Arctic-Yukon-Kuskokwim Salmon Research & Restoration Plan

Prepared by the Arctic-Yukon-Kuskokwim
Sustainable Salmon Initiative
Scientific and Technical Committee

First Edition

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Arctic-Yukon-Kuskokwim Salmon Research & Restoration Plan

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Sustainable Salmon Initiative Scientific and Technical Committee

Building a clear understanding of the trends and causes of variation in salmon abundance and fisheries and improving management and restoration techniques through a collaborative and inclusive process.

Preface

About the AYK SSI and the Research and Restoration Plan

AYK SSI Vision
By 2012 we will have expanded knowledge to assure sustainable uses of wild salmon for future generations (2004).

The Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI) is an innovative partnership between public and private institutions which provides a forum for non-governmental organizations and state and federal agencies to cooperatively identify and address salmon research and restoration needs. The affected region encompasses over 40% of the State of Alaska; the AYK region includes the watersheds of the Norton Sound region up to and including the village of Shishmaref, the Yukon River Watershed within Alaska, and the Kuskokwim River Watershed (including the coastal watersheds north of Cape Newenham), plus the Bering Sea marine ecosystem.

The AYK SSI is a response to disastrously low salmon returns to western Alaska in the late 1990s and early 2000s, which created numerous hardships for the people and communities that depend heavily on the salmon fishery. Some stocks in the region have been in a decline for more than a decade and a half, leading to severe restrictions on commercial and subsistence fisheries. The first step for the AYK SSI has been to collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.

Created via a memorandum of understanding (www.aykssi.org), the AYK SSI partnership includes the Association of Village Council Presidents (AVCP); the Tanana Chiefs Conference (TCC); Kawerak, Inc.; Bering Sea Fishermen's Association (BSFA); Alaska Department of Fish and Game (ADF&G); National Marine Fisheries Service (NMFS); US Fish & Wildlife Service (USFWS); plus additional native, governmental, and NGO ex-officio partner institutions. In 2001, the partners established the AYK Sustainable Salmon Initiative (AYK SSI) and created a process and structure to ensure the coordinated expenditure of research funds. The AYK SSI is governed by an eight-member Steering Committee (SC) and advised by a six-member Scientific and Technical Committee (STC). Congress has appropriated $20.5 million as of June 2006 to support the AYK SSI.

The kinds of information and the means of collecting it are defined by the diverse nature of the SC's membership. In addition to studying the biology and physics of salmon production, the SC is concerned with how humans impact salmon and with the evaluation and development of tools to be applied to managing human impacts on the fishery and ecosystem. As understanding salmon and their movements through the AYK ecosystems has been a preoccupation of local inhabitants for millennia, the SC's studies will rely on local residents as much as possible to provide necessary information and to identify avenues of inquiry to achieve the Program goal. To acquire the information necessary to sustainably manage salmon, the SC is also interested in assisting in building the infrastructure and personnel capacity to support salmon research and restoration in local communities.

The Research and Restoration Plan (RRP) was prepared by the STC, with guidance from a committee of the U.S. National Research Council (NRC 2004a), for the SC and its constituencies, which include resource-dependent communities in the region, researchers, resource managers, directors of research programs, and other decision makers throughout the range of the AYK salmon. It also serves to inform authors of proposals to the AYK SSI for funding and serves the STC in its evaluation of proposals.

The RRP explains what needs to be done, why and when it needs to be done, and how it can be accomplished. The RRP's conceptual foundation establishes why and when research and restoration actions are necessary by explaining the current understanding of the most important variables responsible for production of AYK salmon. What needs to be done is determined by answering critical questions surrounding the trends and causes of variation in salmon abundance and human use of salmon.

The goal of the AYK SSI Research and Restoration Program is to understand the trends and causes of variation in salmon abundance and fisheries through the assembly of existing information, gaining new information, and improving management and restoration techniques through a collaborative and inclusive process.

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Executive Summary

AYK SSI Vision

By 2012 we will have expanded knowledge to assure sustainable uses of wild salmon for future generations (2004).

An Innovative Partnership Creating a Legacy of Salmon Science

The Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI) is an innovative partnership between public and private institutions which provides a forum for non-governmental organizations and state and federal agencies to cooperatively identify and address salmon research and restoration needs. The region encompasses over 40% of the State of Alaska; the AYK region includes the watersheds of the Norton Sound region up to and including the village of Shishmaref, the Yukon River watershed within Alaska, and the Kuskokwim River watershed (including the coastal watersheds north of Cape Newenham), plus the Bering Sea marine ecosystem.

Created via a memorandum of understanding (www.aykssi.org), the AYK SSI partnership includes the Association of Village Council Presidents (AVCP); the Tanana Chiefs Conference (TCC); Kawerak, Inc.; Bering Sea Fishermen's Association (BSFA); Alaska Department of Fish and Game (ADF&G); National Marine Fisheries Service; US Fish & Wildlife Service (USFWS); plus additional native, governmental, and NGO ex-officio partner institutions. In 2001, these partners established the AYK Sustainable Salmon Initiative.

The AYK SSI is governed by an eight-member Steering Committee (SC) and advised by a six-member Scientific and Technical Committee (STC). The SC and STC are assisted by staff dedicated to the Program. Congress has appropriated $20.5 million as of June 2006 to support the AYK SSI.

The purpose of the AYK SSI is: To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK Salmon. This long-range strategic science plan, central to the mission of the Initiative, identifies significant information needs, establishes research priorities, and, without duplication, complements other relevant research in the region. In doing so, the research plan provides a science-based roadmap for the Initiative and serves as a means of ensuring that the AYK SSI funds target the high-priority research questions and issues.

The Research and Restoration Plan (RRP) was prepared by the STC, with guidance from a committee of the National Research Council (NRC 2004a), for the SC. The integration of local and traditional knowledge (LTK) and capacity building activities are essential elements of the AYK SSI Research Program and contribute to the collaborative nature of the Initiative. The Plan also addresses issues and provides research recommendations regarding the design and approach to restoration projects.

Scientific Foundations

The Plan is based on a hierarchy starting with a Conceptual Foundation at the top and is followed by hypotheses, key variables, and last by example questions under each of three conceptual frameworks at the bottom as presented in Figure ES.1.

At the highest level of the hierarchy, the Plan is informed by a conceptual foundation, a model that reflects our current understanding of the suite of freshwater and marine processes which interact with each other to control the production of adult salmon which return to the AYK region each year (Figure ES.2).

From the Conceptual Foundation, a goal was developed for the AYK SSI Research and Restoration Program:

To understand the trends and causes of variation in salmon abundance and fisheries through the assembly of existing information, gaining new information, and improving management and restoration techniques through a collaborative and inclusive process.

To accomplish this goal, the AYK SSI Program will investigate, synthesize, and integrate information that already exists, as well as gather new information through the program of research outlined in this Plan. Informed by the research goal and conceptual framework, a set of overarching questions was developed (Figure ES.3). These questions provide connections among the various elements of the Plan and serve as the "glue" that joins the conceptual foundation, presented above, to the frameworks, themes, and hypotheses which follow.

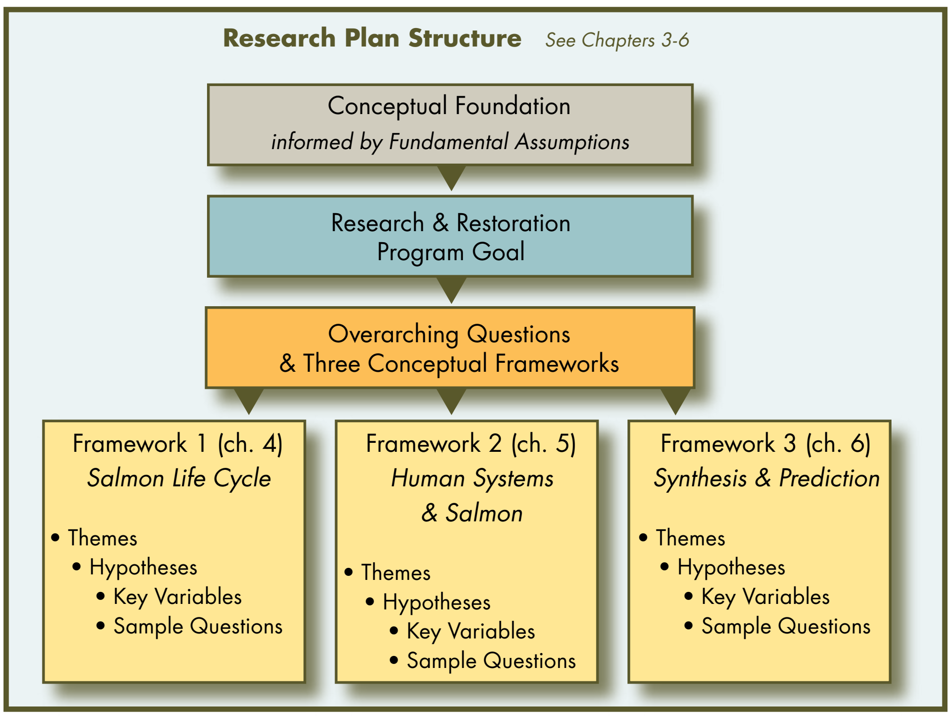


Figure ES.1 Relationship among assumptions, conceptual foundation, Program goal, and overarching questions including the formulation of frameworks and hypotheses

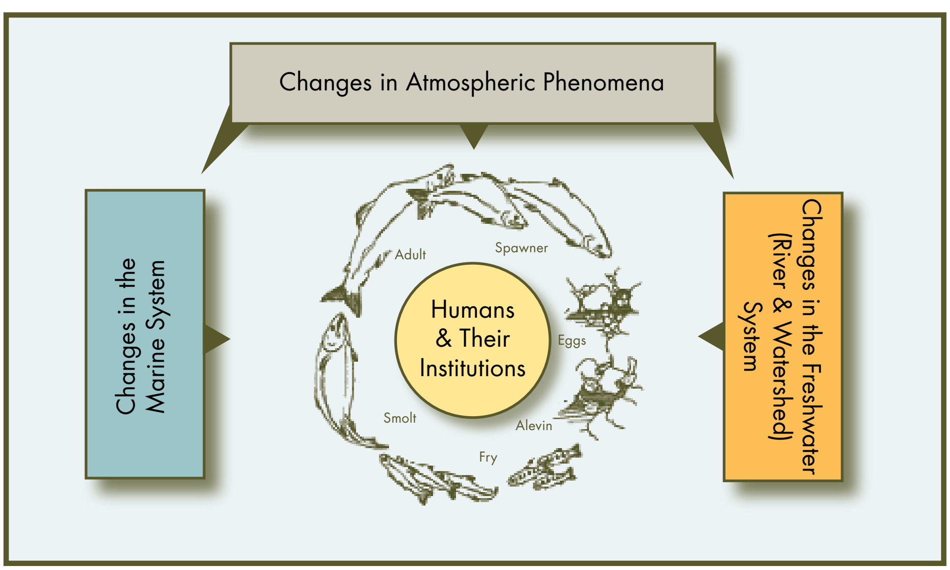


Figure ES.2 The conceptual foundation connecting the physical, biological, and human processes which affect salmon abundance and are used to organize the AYK SSI Research and Restoration Plan

Three frameworks serve as a guide to the building of knowledge in a systematic fashion and provide an umbrella under which research themes, hypotheses and questions are situated. The frameworks, which represent organizational constructs to focus inquiry into the conceptual foundation and to address the overarching questions, are as follows:

1) Salmon Life Cycle Framework organizes studies around the life stages of the salmon and the three sources of variation (marine, freshwater, and atmospheric systems) depicted in the conceptual foundation.

2) Human Systems Framework explores understanding the phenomena of humans and their institutions, as well as their interactions with the salmon life cycle. This framework encompasses the social, economic, and political linkages, including laws and international agreements which govern salmon fisheries.

3) Synthesis and Prediction Framework examines ways of synthesizing the knowledge gained from the first two frameworks to develop an integrated understanding of the AYK ecosystem. The third integrative framework links the previous two frameworks by seeking to 1) to better understand the causes of variation and resilience of the AYK salmon and (2) to refine and develop management tools, as reflected in Figure ES.4.

Each framework is described by a set of themes, hypotheses, key variables, and example questions. A total of ten research themes split among the frameworks are identified. These themes embrace a broad subject matter important for "understanding the trends and causes of variation in salmon abundance and human use of salmon." Each theme is associated with broad process-related hypotheses consistent with the conceptual foundation of the Plan. Hypotheses presented here reflect statements about how processes may cause salmon abundance to vary. Hypotheses are not current facts or beliefs but are propositions about how the salmon system may work – they may be true, or they may be false. Nested within each research theme are questions posed as examples, which are intended to assist the annual development of requests for proposals and to stimulate the thinking of prospective project leaders.

OVERARCHING QUESTIONS:

Salmon Abundance in Space and Time

- What has been the historic variability in salmon abundance in different river systems and has this variability increased, decreased, or stayed the same over the past three decades?
- What physical and biological processes cause changes in salmon abundance at annual, decadal, and century or longer time scales?
- Do all processes have important effects on salmon populations everywhere, or are some processes important only to specific rivers and their populations (e.g., influences of marine-derived nutrients from decaying adults on subsequent generations)?

Human Use Patterns and Processes

- How does human use at local, regional, and global scales affect salmon abundance over short- and long-time scales?
- What variables have caused human use to change over time and location?

Synthesis, Integration, and Application

- How do the physical, biological, and human processes interact with each other to cause salmon abundance to vary, and can these interactions be used to successfully reevaluate historic abundance and forecast future salmon abundance?
- What are the best management practices to use which incorporate a growing understanding of the processes which affect salmon abundance and ensure the sustainability of the fisheries?

Figure ES.3 The overarching questions serve as the "glue" that joins the conceptual foundation, presented above, to the frameworks, themes, and hypotheses.

Identifying High Priorities for AYK Salmon Research

In light of limited funds, time, and an evolving information base, priority setting among the numerous research themes and hypotheses is a critical task of this Research Plan. Based on a three-stage process, a set of high priority research themes and hypotheses is identified to help guide the development of annual requests for proposals. In Stage One, the research themes, hypotheses, and questions are evaluated against a set of eight criteria. In Stage Two, assessment of the current state of the information base will occur though the strategies called "Dynamic Gap Analysis." This assessment allows priorities to adapt over time by providing the means to identify (1) current gaps in knowledge, (2) research themes not being addressed by other programs, and (3) opportunities to coordinate priorities among programs. In Stage Three, the results of evaluating research hypotheses against the criteria (Stage One) are compared against the results of the dynamic gap analysis (Stage Two) regarding the relative amount of existing information. Those research hypotheses or questions, which address many or most of the criteria for which little information exists and which are not being addressed by other programs, are ranked as a high priority for the AYK SSI Program (see table below). The STC takes an adaptive approach to priority setting by anticipating these priorities will change over the coming years in response to advances in understanding the AYK salmon ecosystem.

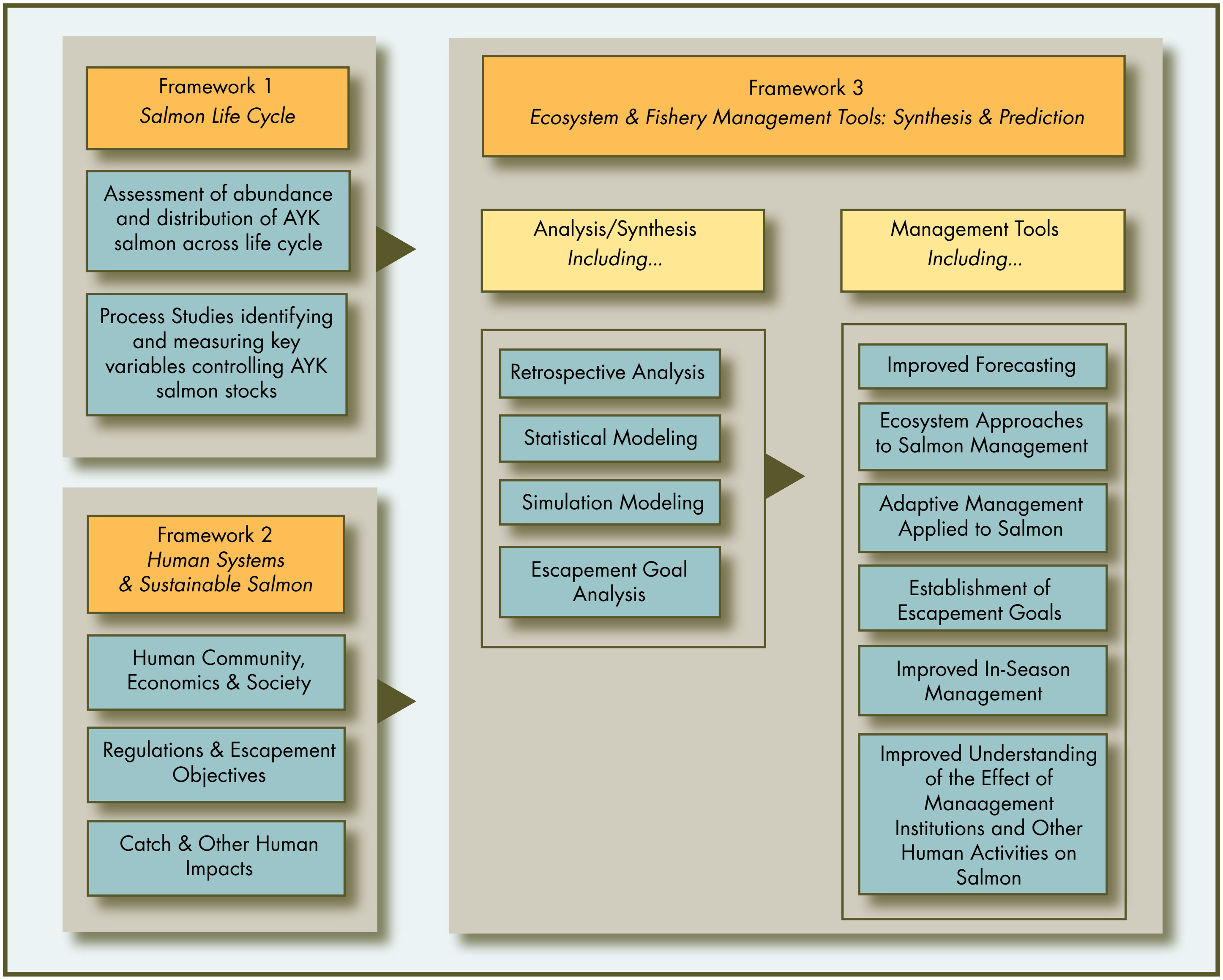


Figure ES.4. Flow chart depicting the linkages between frameworks 1, 2 and 3 and the interaction between two principle components of Framework 3: a) analysis and synthesis and b) development and evaluation of fisheries management tools

Research Framework	High Priority Hypotheses
Salmon Life- Cycle	Marine survival of salmon is more affected by variability in ocean temperature and environmental variables than by variability in marine fishing mortality.
	Spawning escapement and subsequent egg deposition are the most important determinants of the abundance of the next generation of salmon.
	Selective fishing over time has altered size, sex ratio, and life-history type composition of salmon populations.
	Adult salmon abundance in streams shows regular periodic changes and has varied widely over the past two centuries.
Human Systems	In the AYK region, human populations will increase over the next fifty years, but alternative affordable food resources will become more available causing fishing and harvest of salmon to remain the same or decline.
	The cumulative effects of habitat loss by mining activities can be severe at local levels but not at regional scales, except in the Norton Sound region.
Synthesis and Prediction	Models that predict historic variability will forecast future salmon abundance.
	Escapement goal setting to ensure sustainable fisheries can best be accomplished by using stock-recruitment models in combination with life-history and habitat-based modeling.
	Stock diversity and salmon stock abundance can be sustained by regulation of fishing gear and fishing times using an escapement goal management approach.
	A combination of demographic and ecosystem variables affects the variability of salmon returns in the AYK region.
	Future salmon abundance will support expected harvest demand and provide sufficient spawning salmon to maintain self-sustaining salmon returns in the AYK region.

The content of the annual AYK SSI "Invitation to Submit Research Proposals" will be informed by the priorities as identified above. The annual AYK SSI Request for Proposals (RFP) will solicit proposals focused on addressing a set of hypotheses and questions selected by the Steering Committee from this list of high priorities.

Consideration of restoration activities is an important part of the AYK SSI, and the National Research Council provided advice regarding this topic in its review of the first draft of this Plan. In a separate chapter, a broad array of restoration issues is discussed, including an extensive discussion of the current literature on restoration science, research approaches to restoring damaged habitat, and artificial propagation activities. Advice to leaders of restoration project proposals on issues which must be addressed is provided.

The Plan concludes with a detailed discussion of selected aspects of implementing a competitive contract process for the AYK SSI, including scheduling a review of the Plan and its Program in 2008, fostering capacity building in fishery research, managing data, and communicating research results.

Chapter 1
Introduction

Chapter 1: Introduction

Guide to Chapter 1:

Chapter 1 explains the origins of the AYK SSI process and describes its emergence as a collaborative response of public and private institutions to the disastrously-low salmon returns to western Alaska in the 1990s and early 2000s.

1.1 Introduction to the Research and Restoration Plan

The Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI) is a partnership between public and non-profit institutions which provides a forum for native regional organizations and state and federal agencies to cooperatively identify and address salmon research and restoration needs. The affected region encompasses over 40% of the State of Alaska; the AYK region includes the watersheds of the Norton Sound region up to and including the village of Shishmaref, the Yukon River Watershed within Alaska, and the Kuskokwim River Watershed (including the coastal watersheds north of Cape Newenham), plus the Bering Sea marine ecosystem wherever salmon roam (Figure 1.1). The AYK SSI is a response to disastrously low salmon returns to western Alaska in the late 1990s and early 2000s, which created numerous hardships for the people and communities that depend heavily on salmon. Understanding how these forces cause salmon populations to vary and managing around this variability is the central focus for the AYK SSI Research and Restoration Plan.

The AYK SSI is governed by an eight-member Steering Committee (SC) and advised by a six-member Scientific and Technical Committee (STC). The SC and STC members come from the partner organizations and from other government, university, and private sectors. The mission statement of the AYK SSI, as defined by its Steering Committee, is to collaboratively develop and implement a comprehensive Research Plan to understand the causes of the declines and recoveries of AYK salmon. The STC had the lead role for developing the Research and Restoration Plan. This document describes the Research and Restoration Plan which the AYK SSI will use in the implementation of its Program.

In recognition of the complex nature of the AYK salmon-human system and the diverse nature of the SC membership, the AYK SSI is committed to applying a new and novel approach to the study of salmon in western Alaska. In addition to studying the biology and physics of salmon production, the Program, as directed by the SC, is concerned with how humans impact salmon and with evaluation and development of tools to be applied to managing human impacts on the fishery and ecosystem. As understanding salmon and their movements through the AYK ecosystems has been a preoccupation of local inhabitants for millennia, the Program seeks to include local residents as much as possible to provide information and to identify avenues of inquiry to achieve the Program's purpose. To acquire the information necessary to manage salmon in a sustainable manner, the Program is also interested in building the capacity of local and regional rural/tribal organizations to meaningfully participate in salmon research and restoration activities.

In 2003, a National Research Council (NRC) Committee was organized at the request of the Steering Committee to provide guidance to the AYK SSI concerning development of a research plan. This committee was tasked with outlining essential components of a successful long-term science plan, identifying research themes on which the research plan should be based, and identifying critical research questions within the research themes.

In mid-2003, the NRC established a study committee which met three times and held public sessions in Bethel, St. Mary's, Aniak, -Nome, Unalakleet, and Fairbanks. In conjunction with the Fairbanks session, some committee members and staff attended the Tanana Chiefs Conference Natural Resources Coalition meeting. Most of the committee members attended a workshop in Anchorage organized by the AYK SSI. In August 2004, the NRC released a prepublication report titled Developing a Research and Restoration Plan for Arctic-Yukon-Kuskokwim (Western Alaska) Salmon (NRC 2004a). That report provided significant input to the development of this Plan.

The NRC Committee identified three frameworks to be used to develop this research and restoration plan (NRC 2004a):
1) Salmon life cycle,
2) Human social, economic, cultural, and political linkages, and
3) Historical perspective on the resilience of the AYK salmon-human system.

Each framework was used to provide different insights and questions focused on how to restore and manage salmon populations in a sustainable manner in the AYK region. The NRC committee further recommended the Research and Restoration Plan include the components which follow:

- A mission and/or vision statement: the mission is an intellectual statement which defines what the AYK SSI's role is, and the vision statement comes from informed imagination.

- Background information: this includes a brief regional description, the present state of knowledge, and lists other relevant Science Plans.
- An overarching theme which provides the thread which binds the individual research hypotheses and questions together.
- A set of research themes which includes such topics as processes and variability in the physical environment, species responses to perturbations, food web dynamics, essential habitat, monitoring, modeling, process-oriented studies, and retrospective studies.
- Implementation and protocol issues: this includes policies for identifying/addressing information needs, data management, outreach, and, community involvement.

Using the NRC report, a draft Plan was prepared and released for review and comment by the NRC committee, stakeholders, the general public, and other interested parties. The NRC review comments (NRC 2006), comments from agencies and non-governmental organizations, and the general public were used to develop this version of the Plan.

1.2 Recent Declines in Catches and Agency Designations of Stocks and Fisheries

Recent sharp declines of salmon abundance plus low market demand for salmon have combined to cause severe hardship and anxiety for the fishery-dependent communities in this region. Since 2002, some runs have increased, while others remain at low levels. Between 1997 and 2002, the unexpected and dramatic declines of AYK salmon runs prompted a total of 15 disaster declarations in different watersheds within the region by the Governor of Alaska and federal agencies, as indicated in Table 1.1.

Table 1.1. State and federal disaster declarations by watershed by year for the AYK Region. Sources: State Disaster Declarations (Alaska Oceans Program 2005); Federal Fisheries Disaster (Stevens 2000); Commercial Fisheries Failure (NMFS 1997).

Watershed	Years	Declaration source	Declaration type
Kuskokwim River Watershed	1997-1998-2000-2001-2002	State	Economic Fish Disaster
Norton Sound Watershed	2000-2001-2002	State	Economic Fish Disaster
Yukon River Watershed	1997-1998-2000-2001-2002	State	Economic Fish Disaster
Kuskokwim Region	1997	Federal	Commercial Fish Failure
Yukon, Kuskokwim and Norton Sound	2000	Federal	Fisheries Disaster

Limited commercial fishing has occurred in the past eight years. Earnings from commercial fishing have sharply declined throughout most of the region due to a combination of initial stock declines, followed by a drop in fishing effort due to a lack of markets for the fish (Buklis 1999, Hilsinger and Cannon 2003). Accompanying these declines have been restrictions on subsistence fishing across a region with high levels of dependence on salmon.

1.3 Role of Local Traditional Knowledge and Capacity Building

Application of LTK and capacity building are important components of the AYK SSI Research Program. Funding of projects will promote creation of management tools, application of LTK, and capacity building whenever it is possible to do so without compromising the basic purposes of the projects funded. This Plan recognizes the valuable role that LTK can play in answering AYK research questions, providing alternative interpretations of existing data, and generating hypotheses for future research.

Addressing the capacity-building needs of the AYK region remains a high priority for the AYK Steering Committee, as reflected in the committee's Vision Statement (2004). Both of these components, LTK and capacity building, are seen as constitutive elements and contribute to the collaborative nature of the AYK SSI.

1.4 Approach Used to Develop the Plan: Dynamic Gap Analysis

Assessing information – To focus the Plan, four steps were used to determine current gaps of information important for understanding salmon and their management. First, in 2003 the AYK SSI Steering Committee requested the National Research Council (NRC) provide advice in how best to develop the Plan (see Appendix 3 for a description of the NRC's contribution). The NRC appointed a committee which helped assess the current state of knowledge and then identify critical components, broad themes, and research questions which should be included in the AYK SSI Plan. The NRC's first report was delivered in August 2004 (NRC 2004a) and provided core input around which the Plan was subsequently developed.

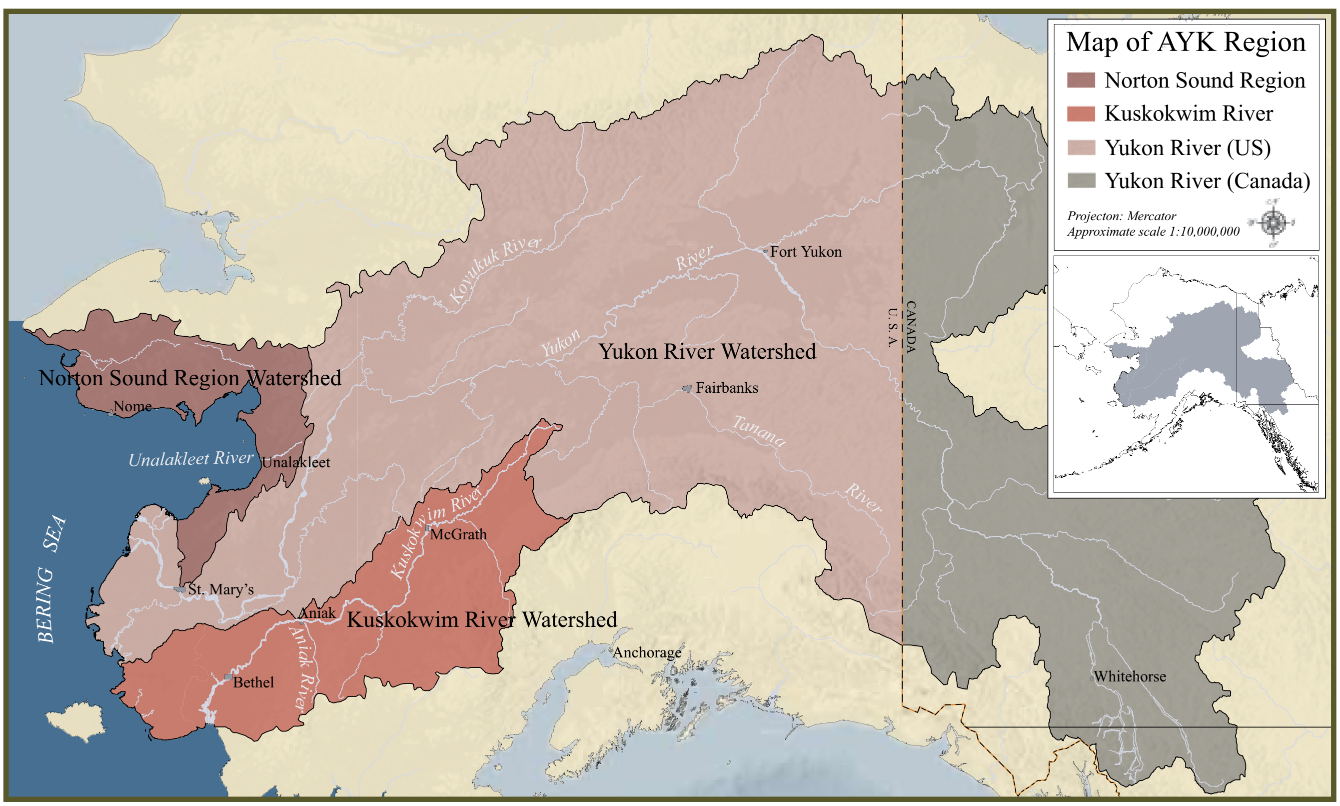


Figure 1.1. Map of the Arctic-Yukon-Kuskokwim region. The region addressed by this plan extends from the upper reaches of the Yukon River drainage in Canada, the Kuskokwim-Goodnews drainages and the drainages between Shishmaref in the north and Cape Newenham in the south to the western Bering and North Pacific Ocean. The eco-regions depicted in this map are based on watershed boundaries.
Source: State of the Salmon Consortium (www.stateofthesalmon.org)

Second, while the NRC was working on their report, the STC undertook their own assessment of the current status of information regarding Pacific salmon and their management both in the AYK region and elsewhere. To assist with this review, a workshop was held in November 2003 to assess the current state of salmon and their management (AYK SSI 2003). Participants included residents of villages from the Kuskokwim, Yukon, and Norton Sound regions, state and federal biologists and managers, and researchers from British Columbia and Washington.

Third, the STC reviewed the focus and priorities of other research plans in the region and elsewhere in Alaska, as well as reviewed current State of Alaska and federal salmon research programs (see Appendix 1). Sub-regional planning documents reviewed included the Kuskokwim Area Salmon Research Plan, the Norton Sound Sustainable Salmon Research and Restoration Plan, the Yukon River US Canada Joint Technical Committee Plan, and the North Pacific Research Board Plan. Additionally, individuals who contributed to the development of these sub-regional plans (e.g., Norton Sound Sustainable Salmon Research and Restoration Plan) directly assisted within a subcommittee of the STC with drafting this Plan. Key published references used in the research framework descriptions of the Plan are cited in chapters 3-6.

Fourth, the STC relied on the knowledge of its own members who have expertise in many aspects of salmon population dynamics, ecology, and management. Expertise on the STC included salmon management, marine ecology, community ecology, early life history ecology, population dynamics and genetics, and human dimensions.

Drawing on all these sources of information, the STC worked to identify the critical gaps in knowledge between what was known and what needs to be known in relation to the Program's goal (described in Chapter 3).

Need for on-going information assessment – Assessment of the current status of the information base was critical to the development of the Plan; however, problems occurred which caused the STC to re-think a one-time approach to assessment of information. During the two years the STC developed the Plan, the STC discovered the information base in the AYK region was constantly changing due to new research initiatives and recognized the Plan likely would be rapidly out-of-date when finished.

The problem was the information base was not static but dynamic. The STC was also convinced that not only information specific to the AYK region was important, but also information from other locations, such as British Columbia and the State of Washington, about Pacific salmon and their management was essential to consider as part of the information base. This source of information was also constantly changing and further assured the Plan would be out-of-date by the time it was completed. As a result, the STC decided this important step in the planning process, the assessment of information, needed to be performed not only during the development of the Plan, but also had to be an ongoing process woven into the implementation of the Program.

Dynamic information gap analysis – To address the problem that the information base continually changes, expands, and improves, the STC embedded into this Plan and, hence, the Program, on-going information assessment strategies. Specifically, processes were inserted into this Plan, which were developed to provide regular feedback to the AYK SSI Program to help update its priorities, inform the annual development of requests for proposals, and allow the Plan to adapt and be dynamic over the life of the Program. These processes are described below.

- Sponsor an annual meeting for AYK SSI principal investigators to present research results at least once during the duration of their project in conjunction with the NPRB and GEM symposium held each January.

- Organize an annual meeting among directors of other programs to coordinate research priorities, to ensure integration among the various projects, and to develop complementary requests for proposals.

- Seek to appoint members of other Alaska research programs (e.g., North Pacific Research Board, Alaska Sea Grant Program) to the STC of the AYK SSI Program. Cross appointments will inform AYK SSI of other programs' priorities and help inform those programs of AYK SSI's.

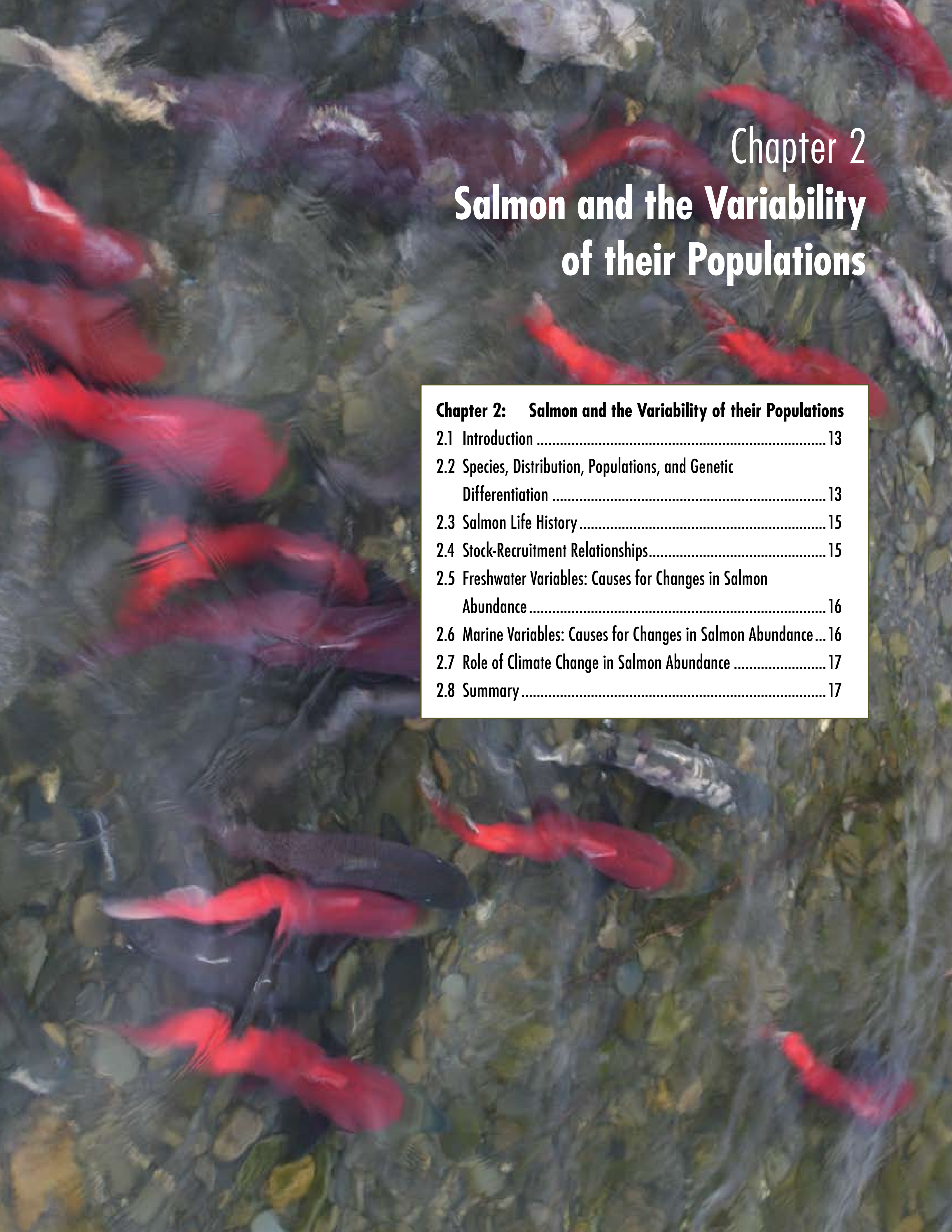
- Compare pre-proposals annually submitted to the AYK SSI Program against the latest priorities of sub-regional plans and programs (see Appendix 1).

- Sponsor and publish a symposium in 2007 entitled *Sustainability of the Arctic-Yukon-Kuskokwim Salmon Fisheries -- WHAT DO WE KNOW ABOUT SALMON ECOLOGY, MANAGEMENT, AND FISHERIES?* Completion of this symposium will immediately precede the first scheduled review in 2008 of this Plan and help update the current state of knowledge and revise information gaps.

Coordination efforts among programs will assist with assessment of changes to the information base. The National Research Council (2005) envisioned that "coordination will occur through at least three pathways: researcher interaction or bottom-up, executive director to executive director or top-down, and cross-fertilization among scientific and technical committees or panels." The approaches described above were developed consistent with this advice.

As a result, the Plan described in the chapters which follow was developed using the current assessment of the state of knowledge with the anticipation that as the information base changed, the Plan and its priorities would change. The results of the current information assessment are reflected in the content of chapters 3 through 6. Priorities for specific research hypotheses are described in Chapter 7. The role of restoration projects is described in Chapter 8. Program implementation, including processes for on-going information assessment, is described in Chapter 9.

The Plan considers topics across many disciplines including salmon life history, marine science, ecology, fishery science, and social sciences. Because of the multidisciplinary nature of the Plan, the text uses a variety of terminology which will be unfamiliar to some readers. A Glossary has been provided as Appendix 1 to assist readers with understanding specialized terms.



Chapter 2
Salmon and the Variability of their Populations

Chapter 2: Salmon and the Variability of their Populations

Chapter 2: Salmon and the Variability of their Populations

Guide to Chapter 2:

Chapter 2 provides a brief review of what is known about salmon, the differences among the species, the concepts of stocks and stock-recruitment relationships, and suspected causes for variation in salmon abundance. This chapter provides some of the background material which was used when developing this Plan.

2.1 Introduction

The AYK salmon ecosystem, including oceans and rivers, is a complex set of physical and biological environments which support the production of salmon (e.g., Stanford et al. 2005). The physical region extends from the upper reaches of the Yukon River drainage in Canada, the Kuskokwim-Goodnews drainages, and the drainages between Shishmaref in the north and Cape Newenham in the south to the western Bering and North Pacific Ocean (Figure 1.1). One portion of the marine environment alone, the eastern Bering Sea, is home to a rich variety of biota, including the world's most extensive eelgrass beds; at least 450 species of fish, crustaceans, and mollusks; 50 species of seabirds; and 25 species of marine mammals (PICES 2004). This ecosystem with its myriad of species contains complex sets of biological relationships (e.g., competition, predation) and physical processes (e.g., wind, temperature, ocean currents) which together cause salmon populations to vary.

Understanding how these forces cause salmon populations to vary and managing around this variability is the central focus for the AYK SSI Research and Restoration Plan. This chapter provides a brief review of what is known about why salmon populations vary. This review is not intended to be comprehensive but provides only a brief introduction to a topic that has served as the subject of several books (e.g., Williams 2006) and hundreds of scientific papers. The references cited in the text below provide the reader entry to this extensive knowledge base. This chapter contains a brief description of salmon biology, life history, stock-recruitment relationships, and the various processes which cause salmon populations to vary in their abundance (freshwater, marine, and climate change).

2.2 Species, Distribution, Populations, and Genetic Differentiation

Five species of the genus Oncorhynchus, commonly known as salmon, use the river drainages of the AYK region for juvenile rearing and adult spawning and the Bering Sea and North Pacific for growth until maturity. The common names of the salmon species are pink (O. gorbuscha), chum (O. keta), coho or silver (O. kisutch), sockeye (O. nerka), and Chinook (O. tshawytscha). A sixth species of Oncorhynchus, the rainbow trout (O. mykiss), also occurs in the Kuskokwim drainage but does not use ocean habitats for growth as part of its life cycle and is not to be considered in this Plan. Hart (1973) and Mecklenburg et al. (2002) describe the taxonomic differences among species.

All five species occur throughout the AYK region. Chum and pink salmon provide important contributions to the region's fisheries. Coho (or silver) salmon are distributed throughout the region to Point Hope, north of Kotzebue Sound, but tend to be more abundant farther south in the region. Similarly, northern Kotzebue Sound marks the northern edge of the region for Chinook (or king) salmon and sockeye (or red) salmon. Chinook salmon reside primarily in the Kuskokwim and Yukon River drainages and are somewhat less abundant in the Norton Sound drainages. Chinook salmon support important fisheries throughout the region. Sockeye salmon in the AYK region are not as abundant in comparison to drainages farther south, such as in Bristol Bay. Mecklenburg et al. (2002) provides more detail about these species' various ranges in Alaska.

Each species is uniquely organized across space and time into populations which are separate during spawning but may co-mingle while in the ocean. A population is a group of fish of the same species which aggregates during the spawning season and interbreeds. Because of the genetic relationship among members within a population, genetically-based traits can accumulate within the population over time. Thus, populations can show specialized traits for behavior, physiology, and life history which are adaptive for survival and reproduction in their habitats. For example, rates of embryo development and juvenile behavior in response to current (rheotactic behavior) are known to differ among populations of Pacific salmon (see Murray et al. 1990; Brannon 1967; Raleigh 1967). The degree of isolation among populations is dependent on population-isolating mechanisms, such as natal homing and geographic distance among populations.

The levels of differences among populations, as detected by genetic methods, differ among the species. Pink and chum salmon tend to show less genetic differentiation among their populations than Chinook, coho, and sockeye salmon. For example, genetic differences among chum salmon populations within specific tributaries of the Yukon River are often not detectable, although differentiation clearly exists at broader geographic scales, such as between the lower and upper river sources (e.g., the Koyukuk vs. Teslin River; Wilmot et al. 1994; Seeb and Crane 1999; Flannery 2004; Beacham 2003; Candy et al. 2005). In contrast, Chinook salmon show higher levels of differentiation from chum salmon within the Yukon River drainage. Genetically different populations of Chinook are detectable among tributaries (e.g., Wilmot et al. 1992; Beacham et al. in prep.).

Populations of salmon are often organized hierarchically into metapopulations (Mundy et al. 1995; Policansky and Magnuson 1998). A metapopulation is a geographically-distributed network of strongly and weakly productive salmon populations which are connected through straying of spawners. Source populations have relatively high productivity (next generation adult return per spawner), and they contribute straying spawners to make the low productivity sink populations less vulnerable to extirpation.

In salmon management, a grouping of one or more metapopulations is usually termed a stock. Stocks, in this case, are multiple spawning populations which are managed as a unit to sustain fishery harvests. Sometimes a single large salmon population may be designated as a stock. See Appendix 1 for a detailed definition of the concept of stock.

2.3 Salmon Life History

Pacific salmon, like other anadromous fishes, tend to occur at higher latitudes (McDowall 1988), where biological productivity is generally greater in the ocean than in fresh water (Northcote 1978; Wootton 1984; Gross et al. 1988). While juvenile and adult migration between fresh water and the sea is energetically costly, the benefits of feeding in the ocean, minus the cost of migration, outweigh the benefits of staying and feeding solely in fresh water. Better growth enhances survival and reproductive potential.

The period of residency in the freshwater and marine environments varies with species, latitude, and other variables. Chinook, coho and sockeye salmon spend from zero to three or more years in freshwater and from one to four years in the sea. In contrast, pink and chum salmon typically go to sea as fry, with pink salmon spending slightly less than two years in the sea, and chum salmon up to four or more years. Variability in salmon abundance is likely to be less for species with spawning runs comprised of multiple-year classes, such as for Chinook and sockeye. Spawning runs with multiple-year classes buffer the effects when survival of one year class has been poor. For some stocks, the time spent rearing in fresh water can vary from zero to three years, and the time spent at sea from one to four years (e.g., Hilborn et al. 2003).

Salmonid fishes are generalists (Larkin 1956), with juvenile salmon occupying a wide range of habitats (streams, rivers, lakes, estuaries) and eating a variety of foods in fresh water. At sea, salmon use coastal and offshore areas and feed on zooplankton, macroinvertebrates, and fishes. In the immature stages, small salmon are prey for various marine fishes, and as adults they are eaten by marine mammals and sharks (Quinn 2005).

2.4 Stock-Recruitment Relationships

Salmon have a resilient reproductive potential; thus, when a population is below carrying capacity within a spawning stream, the number of surviving offspring tends to increase. As salmon abundance approaches the carrying capacity of its spawning habitat, the population increasingly produces fewer surplus fish per spawner (Mobrand et al. 1977; Lestelle et al. 1993; Seiler et al. 2002). This relationship between the abundance of the spawning stock and the production of the next generation is termed the stock-recruitment relationship. As the density of spawning salmon increases, several biotic factors can begin to limit production of smolt for the next generation, such as: competition for favorable redd sites among females, redd superimposition, and competition for food and space among juvenile fish. These factors are termed density dependent processes.

Differences in the stock-recruitment relationships exist between salmon populations; and, therefore, management consideration must be given to these differences, or some stocks will be overfished and driven to extinction (Larkin 1977). The models of Ricker (1954) and Beverton and Holt (1957) predict that at low spawner density, the number of adults of the next generation produced is considerably greater than the number of parent spawners; whereas at high spawner density, the number of adults produced drops off appreciably. In theory, the surplus of adults produced can be harvested, because catching them does not diminish a population's ability to sustain its numbers at carrying capacity. The goal of management is usually to allow spawner escapement into each river which will produce the maximum number of surplus adults in the next generation for harvest fish in excess of the escapement number can be harvested. This approach requires a number of assumptions, such as a stable environment and the stock-recruitment relationships are not changing over time.

Salmon stock-recruitment relationships are used for identifying environmental variables associated with changes in mortality and other dynamic rates. For example, variation in coho smolt production within a stream has been shown to be related to density of pool habitats per given length of stream (Sharma and Hilborn 2001) and to summer low flow (Seiler et al. 2002). At low densities, the relationship between spawner density and smolts is often linear; whereas when carrying capacity is reached, no more smolts are produced from additional adults (Mobrand et al. 1977). However, even when at carrying capacity, the number of smolts produced still varies, because juvenile rearing space changes due to variability in summer low flows (Smoker 1955; Chapman 1966) and due to the frequency and severity of winter floods (Mason 1973; Cedarholm 1997).

2.5 Freshwater Variables: Causes for Changes in Salmon Abundance

Salmon mortality in fresh water can occur during upriver migration, spawning, incubation, rearing, smoltification, and out-migration to the ocean. Both density-dependent and density-independent mortality processes generate variability in salmon population abundance. Density-dependent mortality is attributable to biotic influences such as fecundity and egg size (larger eggs produce larger fry, which have better survival), competition for food and space, predation, and pathogens. Density-independent mortality is associated with abiotic factors, such as changes in flow and water quality. Species that spawn at high densities (sockeye, chum, pink) tend to have lower survival during incubation than those which spawn at low densities (coho, Chinook; Quinn 2005). In the absence of fishing, competition on the spawning and feeding grounds and for juvenile over-wintering sites exerts control over salmon abundance (Quinn 2005). Human induced mortality, such as from fisheries, adds another level of complexity on top of the biotic and abiotic factors causing salmon populations to vary.

Human-induced factors that affect the abundance of salmon in fresh water are many, but those of major importance are relatively few. From the mid 1980s to the late 1990s, Pacific Northwest salmon biologists identified the major culprits as being hatcheries, habitat degradation, hydro operations, and harvest (commercial and sport). From 2000 onward, these problems remained, but added to the list were the effects of climate change (discussed below).

2.6 Marine Variables: Causes for Changes in Salmon Abundance

Various estimates of salmon survival from the smolt to adult stage suggest the bulk of marine natural mortality occurs during the first year at sea (e.g., for coho - Shapovalov and Taft 1954; Forester 1955), with most of it occurring in the early stages of entry to saltwater (Parker 1968; Ricker 1976; Bax 1983). Smolt size is a crucial variable affecting mortality. To reduce the risk of mortality at sea requires salmon enter the ocean at as large a size as possible and grow rapidly upon saltwater entry, if they are to survive and not be eaten. Time of entry to the marine environment is also an important variable. The effects caused by entry timing are probably related in synchrony with food availability and predator distribution. However, optimal time of entry may vary from year to year, because ocean conditions (e.g., temperature, currents, El Nino effects) and other processes affecting salmon food supplies vary from year to year.

On a broad spatial scale, a marked shift in salmon abundance has occurred during the last century. From the 1940s to the 1970s, salmon were more abundant in the south than in the north; whereas from the 1970s onward, the reverse has occurred, probably in relation to extensive changes in climate affecting ocean conditions. But as noted by Quinn (2005), the connection of these variables to salmon survival remains unclear.

2.7 Role of Climate Change in Salmon Abundance

Increasing evidence exists to support that global warming is occurring. Such warming will undoubtedly affect the temperature and flow regimes of streams, and thermal, current, and food regimes in the ocean. In fresh water, warmer temperatures will reduce incubation and cause earlier hatching times. Hatching earlier could lead to the arrival of juvenile salmon being out of phase with that of their food supply in the ocean, possibly resulting in starvation. On the other hand, ocean current patterns and upwellings and, hence, the timing of food availability, are also changing in the ocean. The synchrony of these changes between the freshwater and marine environments is unknown. Also unknown is how salmon may adapt or compensate for these changes.

With climate change, conditions in the ocean will change and affect the distribution, feeding, and survival of salmon at sea. Past correlations, such as those reported by Smoker (1955), as well as those by Vernon (1958) and Parker (1968) on coho and pink salmon survival, are no longer applicable. For example, the adult run of Fraser River pink salmon between 1937-1953 was strongly correlated with temperature in the Strait of Georgia during spring through summer, when the fry were in the Strait (Vernon 1958); but thereafter, the correlation weakened and by 1961 accounted for only 16% of the variation in returns. Correlations, while at times useful for management purposes, must be viewed with caution, as they are often influenced by other variables.

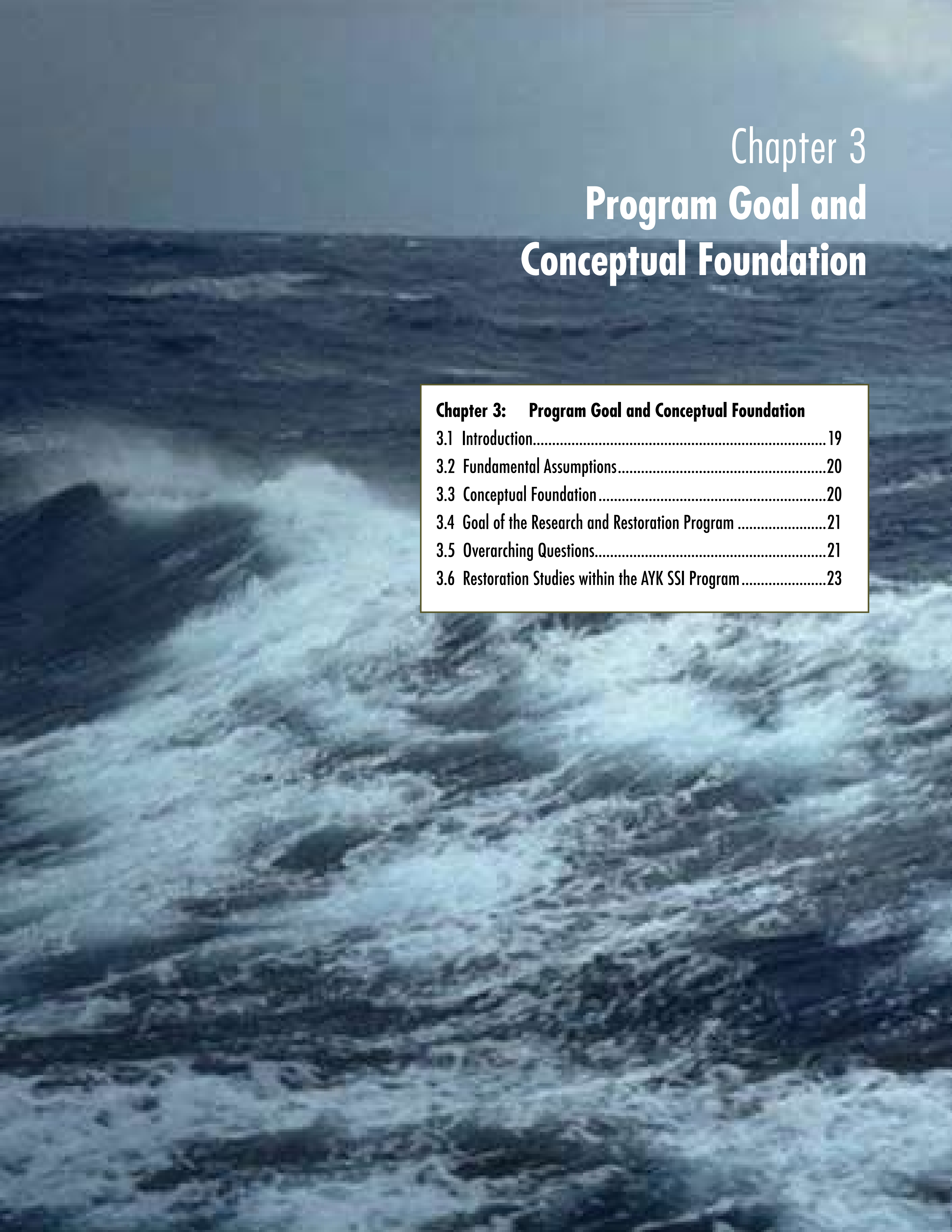
Ocean conditions can exert considerable effects on salmon abundance. For example, the El Nino conditions along the coast in the Pacific northeast in 1983 coincided with a record run of sockeye to the Fraser River; whereas, the returns of Oregon coho salmon and Columbia River Chinook salmon fell well below predicted returns (Quinn 2005). In contrast, higher survival of coho salmon occurred off the Oregon coast than predicted in years with greater upwelling (Nickelson 1986), probably in relation to increased nutrient inputs to surface waters with upwelling.

Some correlations between long-term climate trends during the last century and salmon abundance have been reported. Francis and Sibley (1991) found that the catches of pink and coho salmon in central and southeast Alaska were correlated with air temperature in the region (1920s to late 1990s). On a broad spatial scale level, others (Beamish and Bouillon 1993; Francis and Hare 1994; Hare et al. 1999) reported the salmon abundance in the northern end of their range during the last century varied in synchrony with climate and ocean conditions. Although individual populations were no doubt affected by local conditions, coherence in abundance patterns at broad spatial scales strongly suggests some common influence. It appears the interaction of high and low pressure systems had a major influence on wind patterns and circulation and temperature in the northeast Pacific, which affected growth and survival of salmon (Quinn 2005). The findings reported by the above researchers suggest that certain climatic and ocean conditions affect broad geographic areas and can have important influences on salmon stocks in the region. Such longer term (inter-decadal) conditions have been quantified by the use of composite indices (e.g., Pacific Decadal Oscillation) (Mantua et al. 1997).

2.8 Summary

Variation from year-to-year in the abundance of salmon to spawning streams is caused by a number of factors in both the freshwater and marine environments. Biotic variables, such as spawner abundance, competition, and predation, and abiotic factors, such as ocean currents and stream floods, can cause salmon populations to vary. In addition, salmon populations have internally embedded genetic adaptations that allow them to adjust to changing environmental conditions. Interactions between life history and environmental variation need to be better understood. Moreover, in light of climate-related changing environmental conditions, the importance of biodiversity in maintaining salmon populations and sustainability of fisheries cannot be understated. The concept is illustrated by the biodiversity of the Bristol Bay sockeye complex (Hilborn et al. 2003). This particular sockeye stock complex has sustained record catches during the past two decades in spite of major changes in climatic conditions affecting the freshwater and marine environments of the region (Hilborn et al. 2003). Although the biocomplexity of Bristol Bay sockeye is exceptional, in that it consists of hundreds of discrete stocks structured within productive lake systems, it nonetheless underlines the importance of conserving diversity in salmon stocks in the AYK region and thus maintaining their ability to adapt to changing environmental conditions.

Using the understanding of salmon ecology as described in this chapter, a conceptual understanding of the salmonid ecosystem (called a "conceptual foundation") was formulated to develop a program goal for the AYK SSI Program. These parts of the Plan are described next in the chapter.



Chapter 3
Program Goal and Conceptual Foundation

Chapter 3: Program Goal and Conceptual Foundation

Chapter 3: Program Goal and Conceptual Foundation

Guide to Chapter 3:

Chapter 3 describes the assumptions and conceptual foundation used to develop the overall goal of the AYK SSI Program and overarching questions subsequently used to organize the Plan. The conceptual foundation is a model of the salmon-human ecosystem (Section 3.5). This conceptual foundation is a summary of available scientific knowledge and the options available for restoration actions.

3.1 Introduction

This chapter describes the organizing concepts used to develop the specific elements of this Plan (chapters 4 through 6). By recognizing and explicitly defining assumptions, a conceptual model of the ecosystem that produces AYK salmon was developed, and a goal for the Program was formulated. This chapter describes the overall context, purpose, and focus of the AYK SSI Research and Restoration Program. Some definitions of the terms used in this chapter are provided below.

The conceptual foundation is the model of the AYK ecosystem processes which produce salmon and affect fisheries which was used by the STC to develop this Plan. The model systematically connects the physical, biological, and human processes that are reflected in overarching questions. Within this model are fundamental assumptions based on current knowledge of salmon production in the AYK region (see Chapter 2). Built from this model are overarching questions that illustrate broad information needs associated with the conceptual foundation.

The Program goal provides a broad statement of the intent or purpose which the Program is to accomplish. The goal relates to the fundamental problem that salmon abundance has varied unpredictably over the past decade, and this variation has had large impacts on fisheries. The goal was developed to be consistent with the AYK SSI mission statement (described in Chapter 1). The Program goal provides direction to help define which types of projects are most important to support and, hence, assists in the establishment of research priorities. The goal leads directly to broad overarching questions about physical, biological, and human processes that need answers if we are to understand why salmon populations and their fisheries vary over time.

Restoration is an action which returns a population, habitat, or process to its original, pre-disturbance state. As such, it is markedly different from conservation, rehabilitation, reintroduction, or enhancement; these latter actions can be tools used to achieve restoration but usually have a different end goal.

The organization used in this chapter and the next three chapters uses a nested hierarchical approach that leads from one topic to the next (Figure 3.1). This hierarchy reflects the process used to develop the Plan. Frameworks represent the topics discussed in the chapters which follow this one.

3.2 Fundamental Assumptions

The conceptual foundation, Program goal, and overarching questions are built upon seven assumptions about AYK salmon and the processes which affect them. These assumptions were developed based on input received from rural residents, scientists, and managers who attended the AYK SSI workshop (AYK SSI 2003), knowledge of scientific literature, and the experience of the members of the Scientific and Technical Committee.

- The global ecosystem provides ever-changing habitats for salmon throughout their life cycle.

- Salmon are an integral part of the freshwater and marine ecosystems they use.

- Salmon production is variable and connected with the condition and dynamics of their aquatic communities and habitats.

- Salmon serve different roles in the ecosystem, including prey, predator, fertilizer, and detritus.

- The abundance of salmon is controlled by a combination of forcing by human and natural variables throughout its life cycle.

- Adaptive management strategies that take into account ecological, economic, and sociological factors and incorporate learning over time should be employed, because current knowledge alone is insufficient to manage sustainable salmon fisheries.

- Engagement and support from local communities and fishery managers through the incorporation of LTK, building capacity of local and regional organizations to effectively participate in management, and providing tools to improve decision making are requirements for management strategies to be successful.

3.3 Conceptual Foundation

A conceptual model was developed to describe how processes within freshwater and marine systems interact with each other and human uses to cause variation in salmon abundance. This model helps to connect the fundamental assumptions together in terms of ecosystem structure and function (Lichatowich et. al. 2006). In this Plan, we have called this the "conceptual foundation" for the Research and Restoration Program.

The conceptual foundation is a model which reflects current understandings of the suite of processes in the freshwater and marine systems which interact with each other to control the production of adult salmon that return to the AYK region each year (Figure 3.2). Accordingly this foundation includes: management variables, such as fishing and management strategies; salmon-centric variables, such as the abundance of spawning salmon; the quantity and quality of areas suitable to support spawning and juvenile rearing; and physical variables, such as strength and location of oceanic currents which prescribe food and predator distributions and interact with atmospheric dynamics to affect the quantity and qualities of freshwater habitats.

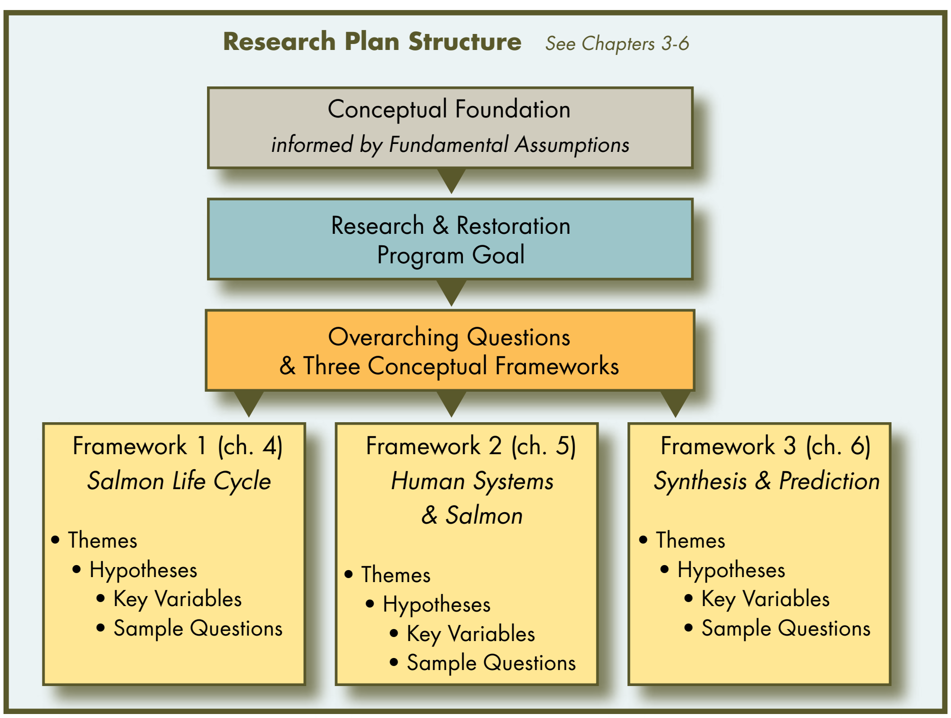


Figure 3.1 Relationship assumptions, conceptual foundation, Program goal, and overarching questions as described in this chapter and the formulation of frameworks, themes, and hypotheses as discussed in chapters 4-6.

At the center of the conceptual foundation diagram are humans and their institutions. This core represents how humans affect salmon. This part of the foundation includes levels of human organization from families in villages to international commissions affecting salmon management. This core interacts with the seven life stages of the salmon which encircle the human element. The salmon life cycle spans from egg to smolt to ocean fish to returning spawner. The cycle is completed when the salmon spawn and die, and their bodies provide detritus and fertilizer to enrich the home of future generations of salmon. Each of these life stages interacts with the biotic and abiotic processes that occur within the atmospheric, freshwater, and marine systems and which vary over the region and over time (seasonally, annually, and over longer time scales, such as decades). The arrows represent interactions among the components of the ecosystem and salmon life cycle. After consideration of the assumptions described above and the conceptual model depicted in Figure 3.2, the goal of the Research and Restoration Program was formulated.

3.4 Goal of the Research and Restoration Program

To understand the trends and causes of variation in salmon abundance and fisheries through the assembly of existing information, gaining new information, and improving management and restoration techniques through a collaborative and inclusive process.

Fundamentally, we want to know: Why has the abundance of salmon varied so widely and unpredictably over the past decade? As this Plan was developed, this question was the underlying motivation which drove the development of the goal, overarching questions, and other elements of this Plan. As a result, the focus of the Program is on understanding the processes that cause salmon populations and their fisheries to vary over time. To accomplish this goal, the AYK SSI Program will investigate, synthesize, and integrate information which already exists within local communities with information gathered in past research projects. The Program will also gather new information by supporting projects which investigate processes important to salmon, fisheries, and management. With a better understanding of what causes salmon populations to vary in abundance, management techniques will be developed and refined to ensure that salmon resources are restored and sustained for use by future human generations. Achievement of this goal will require engaging people with a wide variety of talents, skills, and backgrounds. To address this goal, overarching questions were formulated to guide the development of the balance of the Plan.

3.5 Overarching Questions

Several broad, overarching questions exist about the salmon ecosystem, which if answered, will help achieve the goal. The development of these questions was encouraged by the National Research Council in their review of an earlier draft of this Plan (NRC 2006). To address the overarching questions, three different approaches, termed "frameworks," were used to organize the balance of the Plan (chapters 4-6). Within frameworks, the overarching questions were used to stimulate the formulation of specific hypotheses to help focus the Program. Thus, these overarching questions are the key ideas around which this Plan was organized and which

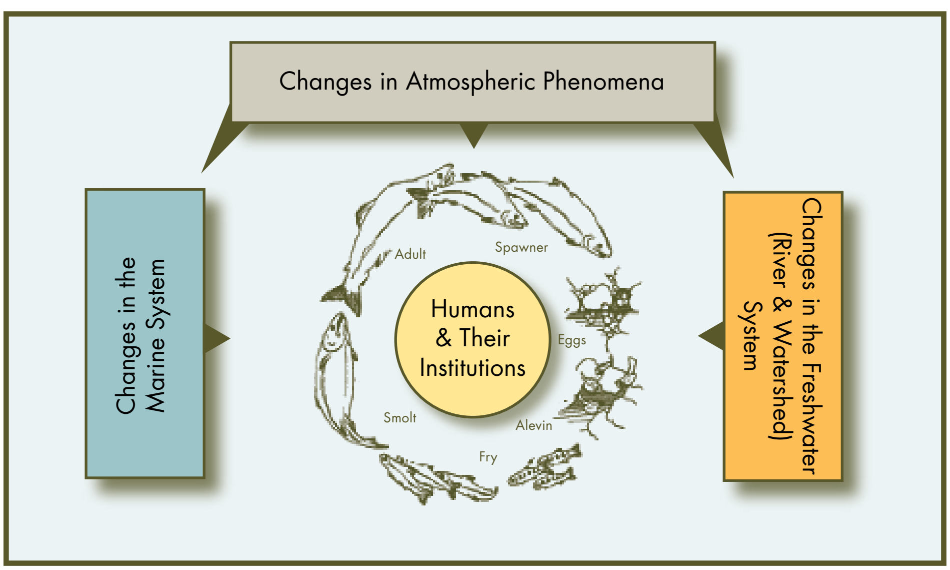


Figure 3.2. The conceptual foundation connecting the physical, biological, and human processes which affect salmon abundance and are used to organize the AYK SSI Research and Restoration Plan

provide connections among the various elements of the Plan-they're the glue that joins the conceptual foundation to frameworks to themes to hypotheses. These questions will hopefully stimulate the reader toward creative thinking about the driving variables, factors, or stressors which cause salmon populations to increase and decrease in abundance over time. These overarching questions are as follows.

Salmon Abundance in Space and Time

- What has been the historic variability in salmon abundance in different river systems, and has this variability increased, decreased, or stayed the same over the past three decades?

- What physical and biological processes cause changes in salmon abundance at annual, decadal, and century or longer time scales?

- Do all processes have important effects on salmon populations everywhere, or are some processes important only to specific rivers and their populations (e.g., influences of marine-derived nutrients from decaying adults on subsequent generations)?

Human Use Patterns and Processes

- How does human use at local, regional, and global scales affect salmon abundance over short- and long-time scales?

- What variables have caused human use to change over time and location?

Synthesis, Integration, and Application

- How do the physical, biological and human processes interact with each other to cause salmon abundance to vary, and can these interactions be used to successfully reevaluate historic abundance and forecast future salmon abundance?

- What are the best management practices to use which incorporate a growing understanding of the processes that affect salmon abundance and ensure the sustainability of the fisheries?

These questions were developed to promote improving our understanding of how biotic and abiotic processes, together with human uses, affect salmon abundance over different temporal and spatial scales. "Human use" implies the direct effects which come from the catch of salmon in different fisheries. Human use also refers to the indirect uses which change habitat at local scales, such as by mining activities, and at global scales potentially though climate warming.

As information increases to provide answers to these questions, we should be better able to understand why salmon have varied in their abundance over the past decade. With improved understanding will come prediction of future salmon abundances and potentially new proactive management actions to sustain salmon fisheries.

3.6 Restoration Studies within the AYK SSI Program

Restoration is an action which returns a population, habitat, or process to its original, pre-disturbance state. Restoration is usually more expensive and less successful than conservation of the original state of the population, habitat, or process (Reeves et al. 1991). Efforts to restore may also do more harm than good when they unintentionally disrupt the system even further. Examples of such disruption include stream bank restoration projects which increase erosion in other places, efforts to restore nutrients which disrupt the food chain to the detriment of target populations (Spencer et al. 1991), enhancement stocking projects which genetically alter wild populations, and fish restoration projects which exacerbate, instead of alleviate, threats to the target population (NRC 1996). For these reasons, restoration should be undertaken only when conservation options have been evaluated and found inadequate. In cases where restoration is warranted, it should be conducted only after assessing the causes of the disturbance, the possible corrections, the potential for incurring further damage, and which tools or methods are suitable for repair of damages (for a case study with salmon, see Reiser et al. 2000).

As part of its task to develop a Research and Restoration Plan, the STC was asked to "develop recommendations for restoration projects which will increase salmon returns to the A-Y-K area" (AYK SSI Memorandum of Understanding). Consistent with this charge, a separate chapter which discusses restoration is included in this Plan (Chapter 8). To be consistent with the AYK SSI's conceptual foundation, goal, and overarching questions, such restoration must emphasize the restoration of ecosystem services needed to produce self-sustaining runs of salmon within the ever-changing physical and biological systems.

As such, salmon restoration projects undertaken should: Restore salmon populations to a level which will allow them to persist over the long term with no further human intervention within a dynamic ecosystem, while retaining the ability to undergo adaptive evolutionary change (Montalvo et al. 1997).

Successful projects will require that the ecosystem is capable of providing the resources needed to carry out their life cycle and that AYK salmon have the requisite abundance and diversity needed to cope with environmental change.

At least three main areas of restoration ecology are pertinent to the potential restoration of the AYK SSI salmon. These areas include the restoration of 1) individual species, such as salmon; 2) landscapes (e.g., watersheds) or specific habitats (e.g., spawning beds); and 3) ecosystem services, such as nutrient cycling (Ehrenfeld 2000) in a naturally dynamic context (Stanford et al. 2005). Successfully addressing the first item, a species, may require addressing the latter two areas. In particular, defining the salmon's habitat and access should be considered an essential first step for attempting to restore a salmon population. The inability to do so has led to salmon restoration efforts that have wasted valuable, limited resources, or jeopardized existing wild populations (Walters and Martell 2004). Thus, under the AYK SSI Plan, proposed restoration work must articulate how its efforts will contribute to the sustainability of the target species, while minimizing the potential for further damage.

In the next three chapters, the Plan uses three research frameworks to address the three categories of overarching questions. The frameworks represent different approaches to learn about salmon (Chapter 4), people (Chapter 5), and to integrate this understanding within fishery management (Chapter 6).

Chapter 4
Research Framework 1 Salmon Life Cycle

Chapter 4: Research Framework 1 — Salmon Life Cycle

Chapter 4:
Research Framework 1
Salmon Life Cycle

Guide to Chapter 4:

Based on the viewpoint of the AYK salmon system as described in the conceptual foundation and the advice of the National Research Council, three specific approaches to research called frameworks were formulated and are described in chapters 4-6. Frameworks represent organizational constructs of the model system described in the conceptual foundation in Chapter 3. The conceptual foundation helps to make the connections among the frameworks. No single approach or framework will embrace all of the information gaps; hence, more than one framework is necessary. The AYK SSI Plan uses three frameworks to organize its Research Program. The three frameworks are 1) basic biology of the salmon life cycle, 2) people's social and economic interactions with salmon, and 3) ways in which information about salmon biology and socioeconomics can be synthesized, integrated, and developed into management tools. This chapter describes the first research framework – Salmon Life Cycle. This research framework is organized into three themes and includes eight hypotheses.

4.1 Introduction

Frameworks represent organizational constructs to focus inquiry into the conceptual foundation (Figure 3.2) and to address the overarching questions (Section 3.5). This Plan uses three frameworks to organize this Plan. The three frameworks are 1) salmon life cycle, 2) people's social and economic interactions with salmon, and 3) ways in which information about how salmon biology and socioeconomics can be synthesized, integrated, and developed into management tools. Three frameworks were developed to guide the building of knowledge in a systematic fashion and to encourage the integration of research into a larger picture than would be available from the results of individual projects (NRC 2004a).

Framework 1 (salmon life cycle) organizes studies around the life stages of the salmon and the three sources of variation illustrated by the boxes for marine, freshwater, and atmospheric systems in Figure 3.2 of the conceptual foundation. This framework is the focus of this chapter. Addressing Framework 1 will enhance our knowledge of the causes for variation in salmon populations by making clear the processes which affect reproductive ecology, growth, and mortality at each life stage.

Framework 2 (human systems) explores understanding the phenomena of humans and their institutions, as well as their interactions with the salmon life cycle, represented by the core of Figure 3.2 of the conceptual foundation, and is described in Chapter 5. The human-centric Framework 2 emphasizes the human systems in which salmon fisheries occur. This framework encompasses the social, economic, and political linkages, including laws and international agreements, which govern salmon fisheries.

Framework 3 (synthesis and prediction) seeks to integrate understanding across frameworks 1 and 2 and is represented by the entire illustration of the conceptual foundation shown in Figure 3.2. This framework is described in Chapter 6.

Each framework is first described by identifying its relationship to the conceptual foundation and overarching questions. Specific themes, hypotheses, key variables, and example questions are then provided to describe the framework. Hypotheses reflect statements about how processes may cause salmon abundance to vary. Hypotheses are not current facts or beliefs but are propositions about how the salmon system may work–they may be true or they may be false! Research projects are sought to determine their validity.

The example questions are provided to assist the annual development of requests for proposals for the Program but are not intended to be the only questions of importance. The questions also may serve to stimulate researchers to craft their own hypotheses and questions as they develop project proposals for the Research and Restoration Program.

4.2 Description of Research Framework Salmon Life-Cycle

The life-cycle based framework uses the natural sequence of events in a salmon's life, from egg to spawner, to systematically organize and identify research topics concerning salmon ecology. Within this framework, research themes were organized into three life stages: early life history, marine life history, and freshwater migration and spawning (Figure 4.1).

The advantage of this framework is it facilitates systematic thinking about the connections between the freshwater and marine-life phases of salmon. This framework requires consideration of the full range of habitats used by salmon and the full range of processes which operate in these habitats. The framework is easily understood because most people know the salmon life cycle and can immediately conceptualize the organization. Also, the framework is familiar to many investigators, because it has been used in other research plans, such as the Norton Sound Research and Restoration Plan (NSSTC 2002) and the Kuskokwim Area Salmon Research Plan (KFRC 2006).

This framework focuses the Research Program on three of the overarching questions described in Section 3.5.

Variation of Salmon Abundance in Space and Time

- What has been the historic variability in salmon abundance in different rivers systems, and has this variability increased, decreased, or stayed the same over the past three decades?

- What physical and biological processes cause changes in salmon abundance at annual, decadal, and century or longer time scales?

- Do all processes have important effects on salmon populations everywhere, or are some processes important only to specific rivers and their populations (e.g., influences of marine-derived nutrients from decaying adults on subsequent generations)?

Studies supported by this Program under this framework should in some way contribute to answering these questions. Use of this framework is intended to encourage the investigation of processes functioning at all levels of ecology-population, community, and ecosystem. The life-cycle based approach embeds what is known about the parts of the life cycle into the matrix of what is known about the biological and geophysical processes which govern the life cycle. Linking life-cycle stages to broad-scale environmental variables which bring about variation in salmon abundance will likely be an especially valuable approach (e.g., Hare et al. 1999; Logerwell et al. 2003; Lawson et al. 2004).

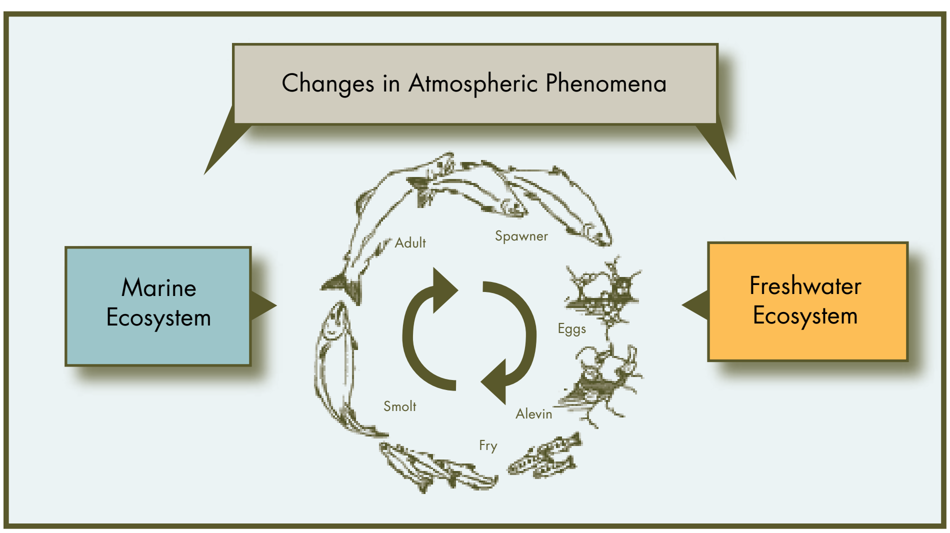


Figure 4.1. Relationship between the salmon life cycle and freshwater and marine ecosystem drivers

4.3 Theme 1 –Early Life Stage (Egg to Smolt)

This life stage stretches from the time the fertilized eggs are buried in the gravel to when young salmon migrate from fresh water into estuaries or the Bering Sea. During this stage, embryos develop and hatch into alevins, which migrate through the gravel and emerge in the stream as fry. Depending on the species, these fry may then spend from days to years in the fresh water before migrating. The differences in habitat use and duration of freshwater residence (i.e., from days to years) indicate each species interacts differently within the freshwater ecosystem.

The hypotheses below are posed as positive statements designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor statements of belief of the AYK SSI Program. It may be helpful for the reader to insert before each statement, "To determine whether…".

Hypotheses:

- Survival from egg to emergence varies across space and time and affects the abundance of smolts and returns of adult salmon to the AYK region.

- Nutrients imported to streams by the death of spawning salmon affect the growth and survival of juveniles, smolts and ultimately salmon returns in the AYK region through complex processes involving decomposer communities within the river and its flood plains.

Key Variables:

- Timing, frequency, and duration of flood events
- Daily and seasonal temperature cycles
- Abundance of beaver and their modification of habitat
- Variability in spawning escapements over time
- Variability in processor communities and feedback mechanisms

Example Questions:

1. What is the seasonal and daily timing of migration out of fresh water (emigration), and does an association exist between the timing of emigration and temperature variation, flood events, effects of beaver, and discharge? How do these associations affect survival of smolts to ocean entry?

2. Do changes in the deposition of salmon carcasses affect juvenile salmon survival and recruitment to the smolt life stage through changes in food availability in the form of salmon eggs/salmon flesh and stream invertebrate production?

4.4 Theme 2 – Marine Life Stage (Juvenile to Maturing Adult)

The marine life stage, from the time smolts first enter brackish water, through the ocean juvenile stage, and then to adult salmon on their homeward migration to spawning, is a critical period for establishing abundance of salmon year classes. For some stocks, ocean conditions appear to be the dominant factor affecting survival (Coronado and Hilborn 1998), and a wealth of literature shows that decadal change in salmon production can be explained by climate variability and changes in ocean process (e.g., Gargett 1997; Hare et al. 1999). Further, some evidence suggests that year-class strength is established during the first year in the marine environment (Beamish and Mahnken 2001). For the AYK salmon stocks, relatively little research has been conducted to date on this life stage.

The hypotheses below are posed as positive statements which are designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor as statements of belief of the AYK SSI Program. It may be helpful for the reader to insert before each statement, "To determine whether…".

Hypotheses:

- Marine survival of salmon is more affected by variability in ocean temperature and environmental variables than by variability in marine fishing mortality.

- Marine survival and growth of salmon varies due to density-dependent processes of competition and predation caused by changes in hatchery salmon abundance and natural variation in salmon stocks.

Key Variables:

- Abiotic environmental variables (wind, sea ice, SST, salinity, currents and early migratory pathways)
- Availability of food (e.g., effects of coccolithophore blooms)
- Competition for food
- Predation (beluga whales, birds, fish, sheefish)
- Fishing mortality

Example Questions:

1. What is the importance of marine mortality, relative to mortality at other life stages, in establishing abundance of returning adult salmon to spawning streams?

2. What are the sources and extent of fishing mortality (bycatch, interception fisheries, targeted commercial, sport, subsistence fisheries) on different AYK stocks?

3. Do density-dependent interactions within and among salmon species affect marine survival, growth, and returning adult abundance?

4. How do salmon migration routes vary among populations from year to year, and what effect do oceanic distributions have on survival, growth, and returning adult abundance?

4.5 Theme 3 – Adult Freshwater Migration to Spawning Life Stage (Freshwater Entry to Spawning)

Introduction – This stage is the period from when maturing salmon enter fresh water to when they spawn and die. Salmon in this life stage generally do not feed and incur most mortality from predation by wild animals, disease, or harvest by humans. Salmon in the AYK region may migrate only short distances in small streams which empty directly into the Bering Sea, or they may migrate over a thousand kilometers in the Kuskokwim and Yukon river watersheds. Although migratory behavior can vary substantially among populations, there are some recognizable trends among different species. The differences in run timing and travel distance among salmon species at this life stage influence their susceptibility to various sources of mortality. These differences also cause variable sensitivities to environmental factors, such as changes in discharge and temperature.

Linking Local/Traditional Ecological Knowledge and Fishery Research – Local and traditional knowledge (LTK) represents a culturally rich source of information which can contribute to addressing the Research and Restoration Program goal by providing long-term knowledge of salmon population variation and ecological change, new interpretations of existing data, and new hypotheses and avenues of inquiry for researchers to pursue.

This theme explicitly seeks to promote the exploration of LTK and linkages between knowledge systems. The living memory of elders and ethnohistorical record reaches back as much as five or six human generations. Thus, LTK can constitute our principle source of information about the historic variability of salmon populations prior to the 1960s and can extend back to the 1890s or even earlier in some cases.

Finally, this theme seeks to advance the communication skills and methods available to researchers to collaboratively link LTK and conventional fishery science. Most salmon researchers lack the training and community contacts to effectively access and use LTK. Efforts to bridge conventional fishery science and LTK are still in an early stage of development, and the products from this theme will help to promote these linkages.

The hypotheses below are posed as positive statements which are designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor statements of belief of the AYK SSI Program. It may be helpful for the reader to insert before each statement, "To determine whether…".

Hypotheses:
- Spawning escapement and subsequent egg deposition are the most important determinants of the abundance of the next generation of salmon.

- Fishing mortality is a more important source of adult mortality than natural predation and disease.

- Selective fishing over time has altered size, sex ratio, and life-history type composition of salmon populations.

- Adult salmon abundance in streams shows regular periodic changes and has varied widely over the past two centuries.

- Spawning populations of salmon have become extinct in some streams and their loss has reduced the productivity of some systems.

Key Variables:
- Abiotic environmental variables (temperature, seasonal discharge variability, migration barriers)
- Total catch by stock and size selective fishing mortality
- Adult escapement to spawning
- Stock extinction and species re-colonization rates
- Historical information about salmon abundance
- Historical catch data
- Intergenerational explanations of the causes for changes in salmon abundance

Example Questions:
1. What is the relationship between adult-run size abundance and subsequent spawning-run abundances?

2. What are the spatial and temporal distributions of adult salmon in rivers during migration and spawning?

3. What are the effects of fishing, disease (e.g., Ichthyophonus), and predation on survival of salmon from freshwater entry to spawning?

4. Do fisheries exert differential fishing mortality among stocks within a drainage system or provide a selection pressure against certain phenotypic traits? Has LTK recorded long-term changes in the maximum size and sex ratios of salmon?

5. What are the locations of spawning sites (currently and historically), and how has the use of these habitats varied over time? How does the information from LTK inform fishery science regarding this issue?

6. What are the effects of climate change on migration, distribution, and habitat use? What are the patterns which have been observed by local fishermen and are known by LTK, and how do these compare to those developed using traditional scientific methods?

7. What is the relative contribution of different stocks within a watershed to the entire adult salmon run, and what are the current and anticipated effects of subsistence, commercial, and sport catch on salmon stock structure?

8. How does abundance and distribution of salmon populations vary over long-time scales (20-200 years)?

9. Are major episodic events (floods, fires, ice conditions, changes in marine productivity, etc.) resulting in changes in salmon abundance (e.g., salmon crashes resulting in human famine or out-migration) recorded by LTK but are unknown to the information base available for salmon management?

10. Has LTK observed morphological types, unusual life history adaptations, or changes in the age structure of populations over time previously unrecorded by conventional science?

11. How do long-term local observations of ecosystem change help us to understand the causes of variability of salmon populations, including habitat use by salmon of local rivers, changes in stream channels, beaver abundance, salmon re-colonization, and climate change?

Chapter 5

Research Framework 2 Human Systems and Sustainable Salmon: Social, Economic and Political Linkages

Chapter 5: Research Framework 2 Human Systems and Sustainable Salmon: Social, Economic and Political Linkages

Guide to Chapter 5:

Human interactions with salmon are complex and come largely in the form of directed harvest of adult-phase salmon in the marine and freshwater environments and bycatch. Many other effects exist, including marine pollution, climate change, habitat disturbance, habitat loss, and possible reductions in marine carrying capacity for wild salmon by introduction of hatchery stocks. Economically- and culturally-important harvests of salmon take place in both marine and freshwater environments involving a web of stakeholders, from individuals to groups of fishers to fishing communities to regulators and management agencies. This research framework focuses on the socio-cultural variables which affect interactions between humans and salmon and is organized into two themes and seven specific hypotheses.

5.1 Introduction: Description of Human Systems and Sustainable Salmon

Stakeholders can have different, competing, and even opposing perspectives on salmon and salmon harvest activities. Human-salmon interactions are complex in that human activities, communities, and institutions are at once greatly influenced by and exert significant effect on salmon populations. The human-system framework is decidedly human-centric, consistent with the center of the conceptual foundation (Figure 3.2) and, hence, critically important to understand. Recognizing the potential breadth of this research framework, the NRC (2004a) used a narrow focus and this Plan is consistent with this approach.

"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. " (Page 9 of NRC 2004a)

Studies to be included in this framework include those which specifically contribute to our understanding of how various human activities, institutions, and management structures may affect salmon populations and habitats.

Major components of the human-salmon interface, as well as linkages to the other frameworks, are illustrated by the diagram below (Figure 5.1). The human community, defined broadly here as "Society, Culture, & Economics," sits at the heart of this framework. From this starting point, a flow of human influences on salmon is depicted, beginning with a system of laws, treaties, and international agreements.

Because salmon in the ocean environment range beyond the U.S. exclusive zone, international fishery agreements, as well as domestic laws, set legal and political boundaries governing the allocation among user groups and conservation of salmon stocks. These legal and political policies are implemented through the promulgation of management regimes and implemented through regulations depicted by the box "Regulations and Escapement Objectives" (Figure 5.1). Human influences which might be broadly regarded as enhancing or protective of salmon are encompassed here, including all aspects of fishery management, research, monitoring, enhancement, and regulation.

Those human activities which are more generally recognized as extractive, consumptive, or detrimental to salmon populations are encompassed in the diagram box labeled "Catch and Other Human Impacts" (Figure 5.1). This component includes all aspects of salmon harvest, as well as human-caused impacts to salmon habitat and water quality. Societies and cultures, in turn, derive benefits from activities, such as harvest, and bring the human-system framework full-circle. These benefits and the role of salmon in the lives and cultures of people are complicated by regional differences in economics, values, demographics, and cost-benefit assessments. Finally, "Catch and Other Human Impacts" also represents the place where the human-system framework intersects with the salmon life-cycle-based approach described in the first framework (Chapter 4).

This framework focuses the Research Program on the fourth and fifth overarching questions listed below (previously described in Section 3.5).

Patterns and Processes of Human Use

- How does human use at local, regional, and global scales affect salmon abundance over short and long time scales?

- What variables have caused human use to change over time and location?

Studies supported by this Program under this framework should in some way contribute to answering these questions. The purpose of this framework is to direct attention toward understanding the effects of human communities and institutions on the variation of salmon populations over time.

5.2 Theme 1 – Socio-Economic Variables and Salmon Catch

The historic use of salmon has been strongly influenced by subsistence resource use patterns, availability of alternative foods, fuel prices, food preferences, and the commercial value of salmon. These variables also influence community resilience (the degree of change resulting from stressors) in response to changes in abundance of the salmon resources. Ultimately, demographic patterns are affected by the availability of the resource yet also are determinants of the effort and success of salmon harvest. This theme promotes research which explores how these variables have varied locally, regionally, and globally over time and consequently affected historic salmon catch.

By understanding these relationships, future demand for AYK salmon catch may be predicted and anticipated by management agencies. Regulatory approaches and other management measures can be implemented to conserve salmon populations and accommodate changing demand.

The hypotheses below are posed as positive statements which are designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor statements of belief of the AYK SSI Program. It may be helpful for the reader to insert before each statement, "To determine whether…".

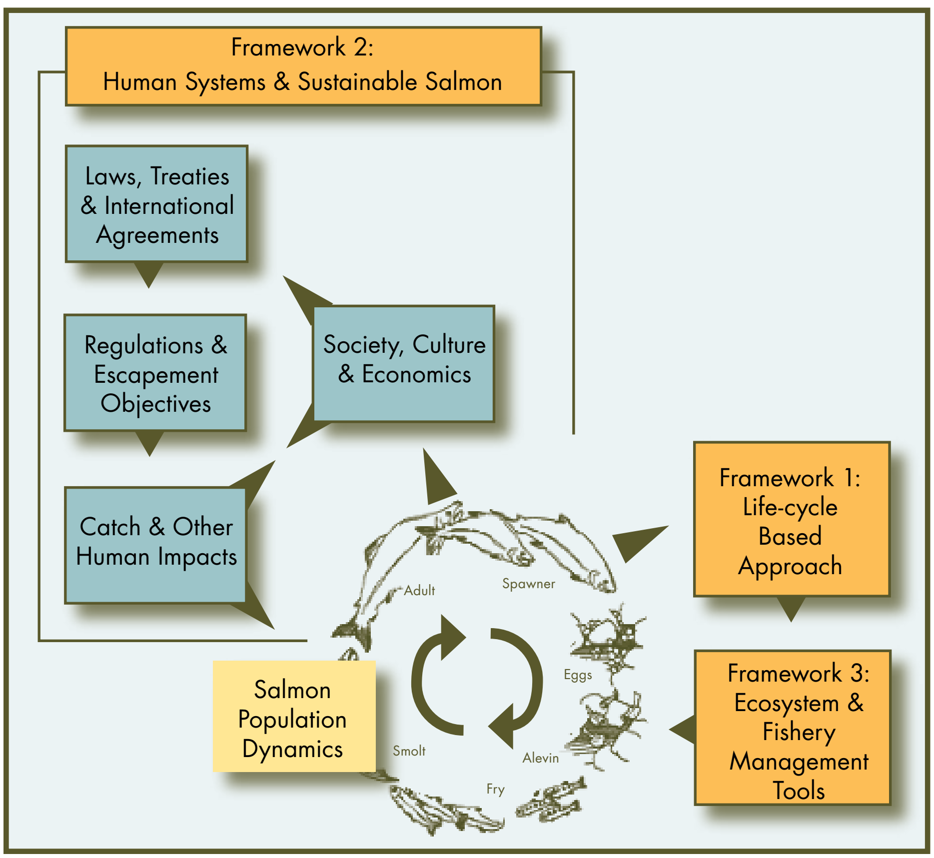


Figure 5.1. Research Framework – Human Systems and Sustainable Salmon: Social, Economic, and Political Linkages (adapted from NRC 2004a, p. 106).

Hypotheses:

- Catch by fishing has influenced both long- and short-term trends in salmon spawning abundance.

- In the AYK region, human populations will increase over the next fifty years, but alternative affordable food resources will become more available causing fishing and harvest of salmon to remain the same or decline.

- Commercial prices for salmon will remain the same or decline, and in response commercial fishing in the AYK region will decline.

- Sport fishing and ecotourism will become more important over the next several decades and provide alternative sources of income for local residents.

- Regulation of fishing practices has significantly affected timing of catch, species caught, and stocks affected.

Key Variables:

- Past and future changes in human populations in the AYK region by age, sex, and socio-economic status
- Past, present, and future changes in dietary preferences at local and regional scales
- Trends in commercial salmon prices, sport fishing effort, and ecotourism business in the region

Example Questions:

1. What are the interactions between socio-economic variables and catch of salmon in the AYK region? Addressing this theme requires the integration of LTK with traditional socio-economic research.

2. Will predicted human demand for salmon exceed the predicted sustainable yield of AYK salmon populations over the next several decades?

3. How have the development, promulgation, and enforcement of marine and freshwater fishing regulations/management regimes affected the distribution of salmon catch in time and space?

5.3 Theme 2 – Human Effects on Salmon Habitat

Beyond the direct effects of fishing harvest, human interactions with salmon are complex and can come indirectly through marine pollution, climate change, habitat disturbance and habitat loss, and high seas competition with hatchery stocks. The hypotheses below are posed as positive statements which are designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor statements of belief of the AYK SSI Program. It may be helpful for the reader to insert before each statement, "To determine whether…".

Hypotheses:

- The cumulative effects of habitat loss by mining activities can be severe at local levels but not at regional scales, except in the Norton Sound region.

- The human use of river corridors by boats causes damage to juvenile salmon habitats and has reduced their capacity over time to produce juvenile salmon.

Key Variables:

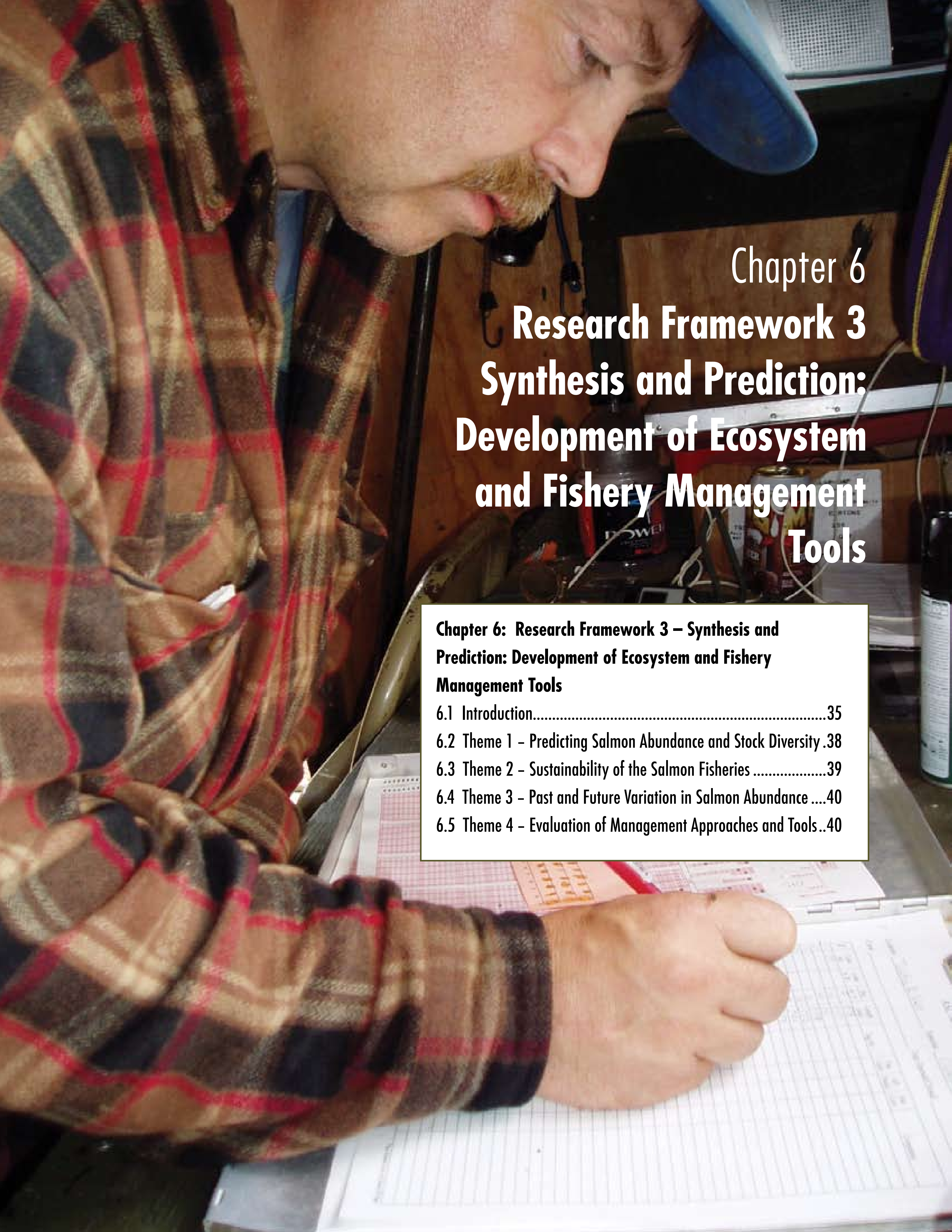
- Distribution and extent of habitat change caused by mining

- Changes in space, time, and intensity of boating activities
- Extent and effects of water pollution at local, regional, and global scales

Example Questions:

1. What are the individual and cumulative effects on salmon from human activities such as mining, boat traffic, and point and non-point sources of freshwater and marine pollution?

2. Are traditional scientific assessments of human impacts consistent with LTK?



Chapter 6
Research Framework 3 Synthesis and Prediction: Development of Ecosystem and Fishery Management Tools

Chapter 6: Research Framework 3 – Synthesis and Prediction: Development of Ecosystem and Fishery Management Tools

Chapter 6: Research Framework 3 Synthesis and Prediction: Development of Ecosystem and Fishery Management

Guide to Chapter 6:

This framework focuses on examining, and functionally connecting, the key variables and processes identified in the first two frameworks and exploring for patterns which explain salmon abundance at different temporal and spatial scales. The discovery of these functional relationships by this framework will permit the identification of those variables and processes which appear to be key determinants of salmon abundance. Identification of variables and processes will allow the development of fishery management tools to forecast abundance and help establish regulations for sustainable harvests. This research framework is organized into five themes and seven specific hypotheses.

6.1 Introduction: Synthesis and Prediction and the Development of Ecosystem and Fishery Management Tools

Introduction – This framework has two purposes which are based on the synthesis of knowledge acquired from activities under the two previously described frameworks – salmon life cycle and human systems – and research in other programs: (1) to better understand the causes of variation and resilience of the AYK salmon and (2) to refine and develop management tools (see Figure 6.1). These two purposes are central to accomplishing the goal of the AYK SSI Research and Restoration Program (described in Section 3.4). The framework is consistent with the recommendations of the NRC (2004a) and was expanded to address synthesizing existing and new information and provide an emphasis on applications to sustainable salmon management. In this section, several concepts will be introduced which may be unfamiliar to some readers but are important to understanding the intent of this framework.

Ecosystem resilience – What is ecosystem resilience? It is an ecosystem's ability to continue to provide a given set of services (such as salmon for subsistence or angling) in the face of perturbations (definitions of ecosystem, ecosystem services, forcing, and resilience in Appendix 1). The dynamics of AYK salmon result from a complex and ever-changing set of forcing factors, consisting of natural (e.g., disease epidemics, episodic floods, climate change) and/or human (e.g., harvest, direct, and indirect impacts to habitat) drivers. The ecosystem will remain functioning in a current state only if the shocks to the system are not too great. Large perturbations to an ecosystem can cause the system to shift to a new state of stability. Damaged ecosystems can show reduced resilience and thus become more vulnerable to shifts to new stability states. Ecosystems with reduced resilience may still function and generate services (e.g., fishing incomes and subsistence) and, therefore, may appear to be functioning normally (Folke 2003). In a non-resilient system, even a small shock may threaten the persistence of the system state (Folke 2003).

How resilient is the AYK salmon ecosystem? Addressing this question requires, in part, an examination of how system-level dynamics occurring at one temporal and spatial scale influence events taking place at another scale (e.g., BEST 2004). For example, what are the connections or interactions between slow, large-scale changes (e.g., climate change) and sudden or episodic changes (e.g., Ichthyophonus infection rates, poor annual escapements, major floods events)?

Synthesis and prediction – Our ability to forecast annual returns of salmon ultimately depends on understanding how the diversity of the salmon's freshwater habitats interacts with ocean conditions to produce salmon. Understanding the key variables responsible for salmon production requires synthesis of existing information spanning the entirety of the salmon's life cycles. The complexity of this issue is intensified by the number of species (five) which exist in the AYK region, multiplied by the large number of major salmon-bearing watersheds.

This framework addresses a range of questions aimed at facilitating synthesis of information in support of sustainable management of salmon fisheries (Figure 3.2). One powerful technique of synthesis is the development of simulation models from information compiled under the first two frameworks (Figure 6.1) and from other research efforts. Retrospective time-series analyses using various parameters (indices of abundance, predator abundances, habitat temperature) can help determine the causes of changes in salmon abundance (e.g., Adkison and Finney 2003). For example, Shotwell, et al. (2005) examined environmental time series to study causes for changes in salmon survival rates. They developed models for the Kuskokwim and Yukon rivers which explained 89% and 81% of the variability in survival rates, respectively. For Kuskokwim River chum salmon survival rates, the best predictors were springtime air temperature during the freshwater life stage, along-peninsula wind stress during the early marine life stage (interpreted as nutrient transport, with the ensuing nutrient-phytoplankton-zooplankton dynamics providing prey), and predation by Kuskokwim coho adults during the early marine-life stage. The best predictors for Yukon fish survival rates included springtime precipitation, wind strength (i.e., turbulence providing mixing to drive the nutrient-phytoplankton-zooplankton sequence or prey production), and the summertime Arctic Oscillation index.

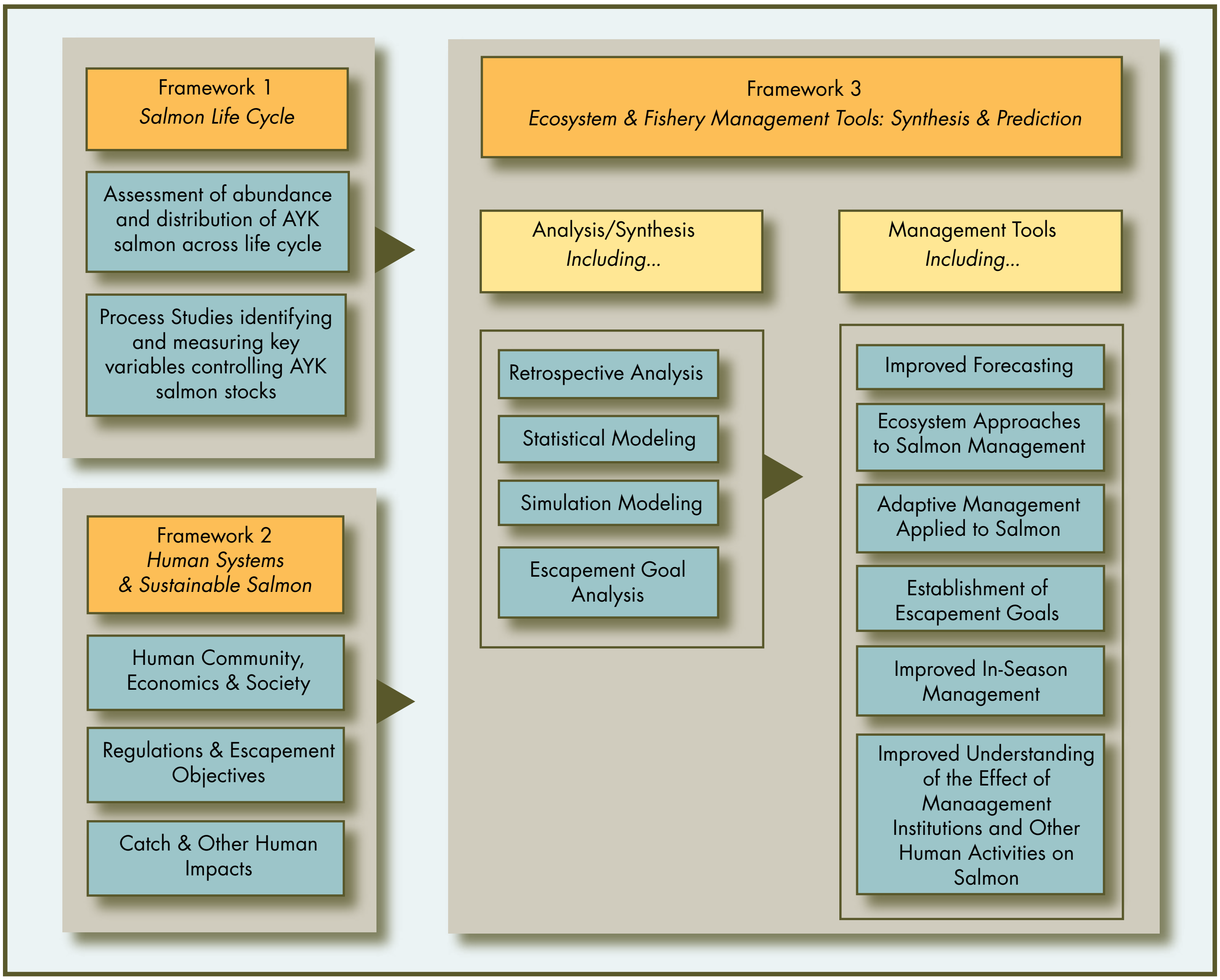


Figure 6.1. Flow chart depicting the linkages between frameworks 1, 2, and 3 and the interaction between two principle components of Framework 3: analysis/synthesis and management tools.

Evaluation and Development of Management Tools – To improve the likelihood of sustainable ecosystem services, the AYK SSI Plan supports the development of new approaches which could more effectively incorporate established ecosystem-based science and policies into tools to provide input to management decision making (e.g., Fluharty et al. 1999; Witherell et al. 2000; NPFMC 2002). To resolve ongoing and future ecosystem management issues requires the melding of well-focused research and the expansion of some of the present management policies (e.g., to include those which are precautionary and/or which best assure sustainability). In addition, strategies need to be developed for improving the use of the best scientific information by management (NRC 2004a, NRC 2006).

Improved Forecasting – Developing tools to improve forecasting of salmon runs will directly contribute to the Program's goal, because it will require understanding the "trends and causes of variation in salmon abundance." At present, quantitative forecasts for salmon runs in the AYK region cannot be provided. As a result, fisheries are managed based on in-season assessments of the runs as they occur (Plotnick and Eggers 2004). Projects which enhance in-season accounting of stocks and provide reliable forecasts (based on model simulations as noted above) are a high priority to the Program and will provide fishery management with improved tools.

Improved In-season Management – Understanding in-season management approaches and how they affect salmon catch and stock structure is an important component of in-season management and of this framework. Maintaining escapements is fundamental to the practice of successful salmon fishery management (Merritt and Skilbred 2002; Walters 1996; Mundy 1998).

Escapement Goals – Escapement goals are defined as the annual number (or range of numbers) of adults which are desired not to be caught by fisheries and spawn within a designated watershed. Critical questions with this approach include the following:
- How do you measure spawning success?
- Are stock-specific goals being met?
- Do all females live long enough to spawn?
- What is the fecundity of the females?

For this management approach to maintain sustainable populations, the escapement goals need to be stock-specific and established close to spawning grounds. The most difficult questions related to spawning are: (1) what number of salmon must spawn to produce enough smolts to attain maximum adult return in the next generation, and (2) do current management procedures allow the maximum potential to be achieved? Genetic identification of various AYK salmon populations is required if management is to occur on a stock-specific basis.

At present, available data are insufficient to adequately describe the population structures of salmon in the AYK region (Utter and Allendorf 2003). Escapement goals and harvest levels also need to be adaptive to reflect changes in ocean productivity (Peterman and Haeseker 2003).

Adaptive Management – Developing adaptive approaches to salmon management in the AYK region is another important priority within this framework (see Glossary in Appendix 1). Adaptive management is an approach to resource management where management policies and actions are used as a tool not only to change the system, but as a tool for managers and others to learn about the system (e.g., Walters 1986). Under this approach, management interventions are designed as experiments to test key hypotheses about the functioning of the ecosystem and improve our understanding of how it responds to change. As noted by the NRC Committee (2004a), "this means that in planning management actions, the need for obtaining data from them [management agencies] as well as from controls should be taken into account."

For example, if a new management policy is implemented which substantially alters fishing effort (e.g., fishing windows) or gear type (e.g. mesh size), the intervention can be designed with experimental controls to collect new information. Adaptive management is an iterative process, "emphasizing the importance of feedbacks from the environment in shaping policy, followed by further systematic (i.e. non-random) experimentation to shape subsequent policy, and so on," (Berkes and Folke 1998). Ecosystem management should be approached in the spirit of cautious experimentation, given the scientific uncertainty (Goodman et al. 2002). Adaptive management requires flexible governance with the ability to respond to environmental feedback (Olsson et al. 2003).

Linking LTK to Research and Management - This framework encourages the use of LTK in both research projects and management programs. LTK is an often under-used source of environmental and sociological information. The importance of using LTK in developing a more complete understanding of Alaskan ecosystems is well recognized in recent reports from the National Research Council (NRC 2004a, 2004b) and in science plans (e.g., BEST 2004; NPRB 2005). Observations made by Alaskan Natives and other rural residents can span temporal scales which exceed those of most projects and data sets. These observations include many physical and biological aspects of the ecosystem, especially salmon and their habitat.

This Plan recognizes that LTK can play a role in answering AYK research questions, providing alternative interpretations of existing data, and generating hypotheses which can be examined through conventional scientific methods. The integration of LTK, conventional science, and management must be a collaborative effort. Researchers and managers will advance our understanding of the AYK salmon ecosystems by recognizing the potential usefulness of LTK contributions and creating opportunities for LTK inclusion. Holders of LTK, likewise, will benefit by collaboratively and cooperatively making LTK available for use.

6.2 Theme 1 – Predicting Salmon Abundance and Stock Diversity

This theme seeks the development of techniques to predict salmon abundance by stock over time and at local and regional scales. The hypothesis below is posed as a positive statement which is designed for studies to either prove or disprove. It is not to be interpreted as a statement of fact nor a statement of belief of the AYK SSI Program. It may be helpful for the reader to insert before the statement, "To determine whether…".

Hypothesis:

- A combination of demographic and ecosystem variables affects the variability of salmon returns in the AYK region.

Key Variables:

- Any combination of variables previously listed in the first two frameworks.

Example Question:

1. What combination of demographic and ecosystem variables, operating on any or all of the life history stages, best predicts salmon abundance by stock?

6.3 Theme 2 – Sustainability of the Salmon Fisheries

This theme promotes investigation into providing reasonable predictions of salmon resource use over time and space and whether future predicted salmon abundance will support this demand. Addressing this issue relies on examination of many variables, including a synthesis of historical population levels of salmon and examination of potential causes for change in salmon populations (salmon life-cycle framework) and their use by humans (human-systems framework).

The hypothesis below is posed as a positive statement which is designed for studies to either prove or disprove. It is not to be interpreted as a statement of fact nor a statement of belief of the AYK SSI Program. It may be helpful for the reader to insert before the statement, "To determine whether...".

Hypothesis:

- Future salmon abundance will support expected harvest demand and provide sufficient spawning salmon to maintain self-sustaining salmon returns in the AYK region.

Key Variables:

- Historical salmon abundance
- Changes in harvest patterns
- Variables identified in the first two frameworks which significantly explain variation in salmon abundance and human demand for fish

Example Questions:

1. Will future salmon abundance support future harvests and bycatch, including subsistence, commercial, and sport fisheries? Are the predictions the same for all species in all regions?
2. What possible management strategies could be used to allocate fishery resources in times of scarcity and conserve salmon populations?

6.4 Theme 3 – Past and Future Variation in Salmon Abundance

The next research theme examines the resilience of AYK salmon populations to withstand perturbations. Sustainability relies on knowing the interactions described in the second theme (above) and on understanding the level of ecosystem resilience which currently exists in the AYK region. Ecosystem resilience is critical to predicting risk and uncertainty of the sustainability of AYK salmon for future human generations. Historical and paleo-records show fluctuating levels of salmon production and evidence which links these variations to climate regime shifts (e.g., Adkison and Finney 2003). Examining such records can provide new information on how the ecosystem behaves or responds with and without human fishing pressure on the salmon stocks. LTK will be an important source of information about past variation in salmon abundance.

The hypotheses below are posed as positive statements which are designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor statements of belief of the AYK SSI Program. It may be helpful for the reader to insert before each statement, "To determine whether…".

Hypotheses:
- Resilience of the ecosystem supporting AYK salmon will decline due to changes in oceans and climate.
- Historic variability in salmon abundance corresponds to regime-level shifts in ecosystem function or state.
- Models which predict historic variability will forecast future salmon abundance.

Key Variables:
- Historical salmon abundance
- Climate change
- Ocean temperatures and currents
- New diseases (Tompkins and Wilson 1998)
- Exotic species invasions (ADF&G 2002)
- Other variables identified in the first two frameworks which significantly explain variation in salmon abundance

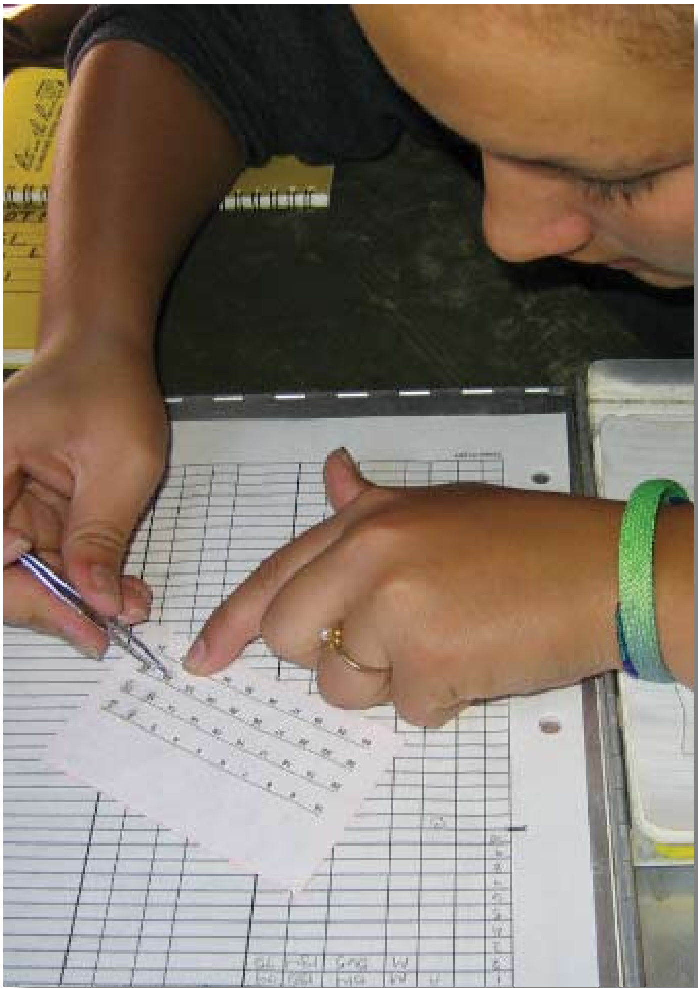
Example Questions:
1. What are the connections or interactions between slow, large-scale changes (e.g., variables associated with climate and ocean change) and sudden or episodic changes (e.g., Ichthyophonus infection rates, poor annual escapements, major floods events)?

2. Has the historic variation in salmon abundance been due to the ecosystem shifting among multiple stable states? Is there evidence of the loss of any AYK salmon stocks?

3. Will new stable states with different sustainable yields occur when runs greatly exceed or fall short of predicted escapement needs?

6.5 Theme 4 – Evaluation of Management Approaches and Tools

This theme focuses on influences of human institutions and their policies through management actions to regulate harvest of AYK salmon. While some of the changes in salmon production result from natural causes and, hence, are inevitable, potential threats exist (e.g., habitat destruction due to development) which can be addressed through policy and decision-making. One of the best approaches to understanding the effects of management actions is to employ an adaptive management approach as described above (Section 5.1).



The hypotheses below are posed as positive statements which are designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor statements of belief of the AYK SSI Program. It may be helpful for the reader to insert before each statement, "To determine whether…".

Hypotheses:
- Stock diversity and salmon stock abundance can be sustained by regulation of fishing gear and fishing times using an escapement goal management approach.
- Escapement goal setting to ensure sustainable fisheries can best be accomplished by using stock-recruitment models in combination with life-history and habitat-based modeling.

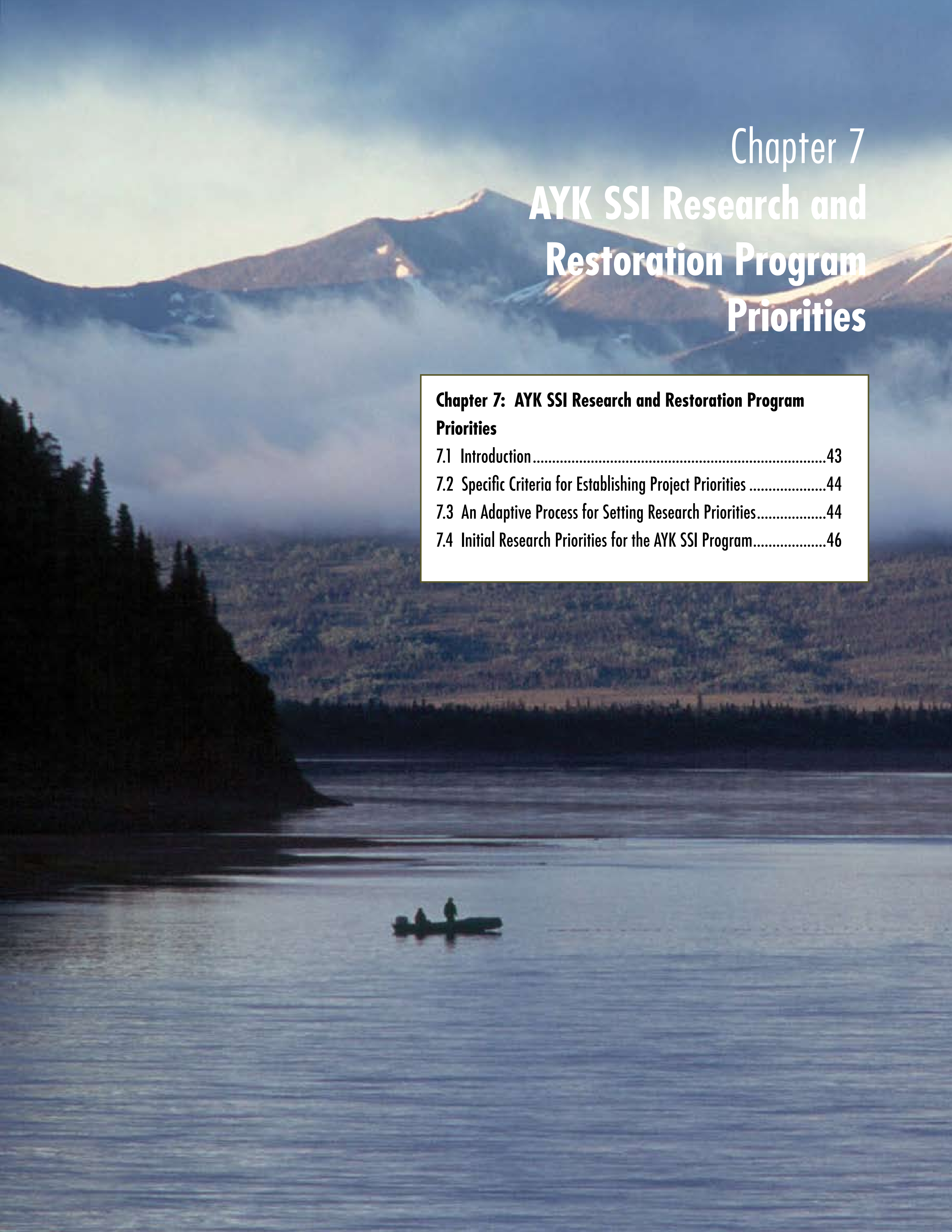
Key Variables:
- Stock diversity
- Stock abundance
- Stock–recruitment–habitat relationships
- Relationships between gear and catch by sex, stock, and size
- Any combination of variables previously listed in the first two frameworks which affect the abundance of salmon

Example Questions:
1. What management regimes and methods are available to affect salmon catch and stock structure?

2. How can fishing regimes enable sustainable harvest without altering heritable traits of adaptive significance (e.g., run timing, stock structure, and genetic variability)?

3. How can fisheries operating on mixtures of stocks with different productivities be managed to sustain both production and stock diversity?

4. What methods exist for determining escapement goals (e.g., habitat-based, ecological, spawner-recruit models), and which ones or combinations are best to use in different drainage systems?



Chapter 7
AYK SSI Research and Restoration Program Priorities

Chapter 7: AYK SSI Research and Restoration Program Priorities

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Guide to Chapter 7:

This chapter describes five challenges to setting Program priorities and how to keep priorities up-to-date with the changing circumstances of AYK salmon and fisheries. The challenges come from 1) the large set of information needs identified in chapters 4-6, 2) modest funding, 3) an unknown time frame for the Program, 4) a dynamic information base, and 5) unknown future information needs. Specific criteria are provided to guide the Program in establishing priorities. These criteria focus on the Program goal, knowledge gaps, LTK, stock-recruitment, ecological processes, prediction, time-efficiency, and geographically-focused investing of Program resources. Use of the criteria is to occur in an adaptive process for the annual setting of priorities. These criteria were used to help identify the high priority hypotheses which the Program should initially emphasize.

7.1 Introduction: Challenges Faced With Setting Research Priorities

The setting of priorities in 2006 for the entire program life of the AYK SSI Research and Restoration Program is impossible because of 1) the large set of information needs identified in chapters 4-6, 2) modest annual funding, 3) an unknown time frame for the Program, 4) a dynamic information base, and 5) unknown future information needs. Ideally, the Program would like to examine each of the information needs listed in the earlier chapters and to explore these at all scales of time and space. However, this approach is not feasible due to limited funds and the length of the life of the Program, currently 2013.

As of June 2006, a total of $20.5 million has been allocated to achieve the Mission Statement and Program Goal of the AYK SSI. This level of funding is modest in comparison with other biological and/or conservation issues. For example, over $120 million has been allocated to understand the decline of a single species, the Stellar sea lion, which lives within a more restricted geographic range than salmon (NRC 2006).

As has been noted in Chapter 2, many of the processes which influence salmon abundance operate over time periods much longer than the Program's remaining seven years (e.g., the decadal-scale regime shifts in the northeast Pacific marine ecosystem; Francis and Hare 1994). The potential also exists that additional monies may be allocated, and the time frame for the Program may lengthen. Hence, the number of topics identified, combined with the limited funds and an uncertain time frame, cause significant challenges in establishing priorities.

The AYK SSI Program's priorities must adapt and shift when some information needs are met and understanding about the salmon system improves (dynamic information base; see Section 1.4). The filling of information needs will come through projects funded by this Program and as a result of the completion of projects funded by other programs within state and federal agencies, as well as by private foundations. For example, several state - and federally - funded projects are underway to annually monitor the abundance of spawning runs of AYK salmon. This data is essential and directly applicable to addressing the Program goal of the AYK SSI.

New research and assessment initiatives are likely to begin in the AYK region over the coming years, and these may provide the AYK SSI with exceptional opportunities for collaboration. For example, since this Plan began to be developed, in 2004 the Kuskokwim River watershed became a focus of long-term studies through the Salmon Rivers Observatory Network Program funded through the Moore Foundation, and these studies are expected to extend through 2009. In funding projects, the AYK SSI Program will seek ways to coordinate its projects with existing and new projects from other programs so as to leverage the AYK SSI's limited funds and to avoid duplicity of research efforts. Thus, Program priorities must be adaptive to the accomplishments of the AYK SSI Program and other programs.

Lastly, unknown future information needs can arise which could redirect and change priorities for information. With a dynamic information base, new paradigms of thinking can emerge which were unknown when this Plan was developed, and these new ways of thinking could afford a strategic opportunity to target future AYK SSI funding. Also, regionally-specific threats to salmon can arise which were unforeseen at the time of Plan development and could cause immediate and urgent information needs. For example, in May 2005 plans were announced for a gold mining project potentially located on the Tuluksak River and in the Kilbuck Mountains, a part of the Kuskokwim River drainage. It is unknown at this time how this new development in the drainage could affect salmon and how this emerging issue will affect the future priorities in the AYK SSI Program.

To address the above challenges in setting priorities, the STC chose to establish specific criteria (Section 7.2) and to implement an adaptive process (Section 7.3) as a means to establish and revise project priorities for the AYK SSI Program. Using these criteria and this process, the AYK SSI Program priorities (based on a perspective in 2006) are developed and described (Section 7.4). These priorities should serve to guide the development of the next few requests for proposals. The STC anticipates these priorities will change over the coming years in response to the challenges described above.

7.2 Specific Criteria for Establishing Project Priorities

The purpose of specific criteria is to help focus research efforts on the most important overarching questions concerning the variability of salmon returns to the AYK region, to facilitate the use of historic data where possible, to create opportunities for collaboration among agencies and organizations, and to maximize the use of the AYK SSI funds (adapted from NRC 2006). These criteria will be helpful when developing annual requests for proposals and will provide standards against which to measure specific project proposals when making funding decisions. The criteria listed below are not mutually exclusive but must be used in combination with each other. Clearly no single priority or specific project will meet every criterion; however, every information priority and project should be compatible with the first two criteria which focus on – the Program Goal and Knowledge Gaps.

1. Program Goal – Priorities must directly help to achieve the goal of "understanding the trends and causes of variation in salmon abundance and fisheries…".
2. Knowledge Gaps – Priorities must fill clear gaps in knowledge, unaddressed by other research and management programs, and must complement and not duplicate past work by others nor provide substitute funding.
3. Use LTK – Priorities must incorporate and evaluate LTK, where possible and appropriate for better understanding of the salmon, and contribute to capacity building
4. Stock-Recruitment Variation – Projects must help understand the cause for variation between observed stock-recruitment vs. predicted stock-recruitment, explore the use of environmental variables as sources of variation, and develop process-based explanations for changes in salmon abundance and stock diversity.
5. Ecological Processes – Priorities must promote the linking of ecological processes across the spatial and temporal scales of the salmon life cycle.
6. Prediction – Priorities must encourage the development of ways to predict the future abundance of salmon-spawning runs, human demand for salmon, and the responses of the fishery to regulatory changes.
7. Time Efficient – Priorities must encourage projects which will produce results within a reasonably short period of time. Retrospective analyses of existing time-series data are especially valuable and time efficient.
8. Focus on Selected Populations – Priorities will help focus a portion of the AYK SSI Program's efforts on specific populations within each of the three sub-regions which have long-term stock assessment projects or other on-going research programs and which will promote working and coordinating with other organizations and their studies.

7.3 An Adaptive Process for Setting Research Priorities

Using the priority-setting process described below will permit the AYK SSI Program to be flexible and adaptive to changes in our understanding of salmon. This section describes a multi-phase process to establish high-priority research topics under this Plan (see Figure 7.1). These priorities will be revised every three years as a core component of the Plan review process (see Section 9.3 below). Priorities for specific years will be selected by the AYK SSI Steering Committee from among this list of high priorities and will be communicated through the annual AYK SSI "Invitation to Submit Research Proposals."

This section was guided by the comments provided by the NRC (2006: 9-13) about the need to clearly articulate linkages among the Program goal, frameworks, hypotheses, and priorities and is based on public comments on an earlier draft of the Plan calling for a reduced number of priorities.

Research planning phase – The Program goal and overarching questions listed in sections 3.4 and 3.5, in combination with the research frameworks, themes, hypotheses, and questions presented in chapters 4 through 6, constitute the research planning phase. These hypotheses and associated questions must be addressed to achieve the Program goal of "understanding the trends and causes of variation in salmon abundance and human use of salmon." However as previously noted, addressing every hypothesis listed is impossible within the funds and time available to the AYK SSI Program.

Priority-setting phase – The priority-setting phase, divided into three stages, facilitates the identification of a set of high-research priorities from among the full suite

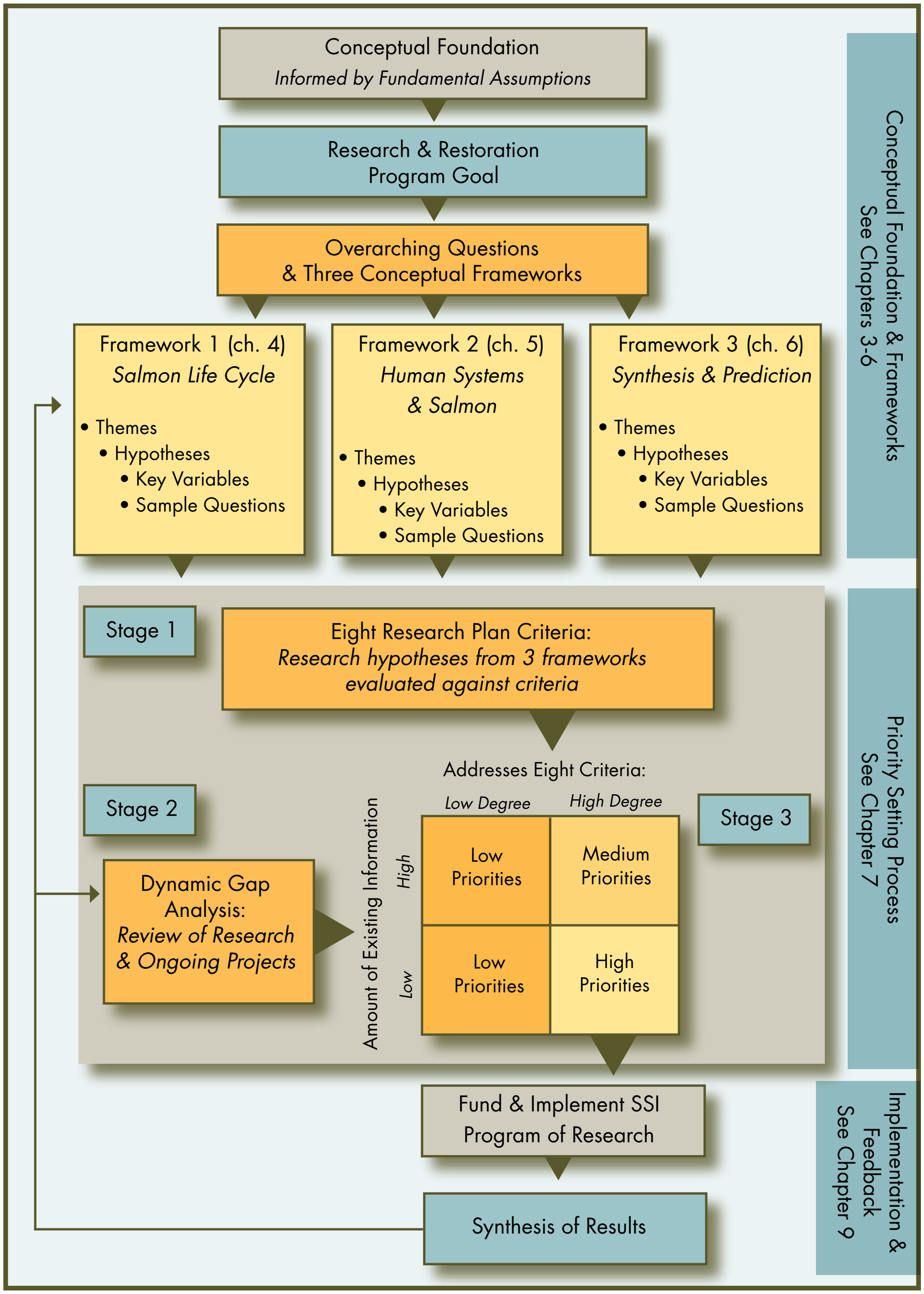


Figure 7.1. The AYK SSI priority-setting process in relation to the research planning phase which precedes it and the implementation phase of the Research Program that follows.

of research priorities which emerge from the conceptual frameworks.

Stage 1: The research themes, hypotheses, and questions of Stage 1 are evaluated by the STC against the set of criteria listed above in Section 7.2. Research themes, hypotheses, and projects will have a high priority when they meet the criteria described in Section 7.2.

Stage 2: Assessment of the current state of the information base will occur though the strategies described in Section 1.4 (called Dynamic Gap Analysis). This assessment allows priorities to adapt over time as information gaps are filled and new ones arise. The assessment occurs through annual meetings of investigators of all programs to share current results, annual meetings of the directors of programs, cross appointments among programs' committees, comparing past priorities with priorities of sub-regional plans and programs, and use of the results of the AYK SSI 2007 symposium.

This assessment will provide the means to identify (1) current gaps in knowledge, (2) research themes not being addressed by other programs, and (3) opportunities to coordinate priorities among programs. This information guides development of new hypotheses and questions and the reprioritization of new and existing hypotheses and questions.

Stage 3: The results of evaluating research themes, hypotheses, and questions against the criteria (stage one) and the results of the dynamic gap analysis (stage two) are arrayed within a two-by-two matrix. This approach facilitates the setting of priorities for the themes and questions. For example, a research hypothesis or question which addresses many or most of the criteria for which there is little existing information and which is not being addressed by other programs will be ranked as a high priority for the AYK SSI Program. Rationale for the final list of high-priority hypotheses is presented in Section 7.4 below.

Implementation and feedback phase – This phase includes selection by the AYK SSI Steering Committee from among this list of high priorities, communication of these priorities through the annual AYK SSI "Invitation to Submit Research Proposals," and synthesis of research results. Feedback loops from the integration and synthesis of new research results inform both: 1) development of new hypotheses and questions and 2) re-prioritization of new and existing hypotheses and questions.

This adaptive approach to priority setting depicted in Figure 7.1 emphasizes the dynamic nature of the information base and importance of updating both the research frameworks and hypotheses in response to new research findings through periodic Plan reviews.

7.4 Initial Research Priorities for the AYK SSI Program

The criteria and processes described above were used to assign priorities to the information needs described in chapters 3-6 for the AYK SSI Salmon Research and Restoration Plan as of 2006. The Program priorities listed below are a starting place for the Program and should be reviewed and revised annually and communicated through the annual "Invitation to Submit Research Proposals." Priority setting was performed with the Program's goal, first and foremost, in mind (goal stated below) and was based on the criteria listed in Section 7.2. Program priorities are described in two tiers. The first tier includes all hypotheses listed in the Plan. The next tier identifies the high- priority hypotheses.

First Tier – The AYK SSI Research and Restoration Plan describes 3 frameworks, 10 research themes, and 22 hypotheses. This list represents a selection by the STC, from among many research lines of inquiry, those hypotheses which would best promote the achievement of the Program's goal listed below:

To understand the trends and causes of variation in salmon abundance and fisheries through the assembly of existing information, gaining new information, and improving management and restoration techniques through a collaborative and inclusive process.

Each of the frameworks, hypotheses, and questions listed in the Plan are important for the achievement of this goal and, therefore, are important to the Program and worthy of support. The priorities listed below for the hypotheses should be used to provide guidance to narrow the focus of the annual RFP by the AYK SSI Program.

Second Tier – High-Priority Hypotheses – Of the 22 hypotheses, 11 (or 54%) were identified as being high priority for the AYK SSI Program to initially support. The hypotheses below are posed as positive statements which are designed for studies to either prove or disprove. They are not to be interpreted as statements of fact nor statements of belief of the AYK SSI Program. These hypotheses are as follows:

Research Framework	High Priority Hypotheses	Example Questions
Salmon Life Cycle	Marine survival of salmon is more affected by variability in ocean temperature and environmental variables than by variability in marine fishing mortality.	• What is the relative importance of marine mortality, relative to mortality at other life stages, in establishing abundance of returning adult salmon to spawning streams? • What are the sources and extent of fishing mortality (bycatch, interception fisheries, and targeted commercial fisheries) on different AYK stocks? • Do density-dependent interactions within and among salmon species affect marine survival, growth, and returning adult abundance? • How do salmon migration routes vary among populations from year to year, and what effect do oceanic distributions have on survival, growth, and returning adult abundance?
	Spawning escapement and subsequent egg deposition are important determinants of the abundance of the next generation of salmon.	• What is the relationship between adult-run size abundance and subsequent spawning-run abundances? • What is the relative contribution of different stocks within a watershed to the entire adult salmon run, and what are the current and anticipated effects of subsistence, commercial, and sport catch on salmon stock structure? • What are the effects of fishing, disease (e.g., Ichthyophonus) and predation on survival of salmon from freshwater entry to spawning?
	Selective fishing over time has altered the size, sex ratio, and life-history type composition of salmon populations.	• Do fisheries exert differential fishing mortality among stocks within a drainage system or provide a selection pressure against certain phenotypic traits? Has LTK recorded long-term changes in the maximum size and sex ratios of salmon?
	Adult salmon abundance in streams shows regular periodic changes and has varied widely over the past two centuries.	• How do abundance and distribution of salmon populations vary over long-time scales (20-200 years)?

Research Framework	High Priority Hypotheses	Example Questions
Human Systems	In the AYK region, human populations will increase over the next fifty years, but alternative affordable food resources will become more available, causing fishing and harvest of salmon to remain the same or to decline.	• What are the interactions between socio-economic variables and catch of salmon in the AYK region? Addressing this theme requires the integration of LTK with traditional socio-economic research. • Will predicted human demand for salmon exceed the predicted sustainable yield of AYK salmon populations over the next several decades?
	The cumulative effects of habitat loss by mining activities can be severe at local levels but not at regional scales, except in the Norton Sound region.	• What are the individual and cumulative effects on salmon from human activities such as mining, boat traffic, and point and non-point sources of freshwater and marine pollution? Are traditional scientific assessments of human impacts consistent with LTK?
Synthesis and Prediction	Models that predict historic variability will forecast future salmon abundance.	• Has the historic variation in salmon abundance been due to the ecosystem shifting among multiple stable states? Is there evidence of the loss of any AYK salmon stocks?
	Escapement goal setting to ensure sustainable fisheries can best be accomplished by using stock-recruitment models in combination with life-history and habitat-based modeling.	• What methods exist for determining escapement goals (e.g., habitat-based, ecological, spawner-recruit models), and which ones or combinations are best to use in different drainage systems?
	Stock diversity and salmon stock abundance can be sustained by regulation of fishing gear and fishing times using an escapement goal management approach.	• What management regimes and methods are available to affect salmon catch and stock structure?
	A combination of demographic and ecosystem variables affects the variability of salmon returns in the AYK region.	• What combination of demographic and ecosystem variables, operating on any or all of the life history stages, best predicts salmon abundance by stock?
	Future salmon abundance will support expected harvest demand and provide sufficient spawning salmon to maintain self-sustaining salmon returns in the AYK region.	• Will future salmon abundance support future harvests and bycatch, including subsistence, commercial, and sport fisheries? Are the predictions the same for all species in all regions? • What possible management strategies could be used to allocate fishery resources in times of scarcity and conserve salmon populations?

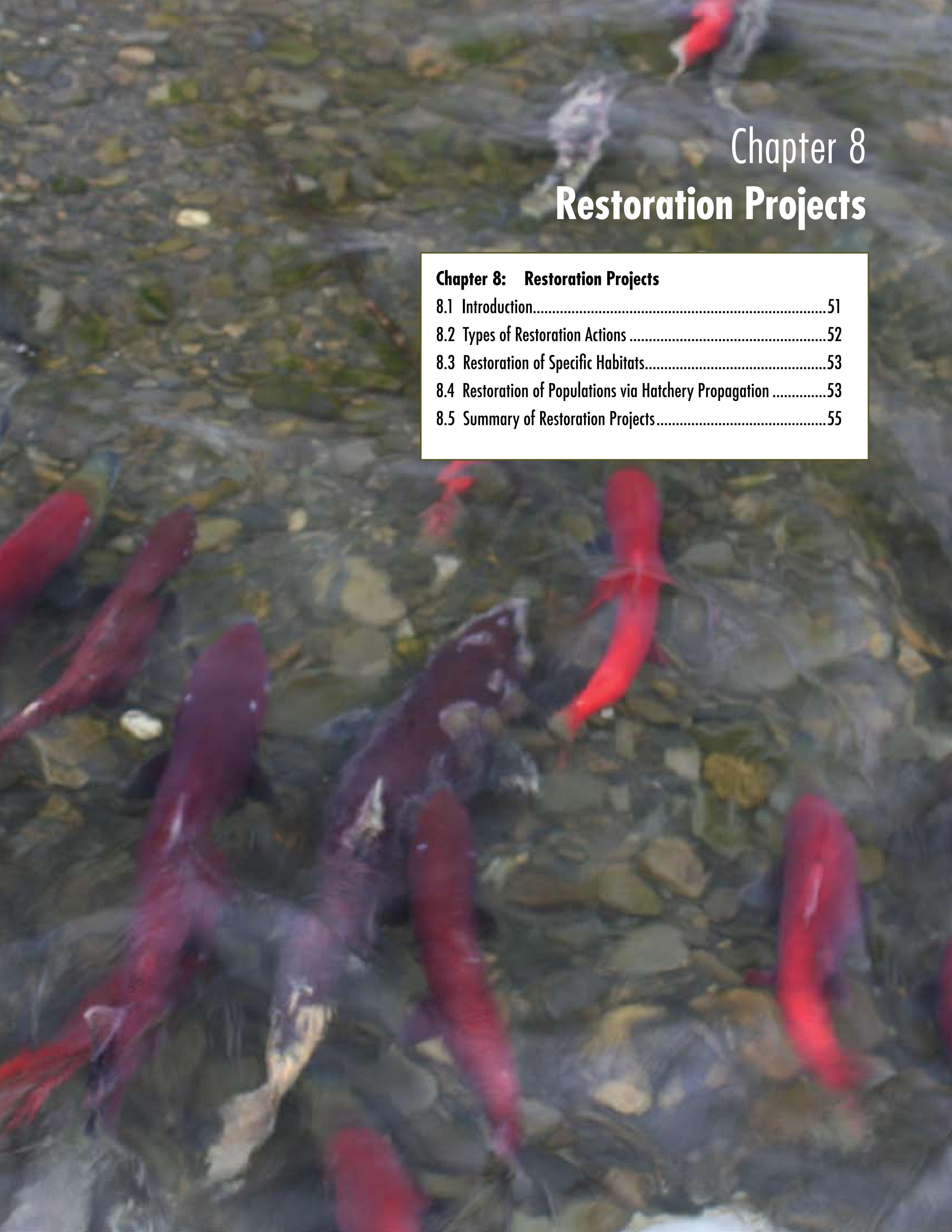
These hypotheses were chosen because each addresses topics important to the 7 overarching questions in Section 3.5 and met most of the criteria established in Section 7.2.

Determining whether these hypotheses are either true or false will contribute important information toward understanding long-term trends in salmon abundance and for forecasting future abundance. Therefore, these hypotheses directly address the Program goal. Verifying or falsifying these hypotheses will require existing data, new data, and LTK as the set of information to analyze. Highest priority should be given to those projects which address these hypotheses with existing data, because such projects will be time-efficient and not require the development of new long-term data series.

The preceding comment is supported by the NRC Committee comments regarding research plan priorities: "This committee endorses the Program's approach of focusing early RFP on retrospective analyses, based on the need to catalog, assemble, and synthesize existing data as an important early step in the program" (NRC 2006). Investigators interested in developing proposals addressing these hypotheses should review chapters 4 through 6 for the key variables and questions associated with these hypotheses.

Eleven of the 22 hypotheses are identified above as high priority. Will it be possible to address the 10remaining hypotheses? These 10 hypotheses continue as important components to address for the achievement of the AYK SSI Program goal; and, therefore, some means should be provided to support especially meritorious projects.

For example, exceptional opportunities could be provided to address one of the remaining hypotheses when a project will significantly advance understanding regarding a hypothesis and when it includes collaborative efforts between the AYK SSI Program and other programs and, hence, leverage the AYK SSI funds with other programs. Such a project would likely meet several of the criteria listed earlier.



Chapter 8
Restoration Projects

Chapter 8: Restoration Projects

Chapter 8: Restoration Projects

Guide to Chapter 8:

Restoration refers to actions specifically designed to promote or re-establish salmon populations which have been depressed or extirpated. This section describes actions that may be used to restore damaged freshwater or estuarine habitat or, if the habitat is ecologically functional, artificial propagation activities which may be used to promote or re-establish populations. A critical aspect of every restoration project is a clear plan for evaluation or assessment of the project once completed.

8.1 Introduction

The goal for restoration projects in the AYK SSI Program is the restoration of populations to a level which will allow them to persist over the long term with no further human intervention within a dynamic ecosystem, while retaining the ability to undergo adaptive evolutionary change (from Section 3.6). Before embarking on specific restoration actions, the causes of population decline must be clearly identified, so that restoration actions can be evaluated in the context of significantly ameliorating or eliminating causalities. Restoration projects which focus only on artificially increasing the abundance of salmon populations without identifying and correcting the problems which have caused declines will give a false sense of the sustainability of the fishery, and, therefore, will ultimately fail.

The causes of salmon declines in the AYK region are complex and incompletely understood as is articulated in detail in the preceding chapters. Fortunately, most areas of the AYK region still have abundant and largely intact and fully-functional freshwater and estuarine salmon habitats. On the other hand, the ability of the marine habitat to support increasing numbers of AYK salmon may have been compromised due to the presence of large numbers of hatchery salmon released from sources in Asia and North America and interactive food web effects associated with ongoing climate change. Also, in some cases mining or other human actions have degraded salmon habitat, and some populations also may have been chronically over-harvested.

Population declines in the AYK region in some cases can be due to non-harvest-related human variables such as physical damage to salmon habitats of the ecosystem or from humans interrupting "ecosystem services" which are vital to the salmon, such as the total amount of water in watersheds or the annual pattern of water runoff. Habitat loss due to mining operations and road building activities may have contributed to salmon declines in some areas of the AYK region. In such cases, effectively identifying and correcting these human factors, especially habitat restoration, may help restore salmon populations. For example, properly rebuilding a culvert which blocks access to spawning and rearing habitat is an action which can restore a population to its original state upstream of a road without having to alter harvest practices or without having to resort to biological measures on the population itself, such as stocking.

Restoration projects undertaken by the AYK SSI must: 1) address the root cause of the population decline, 2) specify the methods by which the restoration will be implemented, 3) describe why this method is preferred over others, 4) incorporate evaluation of costs and benefits in the short and long term, and 5) commit to an evaluation after the action has been taken to assess the response of salmon. Using aquaculture to produce juveniles for re-stocking a population, for example, would not be an effective way to produce sustainable increases in adult returns, if the root cause of the decline is a culvert which impedes adult migration to the spawning grounds. Instead, fixing the culvert will solve the problem. Similarly, re-stocking juveniles into a depressed population would not overcome the effects of over-harvesting at non-sustainable levels, nor would it address losses the depressed population is experiencing in the marine environment due to competition from hatchery fish.

Restoration actions for the AYK SSI should be undertaken in full view of the potential drawbacks which may exist for the ecosystem or population and what, if any, steps have been taken to minimize these drawbacks (Waples and Drake 2004). The AYK SSI restoration actions should draw upon and incorporate the lessons learned about Pacific salmon restoration from the work conducted in the contiguous United States and western Canada over the past 50 years. An extensive literature about restoration of salmon exists and should be reviewed (e.g., Williams 2006).

8.2 Types of Restoration Actions

Actions to restore salmon populations can come in many forms. In most cases, restoration actions will address alteration of human activities, such as levels of harvesting or harvesting in specific localities, to address the negative effects of over-harvesting and reduced levels of productivity due to climate change. Various forms of fishery regulation such as seasons, quotas, and gear restrictions can be useful to reduce the effects of over-harvesting.

The other types of restoration actions considered to be possibly applicable in some parts of the AYK SSI region are the recovery of specific habitats and restoration of populations via aquaculture (Ehrenfeld 2000). Both of these approaches have the potential to benefit or further damage the populations or habitats of concern. In some cases, restoration actions may be necessary to remove man-made barriers to migration, to restore habitats degraded by humans such as by mining, and to prevent these kinds of actions from occurring in the future. These actions are complex and require careful consideration before implementing. Reeves et al. (1991) and ODFW (1999) review various approaches for the restoration of watershed or riparian habitats.

Restoration activities involving hatchery propagation, such as re-stocking depressed populations, are less likely to be undertaken in the AYK region because they often do not result in long-term restoration. However, such actions should not be ruled out as short-term remedies

to speed restoration when used with other restoration actions. For example, stocking could be used in conjunction with habitat restoration actions so as to speed re-colonization of restored habitats. For the benefits and risks to population restoration, useful reviews on such approaches have been provided by Montalvo et al. (1997), Waples and Drake (2004), and Walters and Martell (2004).

More discussion of habitat restoration and the use of hatchery propagation and stocking is provided in the next two sections.

8.3 Restoration of Specific Habitats

Pacific salmon require a remarkable range of habitats over the course of their life cycle and can thus be affected by habitat loss or degradation in a variety of places and times within their life cycle. When a population is in decline, one of the first questions to ask should be has there been a loss of habitat quantity or quality at one or more points of the salmon's life cycle? If so, actions which remedy this loss or degradation may restore a salmon population to its previous condition. Thorough reviews of habitat restoration are provided by Reeves et al. (1991) and ODFW (1999). Case studies relevant to salmon include Doyle et al. (2000) and Gaboury (2003).

Habitat or watershed restoration topics which may be of interest in the AYK region include:

- ***Reconnection of fragmented spawning or rearing habitat*** - This includes reconnecting habitat which has been fragmented by road construction and mining activities. Common remedies include using bridges or culverts to provide fish passage, improving culverts, and replacing culverts with bridges (ODFW 1999).

- ***Restoration of over-winter habitat such as pools*** - Resource extraction activities can change the size and frequencies of pools in rivers and streams by increasing erosion or otherwise altering sediment transport (Meehan 1991). Reductions in pool size or frequency can reduce the quality of winter habitat, which is known to limit the production of salmon smolts in some systems (Reeves et al. 1991).

- ***Restoring riparian vegetation*** - Damage or removal of vegetation can affect salmon by altering stream temperatures, reducing inputs of nutrients, increasing erosion, and altering the flow regimes and the frequency of floods (Hicks et al. 1991; ODFW 1999).

- ***Restoration of spawning and egg incubation habitat*** - Changes to sediment transport within the natural flow regime can cause the gravel needed for spawning and egg incubation to be removed by erosion or be buried by fine sediments. Such losses can be disastrous for salmon populations. Once the cause for the change in sediment transport is corrected, it may be necessary to replace stream gravel within salmon spawning grounds.

8.4 Restoration of Populations via Hatchery Propagation

Before using the products of hatchery propagation to restock depressed salmon populations (sometimes called supplementation), careful consideration must be given to the evaluation of both the positive and negative effects of this strategy. If these effects damage the depressed wild population and fail to address the causes for the decline of a population, the restoration effort can do more harm than good, either by adding to the stress placed on the struggling wild population or by making the population incapable of self-sustainability in the future. In such a situation, humans will have essentially exchanged the wild, self-sustaining population for an artificial population which must be maintained at substantial economic cost in perpetuity by humans.

The AYK SSI restoration projects which involve artificial propagation to restore depressed salmon populations must be supported by a rationale which addresses the consequences listed below and on an evaluation of the benefits and costs of the action in the near and long term. Consequences to consider are from Walters and Martell (2004); Waples and Drake (2004); Reisenbichler et al. (2003):

- ***Failure to produce fish which help the wild population*** - Wild populations are the foundation of sustainable fisheries. Adding fish via supplementation may not increase the salmon numbers if they have poor survival, if salmon production is limited by variables which affect the population after the life stage stocked by a supplementation program, or if the supplemented fish as returning adults do not locate the best spawning and rearing areas. Flooding the system with additional fish can exacerbate many problems. Design of supplementation programs must demonstrate that the fish they provide will successfully reproduce and replenish the wild population. At the same time, reproduction by hatchery origin fish must not reduce the fitness of the wild population through the introduction of maladapted genetic traits through interbreeding.

• ***Artificial increase in fishing mortality*** - Increased harvest pressure on the wild, depressed population can occur when hatchery-origin fish return, co-mingle with the wild population, and attract high levels of fishing effort. If the depressed wild population cannot support any harvest, additional harvest pressure created by the supplemented fish will further reduce wild population numbers.

• ***Use of wild fish to provide eggs for propagation of hatchery fish*** - If causes of the population decline are solved, recovery may occur more quickly when wild fish are left in the stream to spawn rather than if they are removed for purposes of artificial propagation.

• ***Post-release competition occurring between wild and supplemented fish*** - Where resources (e.g., food, juvenile rearing space) are scarce, adding salmon to the system will increase mortality of juvenile wild salmon through competition. As a result, population abundance will not increase, and increased competition may further exacerbate the population decline.

• ***Increased predation and disease risk occurring for wild fish when hatchery fish are stocked*** - Increasing the juvenile densities in streams by stocking may increase natural mortality rates by providing attractive fish densities to predators (e.g., mergansers) and by increasing rates of disease in fish due to stress from competition and direct transmission from hatchery to wild fish.

• ***Loss of genetic diversity*** - Genetic variation can decline in the wild population when hatchery-origin fish derived from too few parents interbreed with the wild population. Using a large effective number of brood stock within artificial propagation programs reduces this risk but increases problems from the third consideration above regarding use of wild fish to provide eggs for propagation.

• ***Loss of adaptive variation*** - Maintenance of the genetic characteristics of the wild population is a critical restoration objective. These genetic characteristics confer a specialized adaptive advantage to the wild population for successful survival and reproduction in their native waters. If artificial propagation is conducted using a subset of the population or a completely different genetic source of fish, a serious risk will exist that these fish may not have the full range of adapted traits needed. For example, supplementing a population with the offspring of only early-run brood stock would reduce the proportion of late-run fish in the wild population and could genetically swamp and lose the genetic characteristics required for late-run fish.

• ***Masking*** - When hatchery salmon return to a stream with a depressed population, the status of the wild population can be masked, and problems can go undetected. This effect can also occur when substantial numbers of unmarked (or undetected) fish from a supplementation project stray into neighboring waters, thereby falsely

increasing the abundance estimate in the neighboring system.

A framework for evaluating the range of risks of population restoration via re-introduction or supplementation has been developed by Waples and Drake (2004) and is provided below. Proposal authors of restoration projects which use hatchery propagation should answer these 4 questions within the body of their proposals.

1. How will you evaluate and guard against potential drawbacks (those eight potential consequences described above)?

2. How will the work yield useful information through assessment about the population restoration (e.g., via an experimental design)? Planning assessment as a part of the project is essential.

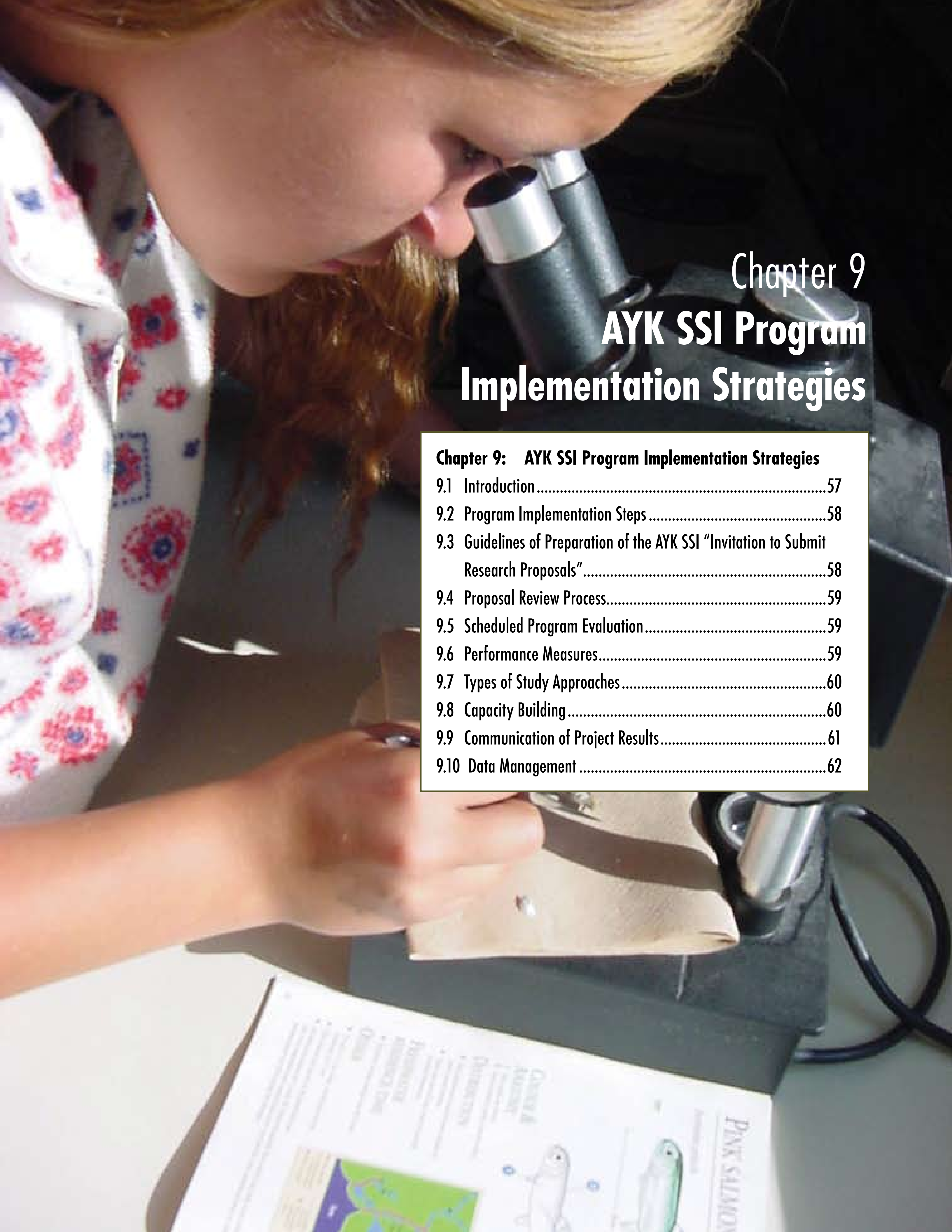
3. Will the work be carried out in an adaptive management framework (e.g., Walters 1986)?

4. Will the work be combined with other recovery methods to provide maximum benefits?

Walters and Martell 2004, Waples and Drake 2004, and Reisenbicheler et al. 2003 are recent reviews which address this restoration approach. A careful review of these publications will be helpful to authors prior to preparing re-stocking (supplementation) proposals.

8.5 Summary of Restoration Projects

Restoration projects within a specific geographic scope can have beneficial effects on localized populations of salmon. The most viable projects are those which restore habitats which have been seriously damaged and which will not naturally recover without human intervention. For example, improvements in fish passage at road crossing culverts will allow salmon access to upstream habitats which had previously been blocked. Supplementation projects should be linked to other restoration actions and must be carefully planned to avoid unintended damage to wild populations. Regardless of the restoration project, every project should have a designed and implemented assessment program so learning can occur to guide future projects.



Chapter 9
AYK SSI Program Implementation Strategies

Chapter 9: AYK SSI Program Implementation Strategies

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Guide to Chapter 9:

In this chapter, the implementation procedures for the AYK SSI Program are described. Procedures are described for the evaluation of the AYK SSI Program, development of the AYK SSI "Invitation to Submit Research Proposals," evaluation of proposals, role of capacity building, and a variety of other topics. Priorities for the annual AYK SSI Request for Proposal process will be identified by applying the priority-setting process outlined in Chapter 7 and modified by the Steering Committee. The details of running a competitive contract process for the AYK SSI, such as communicating project results and managing data, are covered in the balance of this chapter. These sections describe important operational elements of the Program.

9.1 Introduction

The AYK SSI Program is to be adaptive to changes in the state of knowledge of salmon and responsive to emerging new ideas and issues facing AYK salmon. To achieve this characteristic the Program must remain flexible enough to adjust to new results generated by research conducted by the AYK SSI and those from other programs. However, the Program must also be focused enough such that each funded project has high potential to individually contribute to the accomplishment of the Program goal and helps to address the overarching questions and the hypotheses within the frameworks.

Further, assessment or evaluation of the Program must be based on established performance measures and objectives. This assessment must be conducted on a regular basis to provide feedback information which allows Program adaptation over time.

Effective Program implementation requires an annual assessment of the current state of knowledge through feedback from completed AYK SSI projects and progress made in other research programs, such as those organized through the North Pacific Research Board and the Federal Office of Subsistence Management – Fisheries Resource Monitoring Program. This assessment will allow the Program to adjust priorities and communicate these adjustments through the AYK SSI's annual "Invitation to Submit Research Proposals."

This chapter describes the core elements for administration of the AYK SSI Research and Restoration Program including basic implementation steps, scheduled Program evaluation, guidelines for the annual "Invitation to Submit Research Proposals," proposal review process, performance measures, types of study approaches, role of capacity building, program communications, and data management.

9.2 Program Implementation Steps

The overall approach described below should be followed annually to implement the Program:

- The number of years the Program will exist will be predicted for each cycle of funding. The length of Program existence changes with each new round of congressional appropriation.

- An approximate budget for the remaining years will be established, with a firm commitment for the first three years.

- The AYK SSI Program will host an annual meeting of the directors of Alaska federal and state study programs to discuss past and ongoing projects and current Program priorities and will seek ways to collaborate and combine resources to focus on shared priorities.

- The high priority research hypotheses as described in Chapter 7 will be reviewed and considered within the context of other programs. Specific hypotheses will then be identified and pursued within the Program's RFP.

- Projects to implement the high priority hypotheses will be solicited in the annual AYK SSI "Invitation to Submit Research Proposals."

- Standards and accountability for completion of progress and final reports will be established and enforced.

- Regular retrospective evaluation of the Program will occur every three years in terms of the completion of the projects, building the information base for managing salmon, and establishing future research priorities.

9.3 Guidelines of Preparation of the AYK SSI "Invitation to Submit Research Proposals"

The content of the annual AYK SSI "Invitation to Submit Research Proposals" will be informed by the priorities as identified in Chapter 7. These priorities will be adjusted annually as determined by a changing information base, emerging issues, and a balance developed among competing information needs by the AYK SSI's Steering Committee. The AYK SSI RFP will solicit proposals focused on answering the hypotheses and questions as selected by the Steering Committee from the list of high priorities listed in Chapter 7.

Most years, the AYK SSI's RFP will likely direct the Program's focus for that year on specific overarching questions or hypotheses as identified by the Steering Committee. Both the EVOS' Gulf Ecosystem Monitoring (i.e., EVOSTC 2003) and the NPRB (i.e., 2005rfp.doc available on the NPRB web site: www.nprb.org) programs have directed portions of their RFP. In this category, specific topics are presented as a central focus for the RFP and are combined with the expected duration of projects and the approximate funding level for the specific topics. This approach, directed by the Steering Committee, will ensure projects for that year will be proposed which directly address specific overarching questions and hypotheses in the AYK SSI frameworks. The NPRB also has a "general" category which provides a greater degree of researcher creativity. A comparable category may be used in the AYK SSI RFP for all other proposals which lie within the general bounds of the frameworks.

The schedule for the annual AYK SSI "Invitation to Submit Research Proposals" will be adjusted in the 2008-09 funding cycle to accommodate a pre-proposal step. Pre-proposals will provide an opportunity for the Program to interact with project leaders prior to a significant investment of their time in the preparation of full proposals. This step will provide an important opportunity for capacity building in the development and design of project proposals.

The timeline for requests for pre-proposals and proposals including the transition to pre-proposal step is as follows:

2007 Request For Proposals

June 30, 2006	RFP released for full proposals
October 16, 2006	Full proposals due for peer review
January 30, 2007	Approve projects
February 28, 2007	Finalize contracts for implementation

(Approximate Dates) 2008 Request For Proposals and forward (includes pre-proposal process)

January 15, 2007	RFP released for pre-proposals
March 31, 2007	Pre-proposals due 3/31
May 31, 2007	Send approved pre-proposals back for further development
October 15, 2007	Full proposals due for peer review
January 15, 2008	Approve projects
February 15, 2008	Finalize contracts for implementation

9.4 Proposal Review Process

Pre-proposals will be reviewed on how well they address the priority topics identified in the current RFP, their relationship to this Plan and its priorities, feasibility to accomplish, capability of the leaders to accomplish the project, opportunities for capacity building, and clarity of project objectives. Project leaders of pre-proposals deemed to be relevant and feasible will be asked to prepare and submit a full proposal to the Program.

Full proposals will be reviewed by two or more external peer reviewers. Research proposals will be reviewed for their scientific merit, clarity of research objectives, appropriateness of methods to accomplish the objectives, and commitment to deliverables. Restoration projects will be similarly reviewed but will also be evaluated based on how well they address the benefits and risks of the project as discussed in Chapter 8. Peer reviews of each proposal will be discussed by the STC, and funding recommendations will be forwarded to the AYK SSI's Steering Committee.

The Steering Committee, based on this input and their own discussions, will make funding decisions on which project proposals submitted to the Program will be funded.

9.5 Scheduled Program Evaluation

Evaluation of the AYK SSI Research and Restoration Program will be completed by December 31, 2008 and will occur every three years thereafter.

The AYK Research and Restoration Plan is to be a "living document" which is reviewed and revised periodically as new research hypotheses are formulated and as existing ones are answered. As a living document, the planned review in 2008 is essential. The timing was chosen to correspond with the expected publication date of the AYK SSI symposium SUSTAINABILITY OF THE ARCTIC-YUKON-KUSKOKWIM SALMON FISHERIES which will be held in February 2007.

The symposium will provide a valuable assessment of the current state of knowledge and will identify new emerging information needs. In addition, this date was chosen because several on-going AYK SSI projects will be completed by this time; and, hence, an assessment of their contribution to the state of knowledge about AYK salmon and the overall impact of the AYK SSI Program will be timely.

The review will address the following:

- Progress toward answering overarching questions and key hypotheses
- Incorporating new ideas and issues
- Refining hypotheses and questions based on new information

This approach enables the AYK SSI Program to keep pace with the evolving research needs of the region, some of which cannot be articulated a priori, but rather depend on first obtaining answers to an initial set of high-priority research hypotheses and then revising them over time.

9.6 Performance Measures

Performance measures for this Program focus on accomplishment of the Program's goal and will provide the means by which to perform the scheduled Program Evaluation (Section 9.5).

To understand the trends and causes of variation in salmon abundance and fisheries through the assembly of existing information, gaining new information, and improving management and restoration techniques through a collaborative and inclusive process (from Section 3.4.)

The key questions listed below, focused on performance, shall be evaluated and answered every three years. The first evaluation will be completed by December 31, 2008.
1. What progress has been made in answering the overarching questions and hypotheses identified under each of the frameworks?

2. Do we better understand the variables which determine the survival of salmon?

3. Have predictive tools been developed to forecast salmon abundance, and do they associate estimates of uncertainty with those predictions?

4. Do we have a better understanding of human-use patterns and predicted future demand for salmon?

5. Have any management tools been developed which are useful to managers in their decision making, and what are they?

6. Have the results of the Program helped ensure 1) the conservation of salmon and their required marine and aquatic habitats, 2) the protection of customary and traditional subsistence uses and other uses, and 3) the sustained economic health of Alaska's fishing communities?

Performance standards for individual projects will be set in other documents. Standards at the project level focus on the completion of objectives and on the communication of results. For example, the project must ensure data are made available in a timely fashion, publication of project results occurs from projects funded by the Program, and presentations of the results occur at workshops or symposia.

9.7 Types of Study Approaches

What types of study approaches are appropriate to use to address the priority hypotheses? The four generic research approaches generally applied to attain objectives of large research programs are (e.g., see Gulf Ecosystem Monitoring and Research and North Pacific Research Board (NRPB) programs):

- Monitoring and development of indices to detect and track changes in ecosystem elements and to provide data for modeling and context for process studies
- Process studies to identify and understand potentially important rates and processes
- Retrospective studies to maximize use of existing long-term observational records
- Model simulations to direct research, synthesize observations, and extrapolate them in time/space and/or test ideas and forecast future scenarios

Within each of these approaches, development of new technologies and analytical approaches is also a candidate for AYK SSI funding support. The NRC recognized specific needs for basic data in AYK which are fundamental for advancing most of the hypotheses outlined in this Plan. In particular, the NRC noted a need for focus on better information on numbers and distribution of species and stocks at all life history stages, better assessment of numbers in various drainages, genetic make up of populations, and better information on characteristics of human populations which affect salmon, including specific harvest patterns (subsistence, sport, and commercial) and their effects on fish populations (NRC 2004a).

Within the Plan's broad goal of understanding trends and causes of abundance variation in salmon, the STC recognizes the fundamental need for this basic data in support of all priority hypotheses listed in the Plan. As such, the Plan supports escapement monitoring projects, collection of genetic material to establish broad-scale baselines, obtaining samples from key mixed stock regions for application of these baselines to answer questions about intercept fisheries, and collection of basic data which leads to a more informed understanding of harvest patterns.

In light of the LTK pertaining to salmon in the region, LTK should be viewed as an important source of information with application across the study approaches described above. Projects must be carefully designed and include clearly-stated hypotheses and objectives combined with an appropriate experimental design (Peterman et al. 2005). In Appendix 3, a more complete description of these study approaches is provided.

9.8 Capacity Building

Use of the terms "capacity" and "capacity building" in regard to Alaska fishery research is not well defined, and little consensus exists about the appropriate tools and approaches. In an effort to bring clarity to these terms, the AYK Steering Committee adopted the UN Development Program definition of "capacity" as:

the ability of individuals and organizations or organizational units to perform functions effectively, efficiently, and sustainably.

The Steering Committee also developed the following definition of capacity building in the context of rural Alaska salmon research as:

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.

Despite their extensive knowledge about and dependence on salmon, rural organizations, tribes, and regional tribal non-profit organizations generally experience limited involvement in salmon research in the AYK region. Though many rural/tribal organizations possess a strong interest in salmon research, many lack the human resources and technical capacity to effectively compete for funding and meaningfully participate in research programs such as the AYK SSI, North Pacific Research Board, and OSM/FIS.

Addressing the capacity building needs of the AYK region remains a high priority for the AYK SSI Steering Committee. This priority is reflected in the committee's AYK SSI Vision Statement (2004), which includes, as one of its three core components, the goal of developing and implementing "a capacity building program which enables rural residents of the AYK region to effectively participate in co-management of AYK salmon resources."

Development and implementation of the AYK program of capacity building will be reflected in both subsequent AYK SSI "requests for proposals" and are important criteria in the evaluation of proposals.

9.9 Communication of Project Results

New information developed by the AYK SSI must be made accessible to resource managers, AYK SSI leaders, stakeholders, and the public, as well as past and potential new study leaders in a timely and effective way. Doing so entails 1) communicating technical research results to the AYK SSI, other scientists seeking to develop new studies, and resource managers seeking to put recent results to use and 2) communicating summary information about research results to stakeholders and the public, while facilitating access to technical details for those interested.

Communication with diverse audiences can best be accomplished with dedicated and directed programs (e.g., public outreach) which employ specialized techniques and skills. Such programs and techniques are already developed by many of the institutions which comprise the AYK SSI's primary audience and will not, therefore, be addressed in this Plan. Instead, this Plan will focus on successful communication among diverse audiences. Realistically, effective communication back and forth between these audiences will require dedicating specific funds from the AYK SSI to implement a communication strategy. This strategy is the subject of the remainder of this section.

Researchers funded by the AYK SSI must effectively communicate the scope of their work before, during, and after the project to the AYK SSI and stakeholders.

- Before project:
  - (required) Project metadata sheet must be submitted which conforms to an established standard AND which addresses which overarching question, framework and hypothesis is targeted by the project.

- During project:
  - (required) Semiannual progress reports, as required by the AYK SSI.
  - (required) Presentation given at annual workshop held in Anchorage in conjunction with an SC and/or STC meeting or in conjunction with a meeting of Research Program directors.

- After project:
  - (required) Draft final report due 60 days after the project end date. Final Report Summary and Draft Project Products to be submitted in 1 electronic version and 3 paper copies. Draft Project Products will be peer reviewed by one or more qualified reviewers.
  - (required) Final reports shall be revised to address peer review comments and resubmitted for final acceptance.
  - (encouraged) Publication in peer-reviewed journal or conference proceedings.
  - (encouraged) Presentation at scientific conferences or workshops. Expenses will be paid by the AYK SSI if these costs are identified in the proposal.

Communications before the project - These communications should be simple placeholders which will help identify what work is being done on which species, where it is happening, and who is doing it. This is best accomplished with a project metadata sheet submitted with the study proposal. This metadata overview should conform to that used by the Federal Geographic Data

Committee, which approved the Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998) to standardize information and simplify record keeping. In addition, the sheet should indicate which framework and hypothesis is being addressed by the project. This sheet can be updated in progress reports.

Communications during the project - These communications should come in the dual forms of written and oral project reports. All project leaders should submit a two- to three-page annual progress report, on or near December 15. In addition, the AYK SSI will host an annual meeting at which PIs are required to give presentations. This annual meeting may coincide with a Steering Committee or Scientific and Technical Committee meeting or other meetings. Investigators should request travel funds for this meeting in the budgets of their proposals. The meeting will most likely be in Anchorage.

Communications after the project - These communications minimally require a final report delivered within eight months of the completion of data collection and will be indicated in a timeline within the proposal. The final report will include a final metadata sheet. The report will be delivered in both hard copy and electronic form.

In addition, investigators are encouraged to communicate final results at scientific conferences or in peer-reviewed publications, as well as regional stakeholder forums. Such communications should be identified in the proposal so the AYK SSI can provide travel and registration funds for conferences. Past performances of investigators will be gauged in part based on publications in peer-reviewed journals and presentations at conferences. Page charges for publication will be paid by the AYK SSI.

Web site communication by the AYK SSI Program - The AYK SSI will maintain a web site devoted to tracking projects and will update the site twice per year. The web site will serve as the main clearinghouse of information which can be accessed by scientists, resource managers, and other interested parties. The web site will document the accomplishment of the AYK SSI and indicate where and how progress is being made toward addressing information gaps.

The web page will contain the sections which follow:
- List of projects funded each year, including metadata sheets which were submitted with each proposal
- List of projects funded under each framework and hypothesis. This list should be referenced in each RFP.
- Electronic copies of all final project reports which can be fully accessed by scientists and resource managers
- Bibliography of all presentations and peer-reviewed publications which have been funded or partially funded by the AYK SSI.

9.10 Data Management

Data management is a process for describing, storing, and retrieving the observations collected by the projects of AYK SSI. The purpose of the process is to ensure data will be comprehensible and easily available to all who need it at a minimum of time and cost. Although data collected through the AYK SSI funded projects are ultimately owned and controlled by the AYK SSI, the scientists who gather and interpret the data may, in some cases, need to have exclusive use of the data for a limited time to verify its reliability and to publish papers. Project proposals should include a time table which specifies when data will be available to the public.

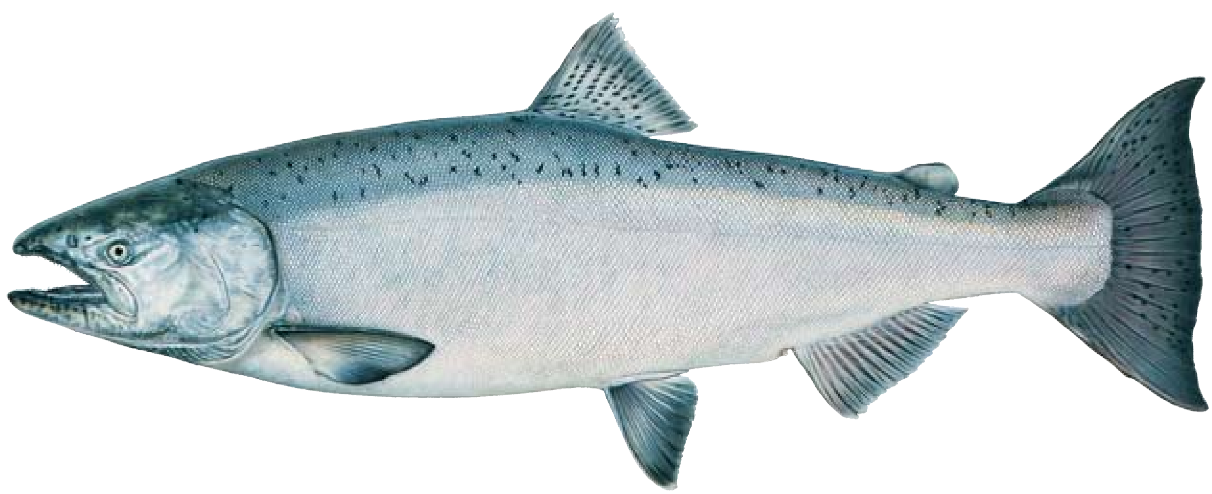
Existing state and federal standards for describing data will be followed by the AYK SSI projects. For example, national standards for describing geospatial data have been established. Metadata, or “data about data,” describe the content, quality, condition, and other characteristics of data. The Federal Geographic Data Committee approved the Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998) in June 1998. The idea behind standard metadata is that a consistent means to share geographic data among all users will produce significant savings for data collection and use and will enhance decision making.

The federal government has enacted the National Spatial Data Infrastructure, which is defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community (www.fgdc.gov). These standards shall be followed for all AYK SSI projects and all proposals must provide explicit plans for data management, including when and how project data will be served to the public.

To facilitate data access, the AYK SSI needs to provide for a spatially-explicit and web-based data management system. The Alaska Regional Library Information Service may be able to serve this function, along with making project reports and papers available to the public as described above in Section 9.9. However, the STC recommends a study be undertaken to determine how the AYK SSI data and informatics can be managed in the most efficient and user-friendly way possible. Because other salmon studies are already funded and in progress, developing a means to meet this pressing need must be done as soon as possible.

Chinook Salmon

(Oncorhynchus Tshawytscha)



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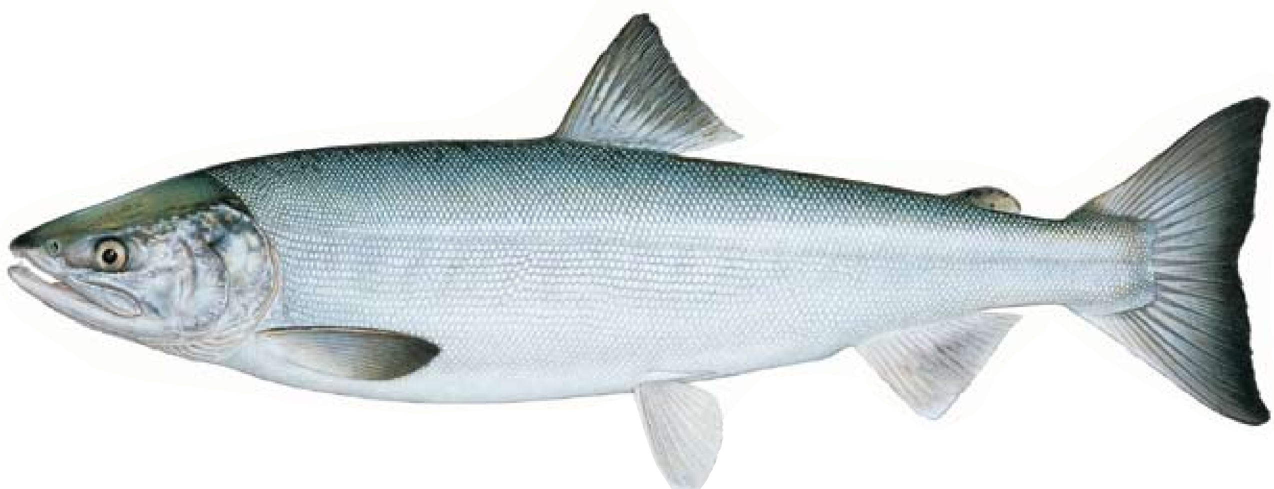
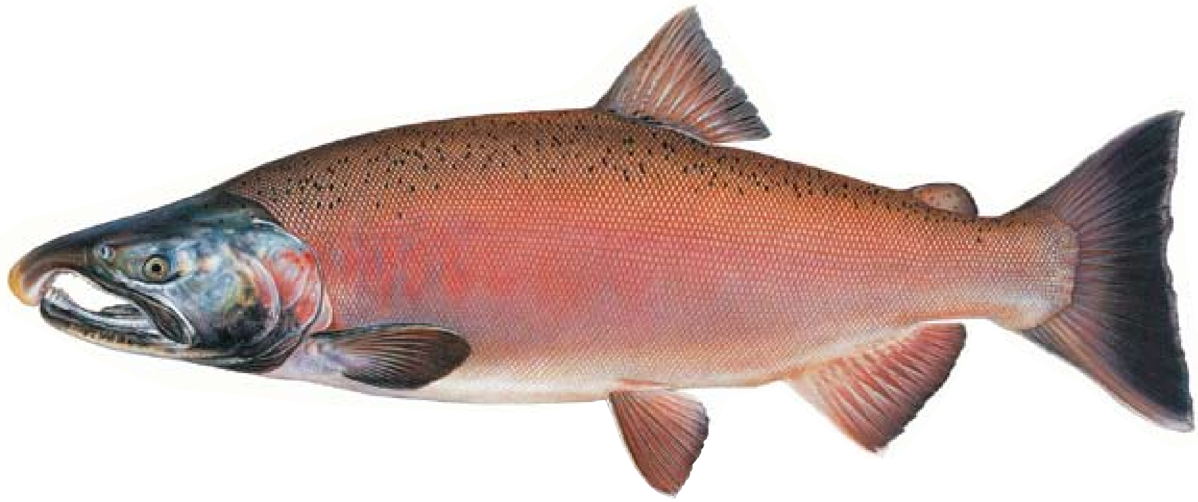
Chum Salmon

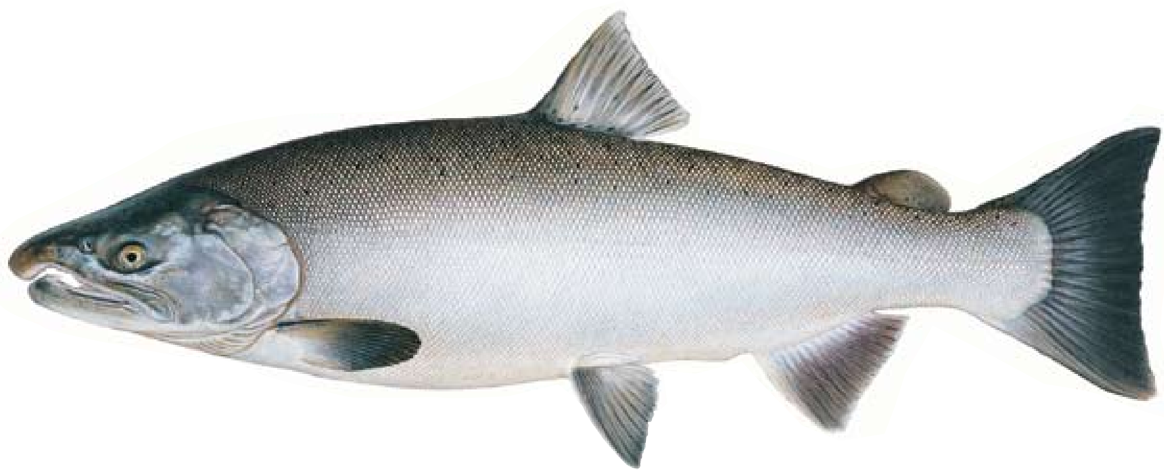
(Oncorhynchus Keta)



Coho Salmon

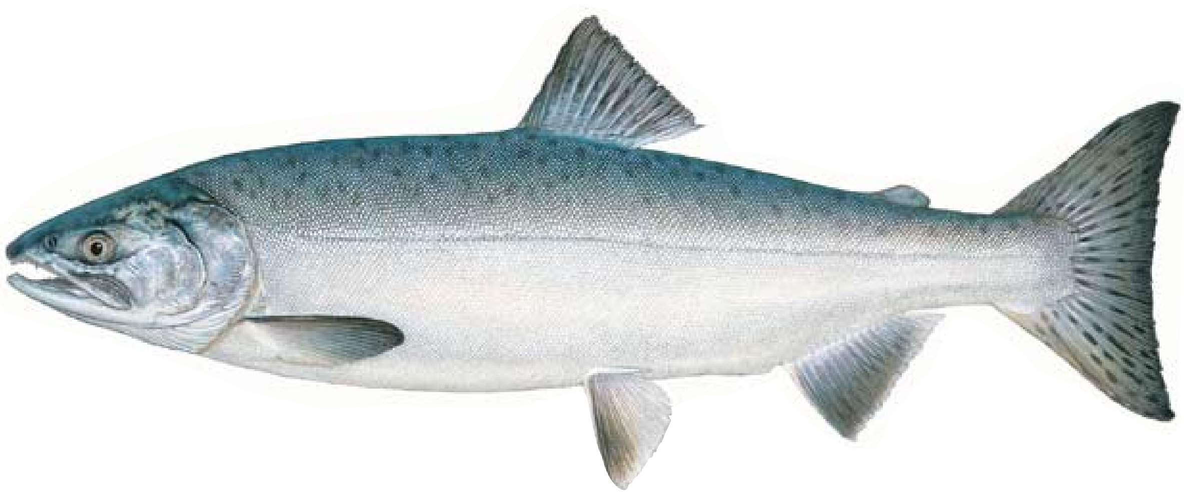
(Oncorhynchus Kisutch)





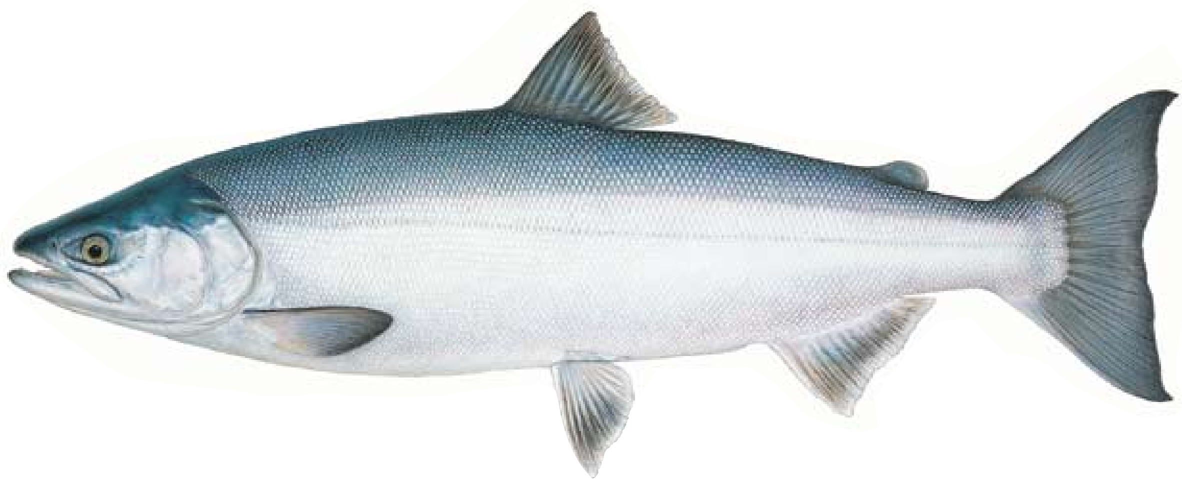
Pink Salmon

(Oncorhynchus Gorbuscha)



Sockeye Salmon

(Oncorhynchus Nerka)



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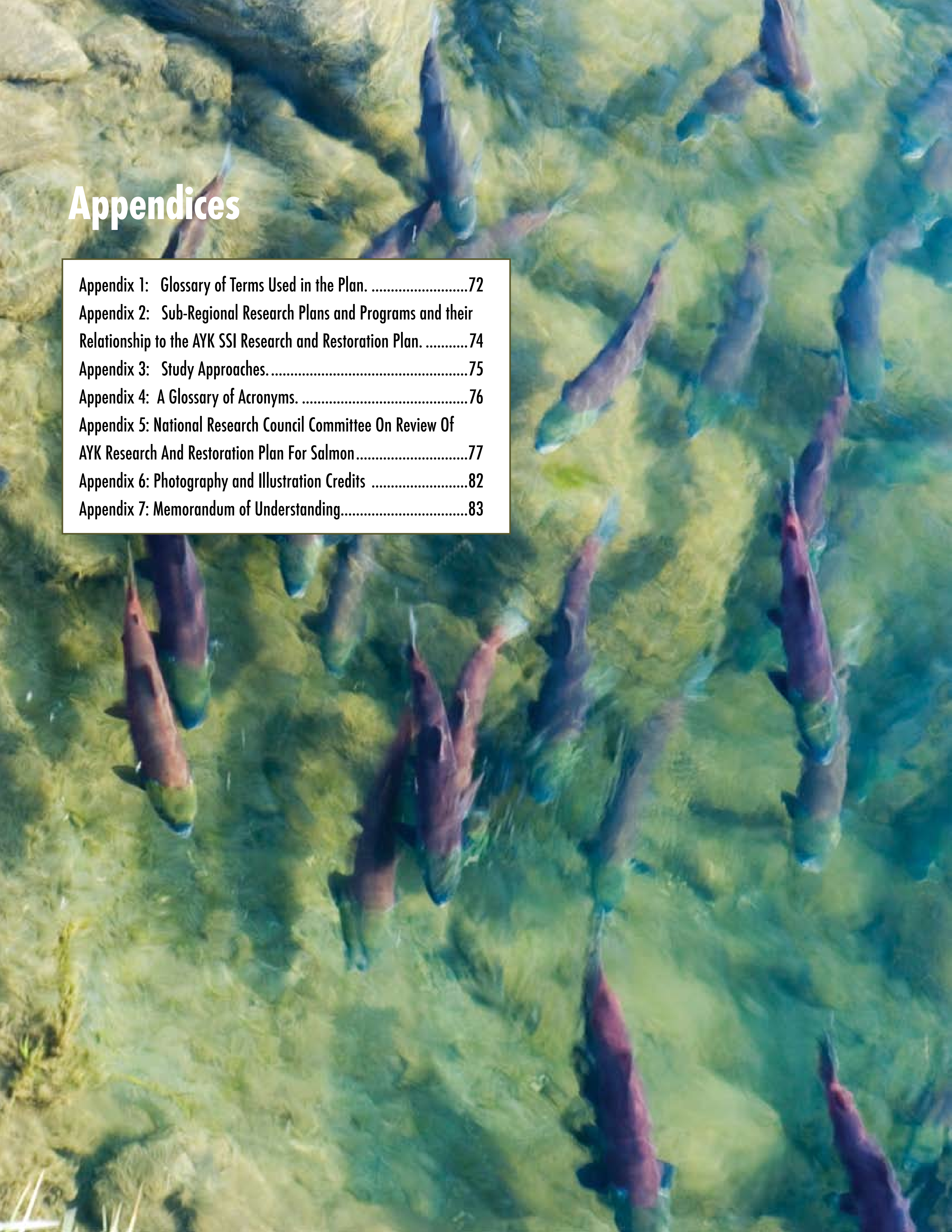

Appendices

Appendix 1:
Glossary of Terms Used in the Plan

Adaptive management
An approach to resource management where management policies and actions are used as a tool not only to change the system, but for managers and others to learn about the system (e.g., Walters, 1986). Under this approach, management interventions are designed as experiments to test key hypotheses about ecosystem functionality and to improve our understanding of how the ecosystem responds to change.

Capacity
The ability of individuals and organizations or organizational units to perform functions effectively, efficiently, and in a sustainable manner.

Capacity Building in the AYK SSI Program
The process by which rural/tribal groups, organizations, and non-governmental organizations (NGOs) expand and develop technical and administrative abilities, enabling them to participate in a range of fishery research activities.

Climate
The average state of the atmosphere and the underlying land and oceans, on time scales of seasons and longer.

Ecosystem
All elements (atmosphere, ocean, ice, freshwater, nutrients, viruses, bacteria, flora, and fauna) and the processes which connect them in the region occupied by AYK salmon. In this context, humans act as both apex predators and as a source of forcing throughout the ecosystem.

Ecosystem-based management
An approach which establishes policies to address human-induced impacts with the goal of conserving the structure and function of entire ecosystems, including sustaining fishery resources. An approach which seeks to manage resources by focusing on the entire ecosystem rather than on individual species or ecosystem components.

Ecosystem services
Food, fibers, and fuels, as well as spiritual, recreational, educational, and numerous other nonmaterial benefits to people provided by the ecosystem.

Enhancement
Enhancement (or supplementation) refers to the artificial propagation and stocking of salmon in streams which contain natural or native runs of salmon. This action is typically done through the collection of gametes from returning mature adults, fertilization, and incubation in a hatchery environment. In some cases, fertilized eggs are planted in spawning gravels or held until they hatch or are reared until they are the size of typical smolts and released to migrate downstream.

Forcing
Changes in the position or state of a thing or entity caused by the influence of power, energy, or other means. Forcing can be manifested by either natural phenomena (e.g., wind-forced currents, El Nino events) or human action (e.g., fishery harvests, habitat alteration or loss). The term "driver" is used to identify the power, strength, or energy which causes the change.

Population
Because the term "stock" has been used by others to describe interbreeding groups and also to mean aggregations of groups which are managed as a unit, the term "population" is used in this Plan to describe local breeding aggregations. A population is a group of "…fish spawning in a particular lake or stream [or portion of it] at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season." (Ricker 1972).

Resilience
An inherent property of an ecosystem which emphasizes its dynamic nature. Ecosystems exist in semi-stable states (not a stable steady state), where forcing (internal or external) can shift them into another regime of behavior, i.e., to another semi-stable state (Holling, 1973). Resilience is measured by the magnitude of disturbance which can be absorbed before the system redefines its structure by changing the variables and processes which control behavior (Gunderson et al. 2002).

Restoration
Ecosystem restoration refers to natural resources management which initiates, facilitates, or accelerates the recovery or re-establishment of native species and ecosystem processes to their historic or pre-disturbance state. Including human interactions with the ecosystem during the development of restoration management strategies is essential for long-term sustainability of restored systems.

Stakeholders
Beneficiaries, especially groups of beneficiaries, of a particular fish and wildlife resource. Included as stakeholders are those who are affected by a resource management regime, as well as those who make decisions about how the resource is governed.

Salmon Stock
A locally interbreeding group of salmon which is distinguished by a combination of genetic, phenotypic, life history, and habitat characteristics or an aggregation of two or more interbreeding groups which occur within the same geographic area and are managed as a unit (Alaska State Policy for the Management of Sustainable Salmon Fisheries).

Supplementation
Supplementation (or enhancement) refers to the artificial propagation and stocking of salmon in streams which contain natural or native runs of salmon. This action is typically done through the collection of gametes from returning mature adults, fertilization, and incubation in a hatchery environment. In some cases, fertilized eggs are planted in spawning gravels or held until they hatch or are reared until they are the size of typical smolts and released to migrate downstream.

Expanded definition of the term "stock":
The term "stock," has been variously applied to salmon. Definitions used for stock have varied somewhat by different authors and over time to meet specific purposes. This variable usage can be confusing. Salmon stock definitions can be divided into two distinct usages: biological and management. Ricker (1972) defined stock in biological terms as, *"...the fish spawning in a particular lake or stream (or portion of it) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season."*

In terms of fishery management, Mundy and Mathisen (1981) defined a stock as *...an aggregate of spawning populations of salmon originating from the same watershed or from several geographically contiguous watersheds upon which fishery management actions are implemented.*

These definitions of stocks are consistent, but not synonymous, with the definition of a *deme* (NRC 1996). The term *deme* is properly applied to a group of reproductively-isolated, freely-interbreeding individuals, spawning in a single locality (NRC 1996). In practice, "stock" as used in this Plan, can be single demes but more commonly refers to aggregations of demes characterized by the sites from which their individual escapement counts are obtained. Although, use of a common definition for stock was attempted, it is important the reader recognize the term stock can have more than one meaning.

References used in the definition of stock in the above paragraph:

Mundy, P. R. and O. A. Mathisen. 1981. Abundance estimation in a feedback control system applied to the management of a commercial salmon fishery. Applied Operations Research in Fishing. K. B. Haley. New York, New York, USA. Plenum Publishing Corp.: 81-98.

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Appendix 2:
Sub-Regional Research Plans and Programs and their Relationships to the AYK SSI Research and Restoration Plan

The region covered by the AYK SSI crosses many jurisdictional and organizational boundaries. Within this region, several governmental and non-governmental organizations are directly responsible for management or investigation of salmon and the salmon ecosystem and, therefore, overlap the AYK SSI research themes. Examination of other research plans and institutional programs relative to the AYK SSI research themes helps to identify gaps and addresses the first two criteria required for setting priorities as defined above. Research plans or programs currently underway in Alaska or the North Pacific Ocean have influenced the structure and content of the AYK SSI planning process.

In preparing this Plan, the following research plans were examined:

- Norton Sound Sustainable Salmon Research and Restoration Plan
- Kuskokwim Area Salmon Research Plan
- Yukon River US Canada Joint Technical Committee Plan
- North Pacific Research Board (NPRB)
- Gulf of Alaska Ecosystem Monitoring and Research Program – Science Plan
- Bering Ecosystem Study (BEST)

Relevant institutional programs analyzed include:

- Alaska Department of Fish and Game (ADF&G) – Commercial Fish Division
- ADF&G – Sport Fish Division
- ADF&G – Subsistence Division
- Bering Sea Fishermen's Association
- Department of Interior, Federal Office of Subsistence Management – Fisheries Resource Monitoring Program
- Regional Native Nonprofits including:
  - Association of Village Council Presidents
  - Tanana Chiefs Conference
  - Kawerak, Inc.
  - Kuskokwim Native Association
  - Council of Athabascan Tribal Governments
- North Pacific Anadromous Fish Commission/ Bering-Aleutian Salmon International Survey (BASIS)
- Yukon River Drainage Fisheries Association

The sub-regional plans played an important role in developing the Plan through identification of existing information, information needs, and priorities. These plans will continue to play an important role in the implementation of the AYK SSI Research Program. For example, the Kuskokwim Area Salmon Management Plan was instrumental in defining hypotheses, key variables, and questions throughout the Plan. The Chair of the AYK SSI Scientific and Technical Committee served as a liaison to the Kuskokwim Fisheries Research Coalition and attended meetings and conference calls as the Plan was developed. This ensured information about both planning efforts flowed in both directions. Additionally, the consultant hired by the KFRC to draft the Kuskokwim plan was hired to work with the drafting committee of this Plan.

Not only did the sub-regional plans have an influence on the contents of the Plan, they will continue to serve as important documents directing research and management efforts within each region. For example, during the 2006 call for proposals, the AYK SSI received a proposal to develop a run reconstruction of Chinook salmon in the Kuskokwim River. The proposal addressed both the AYK SSI priorities and the KFRC priorities (KFRC 2006). Specifically, the proposal addressed retrospective analyses requested in the AYK SSI RFP and addressed several priorities identified in the KFRC (2006) plan. As illustrated the sub-regional plans will continue to play an important role in directing research within each of the sub-regions (both programmatic research and AYK SSI research).

Appendix 3:
Study Approaches

Monitoring

Monitoring provides for detecting and assessing the influences of human-induced and/or natural change on an ecosystem or its individual components. Monitoring also provides raw materials for hypothesis development regarding ecological processes. The collection of physical, biological, and/or socio-economic aspects of the ecosystem and development of indices of ecosystem status from time series can be valuable. Further, monitoring also serves as a venue for incorporation of LTK, community involvement and capacity building. However, the value of monitoring studies is through the eventual retrospective analyses of time-series data collected over decadal or longer scales. Any monitoring project supported by the AYK SSI must be well conceived, because the AYK SSI has a finite lifetime (less than the period of decadal regime shifts). Projects of this nature should be able to demonstrate they will yield retrospective analyses over ecologically significant time scales about processes crucial to understanding variations of salmon and sustaining fisheries.

Process Studies

Process studies help to identify processes, mechanisms, and rates crucial to salmon population dynamics and can be conducted either in a conceptual model or as field studies. Field studies provide the data to empirically test processes defined in conceptual models or in computer models. Studies which identify critical periods of mortality, the variables which control the intensity of the mortality, and their relative importance over the life cycle of the salmon represent high-priority field studies. A conceptual model based on processes likely to affect survival during sequential life-history periods explained a significant (75%) amount of the variation in Oregon coho survival (Logerwell et al. 2003). These authors noted, "Process-oriented field studies are needed to identify these mechanisms and how they function and elucidate direct links between oceanography, marine habitat, food availability and survival, and/or whether predator dynamics interact with the ocean processes." Petersen and Kitchell (2001) also used a conceptual model to examine the potential impact of freshwater temperatures (a function of climate) on predation of young salmon. In a similar approach for chum salmon survival in the Yukon and Kuskokwim rivers, Shotwell et al. (2005) used time series of environmental parameters (both monitored observations and model simulation products) to account for survival rates. Process-oriented studies are also used to determine the functional form of biophysical processes, e.g., how turbulence affects feeding by larval fish (Megrey and Hinckley 2001). Such information is essential to modeling of salmon population dynamics.

Retrospective Studies

Retrospective studies examine existing observations to improve our understanding, including the time and space scales of ecosystem change, and their impacts on various populations, including humans (e.g., salmon productivity by Finney et al. 2000, 2002). Further, such studies can lead to new or refined hypotheses of how a given system functions. It would be important to know, for example, how the dominant regional climate patterns (e.g., the Northern Annular Mode [AKA Arctic Oscillation], North Pacific sea surface temperature) manifest on time/space scales important to a particular life-history stage of AYK salmon. The potential value of retrospective studies of atmospheric parameters and sea ice behavior is evident in its contribution to the development of the Oscillating Control Hypothesis for energy flow over the shelf of the southeastern Bering Sea (Hunt et al. 2002). A more recent analysis of sea ice observations from the eastern Bering Sea for 1972-2003 found there have been five distinct patterns of ice retreat during May (McNutt et al. 2004). Retrospective studies can also develop indicators of ecosystem status and relate these to patterns in recruitment, with the potential for forecasting run abundances (e.g., Logerwell et al. 2003). Much is left to be learned from the existing time series of observations, particularly if viewed from an ecosystem-wide perspective and using new analytical tools.

Modeling Studies

Modeling provides a tool to synthesize the various results from monitoring, process, and retrospective studies into reasonable explanations of the causes of changes in various salmon populations. Goodman et al. (2002) describes some of the aims and uses of models in fisheries research: "Models can take a large variety of forms, but in essence they all serve the same purpose–they allow thoughts, theories, and data (observations of the world) to be organized and simplified such that complicated issues can be cut through and clear logic applied. Theoretical models may be used to follow through to logical conclusions. Statistical models may be used to 'fit' data and estimate parameter values (fixed numbers) to be used elsewhere. Simulation models may be used to combine theory, knowledge and data to consider what might be and to ask 'what if?' questions. Models as used in ecology and fisheries are often highly complex, using state-of-the-art mathematics, statistics, and computing approaches, but they always represent major simplifications of real systems." Modeling can be as simple as a conceptual model or as complex as three-dimensional coupled physical-nutrient-biological or ecosystem simulation models. All can be used to provide insight, to generate new hypotheses, and to enhance our understanding of the salmon and its ecosystem. Modeling is a high priority, because it is the method for turning basic data into useful information for managers, policy makers and other shareholders. According to the National Research Council (2005), "A measure of the success of the AYK SSI Research and Restoration Program is that results from research will lead to the ability to predict changes to the ecosystem, including the abundance of returning adult salmon. These predictions are essential for fisheries management and for maintaining the health and vigor of Alaska's ecosystem, including its Peoples." This metric of success requires the development of models which can digest observations and simulations from other models to generate potential outcomes (e.g., the abundance of recruits) under various scenarios of physical and/or biological forcing. See Aydin (2002) for a sample summary of physical and biological models in the North Pacific and Bering Sea.

Appendix 4:
Glossary of Acronyms

ADCED: Alaska Department of Community and Economic Development

ADF&G: Alaska Department of Fish and Game

AVCP: Association of Village Council Presidents

AYK: Arctic-Yukon-Kuskokwim

AYK SSI: Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative

BASIS: Bering-Aleutian Salmon International Survey

BEST: Bering Ecosystem Study

BSFA: Bering Sea Fishermen's Association

EVOSTC: *Exxon Valdez* Oil Spill Trustee Council

FGDC-STD: Federal Geographic Data Committee-Standard for Digital Geospatial Metadata

GEM: Gulf Ecosystem Monitoring and Research

KFRC: Kuskokwim Fisheries Research Coalition

LTK: Local and traditional knowledge

NGO: Non-governmental organization

NOAA: National Oceanic and Atmospheric Administration

NPFMC: North Pacific Fisheries Management Council

NPRB: North Pacific Research Board

NRC: National Research Council

NSSRP: Norton Sound Sustainable Salmon Research and Restoration Plan

NSSTC: Norton Sound Scientific Technical Committee

ODFW: Oregon Department of Fish and Wildlife

OSM/FIS: Office of Subsistence Management / Fisheries Information Service

RFP: Request for proposals

RRP: (AYK) Research and Restoration Plan

SC: Steering Committee

SST: Sea Surface Temperature

STC: Scientific Technical Committee

TCC: Tanana Chiefs Conference

USFWS: US Fish and Wildlife Service

Appendix 5:
National Research Council Committee on Review of AYK (Western Alaska) Research and Restoration Plan for Salmon

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Appendix 6:
Photography Credits

Cover Page
Salmon swimming upstream
(Photographer unknown)

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Juvenile chum salmon, Kuskokwim Bay, Alaska
(Photo by Christian E. Zimmerman)

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Amanda Goods and Rosalie Perkins on the Takotna River identifying juveniles
(Photo by Clinton Goods)

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Swimming salmon
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Amanda Goods collecting age, sex and length data
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Alaskan Coho
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Momentarily trapped
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Jason Baker and Scott MacLean bringing in a beach seine near Emmonak
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Mature chinook salmon befriending juvenile coho salmon
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Salmon swimming upstream
(Photographer unknown)

AYK Sustainable Salmon Initiative

Memorandum of Understanding

I. Introduction

Salmon returns to western Alaska have been in decline for more than a decade, and the pace of decline has accelerated in recent years. Poor returns of Chinook and chum salmon to the Yukon River, Kuskokwim River, and rivers draining into Norton Sound, (collectively known as the AYK Region) have led to severe restrictions on commercial and subsistence fisheries and to repeated disaster declarations by the state and federal governments. The commercial Chinook harvest on the Yukon River in 2000 was less than 10% of the historical long-term average. The 2000 season followed similar low returns and disaster declarations in 1998 and 1993, and particular salmon run failures in various western Alaska locations throughout the 1990s. In the Norton Sound region, some commercial fisheries have been closed for a decade, and many subsistence fisheries been restricted or closed.

This Memorandum of Understanding has grown from a unique collaboration among regional Alaska Native organizations and the Alaska Department of Fish and Game. The concept of forming a body to provide direction to response efforts for the salmon failures in western Alaska developed through discussions between the Alaska Department of Fish and Game and the "AYK Coalition". The AYK Coalition is comprised of three Alaska Native organizations providing services to over 100 federally recognized Alaska Native Tribes in the AYK region: the Association of Village Council Presidents, the Tanana Chiefs Conference, and Kawerak, Inc. Also included in the coalition is the Bering Sea Fisherman's Association, a non-profit organization that has been active in AYK fisheries issues, including research, for decades. Common concerns over recent drastic declines in salmon returns coalesced into an action plan at a meeting of the parties on June 8, 2001 in Anchorage, Alaska. The culmination of the action plan is this AYK Sustainable Salmon Initiative Memorandum of Understanding (hereinafter referred to as AYK SSI MOU).

II. Purpose

The purpose of the AYK SSI MOU is to provide a mechanism for its signatories to engage in a collaborative effort to develop and implement a comprehensive research plan for the AYK region utilizing the $5 million appropriated for this initiative by Congress for federal fiscal year 2002 (Pacific Coastal Salmon Recovery Fund), and any other funds appropriated or otherwise dedicated to this initiative. The two committees formed by the AYK SSI MOU will develop and implement the AYK Salmon Research and Restoration Plan (hereinafter referred to as the Research and Restoration Plan).

III. Guiding Principles

• Funds available for AYK salmon research and restoration should be spent in a manner to obtain the greatest good for the fisheries and users in the AYK area and the ecosystems upon which they depend. This includes the use of traditional and cultural knowledge, participatory research, and capacity building. The AYK region for the purpose of this MOU encompasses the service delivery areas of Kawerak, Association of Village Council Presidents, Tanana Chiefs Conference and the near and off shore areas of river drainages flowing into, the Bering Sea north of Cape Newenham and south of Shishmaref.

• To maximize the use of available funds, they shall be used to the degree possible and consistent with this MOU, in coordination with other fishery agencies, funding sources and plans. Other agencies include the U.S. Geological Survey, Yukon River Drainage Fisheries Association, National Park Service, the Bureau of Land Management, the Council of Athabascan Tribal Governments, U.S./Canada Yukon River Joint Technical Committee, the North Pacific Research Board, the North Pacific Anadromous Fisheries Commission, and the Gulf Ecosystem Monitoring program. Collaborative research jointly funded with such entities should be undertaken to the maximum extent practicable.

The intent of this MOU is not to duplicate past or existing research but to add to current expenditures in the AYK area for fishery research. Thus, it is the intent that funds administered under the MOU not be viewed as a source to replace funding for research and management projects that were ongoing at the time this MOU was entered into or were undertaken after the MOU was in place without the involvement of or funding by the AYK SSI. It is particularly important that the funds administered pursuant to this MOU not be viewed by agencies and organizations as a means to shift budget priorities to other issues while relying on AYK SSI funds as replacement funds for conducting long-standing, routine, in-season fishery management projects in the AYK. There may be cases, however, where a funding source is no longer available for an ongoing research or management project the continuation of which is important to fulfilling the goals of this MOU. It is therefore the intent of this MOU that a party seeking replacement funds for an ongoing research or management project demonstrate to the Steering Committee that prior funding sources for the project are no longer available in sufficient amounts to conduct the project and the reasons why such funding sources are no longer available and that; 1) the project clearly satisfies the requirements and objectives of this MOU and the Research and Restoration Plan once adopted; 2) the agency or organization seeking replacement funding for a current project is contributing the maximum amount (either in money or in-kind contributions or both) that it can reasonably make available to the project taking into consideration its funding sources and other responsibilities; and 3) the agency or organization seeking replacement funding has in good faith sought funding for the project from other reasonably available sources. Moreover, the Signatories to this agreement agree to continue to actively seek other funds to undertake necessary fishery research regarding AYK salmon and shall make an annual report to the parties of this agreement of such efforts.

• Available funds shall be used for research and restoration consistent with the Research & Restoration Plan for AYK salmon stocks developed through the Scientific and Technical Committee Steering Committee process described below.

• Development of the Research & Restoration plan shall take into account existing research plans of the region and shall be based upon recommendations forwarded by a Scientific and Technical Committee (STC) of disciplinary experts. The STC shall be composed of members that represent relevant scientific disciplines. STC members will exercise, to the greatest degree possible, their independent judgment about research and restoration needs and priorities. The Research and Restoration Plan shall be a comprehensive plan that identifies research needs and priorities including freshwater, near shore and marine phases of AYK salmon stocks.

• Decisions regarding adopting and implementing the Research and Restoration Plan, shall be made by an eight member Steering Committee composed of regional, state and federal representatives. The Steering Committee shall make its final decisions only after reviewing comments and recommendations made by the public and the Scientific and Technical Committee on preliminary decisions. The Steering Committee shall allow adequate time and resources to ensure the spirit of this initiative and an open process.

• The Research and Restoration Plan will go beyond providing a single, static prescription of research activities. Instead, it will provide an ongoing process whereby research activities are guided, selected, reviewed and modified over time to reflect the outcome and knowledge obtained from research and restoration activities.

IV. Steering Committee

1. Membership

The Steering Committee membership will consist of eight members selected by the following agencies or organizations (one member each except ADF&G: one biologist, one social scientist from the Subsistence Division):

Association of Village Council Presidents

Kawerak, Inc.

Tanana Chiefs Conference

Alaska Department of Fish and Game

U.S. Fish and Wildlife Service

National Marine Fisheries Service

Bering Sea Fishermen's Association

Once the initial members are appointed, the Steering Committee shall adopt bylaws that will govern the appointment or election and term of the Chairperson, quorums, appointment of alternates, and other matters necessary for governing the Steering Committee.

2. Steering Committee Decision-Making Process

A consensus decision making process will be used by the Steering Committee. A separate, non-voting Scientific and Technical Committee (STC) shall make recommendations to the Steering Committee. The formations and responsibilities of the STC are detailed in Section 5 below.

3. Steering Committee Responsibilities

The Steering Committee shall adopt a Research and Restoration Plan for the AYK salmon fisheries after considering the recommendations of the STC. The Steering Committee shall:

• Make decisions on how available funding shall be expended. In making decisions to expend funds for research or management projects prior to adoption of the AYK Research and Restoration Plan, the Steering Committee shall, after considering the recommendation of the STC, base such decisions on which projects will provide the most benefit to the fisheries and users in the AYK area and the ecosystems upon which they depend.

• Exercise its authority by deciding the scope, timing, amount and other necessary elements for all grants or other applications necessary to secure appropriated funds, and any modifications thereto. Projects authorized by the Steering Committee shall further specify research and restoration goals of the approved plan. The Steering Committee shall formally review and approve any proposal and any amendment thereto prior to submittal to the funding source.

• Have all necessary authority to solicit projects, work with scientific or other experts, identify and prioritize projects for funding, review project results, and ensure data and results are freely available to the public.

• Require the timely completion of projects and facilitate the communication of research results to other interested agencies and individuals annually.

• Appoint six STC members from nominations from the signatories and other interested parties. The nomination process, membership and disciplinary balance of the STC are described below in Section 5.

• Review and approve reports to the Secretary of the Department of Commerce (or other funding agency) concerning the results of research conducted through the Research and Restoration Plan.

• Ensure the public is provided the opportunity to participate in Steering Committee meetings and to review and comment on proposed projects.

• The Steering Committee shall ensure the efficient and effective expenditure of funds. Whenever possible, projects shall be coordinated with other related research and restoration projects. Jointly funded research projects that meet the goals and priorities set by the Steering Committee shall be solicited.

4. Fiscal Responsibility

Fiscal responsibility for administration of the $5 million appropriated for this initiative by Congress for federal fiscal year 2002 (Pacific Coastal Salmon Recovery Fund) rests with the State of Alaska. Expenditures of these funds will be in accordance with the fiscal procedures and procurement policies of the State of Alaska. As a signatory to the MOU, State of Alaska agrees, as allowed by law, to expend these funds in accordance with the decisions of the Steering Committee.

5. Steering Committee Meetings

The Steering Committee shall meet as necessary to fulfill its responsibilities and conduct business.

Meetings of the Steering Committee shall be open to the public, and the public shall be provided reasonable notice of official meetings.

Meetings shall include, to the greatest degree practicable, participation by organizations active in fisheries research and restoration issues. Such organizations include, but are not limited to, the North Pacific Research Board, the Exxon Valdez Oil Spill Trustee Council, the Northern Fund of the Pacific Salmon Commission, and the Southeast Sustainable Salmon Initiative. These organizations shall be given reasonable notice of all meetings. Copies of all relevant STC recommendations, grant applications, project results and other information will be provided to these organizations and the public upon request. Comments, and direct participation when appropriate, shall be actively solicited from these organizations on relevant issues before the Steering Committee.

Notice of meetings and copies of relevant grant applications, project results and other information shall be provided to the Alaska Board of Fisheries, the North Pacific Fishery Management Council, and the Federal Subsistence Board upon request.

V. Scientific and Technical Committee

1. STC Membership

The Scientific and Technical Committee (STC) shall consist of six members nominated by the signatories to this MOU and the public. The Steering Committee shall select STC members from these nominations.

Members of the STC shall be selected based upon their knowledge, expertise and ability to fulfill the responsibilities of the STC as outlined in this agreement.

Membership shall represent scientific disciplines including, but not be limited to, fisheries sciences, socioeconomic sciences, aquatic habitat restoration, fish culture, marine ecology, freshwater ecology, community and population modeling, and population genetics. Members of the STC may be employed by the signatories to this MOU, and two members shall be ADF&G employees (one biologist, one social scientist from the Subsistence Division). However, no more than one member may be employed by any one of these groups or a federal agency, the Bering Sea Fishermen's Association or a regional Native organization. At least two members must be selected from the private or academic sector.

In addition to relying on its official members, the STC may consult with other scientific and local-knowledge experts in the development of the Research and Restoration Plan.

2. STC Responsibilities

STC members will exercise their best independent professional judgment to advance understanding of salmon abundance and distribution in the AYK area and the fisheries they support, independent of the governmental, academic, or private sector they may represent.

The STC shall:

• Choose a Chair and Vice-Chair for the STC by consensus. The Chair will work closely with the Chair of the Steering Committee. The Vice Chair will act in the capacity of the Chair whenever the Chair is absent from a meeting.

• Within 12 months of the inception of the STC, develop an initial Research and Restoration Plan for AYK salmon fisheries that is consistent with the Guiding Principals of the MOU, and recommend this plan to the Steering Committee. The plan shall identify research needs, , ensure the efficient expenditure of funds, not duplicate but complement other relevant research, and recommend research priorities.

• Develop recommendations for restoration projects that will increase salmon returns to the AYK area.

• Develop a protocol for reviewing and ranking research and restoration project proposals and recommend this protocol to the Steering Committee.

• Evaluate suggested projects based on their merit and make recommendations to the steering committee.

• Regularly review the research and restoration plan and ongoing projects throughout the life of this MOU, including reviewing project design and the utility of continuing ongoing projects, and make relevant recommendations to the SC to ensure research and restoration is conducted effectively and efficiently, and make recommendations for augmenting, updating and revising research questions including regular review of the Research and Restoration Plan.

VI. Support for the Steering Committee and STC

The following support activities will be paid from funds appropriated for this effort:

• Travel and accommodation expenses for the individuals selected to serve on the Steering Committee and the Scientific and Technical Committee.

• Professional Service fees for academic and private sector involvement on the Steering Committee and STC and support services for committee activities.

• Logistical support for the meetings of the Steering Committee and the Scientific and Technical Committee, the coordination of communication and public outreach efforts, administrative support and the hiring of staff.

VII. Mutual Agreement and Understandings

It is mutually agreed that:

• Nothing in this agreement obligates any party in the expenditure of funds, or for future payments of money, in excess of appropriations authorized by law and administratively allocated for these purposes.

• Nothing in this agreement is intended to conflict with federal, state, or local laws or regulations, or international treaties or agreements. If there are conflicts, this agreement will be amended at the first opportunity to bring it into conformance.

• External policy and position announcements relating specifically to this agreement maybe made only by mutual consent of the signatories.

• All signatories shall meet on at least an annual basis to discuss matters relating to this agreement. Many of the criteria and assumptions contained in this agreement are interim assumptions and subject to further refinement. Signatories may request an earlier review. No revision shall be binding to signatories without the written consent of all signatories; provided that a revision that is proposed by the Steering Committee shall become effective 30 days after the Signatories and Steering Committee members are notified of the proposed revision if a majority of the Signatories have consented in writing to the proposed revision and no Signatory has delivered a written objection to the proposed revision.

• The effective date of this agreement shall be from the date of the final signature.

• Any signatory may terminate its participation in this agreement by providing to the other parties notice in writing 30 days in advance of the date on which its termination becomes effective. However, the State of Alaska agrees that in the event the State were to terminate early, the State will again initiate discussions with the parties, with the intent of developing an alternative research and restoration agreement. The State will not unilaterally proceed with a research using funds appropriated or otherwise dedicated for this sustainable salmon initiative in the absence of an agreement among signatories.

VIII. Signatures

Frank Rue, Commissioner
Alaska Department of Fish and Game

Arthur Lake, President
Association of Village Council President

David Allen, Regional Director
United States Fish & Wildlife Service

Loretta Bullard, President
Kawerak Incorporated

Jim Balsiger, Alaska Region
National Marine Fisheries Service

Steve Ginnis, President
Tanana Chiefs Conference

Adelheid Herrmann, Executive Director
Bering Sea Fishermen's Association

Prepared by the Arctic Yukon Kuskokwim Sustainable Salmon Initiative
Scientific and Technical Committee

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