4.4 (Program Performance Measures, pp. 77-78). However, periodic evaluation is different from synthesis. We suggest that this is an excellent opportunity to use an independent scientific review or workshop that includes non-vested experts. Based on the synthesis, new questions may be identified and new priorities set, which is indicated by a feedback loop to Step 5.

Recognizing the importance of synthesis, the draft plan introduces "synthesis" as a tool that will be used to address research themes under Framework 3 (see Figure A, p. 8). As described on p. 43, the purpose of Framework 3 is based on "synthesis of knowledge acquired from activities under Frameworks 1, 2, and other research: (1) to better understand the causes of variation and resilience of the AYK salmon, and (2) to refine and develop management tools (see

Figure 2.3)." In particular, Research Theme 13 (p. 57) mentions "synthesis of historical population levels of salmon and their use by humans."

Step 9. Development of Management Options or an Action Plan

Based on the understanding obtained in Step 8, management options would be developed and implemented by management partners. Management plans need to be periodically reviewed for their effectiveness in solving or ameliorating the identified problems. Because the AYK plan includes restoration in addition to research, the inclusion of management and its effectiveness is an integral and important component of this plan. It should not be viewed as an afterthought. We recommend that the concept of adaptive management as defined in section 1.4 (p. 33) be adopted, as identified in the feedback loop from Step 8 to Step 1. While this logically follows the previous steps, management options can be identified and implemented at any time the causative factors become clear and well-defined.

Management applications are briefly described in section 4.7 (p. 82). This section is the first to mention that the "guiding principle for implementing the AYK SSI Research Program is that projects will be undertaken with a view toward their potential application to enhance management decisions" (from section 4.7). We recommend inclusion of this guiding principal in the introduction to the plan.

Step 10. Implementation of the Management Option

Implementation of fishery management plans is normally based on as much scientific information as is available, as well as on other considerations. Peer review often is involved, at least in the scientific aspects of the plans, through such mechanisms as Fishery Management Councils. This committee judges that peer review of the science aspects of fishery management plans is an essential step, and therefore recommends peer review at this stage. Because adaptive management depends on the quality of the information obtained about management actions, it is essential that management actions be designed so as to facilitate the collection of relevant information. Chapter 5 of this report discusses peer review and other management actions in more detail.

Step 11. Synthesis of Management Result and Incorporation into Problem Formulation

This crucial step is the heart of adaptive management. It is essential that results from management feed back into the problem formulation and hypothesis generation steps of the research program diagrammed in Figure 3-1. Doing so in a transparent way has the additional benefit that the management process itself will become more transparent.

AN EXAMPLE OF DERIVING RESEARCH QUESTIONS FROM A HYPOTHESIS

Figure 2.1 of the draft research and restoration plan illustrates the conceptual model the AYK SSI used in developing its plan. Here, as an illustrative example, we derive a hypothesis from that model and use it to develop a research question, following the advice we provided in our first report (NRC 2005) and in accordance with Figure 3-1 of this report.

Hypothesis. The variability across space and time in smolt survival through the transition to the ocean from freshwater is a major factor affecting the variability of salmon returns in the AYK region.

Importance. The hypothesis is relevant to understanding and predicting salmon population dynamics and stock-recruit relationships, setting escapement goals, and to predicting salmon abundance.

Suggested RFP. Develop a research proposal to test the hypothesis for one or more salmon populations in one or more watersheds in the AYK region.

The above would be the minimal sequence, allowing the investigators to develop research questions. However, if the AYK SSI wished to go further before issuing the RFP, the following steps might be taken.

Research question. How are the numbers of outmigrating smolts in [one or more specified] streams related to the number of returning adults n, n-1, and n+1 years later, where n is the average number of sea years for the species under consideration?

Data needs. The number of smolts migrating to sea in the chosen streams, and adult returns in those same streams the appropriate numbers of years later. The ADF&G already collects information on adult returns for many species in many streams.

Further hypotheses. These will depend on research results and will also be likely to have relevance to program goals.

ADDITIONAL SUGGESTIONS FOR THE RESEARCH PLAN

Following the integrated review of factors affecting salmon abundance outlined in the previous chapter, it would be worthwhile to make some decisions on the SSI's research strategy for improving understanding of variations in salmon abundance. This strategy should be based on the overall goals of the program and the integrated review of population dynamics. Issues to consider include the following:

- Should SSI funded studies focus on populations where ADF&G or other organizations already collect information on escapement and age/weight/length, or should SSI fund projects to collect these kinds of data?

- Should SSI studies focus on representative populations that are particularly amenable to study or particularly important to the communities involved in SSI?
- To what extent should SSI focus on studies that use statistical and process-based modeling efforts to understand problems of interest, and to what extent should SSI focus on studies with significant field-work components? To what degree could the approaches profitably be combined?
- How should SSI divide its attention between the marine and freshwater environments?

Following this section on research strategy, it would be helpful to revisit the question of how research should be prioritized; here we focus on a specific example, the stock-recruitment relationship.

- To what extent should the SSI focus on statistical and modeling research to better understand the stock-recruitment relationship? For example, to what extent should the SSI focus on reducing statistical uncertainty in explaining the stock-recruit relationship?
- To what extent should the SSI focus on process (i.e., field and laboratory) research? For example, to what degree should the SSI focus on understanding the processes responsible for generating the stock-recruitment relationship and the way in which variation in environmental conditions generates variability in this relationship? Of course, some combination of these two approaches is expected; the question is one of emphasis.

This committee has the following suggestions:

- The SSI should focus on studies that are most cost effective in improving statistical descriptions of variations in salmon abundance and process-based explanations of salmon abundance.
- Similarly, the SSI should focus on studies that are likely to produce useful results within a reasonably short period. Both the short initial period (until 2012) of the program and the urgency of gaining information influence this suggestion.
- The SSI should focus on populations for which ADF&G has a long-term stock-assessment program and work with ADF&G to supplement these studies. The SSI should provide improved statistical descriptions of relationships between the stock-recruitment relationship and environmental characteristics and an improved understanding of the processes responsible.
- The SSI should focus its efforts on a small group of representative populations.
- The SSI research should complement work by ADF&G and others, not duplicate it, or provide substitute funding. This implies the development of coordination between SSI-funded projects and ADF&G's ongoing programs, and other regional marine-science and salmon studies.

4

Capacity Building

Capacity building is identified as a major component of the research plan, but very little in the way of specifics is presented. This is not an easy problem, and many people and groups have wrestled with it, but there are some things that are known and that should be specifically identified in the plan. For this reason, guidance on methods for implementing and criteria for assessing capacity building should be incorporated within the plan and should not be in a separate document or appendix (which this committee has not seen).

The draft plan defines capacity building well (pp. 86-87),[1] but it does not articulate how capacity building will be incorporated within, or as part of, an RFP, or as part of the program as a whole. Some questions that the AYK SSI needs to ask investigators so as to evaluate research proposals include the following:

- How will capacity building be incorporated into the proposed research plan?
- How will capacity building be achieved?
- How will success (or progress) in capacity building be assessed?

The draft plan needs to identify benefits of capacity building, which can include improved community participation in research, training of rural scientists, creating a training component, and reinforcing the intrinsic responsibilities of stewardship and pride of ownership with resource conservation. Perhaps the most important principle is that the communities themselves should provide advice on how best to build their capacity. This reflects the broader principle that communities should be involved in programs and projects from the beginning. These advantages should be clearly articulated in the research and restoration plan, which also should state whether money is to be specifically set aside for capacity building.

[1] "[Capacity building is] the process by which rural/Tribal groups, organizations, and NGOs expand and develop technical and administrative abilities, enabling them to participate in a range of fisheries research activities to the maximum level they desire." The Steering Committee also adopted the United Nations Development Program's definition of "capacity" as "the ability of individuals and organizations or organizational units to perform functions effectively, efficiently and sustainably."

Capacity building should either be required or viewed as an important criterion for approval in all RFPs. RFPs should state prominently that proposals with capacity building components will be strongly encouraged.

There should be milestones that allow the AYK SSI to measure success in capacity building. Milestone measurements might vary with categories of RFPs approved (e.g., a multi-year program vs. a single year program)

We suggest the following specific examples of capacity building programs (tribal programs, science camps, graduate students and research) that might be useful for the AYK SSI to consider and to learn from:

- Native American Fish and Wildlife Society
- Native American Vocational Training and Educational Program
- Alaska Sea-Life Center
- The Kuskokwim Native Association – NOAA partnership
- The National Science Foundation's (NSF's) Native Education Program
- The NSF's Tribal College-University Program Initiative

EDUCATIONAL CAPACITY BUILDING

The importance of capacity building in Native communities has been addressed in the research plan, but specific educational components have not. Education is arguably the most lasting component of capacity building, and so it should be addressed by the plan. When this NRC committee visited Native communities, presenters frequently spoke about education. Unalakleet in particular demonstrated community commitment to K-12 and higher education.

Developing technical capacity among Native communities to enable them to become co-managers of the resource is a priority of the draft AYK research plan. Development of that capacity requires that a few members of the community possess extensive educational and technical training. Although the plan states this as a goal, the goal is likely to be difficult to achieve, because at least some co-managers should hold advanced degrees in resource management or fishery science.

The National Science Foundation (NSF) has addressed the issue of encouraging members of minority groups to gain proficiency in natural sciences in a series of publications, and its approach has had some success. The NSF has funded specific programs that encourage K-12 and undergraduate science education. For undergraduates, NSF funds research experience programs (Research Experience for Undergraduates, REU) to supplement its research grants. The REU provides additional funds specifically to mentor students and promote their participation through direct experience. Advantages of this approach include its encouragement of young people to enter careers in science and its selection of investigators who are genuinely interested in science education, because their participation is voluntary. More specifically, the Kuskokwim campus of the University of Alaska Fairbanks has a 5-year grant under the NSF's Tribal College-University Program Initiative. The grant is to increase campus course offerings and student interest in science, technology, engineering, and mathematics.

We recommend that the AYK Research and Restoration Plan include an education component designed to encourage interest in resource management. This should be done by providing supplements to funded grants or by giving priority to relevant grant proposals that include well-planned research experiences for high-school and undergraduate students. This recommendation is consistent with (and influenced by) NSF's approach.

COLLABORATIVE RESEARCH PROGRAM FOR CAPACITY BUILDING

One example of how to build scientific and management capacity within rural communities is to promote a collaborative research program. Such a program would be based on proposals submitted jointly by Native or local groups and scientific laboratories or agencies. In principle, the proposals would be written and submitted by these groups as the lead investigators. The funding for competitive proposals would go directly to local communities with sub-contracts to the laboratories or agencies to give the local groups some control over the research process. The most competitive proposals would have a strong educational component that would engage and train younger members of the community. One useful way of encouraging collaborations would be seed grants to allow groups to work together to develop more detailed and long-term research proposals.

The advantages of this type of program are threefold:

- It incorporates Native or local groups directly into the mainstream of scientific research and provides them with long-term contacts and relationships with the scientific community.
- It ensures that LTK and Native community insights contribute to the formulation of research hypotheses and conceptual designs, and that research is conducted in local areas where the Native or local community lives. Researchers in scientific laboratories and agencies can learn a lot from this process.
- It provides local and Native communities with additional influence, because the funding runs through their institutions.

One of the challenges is to ensure that productive and friendly collaborations are formed. In some cases, researchers in scientific laboratories or agencies might already know Native and local groups with whom they would like to engage (and vice versa). The AYK SSI (STC and Steering Committee) might also be able to identify potential partners on both sides, and other scientists familiar with the region might be able to help get a few good collaborative partnerships formed. Finally, seed-grant funding might be provided to explore partnerships before full proposals are formed.

5

Specifics of the Research and Restoration Plan

RETROSPECTIVE ANALYSES

The emphasis throughout the draft research and restoration plan has been one of declining stocks. Even during the period of general declines, some stocks remained stable and some even increased. Might there be some ecological insights gained by comparing those that have done well with those that have not? In addition, in very recent years, many stocks have had large increases in abundance. To allow the most efficient approach to these issues, we suggest that a portion of the money invested in this program in the early rounds of funding emphasize gathering of data from any repositories within ADF&G, USFWS, and tribal offices. Some of these data might not be in electronic format, and so for retrospective analyses, which should be part of many SSI projects, data identification, verification, documentation, and archiving will be useful. Data quality should be assessed in any retrospective analyses.

Relative to this latter point, as an example, one bit of correlative information that might be developed is to determine whether the False Pass fishery is affecting river catches. This could be accomplished by correlating catches in in the False Pass fishery and in rivers over the years to look for a relationship that might be explored in more quantitative detail if it emerges. Given the short time frame, relatively modest budget available, and need for understanding broad-scale field patterns to guide future research, it makes sense for some initial RFPs be directed toward the compilation, sharing, and analysis of existing data.

Scientific and Administrative Leadership

Running even a modestly funded research program will require that a significant portion of the budget, or additional support from partner agencies, be devoted to administrative matters and scientific guidance (such as directing peer review, synthesis of information, data management, and so on). The current members of the Scientific and Technical Committee, highly qualified as they are, all have full-time positions in other agencies. As a result, they cannot always focus their full attention on the science needs of the plan, and their agencies have responsibilities beyond the AYK SSI. In addition, a committee is not normally the best mechanism for providing executive leadership. To provide coordination, vision, and leadership, this committee concluded that a full-time science director should be hired as part of the SSI initiative. The science director's duties would be to ensure coordinated research projects; to manage the various review processes required, including developing RFPs; and to provide scientific leadership for the AYK SSI's research and restoration program. The director should not have other duties unless they are very strongly related to the direction of the research program, and she or he should not be in a position to compete for research funding from the program. Although providing the science director's salary will reduce the funds available to support research directly, the committee concludes that the net result will be an improvement of the research program.

Conflict of Interest

As in all research-funding programs, it is important for the AYK SSI's program to avoid the appearance and the reality of any conflict of interest. The NRC committee was troubled that persons primarily responsible for preparing the draft research plan, and especially the initial RFPs, also were competing for (and receiving) some of the research funds. Even though the research community in Alaska is smaller than it would be for nationwide competitions for research funds, this committee concludes that it nonetheless is large enough that such conflicts of interest can be avoided without jeopardizing the quality of the research and restoration program. In addition, of course, RFPs should be open to competition from outside Alaska. Having a full-time science director for the AYK SSI would help to alleviate the problem of conflict of interest, because the director could prepare the research plan and the initial RFPs, and would be able to reduce the risk of conflicts of interest through peer review and other mechanisms.

Regional Scientific Coordination

Many research programs are under way in the region, and there is a need for a coordinating and synthesizing body. The AYK SSI draft plan talks about the need for partnerships and collaborations, and this committee endorses that idea. Whereas collaborations with scientists and organizations undertaking closely related work may require simply a joint meeting or two, other more complex activities will require much more coordination. Currently, such a coordinating organization is evolving through the North Pacific Research Board (NPRB), and the AYK SSI is included (see www.nprb.org). The AYK SSI should participate in activities that enhance research coordination, such as those carried out by the NPRB and others.

As the collaborating organization continues to evolve, it should consider the need for coordination and support of meetings of stakeholders, users (subsistence, commercial, recreational), and managers and serve as an independent arbitrator in disputes between parties. There also is a need for communication with other agencies (ADF&G, USFWS, Canada Department of Fisheries and Oceans, etc.) and other programs (Alaska Ocean Observing System, North Pacific Research Board, etc.), perhaps through their oversight councils. Activities in this context might revolve around coordinating research, sponsoring mutually beneficial workshops, supporting an information-sharing web site, developing coordinated research programs, and archiving data.

Peer Review

As Figure 3-1 of this report shows, peer review is needed at several stages of the implementation of the research and restoration plan to provide the program with credibility, independence, and sound scientific advice. Managing peer review is a process that requires time and money, and the AYK SSI Steering Committee will need to plan carefully and be creative in allocating resources and taking advantage of opportunities for partnerships to have sufficient funds for the purpose while retaining sufficient funds for research and restoration activities.[1] Peer review will require written evaluations from those who are familiar with specific and general techniques, statistical analyses, data collection and management, the state of the science in the field of research being evaluated, and so on. It is likely that several people will be needed to provide these evaluations, and alternates will likely be needed in case of unavailability or the need for more than one review of a project. These reviewers (or a panel of reviewers) would rank the proposals; the science director would make the final decision.

To avoid conflicts of interest, individuals should not review proposals for research funding in the same cycle in which they are also competing for funds, and they should not review proposals from their own organizations.

Biological Escapement Goals

The committee could not help noticing that escapement goals were not presented within the context of the AYK SSI Science Plan (save for the statement "Central to current management is the establishment of spawning escapement goals," on p. 60, line 17). Escapement goals, set by the primary management agency, the ADF&G (itself part of the AYK SSI), dictate how fisheries are managed in real time during the fishing season. Because escapement goals affect the amount of salmon that can be taken, they are among the most important aspects of salmon management. Given that the central mission of the research and restoration plan revolves around research on and restoration of salmon in the region, close examination of current management practices would make excellent sense. In addition, as mentioned in Chapter 3, adaptive management requires an integration of management actions into a science plan. Therefore, it is important to understand how these escapement goals are set, how escapement goals and the productivity of managed stocks are related, to what degree population fluctuations in the salmon species could be related to previous rates of exploitation (as determined by escapement goals), and whether escapement goals can be related to the current status of the stocks of salmon in the AYK rivers. The research program should be designed to examine this and other management tools.

[1] Recent agreement to share reviewing activities with NPRB and the EVOS Trustee Council, as suggested by a survey initiated on December 7, 2005, is exactly what this committee had in mind in writing the above.

Data and Data Management

Historical data on salmon abundance and the AYK environment are critical to the success of this science program. Currently, it is not clear how much information there is and how available it is. The metadata for the North Pacific gathered from various local, state, federal, and international programs are located at the NOAA Pacific Marine Environmental Laboratory (PMEL) web site (http:www.pmel.noaa.gov/np/mdb/), which is an excellent initial source for the available data. The metadata will be helpful in generating requests for proposals that address potential testable hypotheses from the science questions contained in the research plan.

We recommend that the metadata for the region contained in the North Pacific Ecosystem Metadatabase be assessed as a first step in the science program. In addition, that metadatabase should serve as a repository for AYK SSI metadata.

A hallmark of this science program should be readily accessible sets of diverse fishery and environmental data. Earlier data, and data gathered with AYK SSI support, will be a valuable legacy of the program, and assurances are needed that the data will be cataloged, documented, archived, and made widely available. Use of a common database for relevant Alaska environmental data would reduce the efforts and costs of data management for all research programs in the region.

We also recommend that the AYK SSI use the Alaska Marine Information System (AMIS) established by the North Pacific Research Board (http:www.nprb.org/amis/index.htm/) to serve as a repository for the earlier data and new data gathered with the support of this program. All new data should be submitted to this database within a year of its collection. It would be helpful also to use the ADF&G web site as a portal or data repository.

Local and Traditional Knowledge (LTK) and the AYK

Although the AYK SSI plan addresses the value of LTK in scientific research, it would be improved by a more thorough integration of this idea throughout the report. An important goal of the AYK research and restoration effort is to enhance the grass-roots process of delivering knowledge, improving management, and building local capacity for sustaining the salmon resource. Making sure that LTK is covered throughout the plan should therefore be a priority in the drafting of the final revision.

Defining and implementing the use of local and traditional knowledge (LTK) is not easy, in part because different disciplines have different ways of studying and using it (Huntington 2005). One of the more comprehensive recent definitions of LTK is that of Pierotti and Wildcat (2000): it "is a body of knowledge built up by a group of people through generations of living in close contact with nature . . . [and includes] 1) respect for nonhuman entities as individuals, 2) the existence of bonds between humans and nonhumans, including incorporation of nonhumans into ethical codes of behavior, 3) the importance of local places, and 4) the recognition of humans as part of the ecological system . . [and] is inherently multidisciplinary because it . . . is not only the basis for indigenous concepts of nature but also for concepts of politics and ethics. There are no clearly defined boundaries between philosophy, history, sociology, biology, and anthropology in indigenous thought."

"The role of LTK and capacity building" is stated as a fundamental aspect of the scientific plan (pp. 12-13), which adds strength to the plan. In other parts of the document, however, LTK tends to be the final statement or final paragraph of various discussions, and it appears to be an afterthought, often coupled with the concept of capacity building. While LTK and capacity building are linked in some ways, LTK should play a much larger role in the overall plan, and should be communicated with greater clarity.

For example, in Chapter 2 of the plan (Research Goals and Frameworks), LTK is left to the final paragraph. It is not discussed in the frameworks or in the figures specifically. We suggest the following revisions:

- Add the following assumption to the list in the conceptual foundation for the AYK SSI plan (p. 36): "Salmon and local people have traditionally been, and continue to be, closely connected in the AYK," and therefore LTK can provide an important source of information on salmon dynamics in the region.
- Add the human component to the discussion of Framework 1 (p. 40). Humans are shown in Figure 2.1 but are not discussed in the text. Discussing humans in the text provides the context for LTK to be used as an information source.
- Incorporate the role that LTK can play into the discussion of Framework 2. The plan currently says "The human community . . . sits at the heart of this conceptual framework," but does not indicate how LTK influences the process or the generation of information on salmon dynamics.
- Add the analysis of LTK to the discussion of Framework 3 and to Figure 2.3 (p. 43). It might be useful, for example, to have "Analysis of LTK" in the list of Analysis/Synthesis items in Figure 2.3.

Incorporating LTK prominently into Chapter 2 is very important, especially since Research Theme 18 "Linking Local/Traditional Ecological Knowledge and Conventional Fisheries Research" (Chapter 3, pp. 58-59) becomes one of the highest-priority themes in the overall plan (Chapter 4, pp. 76-77). One has to read the document quite carefully to see that this theme actually does have the highest priority, because the description in the tables simply says "questions to be selected" beside Research Theme 18* (* added for highest priority). For all the other themes falling into the highest priority category, the topics were concisely stated. Why is this not so for Theme 18? In short, LTK deserves much greater emphasis in the discussion of priorities, and more clarity in the overall document.

Finally, the use of LTK should be added to the "Types of Study Approaches" described on p. 79. This section states, "LTK should be viewed as a potentially important source of information with application across multiple study approaches" (p. 80). Why only "potentially" when earlier in the chapter the linking of LTK to conventional fisheries research fell within the highest scientific priorities? And although this sentence appears, the use of LTK is not incorporated into the discussions of each study approach. LTK is mentioned (along with capacity building) in the discussion of monitoring (p. 80), but it is completely missing in the discussion of process studies (even though LTK could be used to develop and validate conceptual models and field studies specific to the AYK). The integration between LTK and conventional fisheries research should play a more dominant role in this overall section (4.6).

LTK should be used to formulate hypotheses and design conceptual models that can be analyzed scientifically. In addition, LTK should be considered as a critical component of historical data that are used in retrospective analysis or meta-analysis of past trends and processes. Finally, the development of new research methods that integrate LTK with ecosystem and fisheries models should be encouraged in RFPs. One example of such integration is a student at the University of Alaska Fairbanks working with a community on the Yukon River.

6

Summary of Conclusions and Recommendations

The NRC committee commends the AYK SSI for its thoughtful and useful efforts to develop a research and restoration plan. We hope that the plan could be made even better by following the conclusions and recommendations discussed in the previous chapters, which are summarized below.

Conclusion The draft research and restoration plan is thoughtful and in many ways insightful. However, the committee judges that it is too long and that the connections between the principles, goals, and conceptual model described at the beginning of the report and the specific research questions identified as high priority at the end of it are not clear.

Recommendation Shorten the plan and clarify the logical connections as described in earlier chapters of this report.

Conclusion The relationships between the AYK SSI's research and restoration plan and the research being undertaken by other organizations in Alaska are not clear. In particular, it is not clear to what degree and for which other programs the SSI intends to rely on their data, complement their research, or duplicate their research.

Recommendation The relationships between other programs and the SSI plan need to be made clearer and more specific. In addition, the SSI should take advantage of any other efforts to clarify and catalog relevant research being done in the region while continuing to identify new topics that are relevant and important.

Conclusion The draft plan defines capacity building well (pp. 86-87), but it does not articulate how capacity building will either be incorporated within or as part of an RFP, or as part of the program as a whole. It also does not address the educational components of capacity building.

Recommendation The plan should more clearly identify the benefits of capacity building and should provide more specifics on how the AYK SSI intends to implement and assess the results of capacity building. The plan should specifically discuss and implement educational components (K-12 and beyond) of capacity building.

Conclusion As the draft plan recognizes, cataloging, assembling, and synthesizing existing data is an important early step that the program should take.

Recommendation This committee endorses and encourages the AYK SSI's approach of focusing early RFPs on retrospective analyses.

Conclusion The administration of this, like any, scientific program is a significant undertaking and requires the full attention of a dedicated and qualified individual or individuals.

Recommendation The AYK SSI should hire a full-time dedicated science director to manage the plan.

Conclusion There is insufficient separation to avoid the appearance and reality of conflict of interest between the people who write the science plan and the RFPs and evaluate research proposals, and the investigators who submit research proposals.

Recommendation The AYK SSI should reduce the appearance and reality of conflict of interest that result when individuals involved in writing the science plan, and especially in writing the RFPs, apply for research funding from the AYK SSI. Especial care should be taken in those cases to ensure that the reviewers of those proposals have not been associated with any aspect of the program. The AYK SSI's science director should not apply to AYK SSI for research funding. In addition, peer reviewers of the research proposals should not be competing for funds in the same round of funding decisions.

Conclusion Many organizations are conducting research on related problems in the Alaska region. Not all these efforts are well coordinated.

Recommendation The AYK should continue to support the evolving regional organizing activities being undertaken by the North Pacifc Research Board to facilitate the coordination of research, the sharing of information, and the communication of research results.

Conclusion The draft research plan barely mentions important management tools, such as biological escapement goals. Yet these tools depend on good scientific information and profoundly affect the sustainability of salmon in the region.

Recommendation The research plan should devote considerable attention to how biological escapement goals are set, including an analysis of how salmon populations respond to them.

Conclusion Historical and current information about salmon abundance have not been adequately assessed for quality, availability, and scope.

Recommendation The metadata for the region contained in the North Pacific Ecosystem Metadatabase should be assessed as an early step in the science program. In addition, the AYK

SSI should use the Alaska Marine Information System established by the North Pacific Research Board as a data repository or portal (www.nprb.org/amis/index.htm). The ADF&G web site also would be useful for these purposes.

Conclusion Although the research plan addresses the importance of local and traditional knowledge (LTK), it does not adequately integrate the concept throughout the document. The plan also does not adequately distinguish the concept of LTK from that of capacity building.

Recommendation LTK and capacity building should be more clearly distinguished as separate ideas. LTK should play a much larger role in the plan, and that role should be communicated more clearly in the plan. Both LTK and capacity building are critical to the success of the plan.

The committee is optimistic about the research and restoration plan, and looks forward to seeing it develop important and timely results.

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Appendix A

Summary from First Report

INTRODUCTION

Salmon and freshwater fish have been critical to the survival and well-being of the people and wildlife in the Arctic-Yukon-Kuskokwim (AYK) region (Figure S-1) for thousands of years. Salmon influence human societies in the region, and humans affect the lives and numbers of salmon. Modern technology and economies, which make it possible to deplete salmon populations easily, have strained that relationship.

Recent declines in the abundance of salmon in the AYK region have created hardships for the people and communities that depend heavily on this resource. The low salmon returns resulted in lower catches and increased regulatory restrictions on fishing, which in turn resulted in reduced revenue for cash-short communities along the region's rivers. Those losses forced fishers, especially in the lower reaches of the rivers, to reduce fishing times and use less expensive and less efficient gear. Restrictions on subsistence fishing and lower catches also affected all aspects of the lives of people in the region. Especially in interior regions, where other subsistence foods were less abundant during recent salmon declines and groceries are either extremely expensive or not available, people were short of food and had to rely on government subsidies. The loss of subsistence food and reliance on other food sources results in cultural changes—subsistence is a central feature of Native cultures in the region—that include the loss of traditional knowledge and language, and change in cultural priorities. The losses are progressively harder to reverse with time.

The reasons for the drop in salmon returns are not well understood, which makes it difficult for fishery managers and scientists to identify appropriate management actions, although they likely involve aspects of the life cycles of the fish and their environments in freshwater and in saltwater as well as human impacts.

The AYK Sustainable Salmon Initiative (SSI) was created through a $5M congressional appropriation in 2002 to undertake an expanded research program toward gaining an understanding of the declines of salmon and to support sustainable salmon management in the region (an additional $8.5 million has been appropriated through 2004). An AYK Research and Restoration Plan is being developed by the Scientific and Technical Committee (STC) of the

FIGURE S-1 Map of Alaska, showing the Arctic-Yukon-Kuskokwim region. The region of concern for the purposes of this study includes the Yukon River drainage, the Kuskokwim-Goodnews drainage, and the drainages between Shishmaref in the north and Cape Newenham in the south. The area of study does not include North Slope drainages and the northern part of the Northwestern region drainages. Source: Adapted from USGS 2004.

AYK SSI. It is intended to identify the best way to investigate and understand this complex system and ultimately to devise a means to anticipate or predict future sizes of salmon populations.

THE PRESENT STUDY

To help the AYK SSI prepare the research and restoration plan, the STC of the AYK SSI requested the help of the National Research Council (NRC). The committee's statement of task is in Box S-1.

The committee has met three times, beginning September 27-30, 2003, when it held public sessions in Bethel, St. Mary's, Aniak, Nome, and Unalakleet. The committee attended an AYK SSI workshop in Anchorage, November 18-20, 2003, and some committee members and staff attended a meeting of the Tanana Chiefs Conference Natural Resources Coalition in Fairbanks, January 22-23, 2004. The committee held its next meeting February 2-6, 2004, which included public sessions in Nome and Unalakleet. In this first of two reports, the committee is charged with providing insights from the AYK SSI workshop, public sessions, briefings, relevant science plans, published literature, and the committee members' expertise to help the STC avoid difficulties and pitfalls as it develops a draft research and restoration plan. After the AYK SSI submits that plan, this committee will produce a second report that reviews the plan.

SUBSISTENCE

Subsistence as it applies to rural Alaska Natives is not easy to define, but it is integral to their way of life. Its importance is reflected in their language and culture and in placement of their settlements. It is a way of obtaining food, clothing, and other necessities; it is a way of life; it is a connection to the land and the water; and it has been encoded in state and federal laws, which protect it or give it priority over other uses.

This report focuses on subsistence mainly as an activity that takes fish, but a failure to understand the context of its integral and fundamental importance to Alaska Native ways of life and culture would make any discussion of it misguided at best.

LIFE HISTORIES OF SALMON SPECIES IN THE REGION

The life histories of the five species of Pacific salmon—Chinook, coho, chum, pink, and sockeye—found in the AYK region share several general characteristics. All species are anadromous: spawning occurs in freshwater, juveniles then migrate to the marine environment where they obtain 90-99% of their total growth, and mature adults return to freshwater to spawn.

BOX S-1 NRC Committee Statement of Task

The NRC committee will assist the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI) in developing a high-quality, long-range restoration and research (science) plan for the AYK region. The committee will assess the current state of knowledge, describe ongoing research in the region, and identify research questions of greatest relevance to the region. It will outline essential components of a successful, long-term science plan, identify research themes that the science plan should be based on, and identify critical research questions within the research themes. The committee will later review the research and restoration plan drafted by the Scientific and Technical Committee of the AYK SSI.

Little or no food is taken by returning adults in freshwater. Individuals of all species typically home rather precisely to their natal area to spawn. All species are semelparous, spawning only once and dying a few days or weeks later. Typically, females select a redd site and dig a depression in the gravel where they deposit eggs in a series of pockets; they cover each pocket in turn. Males fight among themselves for proximity to a female to increase their chances of fertilizing her eggs; small males may successfully fertilize eggs by sneaking into the nest depression when the female releases her eggs. After spawning, a female typically spends her last few days of life defending her nest site against late-arriving females. In the AYK region, salmon eggs typically hatch in early to midwinter and the young salmon remain in the gravel until they emerge in spring. During this time, they live on the energy reserves in their yolk sac and they can be quite active, often burying more deeply into the gravel, presumably to avoid being disturbed by floods.

After the salmon emerge from the gravel in the spring, the life histories of the five species diverge. Most pink and chum salmon begin their migration to the ocean within a few days of emergence when they are still small. The other three species—sockeye, coho, and Chinook salmon—spend 1 or 2 years in freshwater and reach a larger size before going to sea. The migration of all species typically occurs soon after spring breakup (May to June), and the fish arrive in the marine environment in early summer.

At ocean entrance, juvenile salmon often first aggregate in intertidal (littoral) waters; then as they grow they gradually move offshore to shallow, pelagic areas near shore or over the continental shelf, from low-tide mark down to a depth of about 200 m. There is no evidence of overlap in distribution of Bering Sea and Gulf of Alaska salmon stocks at the juvenile stage for any salmon species. Gradual offshore movements of juvenile AYK salmon continue throughout their first summer and fall in waters over the Bering Sea shelf, where they are distributed in surface or near-surface waters (to a depth of about 20 m). After their first summer at sea, salmon from the AYK region range widely throughout the Bering Sea and Aleutian Islands, the central and eastern North Pacific Ocean, and the Gulf of Alaska during extensive ocean feeding migrations.

Data are inadequate to infer migration patterns between juvenile and immature life history stages of AYK salmon. The extent of their offshore movements in the Bering Sea and North Pacific Ocean in late fall and winter is not known. In general, western Alaskan stocks migrate farther offshore in winter than stocks from more southerly regions of North America. Many or most AYK juvenile sockeye, chum, pink, and coho salmon move south through the Aleutian passes into the central and eastern North Pacific Ocean in late fall or winter. Winter trawl surveys have shown that all species of salmon in their first winter at sea can be caught in offshore waters of the North Pacific Ocean by January and February. The area where juvenile AYK salmon are distributed at the end of their first winter at sea may vary from year to year depending on species, stock, age, growth, and environmental conditions. That area could be the approximate high-seas location where they begin their adult return migrations to natal streams.

Upstream migrations of AYK salmon begin between the first of June and the end of October. Interspecific patterns of upstream migrations are similar across the AYK region, with Chinook salmon entering rivers first, followed by summer chum and pink salmon, and fall chum and coho salmon entering last. Very little is known about the marine life history of AYK salmon. Within this broad framework, each species has unique life history characteristics that set it apart from the others. These characteristics include the number of years spent in the freshwater and marine environments and the use that fish make of freshwater and marine habitats.

The fact that mature salmon home rather precisely to their natal areas means that fish spawning in different parts of a drainage are reproductively isolated, and local adaptations can evolve. This has far-reaching implications because these reproductively isolated groups (stocks or populations) often evolve life history characteristics that adapt them to the unique conditions they encounter in the habitats they use for spawning and rearing. As a result, there is considerable stock-specific variation in life history characteristics that fits particular stocks to their particular habitats.

RECENT CHANGES IN FISHERY CATCHES OF SALMON FROM KUSKOKWIM, YUKON, AND NORTON SOUND RIVERS

Although there is a general perception that salmon populations in the AYK region have declined in recent years or even decades, the trends have differed among species and in different parts of the region. In both Norton Sound and the Yukon River, chum fisheries were reduced well before Chinook restrictions. In contrast, in the Kuskokwim region, catches of Chinook, chum, and sockeye were simultaneously reduced in 1993, increased somewhat, and then reduced again in 1996.

DEVELOPMENT AND ESSENTIAL COMPONENTS OF A RESEARCH AND RESTORATION PLAN FOR THE AYK REGION

The elements of a restoration and scientific research plan include a focus of the program, strategies to develop research themes, assemblage of prior research and restoration efforts, and integration of the study plan with existing, ongoing research programs. For the development of research themes, three example approaches are presented in Chapter 4. These approaches are (1) development of a conceptual framework, (2) studies of mortality and productivity rates and of the metapopulation structure, and (3) studies of the resilience of the AYK salmon structure in the face of millennia of environmental change and human exploitation. The existence of numerous research programs in the North Pacific, Bering Sea, and Arctic Ocean will enhance the ability to develop AYK salmon research programs through coordination. The development of a restoration plan depends on the results guided by the research plan, along with what is already known about AYK salmon. It is difficult to develop an effective restoration plan before the general factors that affect AYK salmon abundance are better understood. The committee judges that, aside from a few actions that could only help with no risk of doing harm or a few actions that should be undertaken on an experimental basis, it is premature to develop a detailed restoration plan until better research results are available.

ESSENTIAL COMPONENTS OF AN AYK SSI SCIENCE PLAN

- A mission and/or vision statement: the mission is an intellectual statement that defines AYK SSI's role, and the vision statement comes from informed imagination.
- Background information: this includes a brief regional description, present state of knowledge and other relevant science plans.

- Research and restoration issues and needs the plan will address: these include fishery management and ecosystem concerns along with other scientific issues.
- An overarching theme: the theme is the thread that binds the individual research topics together.
- A set of research themes and approaches to accomplish the needed research: this set often includes topics such as processes and variability in the physical environment, species responses to perturbations, food web dynamics, contaminants, essential habitat, monitoring, modeling, process-oriented studies, and retrospective studies.
- Implementation and protocol issues: these include topics such as policies for cooperation, identifying and addressing user needs, data quality, management and dissemination, logistics, outreach and education, and community involvement.

FRAMEWORKS FOR UNDERSTANDING THE ECOSYSTEMS OF SALMON

The committee concluded from its review of other research programs as well as from the members' own experiences that the best way to develop a research plan is to begin with a model or framework of how the system works. In the present case, the system can be defined in a variety of ways, each with a variety of possible boundaries. They include a biophysical system, a socioeconomic system, a sociocultural system, and a legal system as well as other possibilities. The committee used three system models or frameworks: one based on the life cycle of salmon; another based on human social, economic, cultural, and political linkages; and another based on a historical perspective on the resilience of the AYK salmon-human system. Using three frameworks allows each to provide different insights and can lead to different questions. However, some of the questions that arise are common to all the frameworks.

DEVELOPMENT OF RESEARCH THEMES

Research has developed an enormous amount of information in the AYK region. However, because the region is so large and so sparsely populated, an even greater amount of information remains unknown. The committee has reviewed previous, ongoing, and planned research in the region, as described in Chapter 3. On the basis of that review, the committee concludes that the following questions are of great importance to the region's stakeholders.

- What can be learned about the role of predation in the population dynamics of Pacific salmon? How does predation interact with other factors regulating abundance and determining year-to-year variability in abundance? To adequately address questions about predation mortality of AYK salmon, better information is needed on the distribution, life history, ecology, and population dynamics of the major predators of salmon and their trophic community structure in the Bering Sea and North Pacific Ocean. Essential components of a successful research program include both field research and computer modeling.
- What anthropogenic factors might increase predation mortality of AYK salmon (climate change, hatchery releases, and large-scale marine fisheries)?

- What are the effects of climate-, fishery-, and hatchery-induced changes in Bering Sea and North Pacific marine ecosystems on predation mortality of AYK salmon at each ocean life history stage (juvenile, immature, maturing, and adult)?
- What knowledge is required to identify excessive fishing mortality so that in-season regulation can be effectively applied to reduce this excess mortality?
- Can we identify genetically distinct breeding populations of the five species of salmon in the AYK region? Current information on chum and Chinook salmon is more extensive than that for coho, pink, and sockeye salmon, for which much more extensive analysis is needed throughout the range.
- For the major breeding populations, can we measure the relative abundance and vital rates of the population to predict future population trends? Little is known about the baseline measures of population viability even in the salmon that have been distinguished as separate breeding populations. We need to know fecundity, survival, escapement, and straying rates among these populations if we are to predict their future.
- Are there identifiable trends in fishing mortality within a given stock from current or recent sampling?
- Can we use simulation models, based on estimated vital rates of local populations, to assess the impact of fishing mortality on population viability?
- Can we measure gear- or time-specific mortality on separate stocks within the mixed-stock stream fisheries?
- Can we measure gear- or time-specific mortality on separate stocks within the mixed-stock ocean fisheries?
- In the meetings and workshops with residents of the AYK region as part of this review, the continued harvest and use of salmon was stated as being of paramount importance for sustenance, livelihood, community sustainability, and cultural continuity. What level of harvest can be sustained during the short term (5, 10, or 15 years)? Recognizing that salmon populations generally have been declining in the past decade or more, and harvests have been restricted and curtailed in many instances, what amount of harvest, if any, can be expected in each region, for each species, during rebuilding of salmon stocks? What level of harvest can be sustained over the long term (20 or 40 years)? What role can salmon play in the livelihood of families and communities during the next two generations? Salmon have been a major contributor to the economic and cultural continuity of many communities in the AYK for centuries. Major changes in community economies have become necessary with continued declines in salmon abundance. However, estimates of future salmon abundance are important for community self determination.

HOW TO INTEGRATE TRADITIONAL KNOWLEDGE AND TRADITIONAL SCIENCE

Traditional knowledge and Western science might be woven together best by someone who has grown up with a traditional indigenous upbringing and then gained an understanding of the scientific method through standard research techniques learned on the job or within a university setting. This method could be better than relying on a university-educated person to meet, learn about, and build relationships with an indigenous community or someone raised within an indigenous community attempting to apply the scientific method without proper training. It is often difficult and can take decades for outside researchers to gain the trust and support of indigenous community members. Because of this, many researchers often are not given the "whole story" because a trust relationship has not developed. The encouragement of scientific interests of Native students could help nurture community involvement in the scientific work.

Traditional knowledge and indigenous researchers should be involved in the research within their traditional homelands and about the resources they depend on. Indigenous people have an extensive, historical, and indivisible affinity with the land they call home and a fundamental interest in the outcome of all research pertaining to that land. Their greater involvement in all stages of the research would benefit both the research and the people of the region.

This can be achieved by identifying and encouraging indigenous and collaborative research projects that weave traditional science and traditional knowledge with Western science. Included in this would be consolidating salmon research into a library, including geographical information system data. Local communities should be involved in scientific research. Flow of information should be bidirectional. Entire populations, from elders to schoolchildren, should be represented where appropriate.

CONCLUSIONS

The data show clearly that salmon returns in the AYK region in the 1990s and early 2000s were lower than previously. Those low returns have caused considerable social and economic hardship in the region. The committee concludes further that current scientific information is not sufficient to explain the reasons for the low returns with any confidence. It is at least possible that the low returns represent population fluctuations rather than a long-term declining trend.

Identifying the nature of the declines (or fluctuations) in salmon runs and their causes will take a great deal of research. Conducting that will require much time and money—much more money than the $13.5 million that has been appropriated and even more than the total of $18.5 million whose appropriation is hoped for. However, at least some of that research will need to be completed before a fully developed restoration plan is undertaken, if indeed one proves to be needed. The committee judges that insufficient information is currently available to initiate a large-scale restoration program, although some small-scale local programs appear to be worth investigating. This judgment does not extend to the potential benefits of management actions to reduce fishing mortality or competition with hatchery fish at sea if such actions are supported by available information.

An encouraging aspect of the research enterprise in the region is the degree to which it involves Alaska Native organizations and communities. Any increase in that involvement is likely to benefit the research and the communities themselves even more. In addition, the AYK SSI appears to recognize the need to coordinate and partner with other research programs in the region and elsewhere. Given the large spatial extent of the region (and hence the research problem) and the relatively modest amount of money available, such coordination is essential, as are partnerships.

The committee has not explicitly considered research into social and economic matters for their own sake. That is, the committee has considered social and economic research that is directly tied to the sustainability of salmon runs, but not if it is tied mainly to the sustainability of the communities in the region. The committee interpreted its charge as guiding it in that manner.

RECOMMENDATIONS

Research

This report has described a large number of research themes and questions. Those questions all have scientific interest and all have some potential to shed light on the relationship between human and environmental factors and fluctuations in runs of AYK salmon. However, if results that are useful to management are required in a reasonable amount of time, then prioritization is required. The committee suggests the following approaches to prioritizing research funding. We assume that the ultimate goal of the AYK SSI is management, that is helping to ensure that salmon runs can be exploited sustainably, and our suggestions for research prioritization are made in that context. The committee judges that focusing the research effort on the topics below would be cost-effective and productive.

- The greatest research need appears to be better information on the numbers and distribution in space and time of the various species and stocks of AYK salmon. We need to know more about population sizes and productivity (how many fish there are) and more about the genetic makeup of species and populations. The latter information is a prerequisite for assessing the interaction of human and environmental factors with salmon populations, because different salmon populations have different growth rates, fecundity, productivity, and in general can respond differently to those factors. Better assessments are needed of the numbers of salmon of the five species originating in the various drainages at all life stages and in all the environments they inhabit. Without analyses of numbers and of genetic makeup, analyzing the effects of fishing, including fishing on mixed stocks, is not possible. This research theme is pervasive and the knowledge it embodies is a prerequisite for answering many of the more detailed questions we have described elsewhere.
- It would be of great value to be able to partition factors that affect AYK salmon runs into those that operate mainly in freshwater and the adjacent landscapes, and those that operate mainly in the marine environment. If such partitioning of factors can be achieved, it should be possible to learn whether the most important factors are marine or freshwater; or whether at certain times they are marine, and at other times freshwater; or whether both marine and freshwater factors are important most of the time. For freshwater, this requires a better understanding of habitat variations and their effects on AYK salmon than we now have.
- Better information is needed on the extent, nature, and distribution in time and space of human activities that affect salmon, and the degree to which they affect salmon. In the AYK region, those activities are mainly fishing. In particular, better information is needed on the amount and consequences of recreational fishing and the amount and effects of bycatch and directed fishing at sea. Better information about the spatial and temporal distribution and landings of subsistence and commercial fishing within and near the rivers of the AYK also would be helpful, as well as about the dependence of that variation on the number and kinds of salmon available. We need to understand factors that influence the development, promulgation,

and enforcement of fishing regulations and people's compliance with them. This research theme also is pervasive and a prerequisite for answering many more detailed questions.

Restoration

The committee does not recommend the initiation of a large-scale restoration plan until better information is produced by the research outlined above. However, small-scale local initiatives might hold promise. They include the following:

- Controlled-design experiments to assess the effects on salmon populations in small streams of existing hatcheries if any are re-opened, and on incubation boxes and other enhancement techniques.
- Retrospective analyses should be done on hatchery and incubator systems, both those currently in operation and those that have ceased operations. Such analyses should include North Pacific and Bering Sea hatcheries that seem likely to shed light on issues within the region.

Implementation

The implementation of this research program should use monitoring, process studies, retrospective analyses, and theoretical studies. Models are useful tools in many of these research activities. In addition, adaptive management has the potential to be effective and to contribute to knowledge that could help to form the basis of a restoration plan. In many if not all cases, this would require the cooperation and involvement of management agencies, especially the Alaska Department of Fish and Game (a member of the AYK SSI). Management actions should be designed to include the gathering of scientific data; in other words, they should be thought of as if they were controlled experiments. In truth, management actions often are experiments, but they usually have poor or no experimental controls.

The resources required to address salmon variability in the AYK region are significant because the problem has a variety of geographical scales and it has interdisciplinary aspects. Salmon variability could depend on very small-scale influences such as stream temperature or flow. It also might depend on oceanic conditions that affect the ocean carrying capacity of the Bering Sea and the North Pacific Ocean. Physical, biological, and chemical variations in the ocean, atmosphere, and terrestrial environment could play important roles. This is a large, complex problem, and the ecosystem will be continually changing. This daunting task is made easier through interactions with ongoing and future science programs in the region. The AYK SSI would benefit from coordinating with them, perhaps to the extent of joint funding of research projects. Examples of such programs include the North Pacific Research Board, the Exxon Valdez Oil Spill Gulf Environmental Monitoring Program, the Alaska Ocean Observing System, Ecosystem Fisheries Oceanography Coordinated Investigations, the Bering Sea Ecosystem Study, the Bering-Aleutian Salmon International Survey, the Norton Sound Sustainable Salmon Initiative, the United States/Canada Yukon River Joint Technical Committee Program, the World Wildlife Fund/National Science Foundation Program, and the National Oceanic and Atmospheric Administration Arctic Program.

In addition, the committee recommends monitoring programs as being likely to provide useful information and having the potential to provide long-term data sets. Managing, coordinating, synthesizing, and making available the data collected by all these programs, including research funded by the AYK SSI, are important challenges that need careful consideration in any research plan.

Appendix B

Biographic Information on the Committee on Review of Western Alaska (AYK) Research and Restoration Plan for Salmon

Thomas Royer (Chair) is a Slover Professor of Oceanography for the Center for Coastal Physical Oceanography at Old Dominion University in Norfolk, Virginia. Dr. Royer earned his bachelors degree from Albion College, as well as an M.S. and Ph.D. from Texas A&M University. For 33 years, Dr. Royer has carried out measurements of hydrography in the Northeast Pacific from Alaska to Hawaii during all seasons of the year. This work led to the discovery of a significant coastal current along the coast of Alaska that is driven by freshwater discharge. He served as the University of Alaska Fairbanks Chancellor's Faculty Associate for Research in 1992-1993, where he administered the research activities of that campus. He was awarded the Edith Bullock for excellence in service to the University of Alaska. He has been active in the University-National Oceanographic Laboratory System (UNOLS), having served on the Fleet Improvement Committee, the Advisory Council, and as vice chairman. He was chairman of a national committee that designed a new Arctic research vessel. In addition, Dr. Royer has served on the MMS Scientific Advisory Committee and on various committees of the National Research Council and its Ocean Studies Board. He is active in the international North Pacific Marine Science Organization (PICES) and serves as a U.S. representative to the Technical Committee on Data Exchange of PICES. Dr. Royer also serves on the Scientific and Technical Committee of the Oil Spill Recovery Institute (OSRI) of the Prince William Sound Science Center (PWSSC), Scientific and Technical Advisory Committee (STAC) of Exxon Valdez Oil Spill (EVOS), and the Science Panel of the North Pacific Research Board (NPRB).

LaMont Albertson is guide and owner of Wilderness Experiences, a fishing and naturalist guide service in the Aniak River valley in Aniak, Alaska. He also serves as charter member of the Kuskokwim River Fisheries User Group, serving as a representative of sport fishing interests. In his career as an educator, Mr. Albertson has served as both director and president of the Kuskokwim Community College, and he has served as classroom and distance education instructor, principal, and personnel director for Alaskan educational institutions. He received a B.A. from Oklahoma Baptist University and an M.Ed. from the University of Florida and Florida

Atlantic University. Postgraduate studies have been conducted through Cornell University and other academic institutions.

Elizabeth Andrews has over 25 years experience in policy analysis, project and program management, and analytical research, all pertaining to conservation and management of fisheries and wildlife resources in Alaska. In recent years, she was an assistant director with the Alaska Department of Fish and Game, and served as the department's liaison with five federal agencies in Alaska for managing fisheries and wildlife in areas of overlapping management jurisdiction. Dr. Andrews is familiar with current relevant social science research in the AYK region and salmon management and has worked on the state's response to the failure of salmon returns to the region. Throughout her career, Dr. Andrews worked in partnership with federal agencies as well as with fisheries organizations and other interested groups for the purposes of managing fisheries resources in Alaska. She has considerable experience working as a team member with various management entities and government resource managers in efforts to provide for multiple uses of fisheries resources in a balanced and meaningful way. Dr. Andrews left the committee in October 2005 to become director of the Subsistence Division of ADF&G.

Ronald K. Dearborn is the former director of Alaska Sea Grant at the University of Alaska Fairbanks. His past professional experience also includes positions with the State of Maine Department of Environmental Protection and as sea grant director at the University of Maine. Mr. Dearborn earned an M.S. in ocean engineering from the University of Massachusetts, and a B.S. in mechanical engineering from the University of Maine. His professional interests include the impact of environmental change on marine resource populations and the challenges of resource management in a changing environment. Mr. Dearborn has served as president of Sea Grant Association, 1987-1988 and 1997-1998.

Craig Fleener first entered the field of natural resource management in 1990 when he began working for his tribe. In 1991, he moved to the Council of Athabascan Tribal Governments to work on behalf of the tribes in his region. Most recently, Mr. Fleener has designed and implemented a three-phase research project collecting traditional ecological knowledge of salmon through interviews with tribe elders. He designed the project to identify historically active spawning grounds in an effort to restore these locations and enhance the salmon spawning in the upper Yukon. Mr. Fleener has attended Yukon River panel negotiations, salmon fisheries conferences, natural resource management conferences, and sat on resource advisory committees as a knowledgeable subsistence user, gaining an intricate knowledge of the overall fisheries management system within Alaska and of the body of knowledge related to salmon fisheries available today. Mr. Fleener has a B.S. in natural resources management (1999) from the University of Alaska Fairbanks and has continued study in wildlife biology, resources, and the environment at the University of Calgary.

Robert Huggett is professor emeritus of zoology and the former vice president for research and graduate studies at Michigan State University. He also is professor emeritus of marine science at the College of William and Mary. Dr. Huggett's aquatic biogeochemistry research has involved the fate and effects of hazardous substances in aquatic systems with a focus on hydrophobic chemicals and their partitioning between sediment and pore water, which governs the chemicals' biological availability. From 1994 to 1997, Dr. Huggett was the assistant administrator for research and development for the U.S. Environmental Protection Agency, where his responsibilities included planning and directing EPA's 500-million-dollar-per-year research program. Dr. Huggett earned his Ph.D. at the College of William and Mary in Williamsburg, Virginia. He also serves on the National Research Council's Board on Environmental Studies and Toxicology and served on the Committee on Endangered and Threatened Fishes in the Klamath River Basin.

Nicholas Hughes is an assistant professor in the Fisheries Division for the School of Fisheries & Ocean Sciences at the University of Alaska Fairbanks. Dr. Hughes studies interactions between stream salmonids in freshwaters and their habitats. His theory is that stream habitat acts as a template, guiding the way natural selection shapes the ecology and behavior of individual fish, and that large-scale properties such as distribution patterns, population dynamics, and community structure can be explained in terms of the ecology and behavior of individuals. He received a B.S. and an M.A. from the University of Oxford, and a Ph.D. from the University of Alaska Fairbanks.

Cynthia M. Jones is professor of ocean, earth, and atmospheric sciences, and director of the Center for Quantitative Fisheries Ecology at Old Dominion University in Norfolk, Virginia. She received her B.A. in zoology (honors) at Boston University, as well as her M.S. and Ph.D. in oceanography at the University of Rhode Island. Her research interests are population dynamics, fisheries management, and population ecology. In addition, Dr. Jones has served on four National Research Council committees: the Committee for Review of the National Marine Fisheries Service: Use of Science and Data in Management and Litigation (chair, 2001-2002); the Committee on Improving the Collection and Use of Fisheries Data (1998-2000); the Committee on Fish Stock Assessment Methods (1995-1997); and the Committee to Review Northeast Fishery Stock Assessments (1997).

Katherine W. Myers has served as a fisheries biologist for the High Seas Salmon Research Program in the School of Aquatic & Fishery Sciences at University of Washington since 1981. Dr. Myers received a B.S. in fisheries at the University of Washington-Seattle, an M.S. in fisheries at Oregon State University-Corvallis, and a Ph.D. in fisheries at Hokkaido University, Hakodate, Japan. Her research interests include oceanic and biological processes affecting salmon growth and productivity. Dr. Myers has served as co-principal investigator for a study on the Gulf of Alaska salmon (research grant funded by U.S. GLOBEC/National Science Foundation) and as a principal investigator for a study on trawl chinook (research grant funded by Yukon River Drainage Fisheries Association/NOAA). In 2000, Dr. Myers received a Distinguished Service Award from the American Institute of Fishery Research Biologists. She also has served as a U.S. salmon expert and U.S. editor for the North Pacific Anadromous Fish Commission. Dr. Myers continues to serve as a member of the commission's Committee on Scientific Research and Statistics (1993-) and the U.S. member of the Science Sub-Committee (1998-).

Rosamond Lee Naylor is a senior fellow at the Center for Environmental Science and Policy (CESP) at Stanford University. She received her B.A. in economics and environmental studies from the University of Colorado, her M.S. in economics from the London School of Economics, and her Ph.D. in applied economics from Stanford University. Her research focuses on the environmental and equity dimensions of intensive food production. Dr. Naylor has been involved in a number of field-level research projects in Southeast Asia, Mexico, Micronesia, and North America (Pacific Northwest and Alaska) researching aquaculture development, salmon fisheries, high-input agricultural development, biotechnology, climate-induced yield variability, and food security. Dr. Naylor was named fellow in the Aldo Leopold Leadership Program in Environmental Sciences in 1999; Pew Fellow in Conservation and the Environment in 1994; and McNamara Fellow by the World Bank for her work on women and rural development in 1990.

Jennifer Ruesink is an assistant professor in the Department of Biology at the University of Washington – Seattle. Her research interests are marine community and population ecology, with an emphasis on thresholds in species and food-web interactions, introduced species, and ecological values of biological diversity and ecosystem functioning. Dr. Ruesink received her Ph.D. from the University of Washington. She has studied the ecological impacts of the *Exxon Valdez* oil spill on the ecology of tidal communities in Prince William Sound, including work with National Academy of Sciences member Dr. Robert Paine. She also served on the National Research Council's Committee to Review the Gulf of Alaska Ecosystem Monitoring Program (2000-2002).

Roy A. Stein is a professor in the Department of Evolution, Ecology & Organismal Biology at Ohio State University. He has a B.S. from the University of Michigan, an M.S. from Oregon State University, and a Ph.D. from the University of Wisconsin-Madison. Dr. Stein has considerable direct experience with fishery management. His research interests are freshwater community ecology and fishery biology. He has been a U.S. commissioner on the Great Lakes Fishery Commission since 1998 and is currently serving as its vice chair. Dr. Stein also has served on the National Research Council's Committee to Review the NOAA National Sea Grant College Program (1994).