PROTECTING THE FUTURE OF SALMON

ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

RESEARCH & DISCOVERY REPORT 2002–2010

AYK SUSTAINABLE SALMON INITIATIVE

MEMORANDUM OF UNDERSTANDING

ENACTED ON FEBRUARY 21, 2002

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 & Restoration Plan (hereinafter referred to as the Research & 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 & 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 Technical Committee and Steering Committee processes 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 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 & 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 & 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 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 & 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 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 & 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 & 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 & 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 TECHNICAL COMMITTEE

1. STC Membership

The Scientific 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 & 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 & Restoration Plan for AYK salmon fisheries that is consistent with the Guiding Principles 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 & 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 & 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 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 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 may be 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.

2002–2010

RESEARCH & DISCOVERY REPORT

ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

AYK SUSTAINABLE SALMON INITIATIVE

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THE AYK SSI ACKNOWLEDGES…

THE NORTH PACIFIC RESEARCH BOARD AND STAFF FOR THEIR INSPIRATION, COOPERATION, AND SUPPORT.

ANDROMEDA ROMANO-LAX FOR HER METICULOUS SCIENCE WRITING CAPABILITIES.

MIKE KIRKPATRICK WITH SCREAMIN'YETI DESIGNS (SYD) FOR HIS CONTRIBUTIONS TO THE DESIGN AND GRAPHIC ELEMENTS.

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AYK SUSTAINABLE SALMON INITIATIVE

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CHRISTIAN E. ZIMMERMAN

PROTECTING THE FUTURE OF SALMON:

AN INNOVATIVE PARTNERSHIP ADDRESSING THE URGENT RESEARCH NEEDS FACING OUR REGION

Salmon runs of the Arctic-Yukon-Kuskokwim (AYK) region have been critical to the survival of the people and wildlife for thousands of years. Over eighty rural communities in the region depend heavily on the harvest of salmon which forms the foundation of their subsistence diet. However, dramatic declines in salmon runs across the AYK region over the past decade have led to restrictions on subsistence fishing and closure of many commercial fisheries. Since 1997, the unexpected and dramatic declines of AYK salmon runs prompted a total of 16 disaster declarations in different watersheds within the region by the State of Alaska and federal agencies. As a result, harvest restrictions, including those during the 2010 season, have created tremendous hardships for the communities in a region with the highest subsistence dependence on salmon in the state, coupled with some of the lowest incomes in the state.

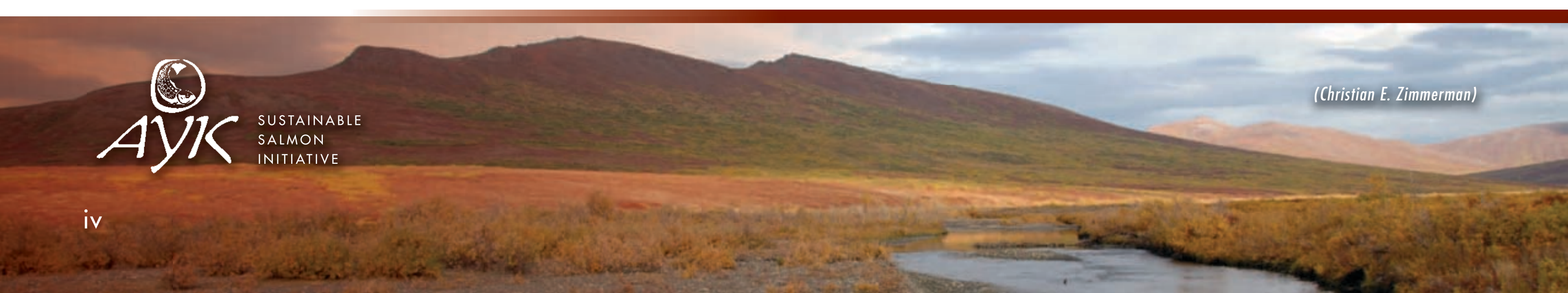
In response to these declines, regional Native organizations joined with state and federal agencies to create the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI), a proactive science-based program working cooperatively to identify and address the critical salmon research needs facing this region.

Created via a Memorandum of Understanding in 2002, this innovative partnership includes: Association of Village Council Presidents (AVCP); Tanana Chiefs Conference (TCC); Kawerak, Inc.; Bering Sea Fishermen's Association (BSFA); Alaska Department of Fish and Game (ADF&G); National Oceanic and Atmospheric Administration (NOAA-Fisheries); and the United States Fish & Wildlife Service (USFWS). The AYK SSI is governed by an eight-member Steering Committee (SC) and advised by a six-member Scientific Technical Committee (STC). To date, U.S. Congress has appropriated $20.5 million to support the AYK SSI.

The first step for the AYK SSI was to collaboratively develop and implement a comprehensive research plan to address the AYK SSI's core goal:

> ***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. (AYK SSI 2006)***

Our resulting AYK SSI Salmon Research & Restoration Plan, developed with the assistance of the National Research Council of the National Academies, identifies significant knowledge gaps and establishes a set of key research priorities that complement other relevant research programs in the region without duplication of effort. In doing so, this plan provides a science-based roadmap guiding the AYK SSI's "Invitations to Submit Research Proposals" and helps to ensure that available funds target the highest priority research questions and issues. A listing of our research priorities can be found on page 110. In addition to using a focused research plan to guide funding, the AYK SSI works to maintain the highest scientific standards for research by the consistent use of expert peer reviewers to evaluate competitive proposals.



(Christian E. Zimmerman)

COLLABORATIVE RESEARCH SUPPORTING SUSTAINABLE MANAGEMENT

The AYK SSI, with the help of our member organizations and principle investigators, is different from other approaches in several important ways. It is through this unique approach and innovative partnership that the AYK SSI has created a legacy of salmon science.

- **Collaborative Problem Solving:** While funding the highest quality salmon research, the AYK SSI remains focused on harnessing that research to understand the causes of AYK salmon declines and to support improved sustainable management of these stocks. The AYK SSI Salmon Research & Restoration Plan includes a core focus on the development of new fisheries management tools and the synthesis of information for improved forecasting.

- **Interdisciplinary:** Expanding knowledge of the causes of these salmon declines requires research on all key factors driving salmon populations. As evidenced in the following project synopses, the AYK SSI is strongly interdisciplinary, drawing on and synthesizing information from diverse fields including: population biology, freshwater and marine ecology, oceanography, genetics, modeling, statistics and social science.

- **Gravel to Gravel Research:** The AYK SSI is a unique research program dedicated to understanding the causes of the declines of salmon across both the freshwater and marine ecosystems of the region, advancing research across the entire lifecycle of the salmon.

- **Capacity Building:** Our approach to conducting research includes an integrated program to expand the capacity of Native and rural organizations to participate in and lead the salmon research we fund.

Since 2002, we have funded salmon research projects implemented by a diverse array of scientists within state and federal agencies, regional organizations, universities, non-governmental organizations and the private sector. These projects address a range of high priority hypotheses and key research questions drawn from the AYK SSI Salmon Research & Restoration Plan.

> ***By setting aside differences and working with common purpose, our seven Native, state and federal partners have created one of the largest, most diverse collaborative research efforts to rebuild salmon runs on the entire North Pacific coast.***

The project synopses which follow provide you with brief and accessible views into the depth and breadth of research that we have sponsored. We invite you to explore the work of the AYK SSI through these project synopses, and visit us on the web at www.aykssi.org.

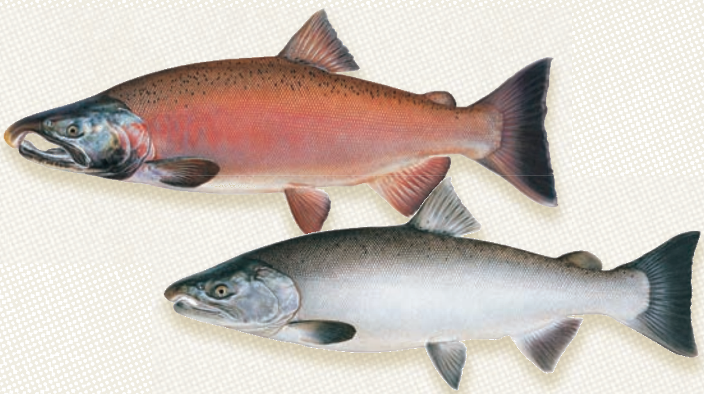
Salmon research in the AYK region has been chronically underfunded. Much work remains to be done to advance the understanding of the causes of the declines of AYK salmon stocks and to support management. The AYK SSI remains committed to our mission and looks forward to working with our partners and our community of principle investigators to continue to provide the highest level of scientific integrity within our portfolio of funded projects.

(Christian E. Zimmerman)

CHINOOK "KING" *(Oncorhynchus tshawytscha)*

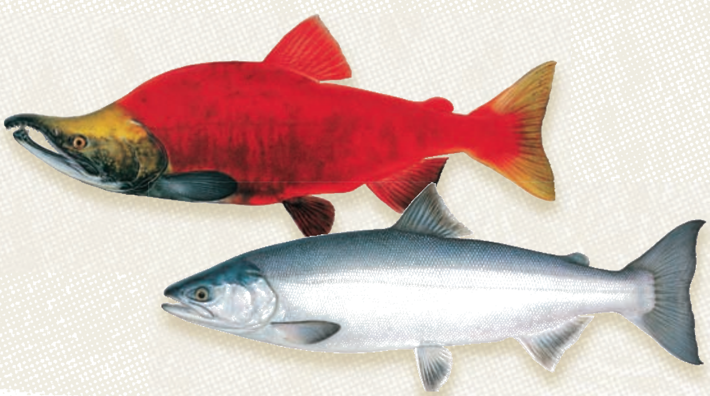
CHINOOK - OCEAN BRIGHT

COHO "SILVER" *(Oncorhynchus kisutch)*



COHO - OCEAN BRIGHT

SOCKEYE "RED" *(Oncorhynchus nerka)*



SOCKEYE - OCEAN BRIGHT

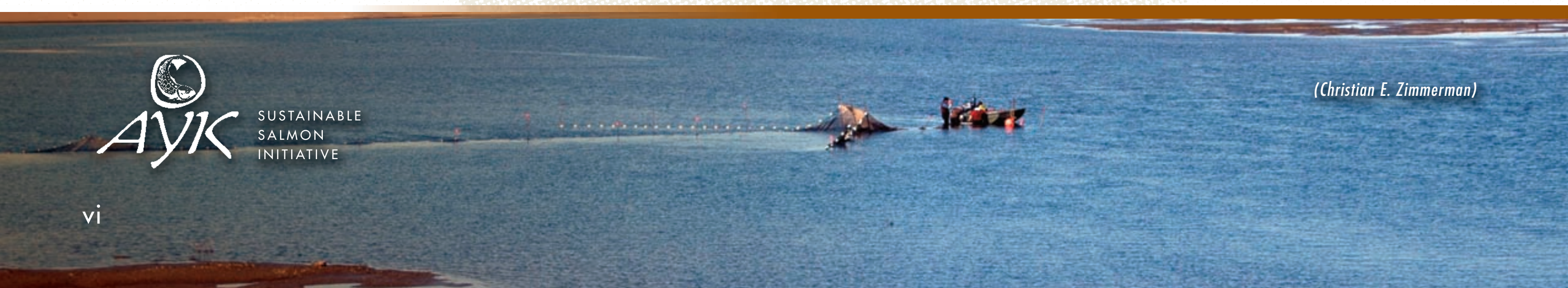
CHUM "DOG" *(Oncorhynchus keta)*

CHUM - OCEAN BRIGHT

PINK "HUMPY" *(Oncorhynchus gorbuscha)*

PINK - OCEAN BRIGHT

Illustrations © Joseph R. Tomelleri



(Christian E. Zimmerman)

(Christian E. Zimmerman)

UNCERTAINTY ANALYSIS FOR SELECTED WESTERN ALASKA CHUM SALMON STOCKS

PROJECT 303

PRINCIPAL INVESTIGATOR

Daniel Goodman
Montana State University

RESEARCH PERIOD

June 2003 - May 2004

BUDGET

$35,000.00

UNCERTAINTIES IN SALMON MANAGEMENT

Many western Alaska chum salmon stocks have experienced low productivity and reduced runs in recent years, causing hardship for subsistence users. Management of the harvests of these stocks is guided by biological escapement goals based on estimates of the maximum sustained yield. Concerns expressed about this management model have been ecological (depletion of marine-derived nutrients), statistical (stock recruitment estimates are subject to several sources of error), and environmental (lack of realism in the assumption of a constant environment).

OUR OBJECTIVES

Conduct a formal, but preliminary, uncertainty analysis for several western Alaska chum salmon stocks.

Investigate the nature of the recent productivity decline.

HOW WE DID IT

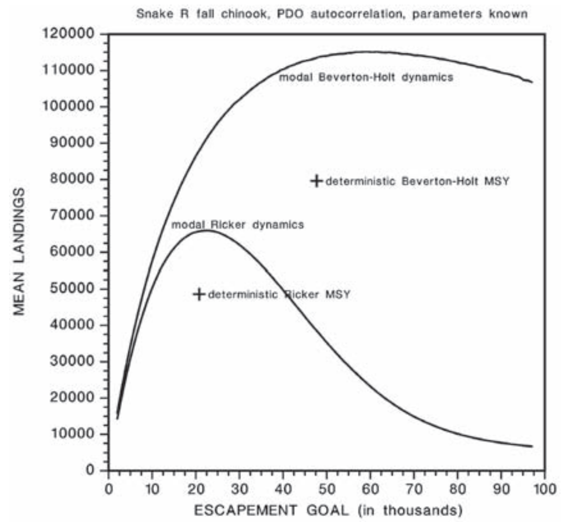
We used the stock recruitment data for summer chum salmon from the Andreafsky (1972–1995) and Anvik (1972–1997) rivers, and chum salmon stocks from the Kwiniuk River (1965–1995). We quantified uncertainties in the data for the purpose of setting escapement goals. We focused on the uncertainty about the estimate of the escapement level that is associated with maximum sustained yield, uncertainty about the recruitment rate at spawning escapements well above the unharvested

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION – *PRIORITY #8*

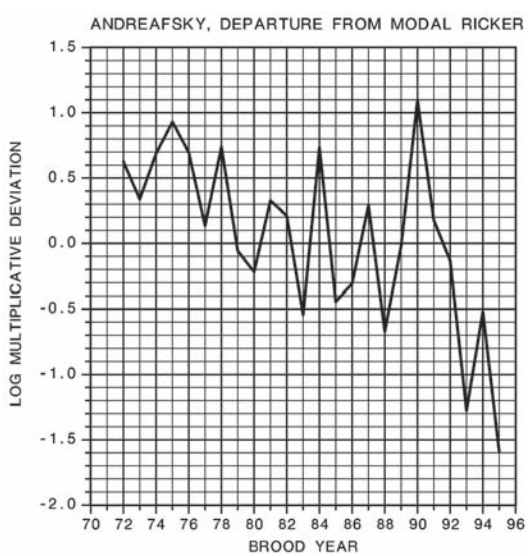
SNAPSHOT

Strong correlations in the declines of all three stocks indicated that one or more regional processes are driving the observed declines.

A formal uncertainty analysis for three western Alaska chum salmon stocks yielded no evidence of over-escapement, which fisheries managers define as an excess of salmon, beyond current escapement goals, arriving to spawn at natal rivers or streams.



Management strategy evaluation of constant escapement goal policies applied to Ricker and Beverton-Holt operating models that were fit to the same real data. (Goodman, MSU)



A very marked downward trend that is essentially linear. Biologically this tells us that the Andreafsky chum salmon stock has been experiencing a fairly continuous downward trend in productivity over the 24 year period of record. (Goodman, MSU)

equilibrium, and patterns in the departure of productivity from the expected level.

WHAT WE DISCOVERED

All three stocks show large recent declines in productivity and large uncertainty in the parameters of their stock-recruitment curves, exhibit the same, nearly linear, downward trend in the recent two decades, and all three conform to an early episode of increasing trend. These between-stock correlations in declining productivity show there is promise in a search for specific environmental variables that are the drivers of the ongoing declines and variation. There is no evidence for over-escapement in any of the three Arctic-Yukon-Kuskokwim chum salmon stocks analyzed in this study.

Additionally, all three stocks show large uncertainty in the parameters of the stock-recruitment curve, resulting in large uncertainty in setting maximum sustained yield escapements.

PRODUCTS AND OUTREACH

Our results and recommendations have been made available to Arctic-Yukon-Kuskokwim region salmon managers.

WHAT'S NEXT?

There is promise in a search for specific environmental variables that are the drivers, and to elucidate the causes of the ongoing decline and episodic deviations. The fact of the correlation indicates that the cause almost certainly includes one or more common factors operating on a regional scale—this could be a meteorological factor affecting the freshwater phase of the life history, an oceanographic factor affecting the saltwater phase, competition in saltwater, or variation in ocean harvest mortality that is not accounted for in the run reconstructions.

We recommend that managers do not decrease escapement goals in response to a trend of decreasing productivity of these stocks. This strategy will position the stocks to capitalize on higher productivity events when they occur. Some high productivity events can arise from the high frequency variation, even in the time before the long-term trend turns around. The strong correlation between the declines of the three stocks suggests a regional cause. Further study in this area would be valuable.

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

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EXPERIMENTAL DESIGN PRINCIPLES FOR SALMON POPULATIONS IN THE ARCTIC-YUKON-KUSKOKWIM

PROJECT
405

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Randall M. Peterman
Simon Fraser University

CONTRIBUTING ORGANIZATION

ESSA Technologies, Ltd.

RESEARCH PERIOD

May 2004 -
May 2005

BUDGET

$12,690.00

A REPORT CARD FOR SALMON RESTORATION

The substantial reduction in abundance of salmon in the AYK region of Alaska during the last decade had a large effect on people in this region. Despite the lack of a clear answer about the causes, there have been many suggestions about possible actions to reverse the decline. Similar attempts elsewhere on the North Pacific Rim have produced mixed results. There have been some clear successes, some dismal and expensive failures, and other cases where the outcomes were unclear. Restoration actions should be viewed as experiments, where the intent is to determine, through manipulation of the ecological system and follow-up monitoring, which approaches best achieve management objectives.

OUR OBJECTIVES

Compile a detailed overview of the principles of experimental design that are directly relevant to restoration efforts in the AYK region.

Combine these principles into a framework that can be used by managers to design projects, and by funding agencies to assess how easily the future effectiveness of proposed restoration activities for salmon can be evaluated.

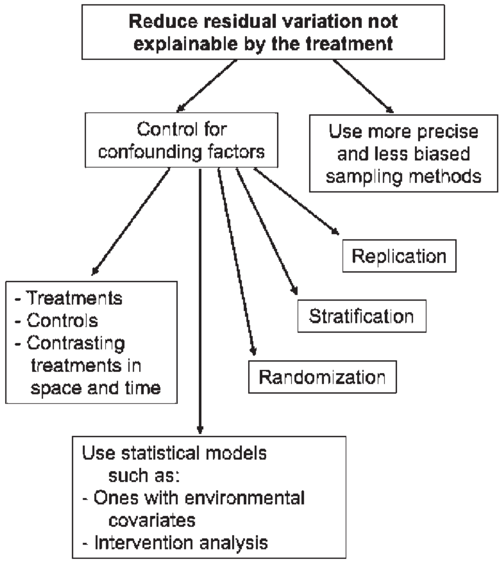
HOW WE DID IT

We reviewed past experiences and literature.
We developed our framework with two audiences in

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION –
PRIORITY #7

SNAPSHOT

This project reviewed past experiences and literature to develop a framework for the application of experimental design to salmon restoration projects in the AYK region. The framework will allow managers and funding agencies to evaluate the effectiveness of restoration actions and identify unpredicted negative effects.



Methods that could be used to reduce the residual variation that is not explainable by the treatment imposed; in particular, to reduce confounding factors. (Peterman, SFU)

mind: those conducting restoration projects and those choosing which projects to fund.

WHAT WE DISCOVERED

All restoration actions should have at least two clearly stated main objectives: achieve results in terms of salmon abundance, and determine which restoration actions work best and which do not. Restoration projects should be coordinated to minimize unintended interactions between projects, and should be part of a larger experimental design using treatments and controls. A carefully designed monitoring and evaluation program including data collection, analysis, and dissemination should be used to determine how well the projects were implemented and whether they had the intended effects. We also found that restoration programs should address habitat-forming processes rather than merely rehabilitating site-specific conditions.

The benefits of applying defined experimental design principles would be substantial, but are challenging.

PRODUCTS AND OUTREACH

Our project evaluation framework is available for use by fisheries managers and funding organizations.

WHAT'S NEXT?

While implementing our recommendations can be expensive, there can also be enormous costs associated with not taking an experimental approach. For instance, unsuccessful projects may be allowed to continue or even expand. An even worse outcome might arise from counterintuitive negative effects of an action that is allowed to continue, such as diseases unknowingly being spread to wild stocks by supplementation with hatchery juveniles. Without a rigorous framework for evaluating restoration actions, such negative impacts will not be detected, let alone avoided in the future. By collecting data in the near future to test hypotheses about mechanisms causing change in AYK salmon abundance, people in the region will potentially be better able to respond relatively quickly to any future detrimental changes in that abundance.

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

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(Christian E. Zimmerman)

EFFECTIVE POPULATION SIZE OF CHINOOK SALMON IN YUKON AND KUSKOKWIM RIVER TRIBUTARIES

PROJECT 425

PRINCIPAL INVESTIGATOR

Jeffrey B. Olsen
United States Fish and Wildlife Service

RESEARCH PERIOD

May 2004 - July 2005

BUDGET

$47,109.00

GENETIC HEALTH CHECK

Maintaining genetic diversity is necessary for maintaining healthy, viable populations. To determine genetic health, we used effective population size rather than actual population size. The effective population size is the number of breeding adults in an "idealized population" that would lose genetic diversity at the rate observed in the actual population. Because real populations rarely exist under ideal conditions, the effective population is typically much smaller than the actual population—on average, by a factor of ten times. This underscores the danger in relying solely on census population size to evaluate short- and long-term population health. Conservation guidelines suggest that isolated populations with effective population size below 500 or 50 are at risk of significant loss of genetic diversity in either the long-term or, in the case of the latter figure, the short-term. Our study provides the first effective population size estimates for Chinook salmon in the AYK region.

OUR OBJECTIVES

Use genetic analysis to estimate the effective population sizes of Chinook salmon in Yukon and Kuskokwim river tributaries.

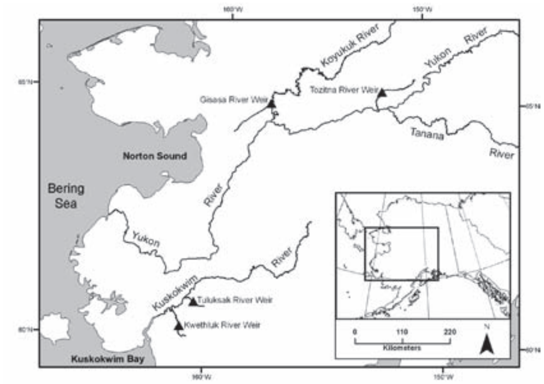
Derive two estimates for each of these populations: one that assumes the populations are isolated and one that assumes that there is migration.

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION – *PRIORITY #10*

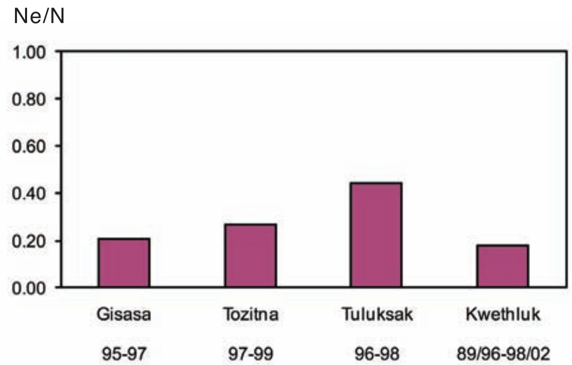
SNAPSHOT

This project focused on the genetic health of Chinook salmon populations in two Yukon and two Kuskokwim river tributaries.

After estimating effective population sizes—a more accurate indication of genetic health than actual population sizes—and comparing them to demographic factors, researchers learned that, over the short term (less than 10 years), sex ratios and reproductive success affect genetic health more than changing population size.



Map of western Alaska showing the Kwethluk, Tuluksak, Gisasa, and Tozitna rivers. (Olsen, USFWS)



The ratio of effective population size (Ne) to total census size (escapement, N) for the Gisasa, Tozitna, Tuluksak, and Kwethluk rivers. (Olsen, USFWS)

Assess the relative influence of demographic factors (population sizes, sex ratios, and reproductive success) on genetic health.

HOW WE DID IT

We estimated effective population sizes for Chinook salmon in the Gisasa and Tozitna rivers in the Yukon River watershed, and in the Kuskokwim River tributaries: the Kwethluk and Tuluksak rivers. We used archived tissue samples for DNA sources. Tissue from adult salmon was collected in each of the four rivers between 2001 and 2003, and from juveniles on the Kwethluk River only during 1990 and 2003. We used sex-specific population data from escapement surveys conducted during two or more years between 1991 and 2003.

WHAT WE DISCOVERED

Our effective population size estimates, assuming isolation, range from 2,307 to 7,674. Estimates that assume migration range from 448 to 576. The average ratio of effective to actual population size was 0.28. Our findings suggest that the two Yukon River populations are less influenced by gene flow and more vulnerable to loss of genetic diversity and extinction than the lower Kuskokwim River populations. We also found that the effective population sizes of all of the stocks examined are influenced most by unequal sex ratios and variance in reproductive success, and least by fluctuating population size over the short time period studied.

PRODUCTS AND OUTREACH

This report was published in a collection of symposium proceedings.

WHAT'S NEXT?

We recommend that managers strive to maintain connectivity among populations and continue to monitor sex ratios. Our ratio of effective population size to actual population size can be used to estimate the genetic health of other Yukon and Kuskokwim river Chinook salmon populations. A larger study is needed to evaluate gene flow patterns among populations from different regions in each watershed.

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(Christian E. Zimmerman)

ALTERNATIVE METHODS FOR SETTING ESCAPEMENT GOALS IN THE ARCTIC-YUKON-KUSKOKWIM

PROJECT 606

PRINCIPAL INVESTIGATOR

Ray Hilborn
University of Washington

CONTRIBUTING ORGANIZATIONS

Bue Consulting, LLC

Montana State University

University of Alaska Fairbanks

University of Montana

RESEARCH PERIOD

May 2006 - June 2007

BUDGET

$150,378.00

A FRESH LOOK AT ESCAPEMENT GOALS

Escapement goals and management strategies for salmon stocks in the Arctic-Yukon-Kuskokwim region have been the subject of considerable controversy. Traditional methods of creating brood tables and using stock-recruitment curves are hampered by limited information. In recent years, new initiatives have been developed that incorporate uncertainty, habitat condition, life history, watershed biocomplexity, and evaluation of objectives other than maximum sustained yield.

OUR OBJECTIVES

Evaluate new methods of determining salmon escapement goals for the AYK region.

Summarize all the existing data and identify data quality.

Compare the results obtained from setting escapement goals using traditional stock recruitment relationships, a life history model approach, and a habitat-based approach.

Assess the value of marine-derived nutrient information.

HOW WE DID IT

We collected salmon abundance and age, sex, and length data for specific species from eight river systems in the AYK area. Escapement, total run-size, harvest, and age composition data were analyzed for quality and rated using a four-level system. We then re-analyzed the changes in productivity in chum salmon stocks in the

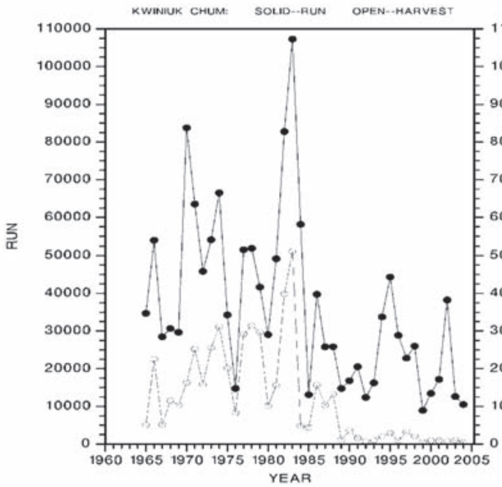
RESEARCH FRAMEWORK:

SYNTHESIS & PREDICTION – *PRIORITIES #8 AND #9*

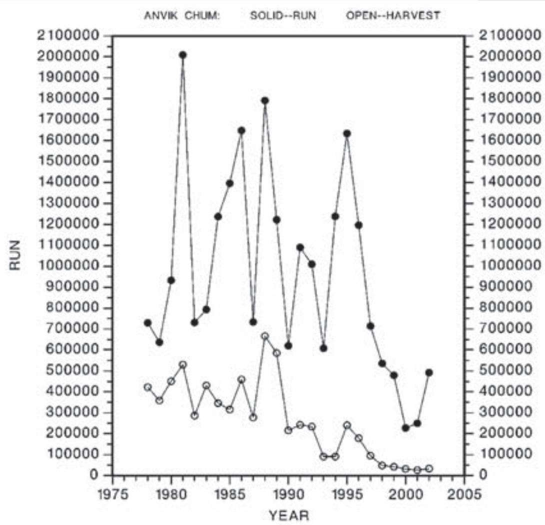
SNAPSHOT

This project explored alternatives to traditional ways of determining salmon escapement levels in the AYK region. Available historical data was evaluated, re-analyzed for population trends, and used to derive escapement levels using a life history modeling approach.

Researchers also conducted a preliminary study on estimating juvenile salmon densities using habitat analysis, and explored the effects of marine-derived nutrients.



The historic peak run size and harvest of the Kwiniuk River stock occurred in 1983, still leaving a large spawning escapement; but in 1985 the run was lower than had ever been recorded before in the data set starting with 1965. Harvests were greatly reduced in 1984, and stayed low, but the run sizes never really recovered. (Hilborn, UW)



The runs for Anvik River show broad variation from 1978-1997, and then shifted to a lower range starting in 1998. (Hilborn, UW)

Kwiniuk, Anvik, and Andreafsky rivers using data from 1965–2004. We constructed a generic life history model with three variations and used those and the traditional approach to determine harvest rates, fixed escapements, and resulting yields. We also used satellite imagery to link habitat types to juvenile chum salmon density on the Kwethluk River in order to provide estimates for the Kwiniuk, Anvik, and Andreafsky rivers.

WHAT WE DISCOVERED

Our analysis revealed that all three of the Kwiniuk, Anvik, and Andreafsky river stocks exhibited strong downward trends in recruits-per-spawner. Some regional factor appears to be affecting all of these stocks simultaneously. Using the life history model approach resulted in lower escapement goals than using traditional analysis. We determined that it probably would not be effective to analyze these salmon stocks using changes in marine-derived nutrients from salmon carcasses. We were able to achieve rough estimates of juvenile chum salmon densities on the three rivers using the Kwethluk River model; however, this study was preliminary.

PRODUCTS AND OUTREACH

Our data are located in an electronic database.

WHAT'S NEXT?

Further research is needed to determine the factor(s) controlling salmon abundance on the Kwiniuk, Anvik, and Andreafsky rivers. Additional information on survival rates will help to refine our life history approach to determining escapement goals. Further research on juvenile density on the Kwethluk River will provide us with a more accurate habitat-based model.

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LANDSCAPE GENETICS OF ARCTIC-YUKON-KUSKOKWIM SALMON POPULATIONS

PROJECT ***617***

PRINCIPAL INVESTIGATOR

Jeffrey B. Olsen
United States Fish and Wildlife Service

CONTRIBUTING ORGANIZATIONS

Alaska Department of Fish and Game

Kawerak, Inc.

RESEARCH PERIOD

June 2006 - June 2008

BUDGET

$213,070.00

SALMON GENETIC LANDSCAPES

Identifying the factors influencing population structure is important for understanding how populations evolve and for predicting how they may change in the face of environmental changes. To better understand the genetic diversity of western Alaska Chinook, coho, and chum salmon, we need to understand how these species' population structures are affected by their habitat. Landscape genetics allows us to identify geographical landscape effects on genetic processes such as gene flow, genetic drift, and selection.

OUR OBJECTIVES

Estimate the influence of geographical, environmental, ecological, and life history factors on the genetic diversity of Chinook, coho, and chum salmon from Norton Sound and the Yukon and Kuskokwim rivers.

Create a freely accessible GIS database of genetic data from these populations.

HOW WE DID IT

We used microsatellite genotypes collected from Chinook salmon in 47 locations, coho salmon in 28 locations, and chum salmon in 53 different locations. We used an average of 85 samples from each species. We then created a GIS data layer of the sampling locations. We obtained habitat GIS data layers from the Alaska Geospatial Data Clearinghouse and the Canadian GeoBase. We examined

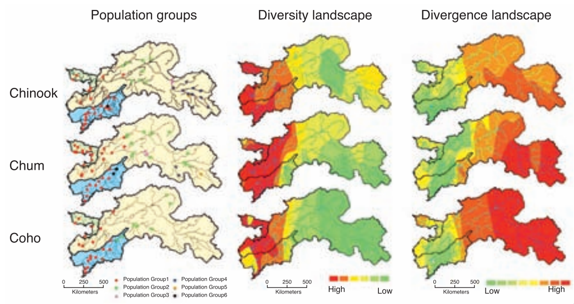
RESEARCH FRAMEWORK:

SYNTHESIS & PREDICTION – *PRIORITIES #8 AND #10*

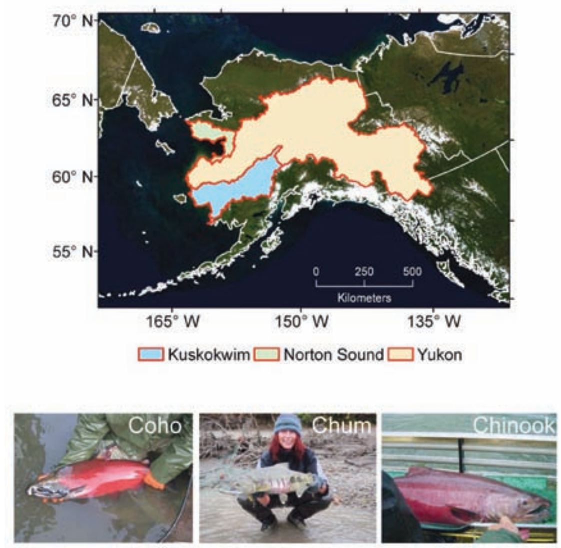
SNAPSHOT

We examined the population structure of Chinook, coho, and chum salmon from Norton Sound, and the Yukon and Kuskokwim rivers. We compared the genetic composition of these populations with environmental factors, particularly habitat variety.

Our results suggest that conservation efforts should focus on coastal versus inland populations rather than at the level of the three watersheds.



Coastal and inland population groups for Chinook, chum and coho salmon from Norton Sound and the Yukon and Kuskokwim rivers. The colored symbols indicate population groups defined by combining genetic and geographic data. (Olsen, USFWS)



Map showing Norton Sound and the Yukon and Kuskokwim river watersheds. Chinook, chum and coho salmon were sampled from each watershed for genetic analysis. (Olsen, USFWS)

nine habitat attributes representing four general categories (spatial isolation, habitat size, climate, and ecology).

WHAT WE DISCOVERED

We found similar, but unexpected, population structure patterns for each species. Notably, each species exhibited a single coastal population group and one or more inland population groups rather than the expected greater difference among the three major watersheds. Some inland population groups were inconsistent with the waterway network, suggesting influence by historical events. Region-wide population structure of each species was partially explained by multiple factors. However, only precipitation was a factor for all species. This suggests that the population genetic response to environmental changes will probably vary among species.

PRODUCTS AND OUTREACH

Our data are available in a spreadsheet format and as a Google web map on the Internet. We have submitted a manuscript for publication in a peer-reviewed journal.

WHAT'S NEXT?

Our results suggest that conservation efforts should first focus regionally at the coastal-inland population dichotomy rather than at the level of the three watersheds, which is the present scale of management. Since the region-wide models were not supported at the coastal and inland scales, we recommend further analysis at these smaller scales including more population samples and more precise data collection on habitat variation.

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A RISK ASSESSMENT FRAMEWORK FOR ARCTIC-YUKON-KUSKOKWIM CHUM SALMON

PROJECT 708

PRINCIPAL INVESTIGATOR

Jeremy S. Collie
University of Rhode Island

CONTRIBUTING ORGANIZATION

Simon Fraser University

RESEARCH PERIOD

September 2007 - April 2009

BUDGET

$61,539.00

CAN WE IMPROVE SALMON MANAGEMENT?

Salmon stocks in the Arctic-Yukon-Kuskokwim region consistently experienced low returns in the late 1990s, leading to multiple disaster declarations, calls for more research, and changes in harvest strategies. Management of salmon stocks is complicated by imperfect data, harvest rates that differ from those set by managers, and changing environmental conditions. Given these pervasive uncertainties, there is a clear need for methods that provide scientific advice to managers that explicitly takes these uncertainties into account.

OUR OBJECTIVES

Develop a risk-assessment framework for evaluating alternative management policies, particularly for AYK chum salmon populations.

Use this framework to estimate trade-offs resulting from various harvest policy choices between commercial and subsistence harvests, and spawner abundance.

HOW WE DID IT

We selected five chum salmon stocks for analysis: the combined Kwiniuk and Tubutulik rivers in the Norton Sound area; Yukon River fall chum salmon; two Yukon River tributaries, the Anvik and Andreafsky rivers, with summer chum salmon runs; and the Kuskokwim River. The model was a closed-loop simulation that included

RESEARCH FRAMEWORK:

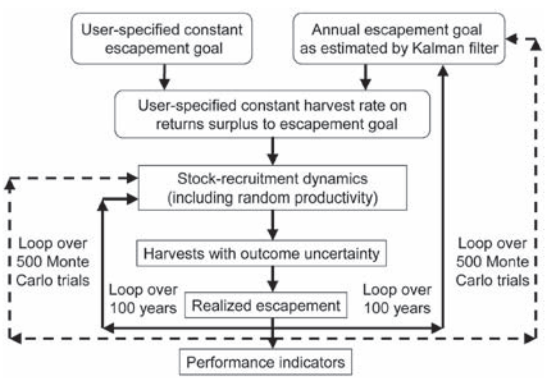
SYNTHESIS & PREDICTION – *PRIORITIES #8 AND #9*

SNAPSHOT

This project resulted in a model of AYK chum salmon stocks that takes into account inherent uncertainties in data collection, environmental conditions and policy implementation.

The model was used to evaluate the performance of different policy decisions for salmon stocks that experience environmental effects on decadal time scales.

Map of the Arctic-Yukon-Kuskokwim region showing locations of chum salmon stocks used in this study. Map data from www.rivers.gov/maps. (Collie, URI)



Simulation framework and flowchart for the salmon life-cycle model. The arrows in the middle and to the left define the time-invariant harvest policy. The arrows in the middle and to the right define the time-varying harvest policy. (Collie, URI)

salmon population dynamics and their environmental influences. We also included error in the implementation of harvesting decisions along with uncertainties such as observation errors.

WHAT WE DISCOVERED

Our results indicated that environmental changes taking place over decades have a greater effect on these stocks than year-to-year changes in recruits-per-spawner and that chum salmon productivity is primarily determined by ocean survival. With a harvest policy similar to the existing one applied to a simulated chum salmon stock, in about half the years the escapement target would not be met and the commercially fishery would be closed. Time-varying harvest policies, in which parameters are updated annually as new data come in, did not appear to improve outcomes. We also found that accurately planned policy is easily undermined by outcome uncertainties, such as the actual harvest differing from the goal. This points to a need for increased enforcement of regulations and improved in-season abundance estimates.

PRODUCTS AND OUTREACH

Our model is available for use by fishery managers. We also submitted our results for publication in a peer-reviewed journal.

WHAT'S NEXT?

Our generic model can be used by managers to analyze Yukon River chum salmon management policy; however, due to greater uncertainties with the Kuskokwim River, we caution against its use for those stocks. Follow-up work could include analyzing the sensitivity of the time-varying harvest policy to different sources and levels of uncertainty.

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(Christian E. Zimmerman)

WORK-IN-PROGRESS FUTURE CLIMATE/HABITAT OF ARCTIC-YUKON-KUSKOKWIM ECOSYSTEMS

PROJECT
714

PRINCIPAL INVESTIGATOR

Nicholas A. Bond
University of Washington

CONTRIBUTING ORGANIZATION

National Oceanic and Atmospheric Administration

RESEARCH PERIOD

May 2007 - April 2008

BUDGET

$143,683.00

PREDICTING SALMON ABUNDANCE

Eastern Bering Sea ecosystems are prone to dramatic changes in the abundance and distribution of shore and marine life including salmon species. This substantial variability occurs on multi-year time scales and much of it can be attributed to fluctuations in climate. The future state of the AYK tributaries and the eastern Bering Sea is clearly an important issue to stakeholders. Important questions such as the continuation of the recent warming trend and northward shift of ecosystems may be addressed using new climate model forecasts. The ability to project future climate states and improved knowledge of the response of the ecosystem and of salmon abundance to changes in climate can reduce the uncertainties facing stakeholders when preparing their contingency plans.

OUR OBJECTIVES

Provide ecosystem forecasts that are important to salmon abundance out to 2030 based on evaluations of climate model results for western Alaska.

Work with communities and other investigators to provide confidence estimates on future salmon abundance potential.

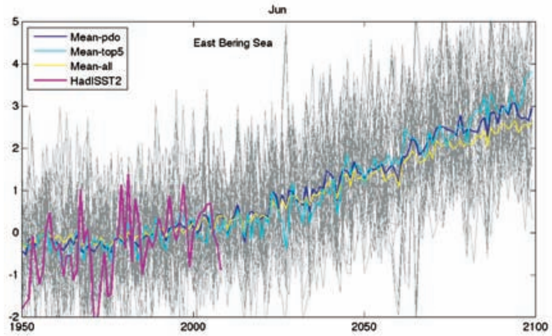
Create a community resource on past and future climate change issues through direct contacts and a website where communities and other investigators can view synthesized results and direct output from global climate model simulations.

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION –
PRIORITIES #7 AND #8

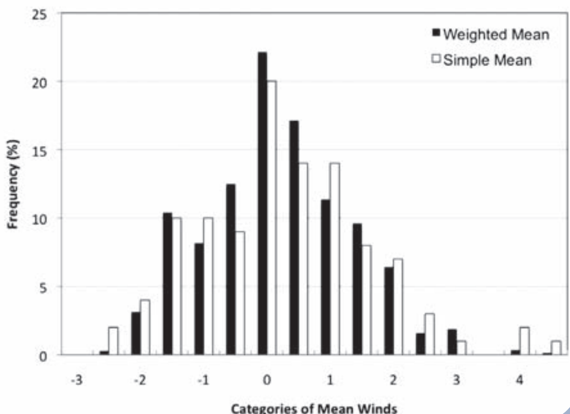
SNAPSHOT

This project will provide forecasts of the eastern Bering Sea ecosystem and salmon abundance from the present to 2030.

Current climate models will be analyzed for accuracy. The most accurate will be used to provide quantitative forecasts that focus on environmental conditions known—or suspected to be—important to Arctic-Yukon-Kuskokwim salmon abundance.



Projected Sea Surface Temperature (SST) anomalies for the eastern Bering Sea during June from ensemble members of 12 IPCC models (gray lines). The colored lines show ensemble means based on different numbers of model projections using the culling strategy. The magenta line indicates the observed value based on Hadley SST2 analysis. (Bond, UW)



Comparison of histograms between simple and weighted ensembles for onshore wind component projections in the southeast Bering Sea using 21 ensemble members and samples from five individual years (2043-2047). There is a shift in mean and a reduction in extremes when the influence of models with poor comparisons to observed winds are given reduced weight. (Bond, UW)

HOW WE WILL DO IT

We will assess current models for their ability to successfully represent the present climate and habitat using environmental variables such as changes in precipitation, seasonal timing of runoff, temperatures, winds, and oceanic conditions in the eastern Bering Sea. We will include both human-caused and natural changes in our analysis. We will then use the most accurate models to catalog the mean, variability, and range in variables of known or suspected importance to salmon and the ecosystem from the present to 2030. Finally, we will work with salmon and ecosystem scientists to help build consensus forecasts for the future of the ecosystem and for salmon abundance using our projections of these environmental conditions.

REPORT COMPLETION

September 2010

***AYK SSI Mission:** To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

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(Mike Dinneen)

WORK-IN-PROGRESS
ESCAPEMENT GOAL SETTING TO ENSURE SUSTAINABLE FISHERIES

PROJECT 902

PRINCIPAL INVESTIGATOR

Mike Jones
Michigan State University

CONTRIBUTING ORGANIZATIONS

Alaska Department of Fish and Game

Bering Sea Fishermen's Association

Bue Consulting, LLC

University of Alaska Fairbanks

RESEARCH PERIOD

June 2009 - March 2011

BUDGET

$276,227.00

ENSURING SUSTAINABLE FISHERIES

A pressing need exists for new and continued research on AYK salmon stocks, and for the integration and coordination of research and assessment programs across government agencies, scientific disciplines, and biological boundaries to advance research and achieve sustainable salmon management. Through implementation of this Research Priority, the AYK SSI will contribute to shaping management measures for the future. This project seeks to maximize its impact on future research programs through broad, effective communication across all research sectors—state, federal, local communities, fishers, and academia.

The AYK SSI Steering Committee, with guidance from the Scientific Technical Committee, convened an Expert Panel for the purpose of addressing Research Priority #8, from the AYK SSI Salmon Research & Restoration Plan (RRP): *"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."* Research Priority #8 was drawn from Research Framework #3: *Synthesis and Prediction: Development of Ecosystem and Fishery Management;* and Theme #4: *Evaluation of Management Approaches and Tools*. Theme #4 focuses on influences of human institutions and their policies through management actions to regulate harvest of AYK salmon. Some of the changes in salmon production result from natural causes and are inevitable, and potential threats exist (e.g., habitat destruction due to development) which can be addressed through policy and decision-making.

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION –
PRIORITY #8

SNAPSHOT

The AYK Sustainable Salmon Initiative will convene an Expert Panel to support the research priority concerned with setting management goals.

This panel will offer advice on the most appropriate research approaches and management efforts.

(John Hilsinger)

(Jeffrey B. Olsen)

The Expert Panel, appointed to implement this task, will address and advance this research hypothesis by undertaking quantitative analysis and providing advice on appropriate methods and strategies for establishing effective harvest policies for AYK salmon stocks.

Improved understanding of the dynamics of salmon populations over time will help fishery managers understand causes of declines and recoveries of western Alaska salmon stocks, anticipate changes in salmon abundance, and ensure management strategies provide for sustainable salmon management.

OUR OBJECTIVES

Organize an Expert Panel to assist with addressing this research priority by providing advice on appropriate methods for establishing and evaluating escapement goals that support effective harvest policies for AYK salmon stocks.

Account for possible management regimes and their effects, such as: the influence of uncertainty and risk; the quantity and quality of available data; and the potential influences of future environmental changes.

Consider both empirical stock-recruitment analysis methods and approaches that predict recruitment or production based on environmental factors.

HOW WE WILL DO IT

We plan to ensure that the panel has access to relevant data, has knowledge of the AYK regional salmon management context, is familiar with current research, and can effectively coordinate with data collection organizations. The panel will consider the range of approaches and analytical frameworks such as: What are the best methods for dealing with data limited situation? What methods exist for determining escapement goals and which are best to use in different drainage systems? What is the best model for establishing escapement goals in subsistence dominated fisheries? We will also develop techniques to incorporate uncertainty and risk into management evaluation, and disseminate results among fisheries managers, researchers, and policy makers.

REPORT COMPLETION

March 2011

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

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(Robert J. Wolfe)

WORK-IN-PROGRESS
HUMAN SYSTEMS AND SUSTAINABLE SALMON

PROJECT 903

PRINCIPAL INVESTIGATOR

Robert J. Wolfe
Robert J. Wolfe and Associates

CONTRIBUTING ORGANIZATIONS

Alaska Connections

Alaska Department of Fish and Game

Alaska Department of Labor

Bering Sea Fishermen's Association

Research North

University of Alaska Anchorage

University of Alaska Juneau

RESEARCH PERIOD

December 2009 - March 2011

BUDGET

$340,282.00

MODELING FUTURE HARVEST

A pressing need exists for new and continued research on AYK salmon stocks, and for the integration and coordination of research and assessment programs across government agencies, scientific disciplines, and biological boundaries to advance research and achieve sustainable salmon management. Through implementation of this Research Priority, the AYK SSI will contribute to shaping management measures for the future. This project seeks to maximize its impact on future research programs through broad, effective communication across all research sectors—state, federal, local communities, fishers, and academia.

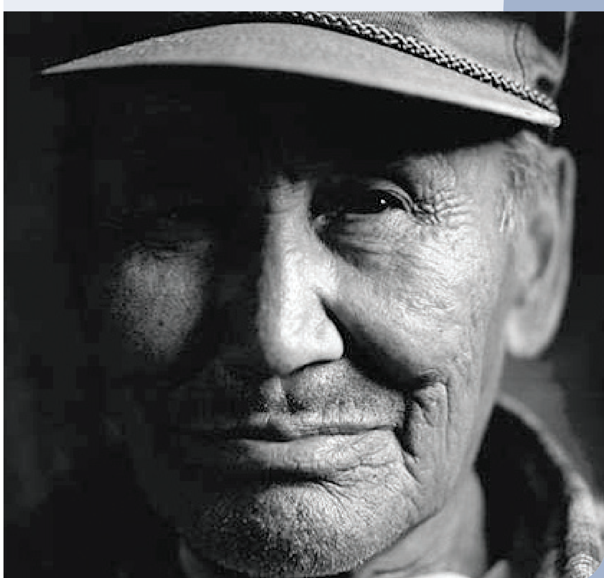
The AYK SSI Steering Committee, with guidance from the Scientific Technical Committee, convened an Expert Panel for the purpose of addressing Research Priority #5 from the AYK SSI Salmon Research & Restoration Plan. Research Priority #5 was drawn from Research Framework #2: *Human Systems and Sustainable Salmon: Social, Economic, and Political Linkages*. The framework acknowledges that human interactions with salmon are complex, primarily as directed or bycatch harvests of adult-phase salmon in the marine and freshwater environments. Additionally, the following general research statement was advanced for this Expert Panel: *"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."*

RESEARCH FRAMEWORK:
HUMAN SYSTEMS – *PRIORITY #5*

SNAPSHOT

An Expert Panel, convened by the AYK SSI, will create a model that incorporates various factors affecting AYK salmon harvests and use the model to predict changing harvests under different future conditions.

(Robert J. Wolfe)



(Council of Athabascan Tribal Governments Staff)

Development of a model for predicting future salmon harvests for subsistence, commercial, and sport uses in the AYK region will enable fisheries managers to better understand and anticipate how fishers respond to changes in salmon abundance, and how different management strategies affect salmon harvests.

OUR OBJECTIVES

Organize an Expert Panel to assist with addressing this research priority. The panel will identify collections of historic salmon harvest data and the factors related to the demand and harvest of AYK salmon. The panel will develop a model relating future potential harvests and demand to these factors, run the model under alternative scenarios, and identify the management implications of model outcomes.

HOW WE WILL DO IT

The model will use quantitative data and assumptions about present and future conditions to predict future salmon harvests for subsistence, commercial, and sport uses in the AYK area in response to demographic, economic, cultural, and biological factors. It will predict harvest by use categories at the levels of drainage, major area, and stock. The model will predict possible future harvests under different future scenarios involving human populations, salmon abundance, numbers of dog teams, monetary income, and other factors.

REPORT COMPLETION

March 2011

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

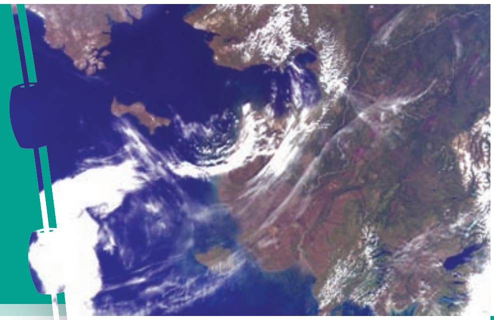
ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

BERING SEA FISHERMEN'S ASSOCIATION
110 W. 15TH AVENUE
ANCHORAGE, AK 99501
(907) 279-6519

AYK SUSTAINABLE SALMON INITIATIVE

Project Synopsis

BERING SEA–MARINE



(Ocean Imaging Corporation)

BERING SEA

ARCTIC-YUKON-KUSKOKWIM SATELLITE-DERIVED ENVIRONMENTAL DATABASE

PROJECT 306

PRINCIPAL INVESTIGATOR

Jan Svejkovsky
Ocean Imaging Corporation

RESEARCH PERIOD

May 2003 - May 2004

BUDGET

$76,293.00

SATELLITES, SALMON, AND A CHANGING SEA

Alaska salmon constitute a critical food and revenue source for the people of the Arctic-Yukon-Kuskokwim region. These salmon have exhibited high variability for more than a decade, creating numerous hardships for the local communities. The exact causes of the declines are not known. Also, the northern Bering Sea is a more difficult region in which to conduct research than the more heavily studied southeastern area.

OUR OBJECTIVES

Establish a clear data baseline characterizing variability in oceanic sea surface temperature (SST), ice melt, sediment runoff, and plankton blooms spanning 16 years.

Compare this information to salmon catch, return, and other abundance records over this period to better understand the influence of these factors on AYK salmon abundance.

HOW WE DID IT

We used satellite imagery of the eastern Bering Sea spring–fall season spanning 1987 to 2003 including daily (when possible), weekly and monthly SST, and weekly and monthly chlorophyll concentrations, both at 1km resolution. We used the Advanced Very High Resolution Radiometer (AVHRR) to determine chlorophyll concentrations during the 1988–1997 period, which was previously a gap in this data record. We analyzed the

RESEARCH FRAMEWORKS:

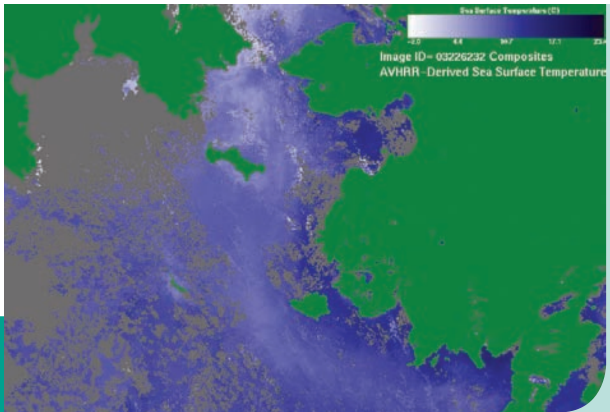
SALMON LIFE CYCLE – *PRIORITY #1;*

SYNTHESIS & PREDICTION – *PRIORITY #10*

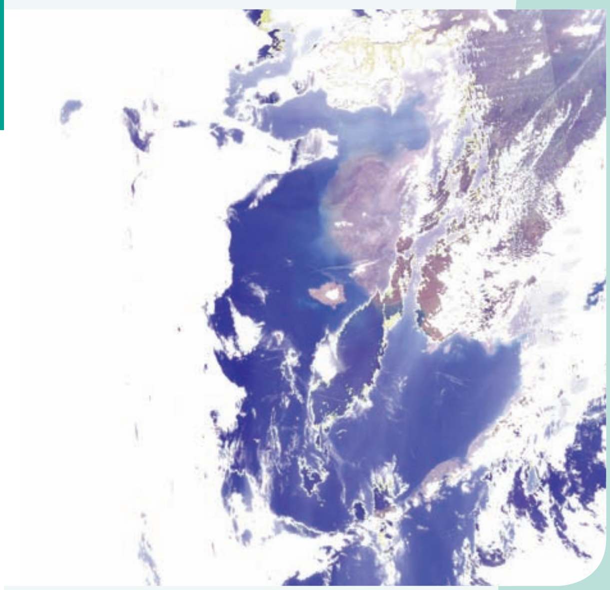
SNAPSHOT

Satellite images were used to collect information about the northern Bering Sea ecosystem over a 16-year period. This data was compared to salmon abundance information in the region.

The correlations found provide some insight into the causes of ongoing salmon population declines and suggest directions for further research.



AVHRR Sea Surface Temperature Composites. (Ocean Imaging Corporation)



MODIS Simulated True Color RGB image from AYK SSI Satellite-Derived Multivariate Database. (Ocean Imaging Corporation)

satellite data series for the whole region, as well as individual watersheds within northern Norton Sound and the Yukon and Kuskokwim rivers, and made comparisons to seasonal salmon abundance records.

WHAT WE DISCOVERED

Our analysis suggested that long-term SST and plankton changes after 1996 are contributors to the decline of salmon populations. However, no single marine environmental variable can be pegged as the causative factor. Our data illustrate the long term increase in SSTs dating back to the early 1980s; high variability in monthly SSTs; and the significant 2000–2003 rise in SSTs combined with a disturbance in the phytoplankton community structure. This suggests that long-term conditions during the marine phase of the salmon life cycle increases the vulnerability of the stock.

PRODUCTS AND OUTREACH

Our satellite image-based database is available on a CD-ROM set and was delivered to the AYK SSI. Workshops were held in communities within our study areas to inform residents about our project and the use of the database. Peer-reviewed articles were published using our data.

WHAT'S NEXT?

Due to the limited, one-year time frame of the study, we were able to complete only a preliminary comparison of the satellite data with salmon abundance records. Because we found correlations, however, we recommend further research and analysis in this area. Our database can continue to be used to analyze the effects of other variables such as climate change, changes to the freshwater habitat, and food chain variability. It will continue to serve as a resource for fisheries managers, researchers and the fishing community when questions arise about 1987–2003 marine conditions.

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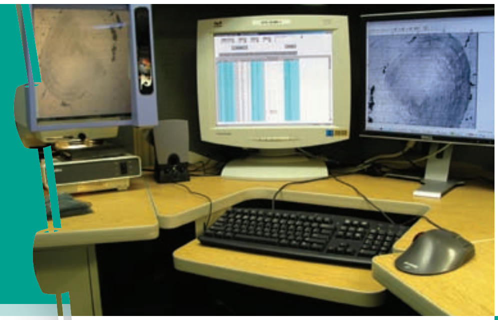

(Greg T. Ruggerone)

RETROSPECTIVE ANALYSIS OF ARCTIC-YUKON-KUSKOKWIM CHINOOK SALMON GROWTH

PROJECT 410

PRINCIPAL INVESTIGATOR

Greg T. Ruggerone
Natural Resources Consultants, Inc.

CONTRIBUTING ORGANIZATIONS

Alaska Department of Fish and Game

United States Geological Survey

RESEARCH PERIOD

September 2004 - June 2006

BUDGET

$122,639.00

SEE HOW THEY GROW

The Yukon and Kuskokwim watershed areas encompass nearly 40% of Alaska and support large runs of Chinook salmon. People living within these river basins depend on salmon for subsistence, commercial and sport fishing, and culture. From 1997–2002, the abundance of returning Yukon and Kuskokwim Chinook salmon declined significantly. Factors affecting this decline are largely unknown. However, growth of salmon in freshwater and the ocean is generally thought to influence salmon survival.

OUR OBJECTIVES

Determine whether or not the growth of Chinook salmon was affected by major ocean-climate events, and if the decline in Chinook salmon abundance was associated with less growth in freshwater or the ocean.

Determine whether the growth of Yukon and Kuskokwim river Chinook salmon were correlated, affected by Asian pink salmon abundance, independent of previous growth at each life stage, or related to gender at similar lengths-at-age.

HOW WE DID IT

We obtained adult Chinook salmon scales collected since 1964 from the ADF&G archives. We measured 50 scales from each of the two dominant age groups: 1.3 (one year in freshwater, three years in the ocean) and 1.4 (one year in freshwater, four years in the ocean) from each of the rivers. We measured each scale from the scale focus to

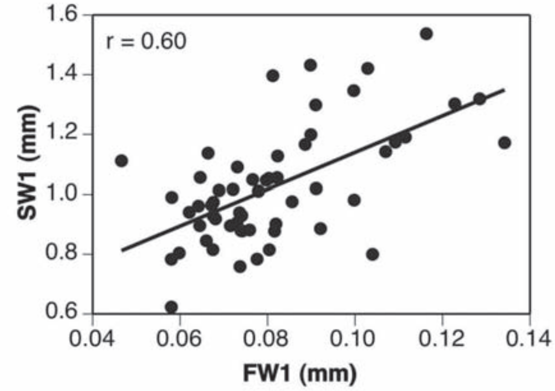
RESEARCH FRAMEWORKS:
SALMON LIFE CYCLE – *PRIORITY #1;*

SYNTHESIS & PREDICTION – *PRIORITY #7*

SNAPSHOT

Archived Yukon and Kuskokwim river Chinook salmon scale samples were used to study the growth of these fish at each life stage. Researchers found that each year's growth is dependent on the previous year, there is an alternating-year pattern, growth varies by age class, and females are consistently larger than males.

The abrupt decline in Chinook salmon abundance in the late 1990s was not clearly associated with a shift in Chinook salmon growth.



Growth of individual Yukon and Kuskokwim river Chinook salmon during the first year at sea (SW1) was positively correlated with their prior growth in freshwater (FW1). This pattern was consistent for both Chinook salmon stocks since the 1960s. (Ruggerone, NRC)

the outer edge of the first freshwater annulus (the winter band of growth rings), spring plus growth zone, each annual ocean growth zone, and from the last ocean annulus to the edge of the scale.

WHAT WE DISCOVERED

Growth in a given year was highly dependent on growth during the previous year for both Yukon and Kuskokwim river fish. This dependence complicated comparisons of growth patterns with abundance trends and environmental factors. Growth during the second year at sea was consistently greater during odd-numbered years, which are also the years of greater Asian pink salmon abundance, indicating that Chinook and pink salmon may indirectly compete for prey. Growth of age 1.3 salmon averaged 11% to 17% greater than that of age 1.4 salmon. Adult females were significantly longer than males (the opposite of sockeye and chum salmon), suggesting that growth may be especially important to the reproductive potential of female Chinook salmon. Greater growth of female Chinook salmon began in freshwater, indicating the importance of freshwater habitat.

PRODUCTS AND OUTREACH

Findings were presented at five meetings involving communities from western Alaska and three scientific conferences. Two journal manuscripts were published and a third manuscript is in preparation.

WHAT'S NEXT?

Additional research is needed on the relationships between Chinook salmon growth and abundance, and environmental conditions, while accounting for the strong dependency of previous year's growth. Further study is needed on the alternating year pattern of growth that we found. It is possible that Asian pink salmon are indirect competitors, consuming shared prey that are one year younger than that consumed by Chinook salmon during their second year at sea. The relationship between growth and survival of female Chinook salmon is being explored.

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AYK SUSTAINABLE SALMON INITIATIVE

Project Synopsis

BERING SEA–MARINE

(Oleg Ivanov)

FACTORS AFFECTING CHUM SALMON GROWTH AND CONDITION

PROJECT 610

PRINCIPAL INVESTIGATOR

Edward V. Farley
National Oceanic and Atmospheric Administration

RESEARCH PERIOD

August 2006 - April 2009

BUDGET

$597,194.00

CLIMATE CHANGE AND CHUM SALMON

Every spring, chum salmon fry from the Yukon and Kuskokwim rivers enter the eastern Bering Sea to begin their marine life history stage and an uncertain future. The highest marine mortality rates for salmon occur during their first year in the ocean. According to the "critical size and period" hypothesis, faster growing juvenile salmon are more likely to escape predators soon after leaving freshwater, and larger fish, after their first summer at sea, are believed to be better fit to survive their first winter at sea.

OUR OBJECTIVES

Understand how changes in climate affect the quantity and quality of food resources for juvenile western Alaska chum salmon.

Use bioenergetics models to analyze the impacts of these changes on juvenile chum salmon growth rate potential.

HOW WE DID IT

From 2002–2007, we conducted late summer and fall surveys along the eastern Bering Sea shelf. This period encompassed a period of unusually warm sea surface temperatures (2002–2005) followed by unusually cold temperatures (2006–2007). We collected data on sea surface temperatures, salmon diet, prey availability, and the relative abundance of juvenile chum salmon from the Yukon and Kuskokwim rivers.

RESEARCH FRAMEWORKS:

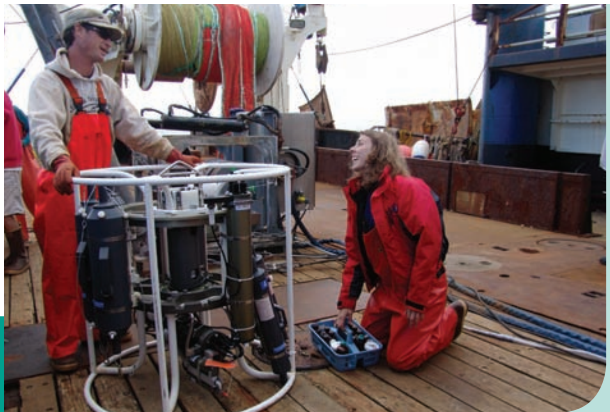
SALMON LIFE CYCLE – *PRIORITY #1;*

SYNTHESIS & PREDICTION – *PRIORITY #10*

SNAPSHOT

We studied the ocean growth of juvenile Yukon and Kuskokwim river chum salmon. We measured water temperatures, prey abundance, salmon diet, and the relative abundance of Kuskokwim and Yukon river chum salmon along the eastern Bering Sea shelf.

We created bioenergetics models that suggest an increased growth potential for juvenile chum salmon during years with warmer sea surface temperatures.



(Oleg Ivanov)

(Oleg Ivanov)

WHAT WE DISCOVERED

Our bioenergetics models indicated that growth rate potential of juvenile chum salmon is much lower during years with cold sea temperatures, due mostly to the quantity of available prey. We also found that the relative abundance of juvenile Kuskokwim River chum salmon and the size of juvenile Yukon River chum salmon are much lower during years with cold sea temperatures. These findings suggest that marine mortality for western Alaska chum salmon is highest during years with unusually cold sea temperatures. However, when we examined the "sensitivity" of our models to increased ocean temperatures, we found that growth rate potential can decline if sea temperatures increase by 20° C above the warmest sea temperatures found during the surveys.

PRODUCTS AND OUTREACH

Our data was used to create a comprehensive database for western Alaska chum salmon. We have prepared seven manuscripts for publication in peer-reviewed journals and presented our findings at a national symposium.

WHAT'S NEXT?

Given climate change predictions, future research must address how western Alaska salmon respond to loss of sea ice, and warming air and sea temperatures along the eastern Bering Sea shelf. For example, we plan to utilize the nutrient-phytoplankton-zooplankton (NPZ) model being developed for the Bering Sea shelf by scientists participating in the North Pacific Research Board's Bering Sea Integrated Research Program. We can use the NPZ model to predict growth rate potential for western Alaska chum salmon under a warming climate scenario to attempt to understand how climate warming will impact early marine growth and survival.

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(Jeanette Gann)

STOCK-SPECIFIC FORECAST OF ARCTIC-YUKON-KUSKOKWIM CHINOOK SALMON

PROJECT 632

PRINCIPAL INVESTIGATOR

William D. Templin
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATION

University of Washington

RESEARCH PERIOD

May 2006 - June 2008

BUDGET

$454,719.00

UNTANGLING SALMON POPULATIONS

Unanticipated poor returns of Chinook and chum salmon to Arctic-Yukon-Kuskokwim drainages have prompted 16 separate disaster declarations by the State of Alaska and federal agencies since 1997. Causes of these poor returns are not known. However, the regional-scale decline of these stocks indicates that the marine environment may play a critical role. In addition, survival rates in the Bering Sea are affected by groundfish trawl fisheries bycatch. Our understanding of marine survival of eastern Bering Sea salmon suffers due to the lack of marine life history information.

OUR OBJECTIVES

Develop a comprehensive baseline for western Alaska Chinook salmon by adding populations to the existing Pacific Rim standardized baseline and identifying a set of genetic markers that provide useful resolution for Bering Sea analyses.

Determine the stock composition of samples from the 2002 to 2007 Bering Aleutian Salmon International Surveys, from the 2005 to 2007 bycatch in the Bering Sea and Aleutian Islands pollock fisheries, and from historic bycatch collections, if usable.

Develop run reconstruction methods to forecast western Alaska Chinook salmon runs based on stock-specific data from juvenile surveys and trawl bycatch.

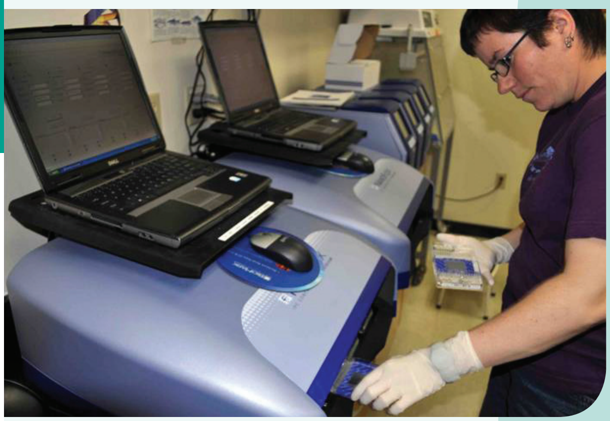
RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION – *PRIORITY #10*

SNAPSHOT

This project resulted in the most comprehensive assessment of the genetic structure of Chinook salmon in the state of Alaska.

This baseline was used to estimate the contributions of 15 regional stocks to samples taken from commercial fisheries and research studies in the Bering Sea.

(Lisa Eisner)



(ADF&G Staff)

(ADF&G Staff)

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HOW WE DID IT

We conducted analyses on spawning samples from 25 populations from underrepresented regions of western Alaska and used the data to increase the existing database of Chinook salmon genetics to 165 populations from throughout the species range. We analyzed tissues from 4,000 Chinook salmon taken as bycatch in the 2005 to 2007 groundfish fishery, and 1,500 juveniles sampled from the 2002 to 2007 Bering Sea research cruises, in the laboratory using single nucleotide polymorphisms. We used this genetic information to estimate the origins of the Chinook salmon in the fishery, and resource samples to reconstruct the distributions of various Chinook salmon stocks in the Bering Sea.

WHAT WE DISCOVERED

This project provided the first stock-specific information available on the distribution of juvenile Chinook salmon from western Alaska during their initial period of life at sea, indicating that juveniles migrating into the Bering Sea from the Yukon, Kuskokwim, and Nushagak rivers remain segregated during their early marine life. Samples taken from the bycatch in the pollock fishery were not representative of the actual bycatch, but estimates were provided for assessing the impacts of this fishery on western Alaska populations.

PRODUCTS AND OUTREACH

The results of these analyses have been presented to scientific, management, and public groups. One peer-reviewed manuscript has been published and two more are in preparation.

WHAT'S NEXT?

The Alaska Department of Fish and Game, Gene Conservation Laboratory is continuing to build the baseline developed as part of this project. Populations from throughout the species range are being added and a major effort has begun to discover more genetic markers to provide additional resolution. This baseline is being used by the NOAA Auke Bay Laboratories to estimate the stock composition of Chinook salmon incidentally harvested in the ground fish fisheries of the Bering Sea and Gulf of Alaska.

DOWNLOAD REPORTS ASSOCIATED WITH THIS PROJECT AND LEARN MORE AT WWW.AYKSSI.ORG


(Deborah Mercy)

WORK-IN-PROGRESS
JUVENILE SALMON DISPERSAL: DRIFTER BASED VIEW

PROJECT
711

PRINCIPAL INVESTIGATOR

Thomas J. Weingartner
University of Alaska Fairbanks

RESEARCH PERIOD

November 2007 - December 2010

BUDGET

$330,205.00

YOUNG SALMON GO WITH THE FLOW

The numbers of Chinook and chum salmon returning to the Arctic-Yukon-Kuskokwim region have shown remarkable variability from year to year. Although the causes for this are not known, evidence indicates that ocean conditions may be responsible, especially during the first few months that juveniles enter saltwater. While a variety of ocean-related phenomena can affect salmon survival during their early marine life stage, nearshore currents are critical in the transport and dispersal of juveniles. Restoration and conservation strategies for Bering Sea salmon stocks require understanding the migratory routes and the shelf habitats salmon use during their early marine life.

OUR OBJECTIVES

Increase understanding of the nearshore circulation field that connects Kuskokwim Bay and northern Bristol Bay with the adjacent Bering Sea shelf.

Examine the seasonal character of these currents, especially during the summer and fall, and investigate how they are affected by winds and freshwater discharge.

Use historical Bering Sea wind data sets to hindcast likely salmon transport pathways.

HOW WE WILL DO IT

We plan to deploy clusters of three to four satellite-tracked drifters in lower Kuskokwim Bay at

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #1*

SNAPSHOT

This project will use satellite-tracked drifters to map nearshore currents in Kuskokwim Bay and northern Bristol Bay.

Seasonal effects of winds and freshwater discharge will be analyzed in order to better understand the role of these currents in transporting juvenile salmon.

(Deborah Mercy)

(Deborah Mercy)

approximately 12-day intervals between mid-May and mid-August over two years. Drifter positions and ocean temperatures will be determined by satellite GPS fixes once or twice per hour. Prior work indicates that we will receive at least 30 positions per day, which is sufficient to resolve tidal motions. We will use forecast wind fields generated by the National Center for Environmental Prediction. Wind predictions are available on a 2.5 degree grid with 6-hourly resolution.

REPORT COMPLETION

February 2011

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(Katherine W. Myers)

WORK-IN-PROGRESS
CLIMATE-OCEAN EFFECTS ON CHINOOK SALMON

PROJECT 712

PRINCIPAL INVESTIGATOR

Katherine W. Myers
University of Washington

CONTRIBUTING ORGANIZATION

Kawerak, Inc.

RESEARCH PERIOD

July 2007 - June 2010

BUDGET

$622,887.00

NATURE OR NETS?

A high priority issue of Arctic-Yukon-Kuskokwim region salmon management is to determine whether the ocean environment is a more important cause of variation in the abundance of salmon populations than marine fishing. At present, however, population-specific data on the ocean life history of AYK salmon are too limited to rigorously test hypotheses about the relative effects of environment versus fishing on their marine survival. Data on Chinook salmon in the marine environment are even more limited because of their low abundance compared to other salmon species. However, they are an important subsistence food to residents of the region.

OUR OBJECTIVES

Examine patterns of use of marine resources (habitat and food) by Chinook salmon and explore how they are affected by climate-ocean conditions in the Bering Sea and North Pacific Ocean.

Develop a comprehensive high seas Chinook salmon database (1955–2009) and map Chinook salmon marine distribution, migration routes and associated climate-ocean conditions, and the variability in ocean growth potential.

Reconstruct the histories of Chinook salmon ocean age, growth, and size-selective mortality; collect new data on diet; estimate consumption and growth under different conditions; and simulate different climate effects on age and growth.

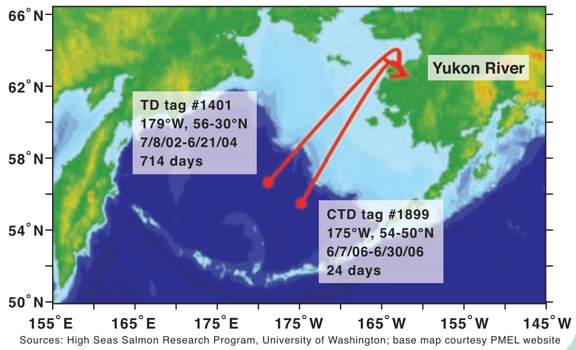
RESEARCH FRAMEWORKS:

SALMON LIFE CYCLE – *PRIORITY #1;*

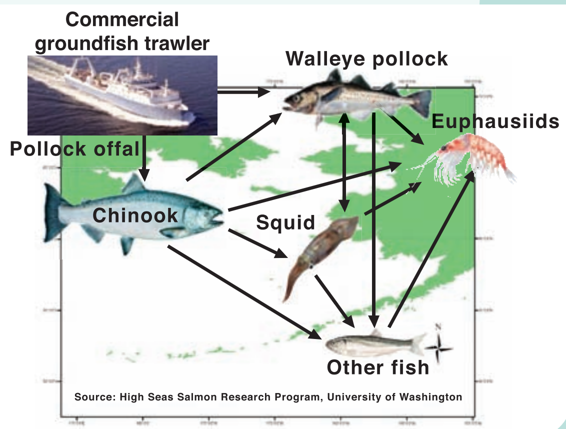
SYNTHESIS & PREDICTION – *PRIORITY #10*

SNAPSHOT

This project will examine the effects of ocean and climate conditions in the Bering Sea and North Pacific on Chinook salmon patterns of feeding and habitat use. Historical and current data will be incorporated into maps and models that will enable researchers to examine ocean migration patterns, bioenergetics, growth potential, and the effects of changing climate.



Wakatake maru international cooperative high seas salmon tagging, 1991-2009: Bering Sea release locations, release & recovery dates, and number of days of data recorded for two Chinook salmon tagged with electronic data storage tags & recovered by Yukon River fishermen. TD=temperature-depth tag; CTD=conductivity, temperature, depth tag. (Myers, UW)



Winter food web of AYK Chinook salmon in the eastern Bering Sea. (Myers, UW)

HOW WE WILL DO IT

We will compile historical data into a database and use this database to develop a GIS atlas of information on stock-specific Chinook salmon ocean distributions. We will also use research and commercial catch data to develop GIS maps of monthly distribution and relative abundance by ocean age and maturity group. Using scales from up to 50 fish per year, we will reconstruct ocean age and growth patterns. Stomach samples will provide information on diet. We will develop a gridded atmospheric and oceanographic database specific to Chinook salmon habitats in the Bering Sea. Using our collected historic and current data, we will create a bioenergetics model, growth potential maps, and a model for simulating climate effects on ocean growth rates of Chinook salmon.

REPORT COMPLETION

August 2010

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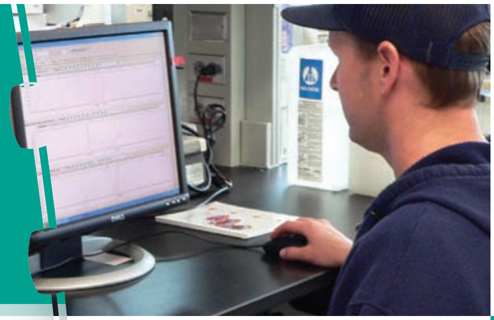


(Christine M. Kondzela)

WORK-IN-PROGRESS GENETIC ANALYSIS OF IMMATURE BERING SEA CHUM SALMON

PROJECT 719

PRINCIPAL INVESTIGATOR

Christine M. Kondzela
National Oceanic and Atmospheric Administration

CONTRIBUTING ORGANIZATION

University of Alaska Fairbanks

RESEARCH PERIOD

July 2007 - March 2011

BUDGET

$561,556.00

IDENTIFYING INCIDENTAL CATCH

Chum salmon bycatch in the Bering Sea groundfish fisheries continues to be an issue of concern that affects a variety of allocation, conservation, and international treaty factors. Although chum salmon bycatch is closely monitored, and observer data and industry's awareness provide invaluable information, one of the underlying questions—the origins and destination of the fish—remains unaddressed, and the dynamics of the variation in their movements is unknown. This knowledge is crucial in determining the ultimate impact of the bycatch.

OUR OBJECTIVES

Determine the marine distribution of chum salmon populations in the eastern Bering Sea across time and space by genetically analyzing chum salmon caught incidentally in groundfish fisheries and in surveys in which admixtures of chum salmon populations are collected.

HOW WE WILL DO IT

We will use chum salmon scale and tissue samples collected between 1988 and 2005 from the Bering Sea and Aleutian Islands trawl fishery bycatch, and from several U.S. and Russian Bering Aleutian Salmon International Surveys (BASIS) research cruises. We will analyze variation at a minimum of 12 microsatellite genetic markers compatible with data from other laboratories, and from a suite of single nucleotide polymorphisms developed within this

RESEARCH FRAMEWORKS:

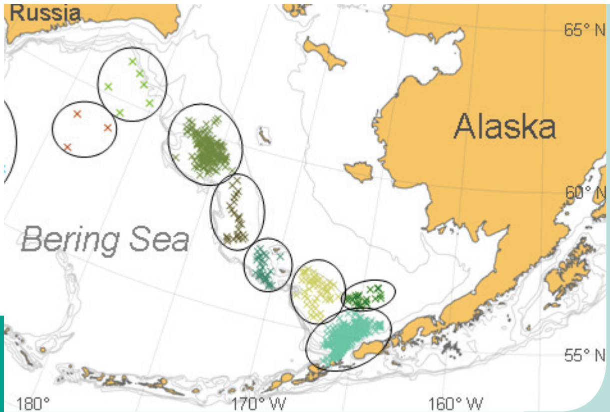
SALMON LIFE CYCLE – *PRIORITY #1;*

SYNTHESIS & PREDICTION – *PRIORITY #7*

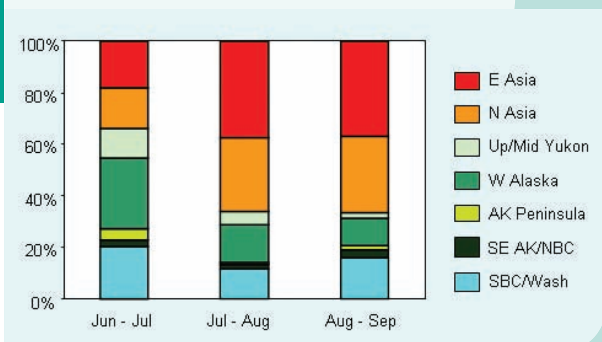
SNAPSHOT

This project will perform genetic analysis on archived chum salmon samples from the Bering Sea and Gulf of Alaska in order to determine the compositions of immature chum salmon aggregations in different regions of the eastern Bering Sea, their seasonal variation, and their variation among years.

The results are expected to shed light on ocean migration patterns and abundance and help determine the impact of chum salmon bycatch on western Alaska chum salmon returns.



Map of locations of chum salmon genetic samples from the groundfish fishery bycatch, and U.S. and Russian BASIS surveys, collected between 1988 and 2005. (Kondzela, NOAA)



Preliminary results of the origin of a subset of chum salmon collected in the Bering Sea during 2005. (Kondzela, NOAA)

project and in collaboration with other laboratories. Our findings will be compared with several collections from the western Bering Sea and Gulf of Alaska. Another task of this project is the acquisition of allele (haplotype) frequency data from representative chum salmon populations throughout the geographic range. After the resolution of the coast-wide baseline is evaluated, the baseline will be used for the mixture analyses.

REPORT COMPLETION

May 2011

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

BERING SEA FISHERMEN'S ASSOCIATION
110 W. 15TH AVENUE
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AYK SUSTAINABLE SALMON INITIATIVE

Project Synopsis

BERING SEA–MARINE

(Greg T. Ruggerone)

BERING SEA

WORK-IN-PROGRESS HISTORICAL ANALYSES OF ARCTIC-YUKON-KUSKOKWIM AND ASIAN CHUM SALMON

PROJECT

809

PRINCIPAL INVESTIGATOR

Bev A. Agler
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATION

Natural Resources Consultants, Inc.

RESEARCH PERIOD

July 2008 - March 2011

BUDGET

$134,106.00

CLUES FROM SALMON SCALES

Salmon scales, which have been routinely collected by management agencies to document salmon age, record the annual and seasonal growth history of salmon in ocean habitats where little direct growth information is available. Growth is a key factor affecting survival and life history characteristics of salmon. We will estimate annual and seasonal growth of Norton Sound, Kuskokwim River, and Asian chum salmon in the ocean from the mid-1960s to 2007. Growth estimates will be compared with ocean-climate shifts, trends in abundance, age-at-maturation of chum salmon, and abundance of pink salmon, a potential competitor with chum salmon for food in the ocean.

OUR OBJECTIVES

Evaluate whether changes in the abundance of pink salmon and climate change are associated with changes in growth and abundance of Norton Sound, Kuskokwim River, and Asian chum salmon.

Determine whether changes in the abundance of Asian chum salmon are associated with the growth and abundance of Norton Sound and Kuskokwim River chum salmon.

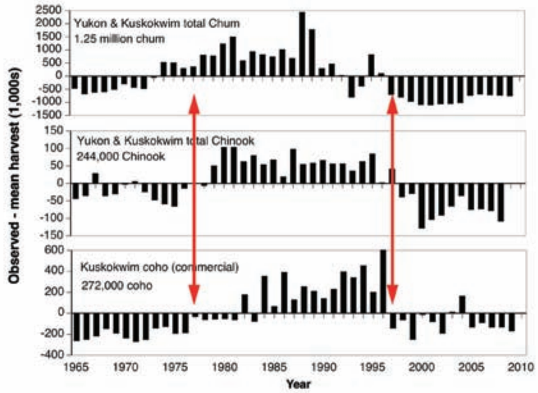
Establish whether common factors affect growth of Norton Sound, Kuskokwim River, and Asian chum salmon.

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION –
PRIORITY #10

SNAPSHOT

Salmon scales provide an opportunity to cost-effectively collect unique growth data on salmon in the ocean.

This project uses collections of adult chum salmon scales from Unalakleet River, Kuskokwim River and Asia as a means to reconstruct growth of these salmon in the ocean during the past 40 years.



Trends in the harvests of AYK chum, Chinook, and coho salmon since 1965. Arrows show the beginning of the 1976/1977 ocean regime shift and the 1997 El Niño event that had a significant effect on salmon in western Alaska. (Ruggerone, NRC)

(Gilk, ADF&G)

HOW WE WILL DO IT

Arctic-Yukon-Kuskokwim and Japanese chum salmon scales were obtained from Alaska Department of Fish and Game storage facilities and from the Japanese government. We are scanning images of the scales to a computer, and measuring seasonal (circuli) and annual scale growth from 50 fish per year per stock. These measurements will provide indices of how well these chum salmon grew during each year at sea.

REPORT COMPLETION

May 2011

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(Dave Folletti)

KUSKOKWIM AREA SUBSISTENCE SALMON HARVEST SURVEYS

PROJECT 309

PRINCIPAL INVESTIGATOR

Tracie Krauthoefer
Alaska Department of Fish and Game

RESEARCH PERIOD

June 2003 - December 2004

BUDGET

$101,591.00

TRACKING A SUBSISTENCE HARVEST

The Kuskokwim area subsistence salmon fishery is one of the largest in Alaska. Fishery managers need reliable information in order conduct valid salmon run reconstructions and to provide the best management possible for the sustained yield of salmon resources—especially after the implementation of a new management plan in 2001 in response to salmon population declines in the region. The Alaska Department of Fish and Game has conducted subsistence harvest surveys since statehood. Unfortunately, agency funding has not been available to continue this effort. AYK SSI funding enabled agency staff to conduct surveys and analyze harvest data from the numerous small communities on the Kuskokwim River.

OUR OBJECTIVES

Collect harvest data that would allow us to estimate the total 2003 subsistence harvest by species for every community in the Kuskokwim River Fisheries Management Area.

Collect information on fishing effort, gear types, participation rates, and harvest timing, and determine how this season compared to previous ones.

Identify fishing households, update household lists, and redesign the survey process to make it more cost-effective.

HOW WE DID IT

We mailed catch calendars used to record daily catches

RESEARCH FRAMEWORK:
HUMAN SYSTEMS – *PRIORITY #5*

SNAPSHOT

Subsistence salmon harvest surveys were conducted in the Kuskokwim area during the 2003 season. Harvests were found to be greater than the previous year for all salmon species except for chum salmon, although Chinook and sockeye salmon harvests were also below recent averages.

Fishing gear information and improvements to survey procedures were also included in this project.

YEAR	HOUSEHOLDS TOTAL	HOUSEHOLDS SURVEYED	CHINOOK	SOCKEYE	COHO	CHUM	PINK	TOTAL
			ESTIMATED SALMON HARVEST					
1989	3,422	2,135	85,323	37,088	57,846	145,106	0	325,363
1990	3,317	1,830	92,675	39,659	50,708	131,470	0	314,513
1991	3,347	2,024	90,226	56,401	55,620	96,314	0	298,561
1992	3,314	1,724	68,706	34,159	44,494	99,577	0	246,937
1993	3,274	1,816	91,722	51,362	35,295	61,724	0	240,103
1994	3,179	1,821	98,378	39,280	36,504	76,949	0	251,111
1995	3,652	1,894	100,157	28,622	39,165	68,941	0	236,885
1996	3,643	1,837	81,597	35,037	34,699	90,239	0	241,572
1997	3,510	1,831	85,506	41,251	30,717	40,993	0	198,466
1998	3,495	1,849	86,113	37,579	27,240	67,664	0	218,595
1999	4,180	2,523	77,660	49,388	27,753	47,612	0	202,413
2000	4,441	2,750	68,841	44,832	35,670	55,371	0	204,714
2001	4,483	2,297	77,570	51,965	31,686	51,117	0	212,338
2002	4,339	2,798	70,219	27,733	34,413	73,234	0	205,599
2003	4,353	2,375	72,498	36,894	38,791	46,291	NA	194,474
2000-2004 Average	4,404	2,555	72,282	40,356	35,140	56,503	0	204,281
1995-2004 Average	4,011	2,239	80,018	39,256	33,348	60,162	0	212,784
All Years Average	3,730	2,100	83,146	40,750	38,707	76,840	0	239,443
	0							

SOURCE: Alaska Department of Fish and Game, Division of Subsistence, Alaska Subsistence Fisheries Database, Version 3.3.

Kuskokwim Area Historic Subsistence Salmon Harvest. (Krauthoefer, ADF&G)

Community		Fishing HH'S*	Setnet	Drift Net	Fish Wheel	Rod and Reel	Seine	Spear	Not Reported
			Gear Types**						
Kipnuk		0	0	0	0	0	0	0	0
Kwigillingok		0	0	0	0	0	0	0	0
Kongiganak		28	2	24	0	0	0	0	3
N KUSKOKWIM BAY	Totals	28	2	24	0	0	0	0	3
Tuntutuliak		54	6	47	0	2	0	0	6
Eek		43	10	20	0	9	0	0	14
Kasigluk		4	0	0	0	0	0	0	4
Nunapitchuk		64	3	52	0	0	0	0	12
Atmautluak		33	7	24	0	0	0	0	6
Napakiak		44	15	32	0	0	0	0	8
Napaskiak		45	10	37	0	11	0	0	7
Oscarville		11	3	9	0	0	0	0	1
Bethel		439	23	300	0	70	0	0	91
Kwethluk		82	20	62	0	39	0	0	11
Akiachak		64	13	52	0	13	0	0	7
Akiak		47	17	30	0	4	0	0	14
Tuluksak		41	19	32	0	17	0	0	1
LOWER KUSKOKWIM	Totals	971	146	697	0	165	0	0	182
Lower Kalskag		29	5	19	0	2	0	0	7
Upper Kalskag		26	7	19	0	3	0	0	6
Aniak		77	11	52	0	36	0	0	10
Chuathbaluk		18	2	11	0	8	0	0	4
MIDDLE KUSKOKWIM	Totals	150	25	101	0	49	0	0	27
Crooked Creek		22	6	20	0	7	0	0	2
Red Devil		5	4	3	0	2	0	0	0
Sleetmute		18	4	11	0	7	0	0	3
Stony River		8	6	0	0	4	0	0	0
Lime Village		9	5	0	0	7	0	0	0
McGrath		50	24	4	0	22	0	0	8
Takotna		0	0	0	0	0	0	0	0
Nikolai		2	0	0	0	0	0	0	2
Telida		0	0	0	0	0	0	0	0
UPPER KUSKOKWIM	Totals	114	49	38	0	49	0	0	15
Quinhagak		86	14	51	0	33	0	0	16
Goodnews Bay		36	9	17	0	19	0	0	6
Platinum		13	5	5	0	3	2	1	0
S KUSKOKWIM BAY	Totals	135	28	73	0	55	2	1	22
Mekoryuk		12	0	0	0	0	0	0	12
Newtok		1	0	0	0	0	0	0	1
Nightmute		2	0	0	0	0	0	0	2
Toksook Bay		2	0	0	0	0	0	0	2
Tununak		1	0	0	0	0	0	0	1
BERING SEA COAST	Totals	18	0	0	0	0	0	0	18
Chefornak		1	0	0	0	0	0	0	1
OTHER	Totals	1	0	0	0	0	0	0	1
TOTAL		1417	250	933	0	318	2	1	268

* Data on households which subsistence fished based upon in-person surveys, returned postcards, or returned calendars.
** A household may use multiple gear types.

Kuskokwim Area Subsistence Salmon Gear Used, 2003. (Krauthoefer, ADF&G)

of each salmon species to all identified subsistence fishing households. Three different calendars were used to accommodate different timing and species availability in different areas. Post-season, we conducted in-person household surveys, and we sent postcard surveys to all households not covered by the in-person surveys. These post-season surveys provided information about salmon harvests, type of fishing gear used, and the quality of fishing for each salmon species.

WHAT WE DISCOVERED

We established contact with roughly half of the 4,535 households located in the Kuskokwim area. We found that the Chinook and sockeye salmon subsistence harvests have increased from the previous year, but were still below the recent five- and ten-year averages. The chum salmon harvest was the second lowest since 1988 when the surveys were reformatted. Only the coho salmon harvest was above the recent five- and ten-year averages. We also collected information on fishing gear used, the amount of fish used for dog food, and how many fish were retained for personal use in the commercial fishery. Despite declines, the majority of respondents described their fishing as “very good” or “average,” even in the chum salmon fishery.

PRODUCTS AND OUTREACH

We published the results of this project in an annual departmental report, in reports to the Alaska Board of Fisheries and made them available online.

WHAT’S NEXT?

Although information on the timing of the subsistence harvest was collected and compiled into a database, funding constraints did not allow this data to be processed. Since this information is critical for the management of the fishing schedule, the need for annual analysis has been included in the redesign of the survey methodology and in the operational plan. We also identified the need for one funding source for all of the separate components.

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(ADF&G Staff)

KUSKOKWIM RIVER SALMON POPULATION ESTIMATES

PROJECT

310

PRINCIPAL INVESTIGATOR

Carol M. Kerkvliet
Alaska Department of Fish and Game

RESEARCH PERIOD

May 2003 - November 2004

BUDGET

$197,593.00

HOW MANY SALMON IN THE KUSKOKWIM RIVER?

Kuskokwim River is the second largest river in Alaska, supporting one of the state's largest subsistence fisheries. It is remote and geographically diverse, and different salmon species of multiple stocks run at overlapping timings. These factors make it difficult to forecast run abundance, monitor actual abundance in season, or have sufficient knowledge of run timing differences among stocks. Due to such constraints, it is difficult for fisheries managers to allow for selective harvest of abundant stocks while protecting less abundant stocks.

OUR OBJECTIVES

Continue earlier projects that use mark-recapture techniques to estimate abundance of sockeye, chum, and coho salmon in the Kuskokwim River. This involves tagging fish at a downstream site, releasing them, and recapturing them farther upriver.

Estimate the total population, run timing, and average travel speed by examining proportion of the tagged fish in the group caught upriver.

HOW WE DID IT

We had two opportunities to estimate population size using mark-recapture techniques. The first was between Kalskag and recovery at Aniak, about 27 river kilometers apart. The second was between Kalskag/Aniak and

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

Mark-recapture techniques were used to provide timely information about the runs of sockeye, chum, and coho salmon in the Kuskokwim River.

This project furthered earlier efforts to better understand this river's salmon stock abundance, run timing, and average speeds.

(ADF&G Staff)

(ADF&G Staff)

recovery at upstream escapement projects. At Kalskag and Aniak, we used fish wheels set on both sides of the river, and drift gillnets in the center of the river, to capture mixed stocks of salmon during the salmon run period, from early June to early September. We inserted spaghetti tags into the captured fish along with a secondary mark. At recovery sites, we examined a proportion of the tagged fish.

WHAT WE DISCOVERED

We were able to estimate abundances of sockeye, chum, and coho salmon; however, we believe that the estimates are inaccurate and unreliable based on harvest and escapement information. We were not able to tag and recover well-mixed stocks. Furthermore, crowding during tagging does appear to increase the chance of recapture of sockeye and chum salmon. We also found that upstream stocks of chum and coho salmon migrated earlier in the season than lower-river stocks.

PRODUCTS AND OUTREACH

Our results were made available to fisheries managers during the field season, and published in an ADF&G technical report.

WHAT'S NEXT?

We will continue to improve mark-recapture techniques, especially capturing and recovering well-mixed salmon stocks. We plan to relocate the Kalskag site farther downstream and omit the Aniak site, increase tagging efforts on gillnets, reduce crowding of the fish wheels while tagging, establish another upstream collection site, and fit radio transmitters to sockeye salmon. We hope these modifications will improve accuracy of mark-recapture salmon abundance estimates.

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(Sara E. Gilk)

CHARACTERISTICS OF KUSKOKWIM RIVER FALL CHUM SALMON

PROJECT 409

PRINCIPAL INVESTIGATOR

Sara E. Gilk
Alaska Department of Fish and Game

RESEARCH PERIOD

May 2004 - April 2005

BUDGET

$71,036.00

FALL CHUM SALMON STAND APART

Since the mid-1990s, fisheries managers have known that the Kuskokwim River hosts a run of fall chum salmon that were genetically distinct from the more common summer chum salmon population, and whose spawning distribution seemed limited to the upper Kuskokwim River; otherwise, little was known about the fall population. Harvest statistics do not distinguish between the two populations. Escapement monitoring is conducted for summer chum salmon but not fall chum salmon. Low chum salmon run abundance prompted the Alaska Board of Fisheries in 2000 to designate Kuskokwim River chum salmon as a "stock of concern," but no distinction was made between summer and fall populations. Without more information about the fall run, it is difficult for managers to assess the effects of conservation measures on this population.

OUR OBJECTIVES

Address the information gap by describing some key characteristics of Kuskokwim River fall chum salmon in comparison with summer chum salmon. Specifically, we wanted to compare age and sex composition, morphological features, fecundity, spawning distribution, lower river run timing, and relative abundance.

HOW WE DID IT

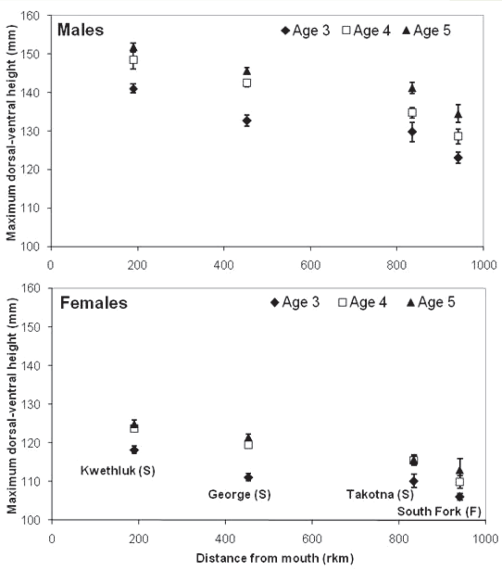
We captured 1,964 summer chum salmon at weirs on the Kwethluk, George, and Takotna rivers, and 336

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

This project compares characteristics of fall and summer chum salmon populations in the Kuskokwim River. Differences were found in age composition, morphological characteristics, run timing, and spawning distribution, but not in sex ratios or fecundity.

(Sara E. Gilk)



Relationship between migration distance and average maximum width for male and female Kuskokwim River summer and fall chum salmon, 2004. (Gilk, ADF&G)

fall chum salmon captured at a fish wheel located on the South Fork Kuskokwim River to compare age and sex composition, morphological features, and fecundity. We also summarized historical aerial survey data to compare spawner distribution of the two populations, and used single nucleotide polymorphisms (SNPs) as genetic markers to estimate run timing and relative abundance from mixed-stock samples collected from fish wheels operated near the Kalskag, in the lower Kuskokwim River.

WHAT WE DISCOVERED

Fall chum salmon had significantly more age 0.2 (zero winters in freshwater/two winters at sea) fish than any summer population, but no differences were found in sex ratios or fecundity. Fall chum salmon tended to be longer and thinner than summer chum salmon but differences were not so profound as to make the two populations easily distinguishable in a mixed-stock setting. Also, these morphological differences may not translate to fish more distant from the spawning areas, such as those harvested in the lower Kuskokwim River commercial fishery. Genetic analysis showed that fall chum salmon composed only a small proportion of the mixed-stock samples collected from the Kalskag fish wheels, and that fall chum salmon were present early in the overall chum salmon run passing Kalskag. Greater resolution about run timing may be achieved through analysis of archived samples. Finally, spawning distribution of fall chum salmon appears to be confined to side-channels of large glacier-fed upper Kuskokwim River tributaries such as Big River and the South Fork Kuskokwim River, while summer chum salmon spawn in small to large tributaries of the lower and middle Kuskokwim River.

PRODUCTS AND OUTREACH

We presented our findings at several national and regional meetings, including meetings that target diverse audiences of Kuskokwim area residents. We published our findings in a technical report and in a collection of symposium proceedings.

WHAT'S NEXT?

Future investigations should incorporate additional Kuskokwim River fall chum salmon populations, compare physical attributes of fall and summer chum salmon spawning habitats, and conduct mixed-stock genetic analysis of fish caught in the lower Kuskokwim River commercial fishery to determine run timing and relative contribution of fall chum salmon.

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(Christian E. Zimmerman)

BODY CONDITION AND FEEDING ECOLOGY OF KUSKOKWIM RIVER CHUM SALMON

PROJECT 424

PRINCIPAL INVESTIGATOR

Julie M. Meka
United States Geological Survey

CONTRIBUTING ORGANIZATION

National Oceanic and Atmospheric Administration

RESEARCH PERIOD

April 2004 - June 2006

BUDGET

$130,670.00

JUVENILE CHUM SALMON FEEDING

Freshwater and estuarine habitat use may have a critical influence on overall survival of salmon. Declines in chum salmon runs since 1998 have been attributed to factors in the marine environment—possibly influenced by high mortality during early life stages in transitional environments. Research on the freshwater early life history of Kuskokwim River chum salmon, however, is currently nonexistent, and little is known about juvenile salmon in Alaskan rivers in general.

OUR OBJECTIVES

Conduct a pilot study to evaluate methods of capturing Kuskokwim River chum salmon fry before and during spring ice break-up in order to document out-migration timing.

Examine variations in feeding ecology, size, and body condition in fry emerging close to or far from the ocean and originating from summer- or fall-run parent stocks.

HOW WE DID IT

We sampled fish from the Kwethluk and Takotna rivers to represent fry emerging close to and far from the Kuskokwim River estuary. We also sampled fry in Kuskokwim Bay to represent juveniles transitioning into salt water. Additionally, we collected juveniles from southeast Alaska to serve as standards representing newly emerged, fed, and starved fry. We examined the stomach contents from a portion of the collected juveniles for lipid class

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

Body condition and feeding ecology of Kuskokwim River juvenile chum salmon was studied to determine if populations of chum salmon demonstrate local adaptation related to distance of migration from the sea.

Upstream fry had higher energy densities than those in the estuary, but the highest energy densities were found in the Kwethluk River, which was farther downstream than other sampled populations.

Marine-derived nutrients, passed to them from the mother, and freshwater nutrients obtained after emergence were important for survival.

(Christian E. Zimmerman)

composition, total fatty acid content, nutrient content, length, and weight for all samples collected.

WHAT WE DISCOVERED

Kuskokwim River chum salmon had the highest energy density shortly after they emerged. Upstream fry had higher average energy density than those from Kuskokwim Bay, but Kwethluk River fry had a higher average energy density than those from the Takotna River, which is much farther upstream. We found that nutrients provided by the mother, and freshwater nutrients obtained as soon after emergence as possible, are both important energy sources for juvenile survival. Dependence on freshwater nutrients also applied to the time fry spent in the estuary. Our data suggest that the proportion of energy allocated to lipid class composition during residence in estuaries by juvenile chum salmon may predict future survival.

PRODUCTS AND OUTREACH

Our results were published in three collections of workshop and symposium proceedings.

WHAT'S NEXT?

Our findings highlight some important management considerations. Ocean conditions are likely to have a much stronger influence on the productivity of upriver stocks because the amount of energy supplied to emergent fry will depend directly on the amount of energy passed to them by their maturing mothers. Also, managers should be aware that juvenile chum salmon residing in the estuarine environment have only small energy reserves and are still dependant on freshwater nutrients. Consequently, reductions in the availability of these freshwater energy sources are likely to reduce survival.

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(Lisa Stuby)

KUSKOKWIM RIVER CHINOOK SALMON RUN RECONSTRUCTION

PROJECT
612

PRINCIPAL INVESTIGATOR

Doug B. Molyneaux
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATIONS

Bue Consulting, LLC

Kuskokwim Native Association

RESEARCH PERIOD

May 2006 -
April 2009

BUDGET

$558,460.00

A SHARPER PICTURE OF THE PAST

Half the annual subsistence harvest of Chinook salmon in the state of Alaska is taken from the Kuskokwim River. Subsistence fishing for Chinook salmon is an integral and fundamental part of life for residents of the 29 communities found within the Kuskokwim River basin. Trying to understand the mechanisms driving variation is hindered by not having reliable historical estimates of the total number of salmon returning each year.

OUR OBJECTIVES

Estimate the total annual number of Chinook salmon returning to the Kuskokwim River from 1976 through 2007.

Combine these estimates with age composition information to estimate the number of fish that returned per spawner.

HOW WE DID IT

We used a discontinuous historical time series of stock assessment and harvest data sets that collectively continued enough information to allow us to estimate annual Chinook salmon run abundance. This information was combined into a statistical model developed to estimate total annual Chinook salmon abundance back to 1976. Finally, the model-generated abundance estimates were used to assess the influence of parental escapement abundance on variations in return between 1976 and 2007.

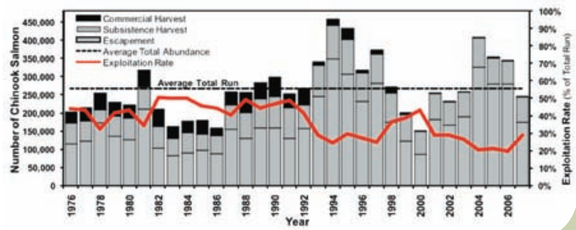
RESEARCH FRAMEWORKS:

SALMON LIFE CYCLE – *PRIORITY #2;*

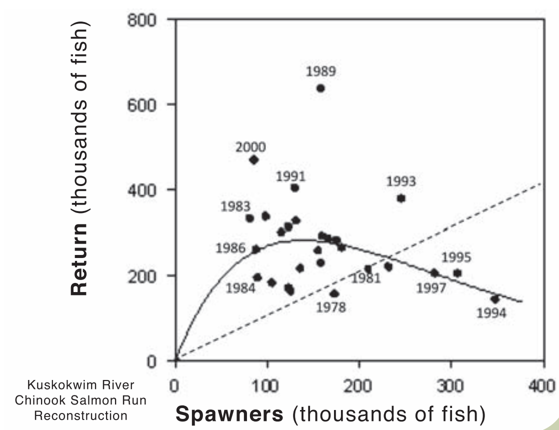
SYNTHESIS & PREDICTION – *PRIORITY #10*

SNAPSHOT

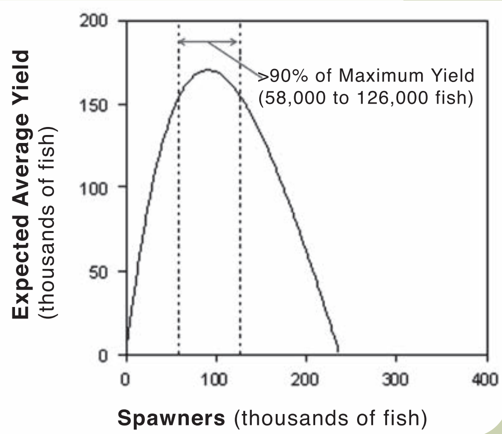
On average, 250,000 Chinook salmon return to the Kuskokwim River each year, and 37% are harvested. The Holitna River drainage is a particularly important spawning area, accounting for 21–31% of the annual spawner distribution.



Preliminary estimates of annual Chinook salmon run abundance in the Kuskokwim River and percent harvested. (Molyneaux, ADF&G)



The fit of the Ricker model to information for the Chinook salmon population returning to the Kuskokwim River and showing selected parent years. (Bue Consulting)



Estimate of average yield (harvest) by the number of spawners from the Ricker model. (Bue Consulting)

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

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WHAT WE DISCOVERED

Some of our preliminary results showed that annual Chinook salmon runs range from 150,000 (2000) to 460,000 fish (1994), and average about 250,000 fish. About 37% of the run is harvested each year, mostly for subsistence use. Large spawning escapements tend to produce low returns while returns from small escapements could be high or low. On average, optimal spawning escapement for maximizing returns would be in the range of 58,000 to 126,000 fish; however, if the fishery were managed towards the lower end of this range, then densities of fish in the middle and upper Kuskokwim River may be so low as to make it difficult for subsistence fishermen to catch fish. Still, even in the low abundance year of 2000, the drainage-wide Chinook salmon escapement was 86,000 fish, which is within the optimal spawning escapement range. The Holitna River drainage is particularly important to Chinook salmon production in that it accounts for 21–31% of the annual spawner distribution.

PRODUCTS AND OUTREACH

We presented our findings at numerous local and regional meetings and one state-wide meeting. Findings are to be published in an ADF&G technical report that is still in development.

WHAT'S NEXT?

The run reconstruction model can be used to continue to generate annual total abundance estimates. Escapement data from weirs is critical input to the model, so stable long-term operation of the weirs is a high priority. The model should be occasionally verified through repeating the mark-recapture portion of the project. Monitoring stock composition in the lower Kuskokwim River through genetic techniques may be an inexpensive alternative to determine if such a shift occurs. Developing a drainage-wide escapement goal for Kuskokwim River Chinook salmon is a likely next step.

(Doug B. Molyneaux)

KUSKOKWIM RIVER SOCKEYE SALMON INVESTIGATIONS

PROJECT
618

PRINCIPAL INVESTIGATOR

Sara E. Gilk
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATION

Natural Resources Consultants, Inc.

RESEARCH PERIOD

May 2006 - September 2008

BUDGET

$445,730.00

SOCKEYE SALMON FUNDAMENTALS

Sockeye salmon are popular among Kuskokwim River subsistence fishers and there is growing harvest interest among commercial fishers and processors. But the number of sockeye salmon that return to the river each year is relatively low when compared to chum or coho salmon, and their basic biology and ecology has largely been a mystery.

OUR OBJECTIVES

Find out where Kuskokwim River sockeye salmon spawn, and whether there were differences in run timing among sockeye salmon bound for different spawning areas.

Determine where the juveniles of these river-type sockeye salmon were rearing and whether their rearing areas change as they got older.

Examine the growth rates of juvenile sockeye salmon, both river- and lake-type fish, among various Kuskokwim River tributaries to see how they compare with sockeye salmon from other locations around Alaska.

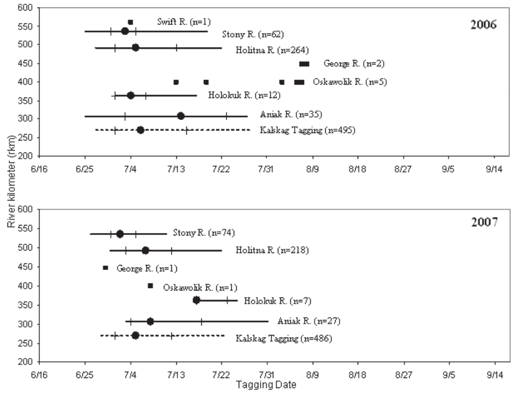
HOW WE DID IT

Specially built fish wheels outfitted with live boxes were used to capture adult sockeye salmon from the mainstem Kuskokwim River near Kalskag in 2006 and 2007. We inserted radio transmitters into the fish, released them back to the river, and then tracked the fish to their final spawning destination.

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE –
PRIORITIES #2 AND #4

SNAPSHOT

Aspects of the freshwater ecology of Kuskokwim River sockeye salmon were determined using radio telemetry, collection of juvenile fish, and analysis of fish scales. Results show that the Kuskokwim River sockeye salmon run is dominated by river-type fish that spawn and rear in streams, rather than the lake-type fish that are more common elsewhere in Alaska.



Stock specific run timing for radio-tagged Kuskokwim River sockeye salmon in 2006 and 2007, including median, quartile, 10th percentile, and 90th percentile dates. (Liller, ADF&G)

(Jay Baumer)

(Ted Wittenberger)

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KUSKOKWIM

We also used beach seines to collect and measure juvenile sockeye salmon in the Kogrukluk and lower Holitna rivers from three habitat types: mainstem, side channel with flowing water, and slackwater slough. Scales from adult sockeye salmon were collected and measured to compare growth rates between locations, and with locations outside of the Kuskokwim River.

WHAT WE DISCOVERED

Three major spawning locations were identified: Holitna, Stony, and Aniak rivers. The Holitna and Aniak river fish are "river-type" sockeye salmon, while most of Stony River fish follow the "lake-type" life history strategy. Fish from these three major spawning "stocks" migrate through the lower Kuskokwim River at about the same time. Whether taken early or late in the run, harvest should have about the same mix of these three stocks with a low probability of selective harvest of one stock over another. We found that slough habitat is especially important to the juvenile river-type sockeye salmon in the Holitna River during their early freshwater life (spring).

PRODUCTS AND OUTREACH

We presented our findings at regional meetings and one national meeting. We also conducted community meetings and school visits in Kuskokwim River villages and were featured in a newspaper article and a radio news segment. A technical report is in development.

WHAT'S NEXT?

Fishery managers should establish a goal for the number of spawning sockeye salmon at Kogrukluk River weir, as an index of for sockeye salmon in the Holitna drainage. Similarly, it would be helpful to monitor the annual number of sockeye salmon spawning in Telaquana Lake as an index for lake-type fish in the Stony River drainage. Finally, genetic analysis should be done of sockeye salmon harvested in the lower Kuskokwim River to determine the stock composition.

(Christian E. Zimmerman)

ABUNDANCE, MIGRATION AND SURVIVAL OF JUVENILE CHUM SALMON, KWETHLUK RIVER

PROJECT 619

PRINCIPAL INVESTIGATOR

James E. Finn
United States Geological Survey

CONTRIBUTING ORGANIZATION

United States Fish and Wildlife Service

RESEARCH PERIOD

May 2006 - April 2009

BUDGET

$269,989.00

SURVIVING FROM EGG TO SMOLT

Declines in salmon returns to western Alaska rivers in the late 1990s and early 2000s resulted in restrictions to commercial and subsistence fisheries. The reasons for these declines are unknown and difficult to identify due to a general lack of knowledge concerning salmon populations and their habitats within this region. Determining the relative importance of mortality in freshwater, estuarine, or marine habitats on spawning recruitment will aid fisheries managers in responding to declining salmon returns.

OUR OBJECTIVES

Estimate the population size and calculate egg-to-smolt survival of migrating juvenile chum salmon on the Kwethluk River.

Test our methods, which have not previously been used in the AYK region.

Determine the timing of migration and relative abundance of Chinook, coho, sockeye, and pink salmon.

HOW WE DID IT

In 2007 and 2008, we used floating, inclined-plane traps to catch migrating smolts. All caught fish were counted, and every third day, a subsample of 100 fish were also measured. We used mark-recapture methods to estimate the number of migrants passing the traps. We used these estimates along with estimates of potential egg deposition

RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

The first study of this type in the AYK region, this project produced a method to calculate the egg-to-smolt survival of juvenile chum salmon on the Kwethluk River, a tributary of the Kuskokwim River.

Researchers also estimated the juvenile chum salmon population size, and relative abundance and migration timing of other salmon species.

(Christian E. Zimmerman)

(Christian E. Zimmerman)

to calculate the percent survival of juvenile chum salmon. We also monitored water depth and temperature at the trap site.

WHAT WE DISCOVERED

We estimated a 4.6% egg-to-smolt survival of migrating chum salmon smolts in 2007, and 5.2% survival in 2008. Fluctuations in water depth appeared to be the largest factor influencing the initiation of juvenile chum salmon migration. Similar to other studies, our study found that juvenile abundance for all species increased during high water events, and peak migration timing occurred during early morning. Peak migration occurred from mid-May through mid-June, which coincides with the timing from Yukon River tributaries. We found that our protocols, which we modified to accommodate conditions specific to the Kuskokwim River watershed, worked well. A sampling bias between the traps was identified in 2007 and rectified in 2008.

PRODUCTS AND OUTREACH

In addition to the final report (published as a USGS Open File Report), we are preparing a manuscript that compares survival of chum salmon on the Kwethluk River with survival estimates from a Yukon River tributary and other locations throughout the North Pacific. Outreach efforts include presentations to the Kuskokwim Interagency Fishery Meetings and presentations at scientific meetings.

WHAT'S NEXT?

Our project design may be useful in estimating abundance of other salmon species. Using this method to estimate the abundance of species with multiple age classes is possible if fish rear exclusively upstream of the trapping location. If juveniles migrate downstream to rear in other locations, estimates would need to account for survival in non-natal habitats. In addition, the population size would have to be large enough to provide an adequate number of marks for the abundance estimation.

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(Dave Folletti)

WORK-IN-PROGRESS
HERITABILITY OF TRAITS IN WILD CHINOOK SALMON

PROJECT
725

PRINCIPAL INVESTIGATOR

Jeffrey B. Olsen
United States Fish and Wildlife Service

CONTRIBUTING ORGANIZATIONS

Alaska Department of Fish and Game

National Oceanic and Atmospheric Administration

United States Geological Survey

RESEARCH PERIOD

May 2007 - March 2010

BUDGET

$226,628.00

SIZING UP CHINOOK SALMON

Many Chinook salmon in the Kuskokwim River are harvested in the subsistence fishery using "large mesh" (8 inches or larger) gillnets. This mesh size avoids unintentional harvest of smaller, more abundant species but preferentially captures older and larger Chinook salmon. There is interest in determining if this selective fishery has a population-level impact on traits such as adult size and age. Realistic estimates of trait heritability are needed to fully evaluate this. This selective fishery may also be indirectly influencing abundance if reproductive success is greater for larger fish. To study this issue, estimates of family size for a sample of parents of known length are needed. The results of this study will provide salmon fishers and fishery managers a better understanding of the possible impacts of a size selective harvest on Chinook salmon.

OUR OBJECTIVES

To be able to estimate the heritability of adult size, growth rate, age-at-maturation, and the genetic covariance among these traits in male and female Tuluksak River Chinook salmon.

To be able to determine if the variation in family size is random, and if not, determine if family size is related to the size of the adult parent.

HOW WE WILL DO IT

We plan to sample approximately 1,000 Chinook salmon

RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITY #3*

SNAPSHOT

This project will sample Chinook salmon on the Tuluksuk River to determine whether selective fishing using large mesh size nets is affecting the composition of the population. Genetic analysis will be used to determine the heritability of certain traits and reconstruct family groups to understand the relationship of family size to parental size.

Map of the lower Kuskokwim River drainage showing the location of the Tuluksak River weir. (Olsen, USFWS)

(Jeffrey B. Olsen)

from the Tuluksak River in each of three years from 2007 to 2009 in order to study trait heritability and family size in the 4- to 6-year-old adults born in 2003. The samples will make possible the evaluation of family size and the influence of parent size on reproductive success. Samples will be collected at the Tuluksak River weir and from post-spawning adults taken above the weir. We will use scales and otoliths to determine ages. The scale and otolith data will allow for a comparison of growth rates between cohorts and age classes. We will take tissue samples for genetic analysis. We will use computer programs to reconstruct family groups and estimate genetic variance.

REPORT COMPLETION

December 2010

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

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AYK SUSTAINABLE SALMON INITIATIVE

Project Synopsis

KUSKOKWIM RIVER WATERSHED

(ADF&G Staff)

WORK-IN-PROGRESS
KUSKOKWIM RIVER COHO SALMON INVESTIGATION

PROJECT
801

PRINCIPAL INVESTIGATOR

Doug B. Molyneaux
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATIONS

Bue Consulting, LLC

Kuskokwim Native Association

RESEARCH PERIOD

May 2008 -
March 2011

BUDGET

$723,876.00

WHERE DO COHO SALMON SPAWN?

Coho salmon are the most commercially valuable salmon species returning to the Kuskokwim River. Recent fluctuations in both run abundance and commercial markets dictates the need for fishery managers to better understand the dynamics of Kuskokwim River coho salmon stocks. Our current understanding of the variation in abundance of Kuskokwim River coho salmon comes from a discontinuous time-series of in-river commercial catch and effort data, subsistence harvest estimates, test fishery catch rates, tributary weir counts, and mark-recapture estimates of abundance. Total abundance estimates are necessary as a context from which to focus genetic baseline collections: interpret the impacts of climatic shift, changes in ocean productivity, impacts of interception fisheries, and changes in management practices. The project builds on numerous existing platforms, and incorporates unique partnerships.

OUR OBJECTIVES

Determine whether current in-river harvest patterns have stock-specific effects on Kuskokwim River coho salmon, and whether alternative harvest patterns could affect coho salmon catch and stock structure, or serve as management tools in times of conservation need.

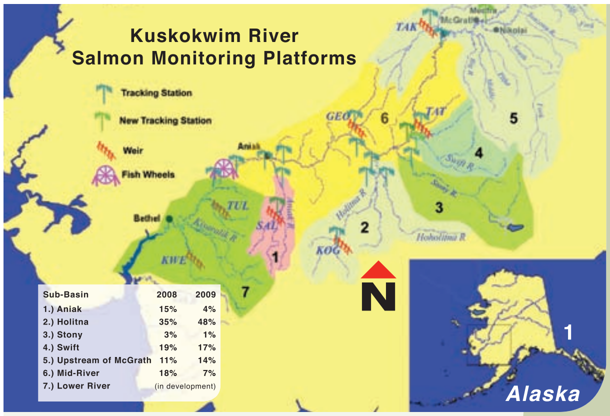
Determine whether there is an even distribution of spawning coho salmon throughout the Kuskokwim River drainage, or whether there are discreet sub-areas that

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE –
PRIORITY #2

SNAPSHOT

This project will use radiotelemetry and mark-recapture studies to describe the spawning distribution of Kuskokwim River coho and estimate historical adult run abundance from 1981 to 2009.

Results will be used to analyze patterns in historical variations in abundance and characterize the spawner-recruitment relationship.



Distribution of spawning coho salmon in various sub-basins of the Kuskokwim River in 2008 and 2009. (Molyneaux, ADF&G)

(ADF&G Staff)

support a disproportionate fraction of spawning coho salmon.

Determine whether adult coho salmon abundance in the Kuskokwim River drainage has demonstrated any periodic changes over the past 20 to 25 years, and determine whether there is a relationship between adult-run abundance and subsequent returns as a mechanism for explaining changes in abundance.

HOW WE WILL DO IT

We plan to use simultaneous mark-recapture and radiotelemetry studies to characterize adult stock-specific run timing and to estimate abundance. We will use radiotelemetry to determine the percentage of coho salmon spawning escapement going six sub-areas upstream of the tagging site located near Kalskag, with an extrapolation for a seventh area consisting of downstream tributaries. We will develop a statistical model to reconstruct total historical abundance of adult coho salmon from approximately 1981 to 2009. We will then use these estimates to assess patterns of variation in total abundance, and to describe the spawner-recruitment relationship. In addition, aerial tracking surveys will be conducted along the mainstem Kuskokwim River, and in major tributaries, to help determine the fate of all radio-tagged fish.

REPORT COMPLETION

May 2011

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(Megan V. McPhee)

WORK-IN-PROGRESS
ECOTYPIC VARIATIONS IN KUSKOKWIM RIVER SOCKEYE SALMON STOCKS

PROJECT
802

PRINCIPAL INVESTIGATOR

Megan V. McPhee
University of Alaska Fairbanks

CONTRIBUTING ORGANIZATIONS

University of Montana

University of Washington

RESEARCH PERIOD

June 2008 - March 2011

BUDGET

$177,661.00

HOW STABLE ARE SOCKEYE SALMON RUNS?

Year-to-year fluctuations in salmon run sizes cause difficulty for fishery managers and fishers trying to anticipate returns. Recent evidence from Bristol Bay has shown that "biocomplexity" contributes to regional sockeye salmon run stability. In this fishery, runs are composed of multiple local populations with diverse life-history and physical characteristics adapted to their specific spawning areas. Because of this high diversity, each local population responds individually to annual variation in climate, weather, and local feeding and growing conditions; some increase and some diminish, but the overall run size remains relatively stable. Because of the growing importance of sockeye salmon in the Arctic-Yukon-Kuskokwim region, it is important to determine whether such population diversity can contribute to run stability there as well.

OUR OBJECTIVES

Characterize ecological and genetic diversity within and between sockeye salmon spawning populations in the Kuskokwim River drainage—specifically in the upper Holitna and Stony River/Telaquana Lake regions.

Identify physical features of spawning habitat, and quantify environmental complexity within and between spawning locations.

Use our data to compare ecological and genetic differentiation with geographic distance and

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION – *PRIORITY #10*

SNAPSHOT

This project will collect information on the ecological and genetic diversity of Kuskokwim River sockeye salmon populations. Researchers will measure adult sockeye salmon morphology and genetics in several river and lake spawning areas, as well as the environmental characteristics of those areas.

Results will be compared with Bristol Bay to determine if similar factors can be expected to contribute to run stability in the Kuskokwim River.

(Dave Cannon)

(Dave Cannon)

environmental complexity in the Kuskokwim River drainage and Bristol Bay.

HOW WE WILL DO IT

We plan to record and sample four to five spawning areas during each of two field seasons. The first season will focus on the upper Holitna River (river-type sockeye salmon), the second on Telaquana Lake (lake-type sockeye salmon). We plan to collect up to 100 adults from each aggregation, anesthetize and photograph them, collect various body measurements, collect a fin sample for genetic analysis, and take a small egg sample. At the end of the spawning period, we will return to these areas to collect otoliths for age and sex data. We will also use historic data when available. We will use 16 microsatellite DNA markers to analyze population differences. In each spawning area, we will collect data on temperature, and intergravel and surface hydraulic flow, and conduct sediment-size profiles in the river areas. We will use statistical analysis to compare our information with similar data from Bristol Bay.

REPORT COMPLETION

May 2011

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(Greg T. Ruggerone)

PRODUCTIVITY OF KUSKOKWIM RIVER JUVENILE COHO SALMON

PROJECT 805

PRINCIPAL INVESTIGATOR

Greg T. Ruggerone
Natural Resources Consultants, Inc.

CONTRIBUTING ORGANIZATION

Alaska Department of Fish and Game

RESEARCH PERIOD

May 2008 - March 2010

BUDGET

$76,659.00

SALMON AND SATELLITES

The Kuskokwim River is the second largest watershed in Alaska and relatively little information is available on growth of juvenile coho salmon in relation to habitats in tributaries of the Kuskokwim River and Kuskokwim Bay. Growth of juvenile coho salmon, which typically inhabit freshwater for two growing seasons, likely reflects the quality of the watershed in which they live. Salmon growth is key to their survival. Growth information is important because threats to salmon habitat, such as mining, may continue or possibly increase in the future.

OUR OBJECTIVES

Reconstruct annual growth of juvenile coho salmon originating from eight tributaries in the Kuskokwim area, and compare these measurements with watershed habitat characteristics to determine which features contributed to growth.

Compare smolt size of Kuskokwim area coho salmon with that from other regions of Alaska, British Columbia and Russia.

HOW WE DID IT

We measured growth rings on adult salmon scales collected on eight Kuskokwim area tributaries from 2003 to 2007. We also developed a relationship between juvenile coho salmon length and the radius of their scale so that juvenile length could be back-calculated from

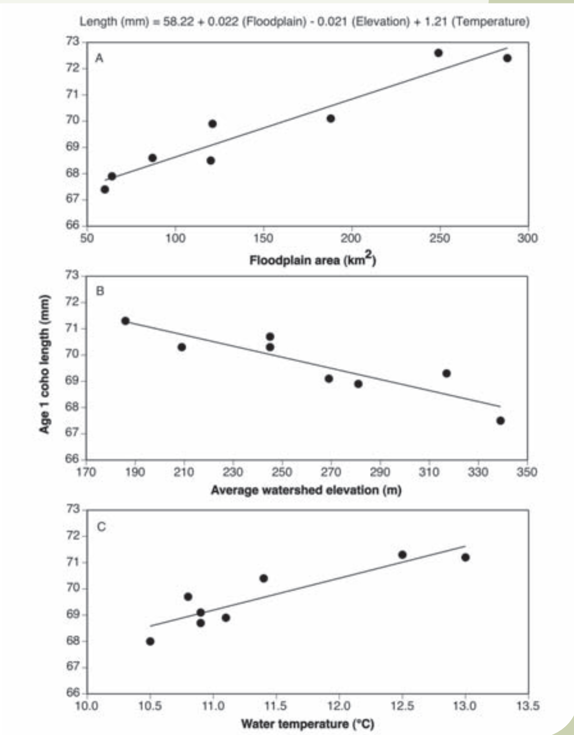
RESEARCH FRAMEWORKS:
SALMON LIFE CYCLE – *PRIORITY #1;*

SYNTHESIS & PREDICTION – *PRIORITY #7*

SNAPSHOT

How can salmon growth be compared with habitat across the Kuskokwim, a huge region of Alaska? The answer lies in adult salmon scales and remote-sensing satellites.

(Greg T. Ruggerone)



Relationship between annual mean length of juvenile coho salmon after one year in freshwater and the following watershed characteristics: A) floodplain habitat area, B) average watershed elevation, and C) average summer water temperature. (Ruggerone, NRC)

the measurements of adult scales. Next, we obtained habitat data for each watershed collected from satellites in space (University of Montana, Flathead Biological Station), and measured water temperature using a data logger. Smolt sizes from other regions were obtained from the literature.

WHAT WE DISCOVERED

Growth in freshwater is likely a key factor contributing to the relatively great abundance of coho salmon in the Kuskokwim area. The amount of floodplain habitat (for example, old river oxbows) was the primary factor influencing growth of coho salmon, indicating the need to protect this type of habitat. Water temperature and the presence of pink salmon (prey) also affected growth. Coho salmon smolts were relatively large compared with smolts from other regions of Alaska, British Columbia and Russia suggesting growth may be a key factor leading to high abundance of coho salmon in the Kuskokwim area.

PRODUCTS AND OUTREACH

A technical report was prepared and is available online. Findings were presented at three meetings involving communities from western Alaska, and two scientific conferences.

WHAT'S NEXT?

We plan to continue exploration of factors affecting coho salmon growth in freshwater and the ocean as a means to evaluate factors influencing survival and abundance of Kuskokwim area coho salmon.

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(USFWS Staff)

WORK-IN-PROGRESS KUSKOKWIM RIVER COHO SALMON GENETICS

PROJECT 810

PRINCIPAL INVESTIGATOR

Penny A. Crane
United States Fish and Wildlife Service

RESEARCH PERIOD

June 2008 - March 2011

BUDGET

$247,677.00

UNDERSTANDING UPPER RIVER STOCKS

Coho salmon are the second most abundant salmon in the Kuskokwim River watershed and provide the largest commercial harvests, making them a mainstay to the ecology and economy of the region. Coho salmon in the Kuskokwim River are subdivided into two genetic groups: one comprising salmon spawning from the river mouth to, and including the Takotna River; and one of populations upstream of the Takotna River. Although the number of stock assessment projects monitoring coho salmon escapement and abundance has increased greatly since the 1990s, there are no assessment projects operating on populations representative of the genetic diversity group upstream of the Takotna River. Mixed-stock analysis uses genetic characters to estimate the stock components of mixtures given the underlying frequency of genetic characters in stocks contributing to the mixture. Maintenance of biocomplexity of salmon stocks is critical to sustaining salmon productivity.

OUR OBJECTIVES

Determine the relative contribution of three stocks of coho salmon to fish sampled from the Bethel Test Fishery.

Determine if run timing of coho salmon at the Bethel Test Fishery is stock-specific.

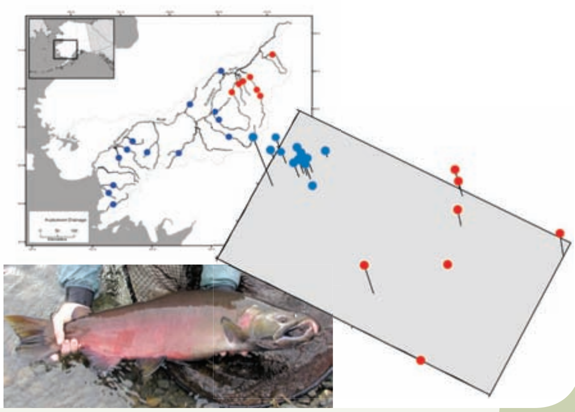
Determine if relative contributions of the stocks of coho salmon vary among years.

RESEARCH FRAMEWORK:

SYNTHESIS & PREDICTION – *PRIORITY #9*

SNAPSHOT

This project will collect samples from coho salmon at the Bethel Test Fishery. Genetic analysis will be used to estimate the relative contributions of three Kuskokwim River stocks to the Bethel Test Fishery samples and determine if stock contributions vary within and among years.



Large genetic differences exist between coho salmon spawning in the upper Kuskokwim River (orange) and lower Kuskokwim River (blue). (Crane, USFWS)

Sequencer (lower right) used to visualize coho salmon genotypes (upper left). (Crane, USFWS)

HOW WE WILL DO IT

We will collect fin clips from up to 50 coho salmon per day at the Bethel Test Fishery, and up to 400 fish for each District W1 fishery opening, if the commercial fishing season extends beyond the dates for the Bethel Test Fishery. Collections will be achieved for the 2008, 2009 and 2010 seasons. We will provide basic abundance and run timing information for coho salmon spawning in the upper Kuskokwim watershed by conducting genetic analysis on microsatellite DNA extracted from these samples.

If the commercial fishing season extends beyond the dates for the Bethel Test Fishery, up to 400 fish for each District W1 fishery opening will be sampled at fish processors in Bethel.

REPORT COMPLETION

June 2011

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

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(Colin K. Harris)

PATTERNS AND TRENDS IN SUBSISTENCE SALMON HARVESTS, NORTON SOUND AND PORT CLARENCE

PROJECT 401

PRINCIPAL INVESTIGATOR

James Magdanz
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATION

Kawerak, Inc.

RESEARCH PERIOD

July 2004 - August 2005

BUDGET

$117,000.00

HOW CAN WE BEST ESTIMATE AND PREDICT SUBSISTENCE SALMON HARVESTS?

Estimating and predicting wild food harvests in rural Alaska presents many challenges. The best estimates come from household surveys. But surveys are expensive and time-consuming, and every year some households and even entire communities cannot be surveyed. To compare harvests from year to year, we must expand each year's reported harvests to account for "missing" households and communities. Different types of households and different communities have very different salmon harvest patterns. Exploring existing harvest data, as this project did, is one way to better understand how differences among households and communities might affect estimates of salmon harvests. This also can help researchers build computer models to predict future subsistence salmon harvests.

OUR OBJECTIVES

Analyze the survey data collected from ten communities in the Norton Sound/Port Clarence area from 1994 to 2003.

Increase understanding of the subsistence salmon harvest at the household level.

Verify the data from previous surveys, collect additional information on household characteristics, and merge it all into one dataset.

Separate households in this dataset into different categories and compare harvest patterns among the categories.

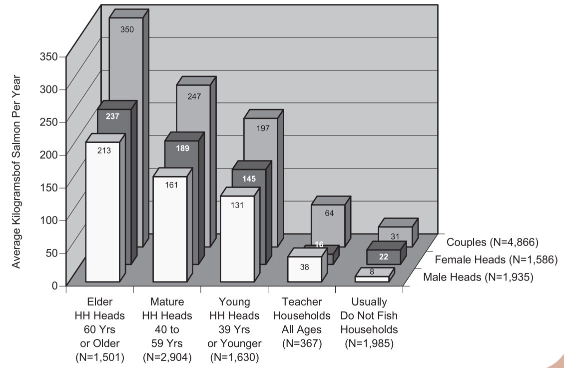
RESEARCH FRAMEWORK:

HUMAN SYSTEMS – *PRIORITY #5*

SNAPSHOT

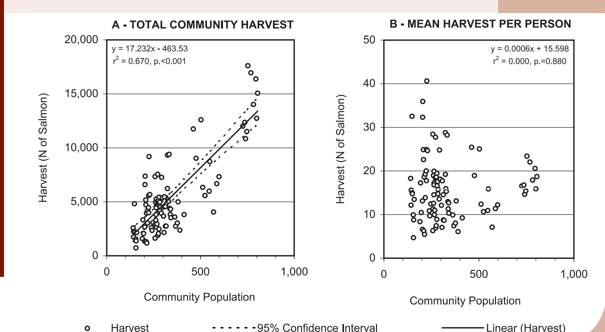
Annual subsistence salmon harvest data collected from 1994 to 2003 in 10 Norton Sound communities were merged, reviewed, cleaned, and supplemented with additional household information.

Researchers then explored patterns and trends in households' subsistence salmon harvests, seeking to better understand what influences households' salmon harvests.



Association of estimated household subsistence salmon harvests with household social type (age and gender of household heads) in 10 Norton Sound–Port Clarence area communities, 1994–2003. (Magdanz, ADF&G)

Annual household subsistence salmon harvest surveys were conducted in 10 communities (solid circles) during 1994–2003. (Magdanz, ADF&G)



Association of estimated total community salmon harvests (A) and estimated mean salmon harvests per person (B) with community populations in 10 Norton Sound-Port Clarence area communities, 1994–2003. (Magdanz, ADF&G)

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HOW WE DID IT

First, we reviewed the surveys for consistency in naming of variables and content from year-to-year, and collated all the yearly surveys into one database. Next, we collected additional information from households and key respondents in the study communities to verify the household identification numbers from the surveys, and gather more information such as household head ages, social characteristics, and major changes. We used all of the accumulated data to investigate the contributions of different types of households to the total harvest.

WHAT WE DISCOVERED

Overall, the subsistence salmon harvest declined over the study period, with greater declines occurring in the first half. The downward trend in harvests was more pronounced in growing communities than in shrinking ones. Each year about 23% of the households harvested 70% of the salmon. Consistently, most of these were the same households, yet there were many unpredictable households in every community. Harvests increased with the age of the household heads, and decreased when household heads were single, especially single males. Neither commercial fishing retention nor major family events seemed to affect harvest levels.

PRODUCTS AND OUTREACH

We have published our findings in an Alaska Department of Fish and Game technical paper. Our database is available for use by qualified researchers who are able to maintain the confidentiality of the data.

WHAT'S NEXT?

Subsequent AYK SSI projects are attempting to model salmon harvest in the region.

(Christian E. Zimmerman)

ESTIMATION OF COHO SALMON ABUNDANCE AND DISTRIBUTION IN THE UNALAKLEET RIVER

PROJECT 416

PRINCIPAL INVESTIGATOR

Phil Joy
Alaska Department of Fish and Game

RESEARCH PERIOD

May 2004 - April 2005

BUDGET

$66,281.00

WHERE DO UNALAKLEET COHO SALMON GO?

The Unalakleet River supports the largest and arguably the most important coho salmon run in Norton Sound. This run supports substantial subsistence and sport fisheries, as well as the largest Norton Sound commercial coho salmon fishery. Unalakleet River residents are concerned about a noticeable increase in sport fishing over the last 10 years. However, little is known about coho salmon distribution throughout the drainage.

OUR OBJECTIVES

Determine Unalakleet River coho salmon spawning distribution and the proportion of the run that passes the established counting tower on the North River, which would allow fisheries managers to estimate drainage-wide abundance using the North River counts.

Estimate Unalakleet River drainage coho salmon escapement and its age, sex, and length composition.

Document spawning areas and estimate the portions of the run in the Unalakleet mainstem; North Fork; and Chiroskey, Old Woman, and North rivers.

HOW WE DID IT

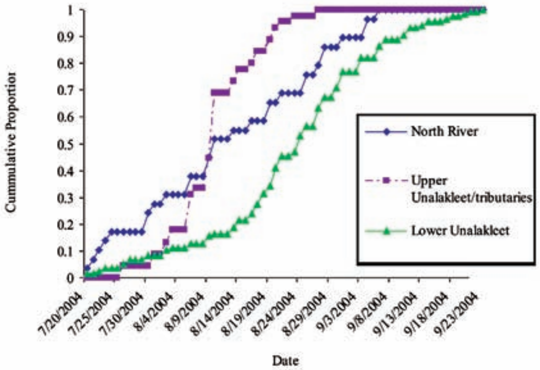
We used beach seines to capture coho salmon between the Unalakleet River mouth and the North River confluence. We identified gender, measured, and marked fish with

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

Unalakleet River coho salmon were tagged and tracked to better understand their distribution in the drainage and to develop a method for estimating drainage-wide abundance using an established counting site. A total coho salmon population of 73,582 was estimated in what may be two overlapping runs.

Distribution and clustering areas were identified and methodology improvements for following study years were suggested.



The cumulative proportion of radio-tagged coho salmon moving into the Unalakleet River drainage in 2005. (Joy, ADF&G)

The furthest distance from the ocean that each radio-tagged coho salmon was detected during aerial surveys between August 15th and October 25th, 2005. (Joy, ADF&G)

a patterned punch unique to their expected placement in the run timing. We tagged 200 fish with internal radio transmitters and external spaghetti tags. We tracked these fish using four stationary towers and several aerial surveys. We also seined for and marked fish in the Unalakleet River upstream from the North River mouth, and in the North River upstream from the counting tower.

WHAT WE DISCOVERED

We estimated a population of 73,582 coho salmon for the entire drainage. We detected radio-tagged fish in every major tributary and many tertiary streams. We found most of the fish in the Unalakleet River section above the Chiroskey River and below the North Fork. Fish sampled in the North River were smaller, on average, than those taken from the Unalakleet River, although their run timing and age distribution was similar, indicating that North River tower counts may be used to estimate the total run abundance. We also found that both rivers seem to have two runs, with the earlier run being composed of smaller and younger fish.

WHAT'S NEXT?

In future years, we will need earlier and more frequent aerial surveys to better track the early part of the run. Mark-recapture studies will need to use the North River tower site as the second counting site since we didn't get enough recaptures at our upriver sites. More research is needed on the age distribution and timing of the two overlapping runs, as well as on-the-ground study of the area between the Chiroskey River and the North Fork, to better understand why the coho salmon would cluster in this area.

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(Christian E. Zimmerman)

ESTIMATION OF ABUNDANCE AND DISTRIBUTION OF CHUM SALMON IN THE UNALAKLEET RIVER DRAINAGE

PROJECT
430

PRINCIPAL INVESTIGATOR

Jeffrey L. Estensen
Alaska Department of Fish and Game

RESEARCH PERIOD

May 2004 - June 2005

BUDGET

$140,010.00

COUNTING UNALAKLEET RIVER CHUM SALMON

Unalakleet River chum salmon, exploited by commercial, sport and subsistence fisheries, have experienced weak returns in recent years leading to fishing restrictions. Determining accurate chum salmon abundance and escapement numbers, however, has been difficult. A test fishery on the lower river and a counting tower on the North River, a Unalakleet River tributary, provide some information on seasonal patterns and North River escapement, but more accurate drainage-wide chum salmon abundance and escapement estimates are needed.

OUR OBJECTIVES

Initiate a multi-year study using radio telemetry and mark-recapture methods to estimate the total Unalakleet River chum salmon escapement, run timing, migration rates, and age, sex, and length composition of the population.

Compare these figures with those of the North River migrants. If these ratios are consistent, the North River escapement information may be used to determine drainage-wide population statistics.

Determine the chum salmon tributary distribution and major spawning locations throughout the Unalakleet River.

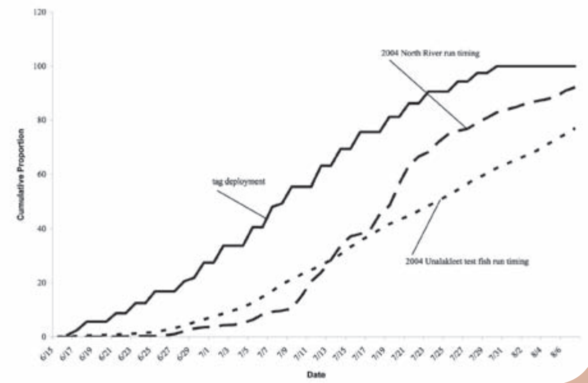
Evaluate the location for a proposed weir.

RESEARCH FRAMEWORK:

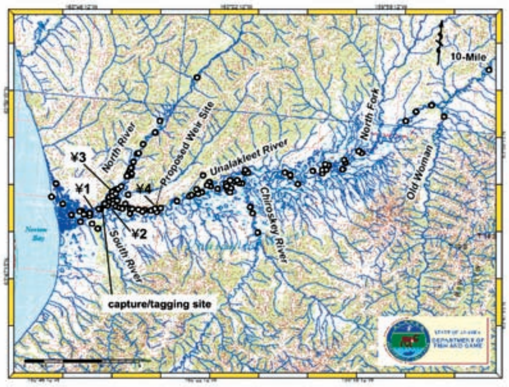
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

In the first year of a multi-year study, radio telemetry was used to gather information about the Unalakleet River chum salmon population. Researchers determined the ratio of chum salmon passing a counting tower on the North River to the total population, and the percentage of the run that traveled past a proposed weir site. They also gathered information on the run timing, migration rates, and the age, sex, and length composition of the population.



Comparison of tag deployment with North River counting tower and Unalakleet River Test Fishery chum salmon run timing, 2004. (Estensen, ADF&G)



Unalakleet River drainage showing spawning locations of radio-tagged chum salmon (circles) determined from aerial tracking flights, the capture/tagging site, stationary receiver sites (SRS), proposed weir site, and major tributaries. (Estensen, ADF&G)

HOW WE DID IT

We deployed 160 externally mounted radio transmitter tags. We established four stationary receiver sites along the Unalakleet River drainage. We also flew six aerial tracking flights. In addition to the tagged fish, we collected age, sex, and length data on 360 untagged fish. All tagged and sampled salmon received a secondary mark.

WHAT WE DISCOVERED

We determined that 13% of Unalakleet River chum salmon enter the North River. Surprisingly, no tagged fish were located in the upper tributaries. Our tag deployment did not track with run timing for the test fishery or North River counting tower, which indicated that the deployment was not distributed proportionally over the course of the run. We found that migration timing was highly variable, and no clear patterns were evident. Just over half (54%) of the tagged salmon passed the proposed weir site, demonstrating how many salmon would have been counted if this site had been operational.

PRODUCTS AND OUTREACH

Data are maintained on an electronic database and are available to other researchers.

WHAT'S NEXT?

This was the pilot year of a multi-year study. Later years will be required to confirm the ratio of North River migrants to total abundance, and to establish patterns in run timing and migration rates. We plan to begin our aerial surveys earlier in case the late start missed early spawners in the upper tributaries.

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(Bruce Murray)

NOME RIVER WATERSHED HABITAT RESTORATION FRAMEWORK

PROJECT 439

PRINCIPAL INVESTIGATOR

Marc Gaboury
LGL Limited, Environmental Research Associates

CONTRIBUTING ORGANIZATIONS

Kawerak, Inc.

LGL Alaska Research Associates, Inc.

RESEARCH PERIOD

May 2004 - June 2005

BUDGET

$142,978.00

FOCUS ON SALMON HABITAT

Placer mining and road construction are known to have altered stream habitat and watershed processes in a number of western Alaska streams with the potential for detrimental effects on freshwater survival and production of salmon. The extent of these effects on western Alaskan watersheds and salmon populations has not yet been evaluated. A first step towards such an assessment involves developing a framework to determine the present condition of salmon habitat, and to identify appropriate measures to restore salmon habitats and watershed processes altered by historic land uses.

OUR OBJECTIVES

Identify high priority areas within the Nome River watershed with high potential for habitat restoration that will benefit salmon populations.

Provide restoration designs for these sites where there is a high likelihood of success, and develop a habitat restoration framework for western Alaska based on the testing of that framework's effectiveness in the Nome River watershed.

HOW WE DID IT

We conducted an overview assessment of the Nome River watershed where we identified the Nome River watershed boundaries and sub-basins; estimated stream discharges; compiled overview information sheets for each sub-basin; and prioritized them for habitat assessments. In 2004, we conducted field assessments in which we recorded

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

A habitat assessment and restoration framework was developed for the Nome River watershed. Researchers identified high priority areas, conducted field assessments, and prepared restoration designs for six preferred sites.

(Bruce Murray)

fish distribution and habitat use, stream habitat and channel condition, and sediment sources. We also documented each measured habitat unit and significant features with digital photos. After analysis, we prepared restoration designs for six sites within high priority reaches where we determined that there is a high likelihood of success.

WHAT WE DISCOVERED

Our habitat assessment and restoration framework appeared to accurately describe the Nome River current fish habitat condition. However, the frequency of poor ratings for most cover types suggests that the rating scheme may need to be readjusted in some western Alaska watersheds. Similarly, the high incidence of poor ratings for pool frequency and percent pools suggests we might need to refine the decision criteria. We characterized the river mainstem and tributaries as moderately disturbed with evidence of sediment in pools and riffles decreasing pool frequency and negatively impacting rearing and spawning habitat. In general, ongoing mining activities and vehicle trails in the tributaries are impeding their natural recovery and contributing to increased sedimentation downstream.

PRODUCTS AND OUTREACH

Our habitat assessment and restoration framework is available as a model for use by fisheries managers and natural resource agencies.

WHAT'S NEXT?

Our assessment and framework approach is widely applicable. However, the protocols will need to be adapted to specific landscapes. We expect that adjustments will be necessary to habitat assessment criteria and the rating scheme for various cover types. We recommend that reference reach surveys be conducted to develop a database of channel and habitat characteristics for western Alaska streams.

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(Christian E. Zimmerman)

USE OF OTOLITH MICROCHEMISTRY IN NORTON SOUND SALMON POPULATIONS

PROJECT 501

PRINCIPAL INVESTIGATOR

Christian E. Zimmerman
United States Geological Survey

CONTRIBUTING ORGANIZATIONS

Alaska Department of Fish and Game

Oregon State University

RESEARCH PERIOD

June 2005 - January 2007

BUDGET

$89,465.00

FISH LEND AN EAR TO SCIENCE

The genetic population structure of Pacific salmon is generally characterized by geographically distinct populations in partial genetic isolation. This structure is a result of the balance between genetic drift within populations and gene flow among populations. Homing and straying are mechanisms that, respectively, lead to increasingly and decreasingly isolated populations. Although understanding homing and straying is an important step in describing salmon population structure and dynamics, little information exists concerning the connectivity of salmon populations in Norton Sound streams. Because otoliths incorporate elements from the surrounding water, and rivers differ in their elemental signatures because of differences in geology, otoliths sometimes can be used to identify where fish are from and where they have been.

OUR OBJECTIVES

Test the utility of otolith microchemistry to identify stream of origin of Norton Sound chum and coho salmon, and build a baseline that could be used to determine the stream of origin of adult salmon. Specifically, to collect water samples, and juvenile chum and coho salmon otoliths from five Norton Sound rivers.

Identify patterns among streams and evaluate their applicability as natural tags to study homing and straying, using elemental and strontium isotope signatures from the otoliths.

RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

This project tested the viability of using elemental and strontium isotope signatures from Norton Sound chum and coho salmon otoliths to identify their streams of origin. Researchers found that this technique is useful for determining the origin of coho salmon, but may not be useful for chum salmon, which spend less time in freshwater.

(Henry Oyoumick)

(Tim Dunmall)

HOW WE DID IT

We collected juvenile coho and chum salmon from the Nome, Niukluk, Fish, North, and Chiroskey rivers using minnow traps and beach seines. We collected 25 fish of each species from each river. We also obtained otoliths from adult salmon from subsistence fisheries on the Fish, Niukluk, and Nome rivers. We analyzed the otoliths using laser ablation inductively coupled mass spectrometry.

WHAT WE DISCOVERED

We found that elemental signatures are different enough among rivers to differentiate river of origin. The method could be successful in studying straying in coho salmon but is not likely to be useful for studying chum salmon. Chum salmon migrate shortly after emerging from the gravel, and otolith material deposited at this stage is still influenced by elements incorporated from yolk material, which includes elements incorporated from marine waters. It is not possible to distinguish a true freshwater signature for most chum salmon.

PRODUCTS AND OUTREACH

During field work, we met with students from Unalakleet to discuss the project, and fish biology in general. We have presented our findings at regional and national scientific meetings and prepared a manuscript for publication in a peer-reviewed journal.

WHAT'S NEXT?

Further work is needed to refine the signatures of other rivers within the Norton Sound region, as well as the AYK region. Following this work, large studies of straying could be conducted using large collections of adult otoliths collected from carcasses on the spawning grounds.

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(Christian E. Zimmerman)

GENETIC VARIATION IN NORTON SOUND CHUM SALMON POPULATIONS

PROJECT
502

PRINCIPAL INVESTIGATOR

Jeffrey B. Olsen
United States Fish and Wildlife Service

CONTRIBUTING ORGANIZATIONS

Department of Fisheries and Oceans Canada

Kawerak, Inc.

Norton Sound Economic Development Corporation

RESEARCH PERIOD

June 2005 - May 2006

BUDGET

$175,635.00

NORTON SOUND CHUM SALMON GENETICS

Norton Sound has suffered a progressive collapse in salmon populations since the mid-1960s that greatly affected the lifestyle and culture of most residents. An adequate inventory of genetic variability and population structure is critical for effective salmon conservation. While past genetic studies have enhanced our understanding of chum salmon stock structure and migration patterns, higher resolution data are needed to better monitor population responses to management changes, and to estimate the origin of chum salmon sampled in Norton Sound.

OUR OBJECTIVES

Estimate the extent of genetic variation within and among chum salmon populations in Norton Sound and make comparisons with Yukon River estimates.

Test whether or not Nome Subdistrict populations, which have declined more rapidly than other Norton Sound populations, have less variability than, and are divergent from, those populations.

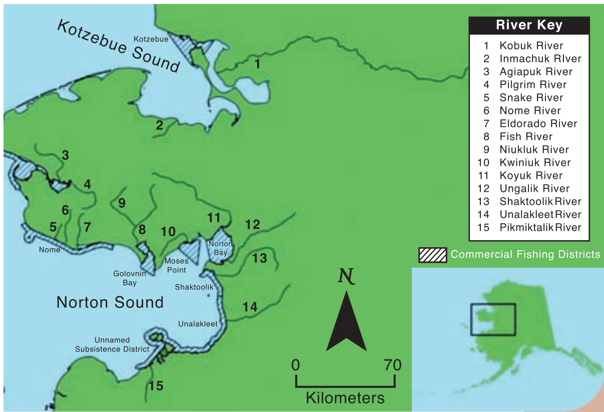
Determine the population structure to identify conservation units, estimate patterns of gene flow, and estimate the effective population size in order to evaluate genetic health.

RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION –
PRIORITY #10

SNAPSHOT

An analysis was conducted of the genetic diversity of chum salmon populations from 13 rivers in Norton Sound and two in Kotzebue Sound. This project found that run timing greatly affects the population structure of this area, and that population connectivity is important to maintaining genetic diversity.

While a high risk of short-term genetic loss wasn't found, the chum salmon populations in the Inmachuk and Koyuk rivers are most vulnerable.



Map of Norton Sound showing the 15 sample locations for chum salmon. (Olsen, USFWS)

(Mike Dinneen)

HOW WE DID IT

We collected fin tissue samples from 200 chum salmon from each of 13 rivers in Norton Sound, and two in Kotzebue Sound. We examined each population using 20 different microsatellite genetic markers, and conducted a series of analyses to determine genetic diversity within and among populations, spatial and temporal separation of different stocks, and effective population sizes.

WHAT WE DISCOVERED

Run timing is the single largest factor affecting the significant population structure that we found to exist. The Nome Subdistrict populations exhibited similar variation to others, and the diversity for Norton Sound was similar to that of the Yukon River. We found that divergence is correlated with geographic distance for early-run populations while late-run populations may differ in the extent to which their spawn timing overlaps with early-run populations. We also found that while current effective population sizes do not indicate a high risk of short-term genetic loss, Inmachuk and Koyuk river populations are most vulnerable. Finally, we found that the genetic health of the early-run population complex depends upon maintaining connectivity among populations.

PRODUCTS AND OUTREACH

The results from this study were included in a poster presented at the AYK SSI 2007 Symposium *Pacific Salmon: Ecology and Management of Western Alaska's Populations* and is available online. A copy of the poster was given to Kawerak, Inc. The results are also included in a peer-reviewed journal paper published in 2008.

WHAT'S NEXT?

Based on our findings, we recommend that managers maintain the connectivity between populations; continue to monitor genetic diversity, especially within the Inmachuk and Koyuk rivers; and use a comprehensive review of life history, ecology, and genetic variation to define conservation boundaries for western Alaska chum salmon. Further tests are needed on the Koyuk River stocks as there is evidence for multiple populations that vary in run timing.

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(Julie Raymond-Yakoubian)

USING LOCAL TRADITIONAL KNOWLEDGE IN NORTON SOUND SALMON POPULATIONS

PROJECT *601*

PRINCIPAL INVESTIGATOR

Julie Raymond-Yakoubian
Kawerak, Inc.

RESEARCH PERIOD

June 2006 -
April 2009

BUDGET

$211,568.00

LOOKING AT CHANGE

Norton Sound residents have long depended upon natural resources to support their traditional subsistence way of life. Because of their long-term, multi-generational understanding of the region, residents often can recall short- and long-term changes in harvest opportunities, escapement, colonization, climate change, and harvest pressure. A multi-dimensional understanding of the ecology of the region, and specifically salmon cycles over time, can be provided by recording this knowledge, tying it to biological information, and placing it into a geographic context.

OUR OBJECTIVES

Document Norton Sound local and traditional knowledge in order to describe observed changes to the salmon resources and environment in a geographic context that would serve as an aid in fisheries management, and freshwater and marine ecosystem research.

Increase the capacity of the regional Native non-profit organization to become more meaningfully involved in both biological and social research projects.

HOW WE DID IT

This project worked with communities in the Norton Sound region, from St. Michael in the south to Wales in the north, and including Diomede and St. Lawrence Island (Savoonga). We used a locally-hired intern as well as a research assistant from each community to

RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITIES #2 AND #4*

SNAPSHOT

Local and traditional knowledge can help shed light on salmon population cycles and other environmental changes.

This community-based project yielded observations from across the Norton Sound region.

(Julie Raymond-Yakoubian)

(Arlo Hannigan)

help conduct interviews with at least four experts within each of the nine communities participating in the project. We used a semi-structured interview guide along with maps to interview participants. Community experts were also asked to quantify environmental changes in measurable ways so that the information could be compared across the region.

WHAT WE DISCOVERED

While the specific changes each community experienced are different, there are broad similarities in the types of changes and their impacts on communities. There is a wide concern from participating communities about both changes to salmon populations they utilize and environmental changes.

PRODUCTS AND OUTREACH

Our report is available for use by resource managers and researchers. We have added searchable interview transcripts to the Eskimo Heritage Program archive, which is open to the public and researchers conducting research for non-commercial purposes.

WHAT'S NEXT?

The information from this project continues to be valuable in advocating for continued and improved opportunities for salmon harvest by region residents. Kawerak is now conducting a similar project about traditional knowledge of non-salmon fish used for subsistence.

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(Greg T. Ruggerone)

RETROSPECTIVE ANALYSIS OF ARCTIC-YUKON-KUSKOKWIM CHUM AND COHO SALMON

PROJECT
614

PRINCIPAL INVESTIGATOR

Greg T. Ruggerone
Natural Resources Consultants, Inc.

CONTRIBUTING ORGANIZATION

Alaska Department of Fish and Game

RESEARCH PERIOD

July 2006 - June 2008

BUDGET

$135,099.00

HISTORICAL CLUES TO COMPLEX INTERACTIONS

As a keystone species, Pacific salmon are considered to be a critical component of a watershed. Yet, in a relatively pristine region of Alaska, exceptionally low numbers of salmon returned to Norton Sound and the Yukon and Kuskokwim rivers in the late 1990s and early 2000s. Large scale climate changes and regional oceanic conditions may be important factors in this decline. Furthermore, interactions with pink salmon, Asian hatchery-raised fish, and pollock also may affect these populations.

OUR OBJECTIVES

Reconstruct annual and seasonal growth of Kwiniuk River chum salmon, and Unalakleet and Kuskokwim river coho salmon during the past several decades.

Evaluate the effects of climate change, pink salmon and Asian hatchery chum salmon abundance, and pollock larval biomass on these populations.

Estimate Norton Sound chum salmon returns from each brood year, and compare productivity with Kwiniuk River chum salmon growth, climate factors, and competition with other salmon.

HOW WE DID IT

We measured growth rings on salmon scales collected on the Kwiniuk, Unalakleet, and Kuskokwim rivers

RESEARCH FRAMEWORKS:

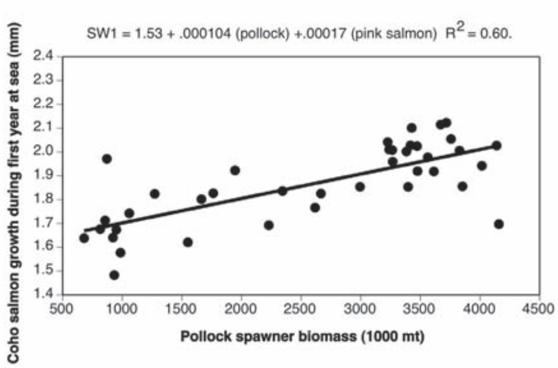
SALMON LIFE CYCLE – *PRIORITY #1;*

SYNTHESIS & PREDICTION – *PRIORITY #7*

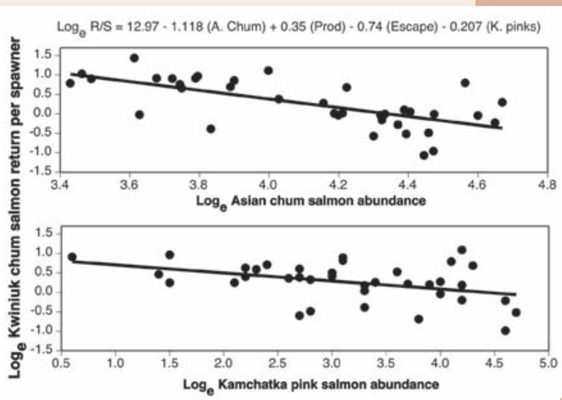
SNAPSHOT

Historical data were used to examine the population trends of Norton Sound chum salmon and Kuskokwim and Unalakleet river coho salmon.

Ocean/climate shifts in 1977 and 1989 resulted in increases in the coho salmon populations, while decreases correlated with climate changes in the late 1990s. Norton Sound chum salmon were negatively affected by increases in pink salmon and Asian hatchery chum salmon, while Asian pink salmon indirectly influenced the coho salmon populations.



Scale growth of Kuskokwim River coho salmon since 1965 was positively correlated with abundance of pollock spawner biomass, which provided an index of larval pollock, a key prey of immature coho salmon in the Bering Sea. Coho salmon abundance was greater when abundance of pollock larvae was relatively high. (Ruggerone, NRC)



This relationship shows the partial effects of Asian chum and pink salmon on Norton Sound chum salmon after accounting for early marine productivity (Prod), and parent spawning abundance of Kwiniuk River salmon (Escape). (Ruggerone, NRC)

since 1975, 1980, and 1965, respectively. We obtained brood tables and escapement data for Kwiniuk River chum salmon, and estimated chum salmon abundance for all of Norton Sound using available age composition and escapement data. We obtained catch per unit effort data on Unalakleet and Kuskokwim river coho, and environmental data from several agencies and online sources.

WHAT WE DISCOVERED

Our analysis indicated that growth was important to the productivity of these salmon stocks. We found that Norton Sound chum salmon may compete with Asian chum salmon (mostly hatchery fish), Kamchatka pink salmon, and with Norton Sound pink salmon during early marine life. In contrast, juvenile Kuskokwim River coho salmon appear to benefit from pink salmon in freshwater habitats, and from larval pollock in the Bering Sea. We also found that ocean regime shifts in 1977 and 1989 led to progressively greater abundance of coho salmon, whereas the 1997 El Niño led to an abrupt decline in coho salmon abundance. Early marine growth of coho salmon was key to determining coho salmon abundance, but additional unknown factors associated with climate variables also influenced abundance.

PRODUCTS AND OUTREACH

Findings were presented at four meetings involving communities from western Alaska and two scientific conferences. Two journal manuscripts are in preparation.

WHAT'S NEXT?

The alternating year pattern of coho salmon growth and abundance that we found highlights the complexity of species interactions in the ocean. Further research is needed to identify the prey and the life history patterns that may contribute to alternating year patterns of AYK salmon. Further research is also needed to evaluate competition between Asian hatchery chum salmon and AYK chum salmon.

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ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

BERING SEA FISHERMEN'S ASSOCIATION
110 W. 15TH AVENUE
ANCHORAGE, AK 99501
(907) 279-6519

(Ben Williams)

WORK-IN-PROGRESS
NOME RIVER COHO SALMON ABUNDANCE AND SURVIVAL

PROJECT
721

PRINCIPAL INVESTIGATOR

Charlie F. Lean
Norton Sound Economic Development Corporation

CONTRIBUTING ORGANIZATION

LGL Alaska Research Associates, Inc.

RESEARCH PERIOD

May 2007 - March 2010

BUDGET

$350,536.00

COHO SALMON NURSERIES

The need to incorporate ecosystem factors into escapement goals and harvest management is receiving increased attention. The relationship between coho salmon smolt abundance and freshwater rearing habitat documented outside of western Alaska has led to a greater use of ecosystem-based management in those areas. If habitat similarly affects Norton Sound coho salmon, using habitat estimates to generate adult production potential (in the form of escapement ranges) in that region may be a cost-effective way to determine management goals.

OUR OBJECTIVES

Estimate Nome River smolt abundance for three years, and combine this data with life history information to estimate the numbers of adult spawners necessary to produce the smolt abundances.

Determine whether fluctuating adult returns from 2001 to 2006 have correlated with changes in smolt abundance and body condition from 2004 to 2009.

Estimate coho salmon marine survival from 2005 to 2008 to better understand the relative roles of freshwater and marine factors.

HOW WE WILL DO IT

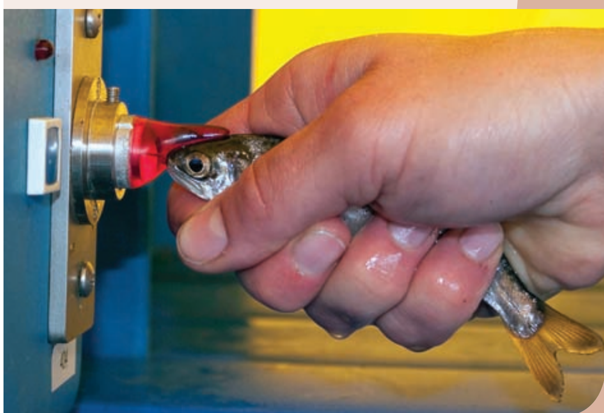
We will capture juvenile coho salmon with two fyke nets about one kilometer apart on the lower Nome River.

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITIES #1 AND #2*

SNAPSHOT

This project, a continuation of ongoing work, will collect information on the influence of rearing habitat on coho salmon abundance in the Nome River. Researchers will estimate Nome River smolt abundance for another three years (making a total of six years) and combine that data with life history information, historic adult returns, and marine survival estimates to produce an ecosystem-based management model for western Alaska coho salmon.

(Ben Williams)



(Ben Williams)

(Ben Williams)

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Fish from the upper net will be given a temporary fin clip; the proportion of these clips in the overall catch at the lower net will yield a population estimate of smolts emigrating from the river. Random samples of smolts will be taken daily for length measurements, and weekly for weight and age analysis. Throughout the sampling season (May through July), we will implant coded wire tags in smolts and clip their adipose fins. The proportion of adults that return the following year with these tags will be used to generate marine survival estimates of the smolt run from the year before.

REPORT COMPLETION

September 2010

(Christian E. Zimmerman)

SEWARD PENINSULA SMOLT STUDIES

PROJECT 731

PRINCIPAL INVESTIGATOR

William Smoker
University of Alaska Fairbanks

CONTRIBUTING ORGANIZATION

Alaska Department of Fish and Game

RESEARCH PERIOD

July 2007 - May 2009

BUDGET

$87,892.00

THE KEYS TO FISHABLE ABUNDANCE

The sockeye salmon populations of the Seward Peninsula are the most northerly in North America and are therefore likely to have unique life history characteristics. The abundance of these populations has increased dramatically in recent years, which may be a response to climate warming, lake fertilization, or to some combination of factors. In managing salmon resources it is important to understand all of the factors controlling abundance.

OUR OBJECTIVES

Determine if the production in Seward Peninsula lakes, and the marine nutrients provided by returning adults, affect fry growth and recruitment any more than does escapement from the fishery (number of spawning adults). Specifically, to compare sockeye salmon adult and juvenile growth rates with annual counts of spawning adults, migrating juveniles, and lake biological production, including the effects of artificial fertilization to increase prey abundance.

Evaluate the effects of smolt age and growth on marine survival, in particular, whether faster-growing smolts are more likely to survive.

HOW WE DID IT

Ms. Lorna Wilson, the project's Graduate Research Assistant, investigated sockeye salmon populations from Salmon Lake, which had been artificially fertilized and has an extensive estuary, and nearby Glacier Lake,

RESEARCH FRAMEWORKS:
SALMON LIFE CYCLE – *PRIORITY #2;*

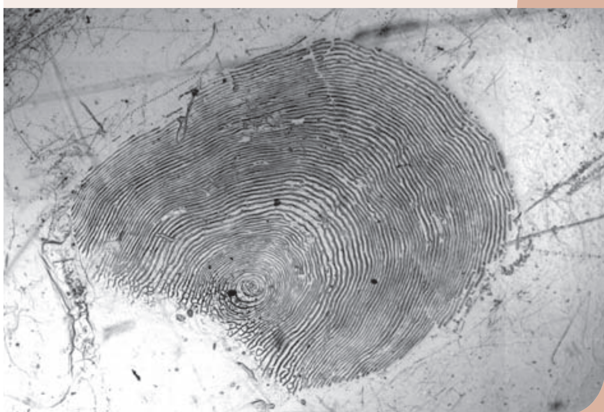
SYNTHESIS & PREDICTION – *PRIORITY #10*

SNAPSHOT

Sockeye salmon growth and environmental conditions in two Seward Peninsula lakes were compared in order to test whether escapement censuses are an adequate predictor of future populations or, alternatively, whether other factors also influence abundance.

Escapement correlates with future abundance better than lake environmental factors, and artificial fertilization cannot be demonstrated to have increased juvenile sockeye salmon growth.

(Lorna Wilson)



(Lorna Wilson)

(Lorna Wilson)

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which has not been artificially fertilized, and has no extensive estuary, but tends to produce larger smolts. She measured 1,153 adult and 1,323 smolt scale samples taken from these populations between 1995 and 2008, and compared these measurements with climatological records and observations from Salmon Lake of lake productivity collected over the same time period.

WHAT WE DISCOVERED

Life histories of Seward Peninsula sockeye salmon are not remarkably different from southern populations. Larger smolts are more likely to survive to adulthood, and recruitment was not any better predicted by measures of lake productivity than it was simply by the numbers of adults spawning in the parent generation. Growth was not necessarily better during years of more productive lake conditions, including years of artificial fertilization. Glacier Lake smolts appear to experience more size-related mortality when they enter the sea than do Salmon Lake smolts.

PRODUCTS AND OUTREACH

The project provided the material for a Master's of Science in Fisheries thesis by Lorna Wilson. She and her advisers are submitting two manuscripts for publication in peer-reviewed journals. Wilson also presented the findings at a regional science conference and instructed high school students from the Bering Strait Region at Salmon Lake.

WHAT'S NEXT?

Fishery managers should understand that artificial fertilization of lakes may not be a useful tool to increase juvenile salmon growth on the Seward Peninsula. Climate warming could improve the rearing environment for Seward Peninsula sockeye salmon populations by increasing both season length and average lake temperature. Smolt production and growth in the ocean environment would be expected to increase as well.

(Christian E. Zimmerman)

WORK-IN-PROGRESS
LANDSCAPE PREDICTORS OF COHO SALMON

PROJECT
803

PRINCIPAL INVESTIGATOR

Kelly M. Burnett
United States Forest Service

CONTRIBUTING ORGANIZATIONS

Alaska Department of Fish and Game

Earth Systems Institute

LGL Alaska Research Associates, Inc.

Oregon State University

United States Geological Survey

University of Alaska Fairbanks

RESEARCH PERIOD

May 2008 -
March 2011

BUDGET

$456,642.00

USING GEOGRAPHY TO PREDICT ABUNDANCE

Habitat quality and quantity are important factors that affect the abundance and distribution of salmon in freshwater. Knowledge about how these variables affect salmon in the Arctic-Yukon-Kuskokwim region is minimal, however. Without more information, it is difficult to predict effects of habitat change or to know whether observed changes in abundance are caused by freshwater factors. Field surveys are critical for contributing to such knowledge, but they are feasible in only a small portion of the AYK salmon-bearing streams. In other regions, modeling approaches have been successful alternatives in identifying factors affecting production, setting management goals, and planning restoration efforts.

OUR OBJECTIVES

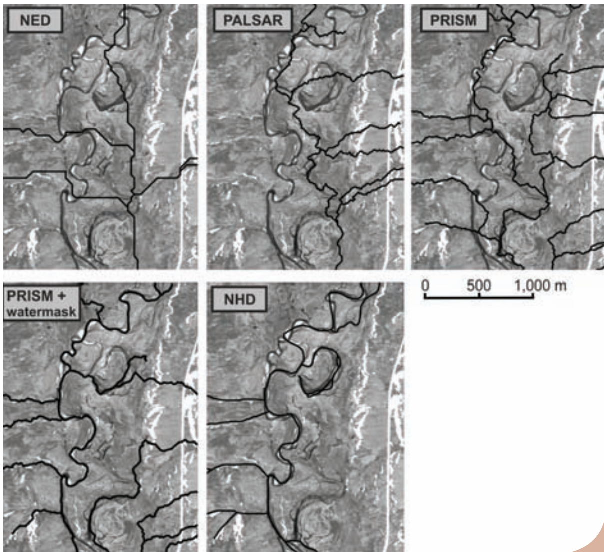
Develop and apply modeling approaches that focus on juvenile Nome River coho salmon, and relate field-measured habitat and fish data collected over small areas to digital geospatial data obtained over much larger areas.

Create high-resolution geospatial terrain and stream data using new satellite imagery and analytical tools, and analyze this data in a GIS-based system to predict habitat attributes and fish abundances in streams where surveys have not been conducted.

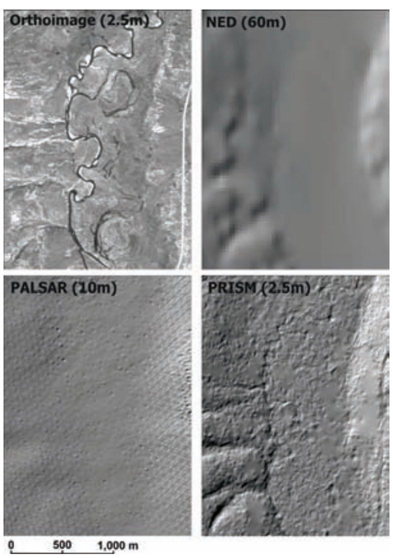
RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION –
PRIORITY #10

SNAPSHOT

This project will collect data on the physical, hydrological, and geographical features of streams in the Nome River watershed using satellites and ground surveys. This data will be combined with juvenile coho salmon abundance estimates to develop models that will allow researchers to map habitat and estimate relative fish abundances using landscape features of local areas, and of the surrounding basin.



The PRISM 2.5-m digital ortho-rectified imagery overlain with streams from different sources: generated from (a) 60-m National Elevation Data (NED) DEMs; (b) 10-m PALSAR-derived DEMs; (c) 2.5-m PRISM-derived DEMs without the PRISM water mask; (d) 2.5-m PRISM-derived DEMs with guidance from the PRISM water mask; and (e) the 1:100,000-scale National Hydrography Data (NHD). (Burnett, USFS)



Comparing PRISM 2.5-m digital ortho-rectified imagery with hillshades produced from the 60-m National Elevation Data, 10-m PALSAR-derived DEMs, and 2.5-m PRISM- derived DEMs. (Burnett, USFS)

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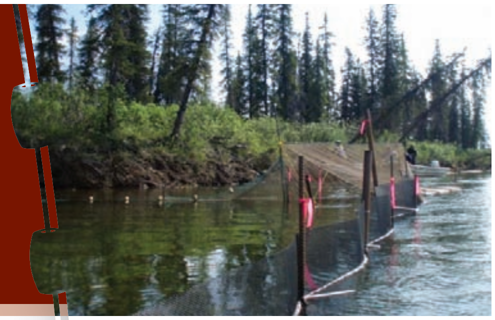
HOW WE WILL DO IT

We will create digital elevation models from two types of satellite imagery and use them, along with additional imagery in the Nome River basin, to identify stream networks, hydrographic and geomorphological features, and ice characteristics that determine juvenile coho salmon winter habitat. We will conduct summer field surveys to estimate juvenile coho salmon abundances by age class, and winter surveys to ground-truth ice cover estimates. We will also collect data on stream physical characteristics at each survey site. We will then develop statistical relationships to estimate relative abundances of juvenile coho salmon from the physical characteristics of each site as well as from landscape characteristics of the surrounding basin.

REPORT COMPLETION

May 2011



(NSEDC staff)

WORK-IN-PROGRESS
TESTING HABITAT-BASED PRODUCTION MODELS FOR COHO SALMON IN THE FISH RIVER

PROJECT

804

PRINCIPAL INVESTIGATOR

Charlie F. Lean
Norton Sound Economic Development Corporation

CONTRIBUTING ORGANIZATION

LGL Alaska Research Associates, Inc.

RESEARCH PERIOD

May 2008 - March 2011

BUDGET

$413,649.00

USING HABITAT TO PREDICT PRODUCTION

There are currently no biological escapement goals for coho salmon in Norton Sound watersheds. The Fish River was slower to rebound from area-wide declines of coho salmon returns in 2003, which led to concern that an increase in harvest pressure was not sustainable. Recent research in the Nome River indicates habitat-based models can accurately predict the range of smolts produced by a river and the subsequent number of adults necessary to produce the smolts. If such relationships apply to other Norton Sound rivers, it may be possible to use habitat to predict smolt production, and then use the smolt production estimate to compute adult coho salmon escapement goals.

OUR OBJECTIVES

Determine if coho salmon smolt (and subsequent adult) production can be predicted from indicators of watershed size among watersheds with contrasting habitat quantity and type. Specifically, to predict and verify coho salmon smolt production from two areas of the Fish River watershed with contrasting habitat, and estimate the number of adult salmon needed to produce both the predicted and the observed numbers of smolts.

Estimate in-river smolt survival, marine survival, and winter habitat loss as possible factors to help explain any discrepancies between our predictions and actual production.

RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITY #1*

SNAPSHOT

This project will identify and characterize coho salmon rearing habitat in the Fish River to create a model predicting smolt and adult production. Statistical models will be verified with a mark-recapture study, and likely factors contributing to the differences between predicted and actual values will be investigated.

(NSEDC staff)

(NSEDC staff)

(NSEDC staff)

HOW WE WILL DO IT

We will use topographical maps to identify the distribution of potential coho salmon rearing habitat within the Fish River. We will conduct field surveys at selected areas to verify our assumptions. We will use statistical models to predict coho salmon smolt abundance from the entire watershed and from each of the two major branches. We will test our estimates using a two year mark-recapture study, and use the resultant smolt estimates in a life-cycle model to determine the necessary adult escapement. We will examine predators (northern pike, Dolly Varden) for a qualitative estimate of predation on coho salmon smolts, and will use coded wire tag smolts for an estimate of marine survival. We will fly the Nome, Fish, and Niukluk rivers to conduct a qualitative assessment of open water areas in winter to identify obvious departures from our model caused by loss of winter habitat.

REPORT COMPLETION

May 2011

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(Christian E. Zimmerman)

WORK-IN-PROGRESS
NORTON SOUND CHINOOK SALMON GROWTH AND PRODUCTION

PROJECT
807

PRINCIPAL INVESTIGATOR

Greg T. Ruggerone
Natural Resources Consultants, Inc.

CONTRIBUTING ORGANIZATION

Alaska Department of Fish and Game

RESEARCH PERIOD

May 2008 - March 2010

BUDGET

$74,187.00

CHINOOK SALMON SCALES

Growth is a key factor affecting survival and life history characteristics of salmon. Using salmon scales, we will estimate annual growth of Unalakleet River Chinook salmon in freshwater and the ocean from 1981 to 2007. Growth estimates will be compared with ocean-climate shifts, trends in abundance, and age-at-maturation.

We expect that the Unalakleet River Chinook salmon scale data, along with our previous studies of Yukon and Kuskokwim river Chinook salmon scale growth, will improve our understanding of factors that influence abundance and life history traits (growth in relation to gender and age-at-maturation) of Norton Sound Chinook salmon, which are vital to the people of this region.

OUR OBJECTIVES

Create a database using salmon scale measurements of Unalakleet River Chinook salmon growth during each year in freshwater and the ocean, for years 1981 to 2007.

Compare scale growth with indices of abundance, ocean-climate shifts, and with growth of Yukon and Kuskokwim river Chinook salmon.

Examine relationships between growth and age-at-maturation.

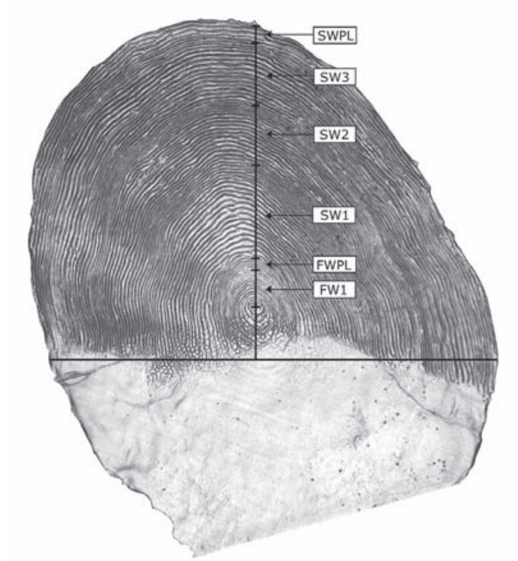
HOW WE WILL DO IT

Routinely collected Unalakleet River Chinook salmon

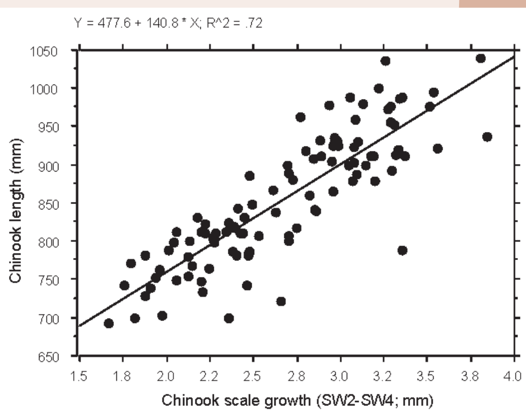
RESEARCH FRAMEWORK:
SYNTHESIS & PREDICTION –
PRIORITY #10

SNAPSHOT

Salmon scales record the annual and seasonal growth history of salmon in freshwater and ocean habitats. This project uses collections of adult Chinook salmon scales from the Unalakleet River as a means to cost-effectively reconstruct past growth of these salmon, which are vital to the people of Norton Sound.



Salmon scale showing circuli and annual growth zones: FW1: first year in freshwater; FWPL: spring growth during smolt migration; SW1, SW2, SW3: growth during the 1st, 2nd, and 3rd years at sea; SWPL: growth during the homeward migration from the open ocean to natal river. Narrowly spaced circuli (black lines or ridges) represent winter transition periods when growth is slower. (Ruggerone, NRC)



In previous work, Chinook salmon length and scale radius measurements taken from Yukon and Kuskokwim river salmon were positively correlated. (Ruggerone,NRC)

scales were obtained from Alaska Department of Fish and Game storage facilities in Nome and Anchorage.

We will scan images of the scales to a computer and measure seasonal (circuli) and annual scale growth from 50 fish per year. These measurements will provide indices of how well these Chinook salmon grew during their single year in freshwater and each of three or four years at sea. These growth measurements will be compared with measurements of Yukon and Kuskokwim river Chinook salmon to identify differences and similarities.

REPORT COMPLETION

September 2010

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(John Eiler)

YUKON RIVER CHINOOK SALMON TELEMETRY AND MARK-RECAPTURE

PROJECT 314

PRINCIPAL INVESTIGATOR

Ted R. Spencer
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATION

National Oceanic and Atmospheric Administration

RESEARCH PERIOD

April 2003 - June 2004

BUDGET

$170,000.00

COUNTING YUKON RIVER CHINOOK SALMON

Chinook salmon returning to the Yukon River support important commercial and subsistence fisheries in the United States and Canada. However, Yukon River Chinook salmon runs have declined dramatically in recent years. Under terms of the Yukon River Salmon Treaty, the U.S. and Canada agreed to conduct cooperative research to determine the migratory patterns and population status of Yukon River salmon returns. As part of this effort, we conducted a drainage-wide, radio telemetry study to better understand Chinook salmon of the Yukon River.

OUR OBJECTIVES

Use radio telemetry to determine stock composition and timing, country of origin, migration patterns, and location of important spawning areas.

Estimate the abundance of Chinook salmon upriver of our tagging site at Russian Mission and the proportion of the total run returning to major tributaries.

Estimate stock-specific run timing, migration rates, and migration characteristics.

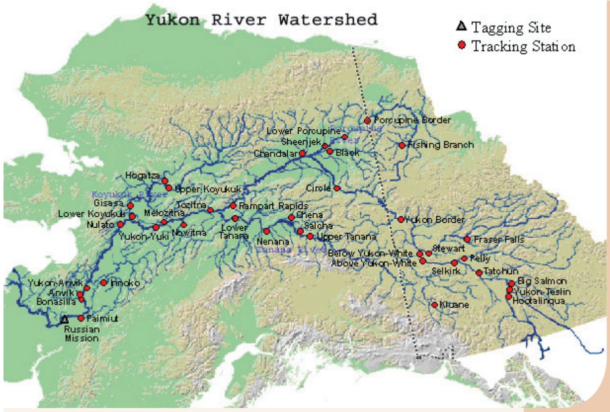
HOW WE DID IT

At Russian Mission, 1,097 fish were caught and tagged during day and night shifts from early June to mid-July, 2003. Radio transmitters were inserted into the

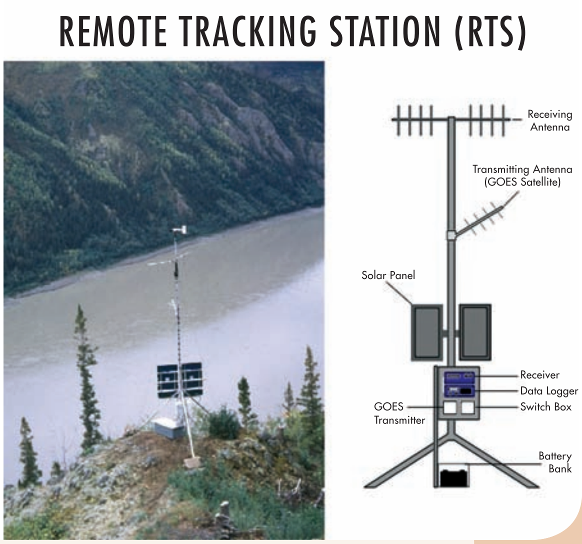
RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

Radio telemetry was used to track tagged Chinook salmon as they migrated throughout the Yukon River basin, allowing researchers to determine the migratory characteristics, abundance, and escapement distribution.



Map of the Yukon River drainage showing the location of the tagging site and remote tracking stations used to track the upriver movements of radio-tagged Chinook salmon, 2003. (Eiler, NMFS)



Remote tracking station used to collect and access telemetry data for radio-tagged Chinook salmon in the Yukon River basin. (Eiler, NMFS)

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fishes' stomachs, and they were externally marked with spaghetti tags. Thirty-nine remote tracking stations were located throughout the basin upriver from the tagging site. Additionally, aerial surveys were conducted in selected reaches of the drainage to locate fish that traveled to areas between station sites and upriver of stations on terminal tributaries. We recovered tagged fish from monitoring projects throughout the basin and from subsistence, sport, and commercial fishers.

WHAT WE DISCOVERED

While Chinook salmon traveled throughout the basin, the majority migrated to the upper basin areas. Canadian fish comprised a slight majority of the total sample. Tanana River drainage fish also comprised a significant portion. Movement rates averaged 51.1 km/day, and we found differences between stocks and regions with upper basin stocks moving faster. We were able to successfully estimate abundance using mark-recapture methods.

PRODUCTS AND OUTREACH

The results of our study have been published in several ADF&G management reports. We presented our research at several in-region public meetings, councils, and teleconferences.

WHAT'S NEXT?

Information from this study has identified new spawning areas, identified relative importance of known spawning areas, expanded the genetic stock identification baseline, and provided population estimates, which have been used to address conservation issues and evaluate abundance estimates from other projects in the basin. Additional information is needed to further address questions related to study findings and annual variation.

AYK SUSTAINABLE SALMON INITIATIVE

Project Synopsis

YUKON RIVER WATERSHED

(Christian E. Zimmerman)

NON-LETHAL ESTIMATION OF ENERGY CONTENT OF YUKON RIVER CHINOOK SALMON

PROJECT 406

PRINCIPAL INVESTIGATOR

F. Joseph Margraf
University of Alaska Fairbanks

RESEARCH PERIOD

May 2004 - July 2005

BUDGET

$20,952.00

SPARING THE KNIFE

Determining the amount of energy stored by Chinook salmon is critical to the study of the success of these commercially and culturally important Yukon River fish. Traditional methods used to analyze the amounts of water, fat, protein, ash, and other components stored require laboratory facilities and personnel, as well as the sacrifice of the fish. Bioelectric impedance analysis (BIA), a nonlethal method which consists of measuring a current while it is passed through a subject, has long been used on humans and has recently been demonstrated to work on fish.

OUR OBJECTIVES

Develop BIA models for Chinook salmon that will permit the non-lethal estimation of body composition (for example, fat, protein, and water content) for use in future field applications.

HOW WE DID IT

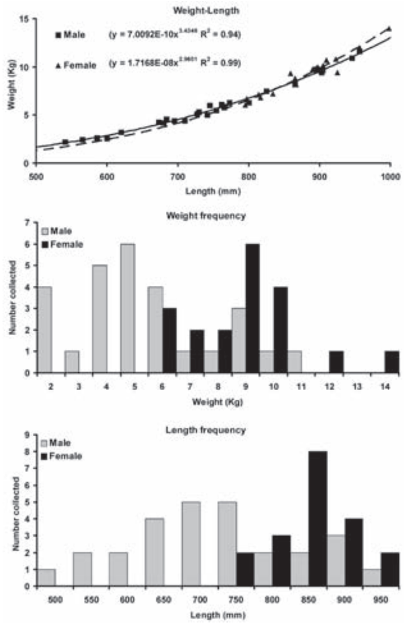
To develop our models, we measured electrical resistance and reactance, and then sacrificed the fish to compare the BIA to traditional body content analysis. We intended to collect 100 Chinook salmon of both sexes and of varying sizes, energy levels, and in different areas of the Yukon River. Due to difficulties obtaining Chinook salmon during a poor run, we were able to collect 46 Chinook salmon from the Rapids Research Center. We supplemented our study with 86 chum salmon from two

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

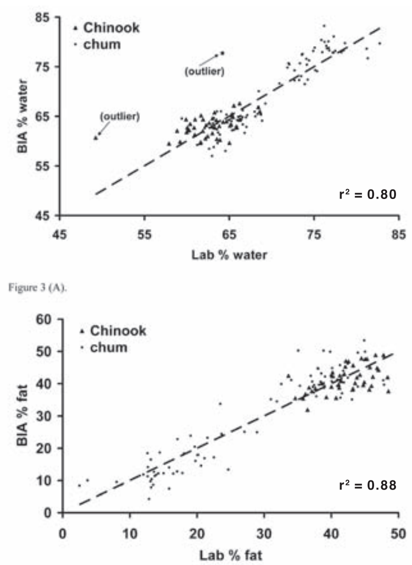
SNAPSHOT

Models were developed for the use of bioelectric impedance analysis of Yukon River Chinook and chum salmon. This kind of easily deployed analysis allows researchers to determine the body content and energy density of individual fish in a nonlethal manner.

YUKON RIVER



Size (mid-eye-to-fork length in mm and weight to nearest 0.1 Kg) demographics for 46 Chinook salmon collected from the Yukon River, 2004. (Margraf, UAF)



Proximate analysis values for fat (lipid) content (x-axis) plotted against the BIA predicted value for fat content (y-axis), expressed as percent dry weight. (Margraf, UAF)

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areas along the river. We conducted BIA measurements in two different locations on each fish, homogenized them using an industrial grinder, and analyzed samples in a laboratory using traditional methods.

WHAT WE DISCOVERED

Despite some problems obtaining Chinook salmon from the planned locations, we successfully developed usable BIA models of body composition and energy density by combining the Chinook salmon data with similar data from chum salmon. Our ability to predict body composition of salmon exceeds that of techniques used on humans in a medical context. We were able to predict fat and protein components and energy density by BIA with accuracies that equal or exceed those obtained in far more sophisticated laboratory settings for small mammals.

PRODUCTS AND OUTREACH

Our models are available to researchers for use in further studies of Chinook and chum salmon in the Yukon River or, potentially, in other rivers.

WHAT'S NEXT?

Application of our BIA models to predict energy levels of fish during their migration will allow managers to evaluate salmon energy use along the migratory path. Correlations with tracking and genetic studies may help scientists better understand the relationship between fat content and distance to spawning grounds. BIA models also provide tools for investigations of the differences in energy stores in spawning and recruitment success, the effects of global warming on salmon stocks, and differences in annual flow and temperature changes on migratory energy costs and recruitment success.


(Paige Drobny)

CAPACITY DEVELOPMENT AND COMMUNITY INVOLVEMENT

PROJECT 414

PRINCIPAL INVESTIGATOR

Kimberly Elkin
Tanana Chiefs Conference

CONTRIBUTING ORGANIZATION

Bering Sea Fishermen's Association

RESEARCH PERIOD

May 2004 - June 2005

BUDGET

$45,732.00

COMMUNITY-BASED DATA COLLECTION

Community involvement and capacity development are important components in the collection of biological data from subsistence fisheries. Involving local communities, in this way, can decrease problems and mistrust between local villagers and biologists and increase public support and resource stewardship. During the past five years of low salmon returns, subsistence harvests have been significantly larger than commercial harvests, yet information characterizing the subsistence harvest is sparse.

OUR OBJECTIVES

Develop transferable training guides for individuals and organizations interested in salmon data collection, and train and mentor up to 30 individuals from up to 10 Yukon and Koyukuk river communities.

Provide biological data to management agencies and enhance the subsistence fisheries database.

HOW WE DID IT

We chose 10 communities based on input from various agencies regarding subsistence harvest data that was lacking from their databases. We entered into personal services contracts with each tribal council. We traveled to each community in accordance with the subsistence fishing schedule to train council-selected individuals to collect biological data from Chinook and summer chum salmon. In addition to biological data, the trained technicians

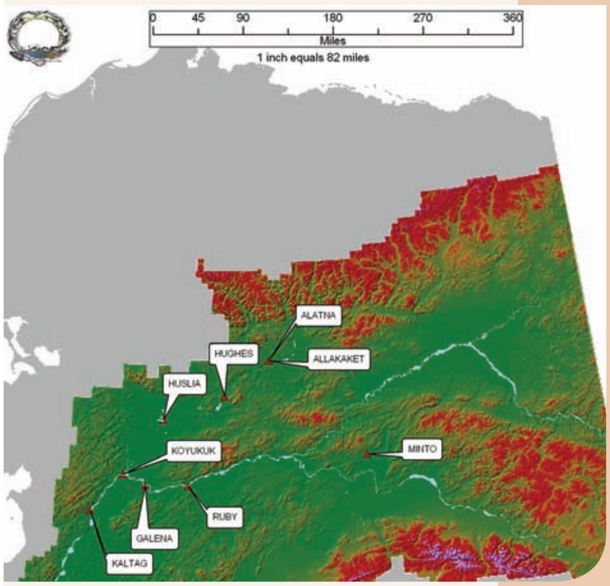
RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

This project engaged communities on the Yukon and Koyukuk rivers in subsistence salmon harvest data collection.

Activities included the development of a manual and training of 21 technicians from seven communities to collect information on gear types, mesh size, and salmon sex, length, and weight. Tissue samples for aging, stock identification, and presence of parasites were also collected.

(Paige Drobny)



Map of the Yukon and Koyukuk river villages from which salmon data samples were collected. (Elkin, TCC)

collected salmon scales, otoliths, and vertebrae for age determinations; fin tissue for stock identification; and heart tissue for the detection of *Ichthyophonus*. Usable data was compiled into an Access database.

WHAT WE DISCOVERED

We were able to train 21 technicians in seven communities. Technicians found our manuals useful for data collection. The best dataset collected consisted of gear type, mesh size, species, sex, length, and weight measurements. Scale samples from Holy Cross were the only ones in good enough condition to determine ages. Vertebrae samples contained too much tissue, and many technicians forgot to collect otoliths, resulting in an inadequate sample size. Problems accompanied the collection of fin and heart tissue, although some of these samples were able to be processed and archived for later analysis.

PRODUCTS AND OUTREACH

Our manual is available for future trainings, and our database is available for continued analysis. We provided all usable collected tissues for addition to existing archives. Our results were displayed on a poster at a regional meeting.

WHAT'S NEXT?

Improvements in data collection will require more training for the technicians. We were limited to two days of training prior to the start of the subsistence season. We recommend focusing on two or three communities, allowing for week-long technician trainings. Our data may be useful in future analyses comparing mesh size of nets to Chinook salmon lengths.

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BERING SEA FISHERMEN'S ASSOCIATION
110 W. 15TH AVENUE
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(John Eiler)

DISTRIBUTION OF SUMMER CHUM SALMON IN THE YUKON RIVER DRAINAGE

PROJECT 426

PRINCIPAL INVESTIGATOR

Ted R. Spencer
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATION

National Oceanic and Atmospheric Administration

RESEARCH PERIOD

May 2004 - April 2005

BUDGET

$93,846.00

TRACKING YUKON SUMMER CHUM SALMON

The Yukon River crosses over 3,000 km of Alaska and covers over 855,000 km^2 of interior Alaska and Canada. Yukon River summer chum salmon are important for commercial fisheries and subsistence. Determining abundance, run timing, and spawning distribution is important because most of the harvest occurs in the downstream portion of the river before the salmon pass upriver monitoring projects. Poor runs from 1997–2002 have increased the urgency in obtaining information about these stocks.

OUR OBJECTIVES

Use radio telemetry to verify fishery manager's estimates indicating that about half the summer chum salmon passing Pilot Station spawn in the Anvik River.

Estimate run timing, migration rates, and the distribution of the return among major tributaries.

HOW WE DID IT

We captured 518 chum salmon using drift gillnets at Russian Mission. We inserted pulse-coded radio transmitters into the stomachs of 208 fish along with external spaghetti tags. We tracked the 124 tagged fish that moved upriver past Paimiut using 45 remote tracking stations installed at 39 sites throughout the Yukon River basin as well as limited aerial surveys.

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #2*

SNAPSHOT

Radio telemetry was used in a preliminary effort to track the Yukon River summer chum salmon run. Information on run timing, migration rates, and distribution of spawning areas was collected and corroborated with sonar data.


(John Eiler)

WHAT WE DISCOVERED

The radio-tagged fish traveled to areas throughout the lower and middle basin. We tracked 74 fish to terminal spawning areas. Our estimate of the proportion of Anvik River fish that passed Pilot Station (31.2%) was similar to the sonar count estimates, which were much lower than in previous years. Salmon passing Paimiut averaged 28.8 km/day, with those from earlier in the return traveling faster. Anvik River fish were present throughout the tagging effort, while Bonasila River fish were present only at the run peak. Koyukuk River fish were found earlier, while lower basin fish heading to undetermined locations were more prevalent later in the run. We found no fish returning to the Tanana River, a known producer of summer chum salmon. Also, many of our tagged fish remained in an area not previously known to be a major producer, and a lower percentage passed Paimiut compared with the Chinook salmon run. These findings suggest that our sample may not be representative of the entire run.

PRODUCTS AND OUTREACH

Final reports were presented to natural resource agencies and fishing organizations within the basin.

WHAT'S NEXT?

We considered this project a feasibility year and our results preliminary. A future study is needed that includes a larger sample size, additional aerial surveys, relocation of the tagging site to Dogfish Village, and tagging fish that are more representative of the run.

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(Christian E. Zimmerman)

CLEAR CREEK CHUM SALMON ECOLOGY STUDIES

PROJECT 436

PRINCIPAL INVESTIGATOR

Christian E. Zimmerman
United States Geological Survey

CONTRIBUTING ORGANIZATION

Bureau of Land Management

RESEARCH PERIOD

May 2004 - April 2005

BUDGET

$97,445.00

CHUM SALMON IN FRESHWATER

Long-term research on salmon ecology and the quantitative evaluation of environmental factors affecting the production cycle are critical components of the management of Yukon River and western Alaska salmon. Unfortunately, there has been limited research on the freshwater ecology of salmon in populations located at the northern extremes of Pacific salmon distributions. Until recently, efforts have been directed at management and harvest concerns. Understanding freshwater life history and ecology has not been a priority.

OUR OBJECTIVES

Increase understanding of salmon freshwater survival. First, to map the spawning locations used by adult chum salmon, describe these habitats, and monitor temperature in spawning gravels. Second, to estimate the number of juvenile chum salmon that migrate from the creek.

Estimate the chum salmon egg-to-smolt survival by comparing the number of juvenile salmon emigrating from the stream with the estimated number of eggs deposited by adult salmon the previous year. These values are critical for developing better models of population dynamics and understanding how environmental variables affect salmon survival.

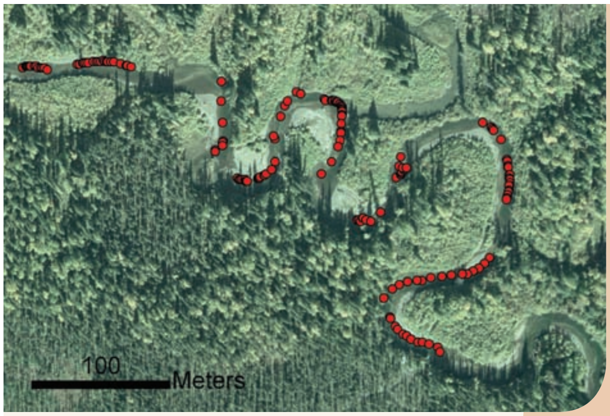
RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITY #2*

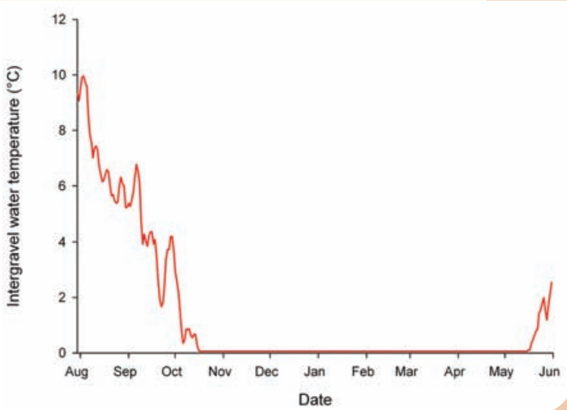
SNAPSHOT

This project mapped chum salmon spawning habitat in Clear Creek and characterized environmental components of the spawning habitat.

Estimates of migrating juveniles were combined with estimates of eggs deposited to determine an egg-to-smolt survival range of 11–21% for chum salmon in Clear Creek.



(Christian E. Zimmerman)



Intergravel water temperature measured adjacent to chum salmon redds, Clear Creek. (Zimmerman, USGS)

HOW WE DID IT

First, we developed a map of the Clear Creek watershed that included the stream and surrounding area using high resolution GPS to map the stream channel and create an overlay with aerial images. During the spawning season, we completed several surveys to map the locations of spawning salmon and redds. Recording thermometers were inserted in the gravel, next to redds, to monitor temperature during the incubation period. Incline plane traps were used to capture and count juvenile chum salmon.

WHAT WE DISCOVERED

Between 2002 and 2005, the total number of chum salmon spawning in Clear Creek ranged from 3,674 to 26,420 chum salmon. In 2004, we mapped the locations of 772 chum salmon redds. While chum salmon in many northern locations use warmer upwelling waters, we found that intergravel water temperatures experienced by incubating chum salmon eggs in Clear Creek were similar to surface water temperatures (and ranged from over 10°C to near freezing). This indicates that Clear Creek chum salmon are using areas of downwelling surface water. Estimates of the abundance of chum salmon smolts emigrating from Clear Creek ranged from 545,000 to over 3 million, and egg-to-smolt survival of chum salmon ranged from 11–21%.

PRODUCTS AND OUTREACH

A geospatial database of all environmental data collected is available electronically from the investigators, and two manuscripts for publication in peer-reviewed journals have been prepared. Outreach activities included employment of interns provided by the Yukon River Drainage Fisheries Association.

WHAT'S NEXT?

More work is needed to refine the role of environmental variation (including temperature and dissolved oxygen) on survival of incubating chum salmon eggs. We recommend combining data from this study with similar studies at other locations to better refine our understanding of the freshwater ecology of salmon in the AYK region.

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(Christian E. Zimmerman)

SELECTIVE FISHERY IMPACTS: YUKON RIVER CHINOOK SALMON

PROJECT 607

PRINCIPAL INVESTIGATOR

Jeffrey F. Bromaghin
United States Fish and Wildlife Service

CONTRIBUTING ORGANIZATIONS

National Oceanic and Atmospheric Administration

Western EcoSystems Technology, Inc.

RESEARCH PERIOD

July 2006 - June 2008

BUDGET

$160,079.00

A FUTURE OF SMALLER FISH?

Like other northern Chinook salmon populations, Yukon River Chinook salmon are characterized by a high proportion of large-bodied, older individuals. The declines in average weight and the reduced frequency of large Chinook salmon in several spawning populations, combined with unexpectedly low abundance in recent years, have precipitated concern that fishery management practices or other unknown factors may be changing fundamental characteristics of this iconic run of fish. The complex natural and fishery selection pressures operating on this population combined with the lack of experimental controls makes it difficult to definitively address these questions using empirical observations.

OUR OBJECTIVES

Investigate the potential for selective exploitation to alter population productivity and demographics—using computer simulation.

Evaluate whether or not selective fishing pressures at the rates found on the Yukon River are likely to induce adaptation.

Develop recommendations for fishery managers to take evolutionary considerations into account.

HOW WE DID IT

We first conceptualized population dynamics as the result of a series of sequential stages within Chinook salmon life history. We developed a sub-model for each stage

RESEARCH FRAMEWORKS:

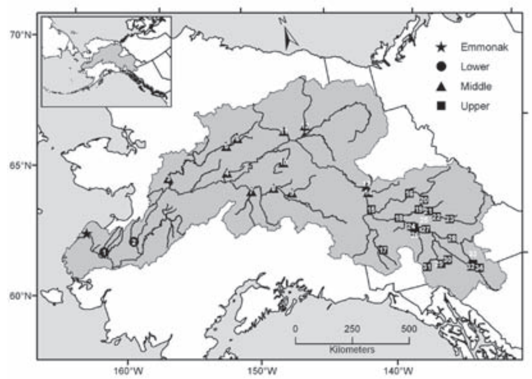
SALMON LIFE CYCLE – *PRIORITY #3;*

SYNTHESIS & PREDICTION – *PRIORITY #9*

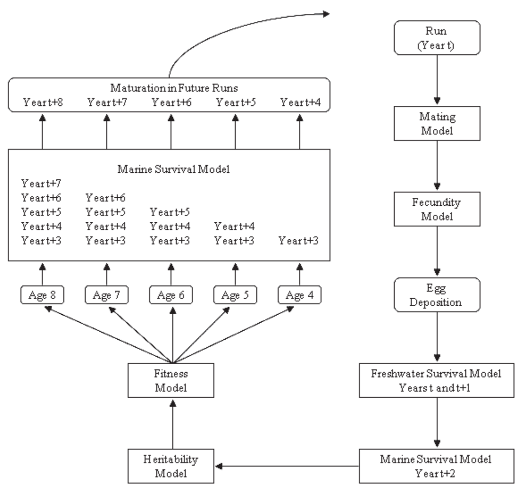
SNAPSHOT

This project used computer simulation to investigate the potential evolutionary consequences of size-selective fishing for Chinook salmon. Researchers found that such pressure could shift the average length and age-at-maturation within 50 to 60 years.

Mitigating effects of various management responses were also explored.



Map of the Yukon River drainage in Alaska and Canada, showing locations of 774 baseline sample collections and the base of mixture sampling in Emmonak, Alaska. (Bromaghin, USFWS)



Schematic diagram of the primary components of the Chinook salmon population dynamics model. Rectangles with squared corners represent model components, while rectangles with rounded corners represent sub-model results. (Bromaghin, USFWS)

(mating, fecundity, egg deposition, freshwater survival, marine survival, and so on) using the best available information. Our final model consisted of all the sub-models operating in sequence.

WHAT WE DISCOVERED

Our results suggest that size-selective fisheries for Chinook salmon employing large-mesh gillnets could shift population demographics and reduce productivity through evolution of length and age-at-maturation within ten generations (about 50 to 60 years). Our model also indicates that maintaining large escapements, especially in years of small returns, may increase the stock's resiliency to selection in later generations. Reducing the fishing intensity and the net mesh size together were much more effective in increasing salmon length and age than either was implemented alone.

PRODUCTS AND OUTREACH

We have submitted a manuscript for publication in a peer-reviewed journal.

WHAT'S NEXT?

An advantage of modeling—simplifying a complex system to understand the interactions of its components—means that assumptions about those components must be adopted. Further research providing improved information about the various parts of our model will increase the accuracy of its predictions. In the meantime, we recommend that managers adopt a precautionary perspective with respect to selective exploitation. This might forestall future decline and increase the potential for the Yukon River Chinook salmon population to persist as a viable and diverse resource that can support a fishery and successfully adapt to future natural challenges.

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(Amy Russel)

NATURAL INDICATORS OF SALMON RUN ABUNDANCE AND TIMING, YUKON RIVER

PROJECT 622

PRINCIPAL INVESTIGATOR

Catherine Moncrieff
Yukon River Drainage Fisheries Association

CONTRIBUTING ORGANIZATION

Alaska Department of Fish and Game

RESEARCH PERIOD

May 2006 - April 2009

BUDGET

$202,445.00

LOCAL AND TRADITIONAL KNOWLEDGE

Between 1997 and 2002, sharp declines in Yukon River salmon abundance caused severe hardships for fishery-dependent communities. For some of the people most affected by fishery management systems, technological advances and statistical constructions are not the only ways to understand or evaluate fish and wildlife populations. Alaska Native fishers from the Yukon River have long relied on their elders' observations of environmental conditions and the behavior of other animals to guide them in preparation for the arrival of the salmon. These "natural indicators," or empirical observations that correlate with the return of the salmon, are culturally important aspects of salmon fishing in the Yukon River drainage.

OUR OBJECTIVES

Document local and traditional ecological knowledge of Chinook, summer, and fall chum salmon in five Yukon River communities.

Promote capacity building in local communities and tribal and non-profit organizations.

HOW WE DID IT

From 2006 to 2009, we conducted interviews with 61 local experts in the Yup'ik communities of Hooper Bay, Emmonak, and St. Mary's and the Athabascan communities of Grayling and Kaltag. We collected information on natural indicators and other methods

RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITIES #2 AND #4*

SNAPSHOT

This project documented local and traditional ecological knowledge regarding salmon runs in five Yukon River communities.

Respondents described the natural indicators they use to gain information about salmon run timing, abundance, and fish size. Salmon habitat and resource use areas in four of the five communities were also mapped.

(Catherine Moncrieff)

(Tori Evans)

used for anticipating salmon returns. We also collected information about current and historical harvest and use patterns, and salmon relative abundance and population trends, as understood locally. We created maps with interview respondents to identify important salmon habitat areas and resource use sites and compiled these maps and spatial data into a GIS database. We consulted with local village assemblies in developing and implementing the project and trained local tribal entities in the use and applications of the maps and research results.

WHAT WE DISCOVERED

Natural indicators are used in each of the five villages. Some indicators are unique to one village. Others, such as snow levels or the arrival of geese, are prevalent in multiple communities. The upriver communities of Kaltag and Grayling have a higher predominance of natural indicators that fall into the "flora and fauna" categories, whereas the lower river communities lean more heavily toward the "marine environment and weather" categories. We found that fishers implicitly separate their observations of natural phenomena into either causal or correlative indicators. In each village, participants repeatedly stated that things are changing and the natural indicators they have used for generations are becoming less predictable or less reliable.

PRODUCTS AND OUTREACH

We developed a GIS database containing mapping data for all the communities except for St. Mary's, whose residents declined to participate in this part of the study. We were able to present and discuss our results and the maps in four of the five communities.

WHAT'S NEXT?

Respondents clearly recognized relationships between weather, animals, plant growth, and salmon run timing and abundance that could inform scientific studies into the mechanisms underlying these observations. Examples of further research include the relationships between salmon abundance and snowfall, water levels, and lamprey populations.

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(Laura Gutierrez)

WORK-IN-PROGRESS
ECOLOGY AND DEMOGRAPHICS OF CHINOOK SALMON

PROJECT
702

PRINCIPAL INVESTIGATOR

Mark S. Wipfli
University of Alaska Fairbanks

CONTRIBUTING ORGANIZATION

Alaska Department of Fish and Game

RESEARCH PERIOD

May 2007 - March 2011

BUDGET

$1,292,384.00

CHINOOK SALMON IN FRESHWATER

Yukon River Chinook salmon have a stream-type life history. Adults spawn in the fall. Fry emerge from the gravel the following spring, overwinter in the river, and migrate to the ocean after spending a full year in fresh water. Research on other species suggests the mortality that regulates Chinook salmon abundance may result from competition for space and/or food during the summer months juveniles spend rearing in freshwater. However, data on Chinook salmon is lacking, probably because they typically rear in large rivers, which makes the necessary fieldwork difficult.

OUR OBJECTIVES

Increase understanding of how ecological processes regulate population size and generate annual variability in the abundance of Chinook salmon in the Chena River. Specifically, to determine whether density-dependent mortality is due to competition among juveniles, the timing of any competitive bottlenecks during the summer rearing season, and whether competition for food is a factor.

Identify the influence of stream flow and other environmental factors on juvenile food availability and understand how they affect growth, condition, and the number of returning adults.

Predict juvenile Chinook salmon density using stream flow patterns and improve management analyses by including the effects of environmental conditions.

RESEARCH FRAMEWORKS:
SALMON LIFE CYCLE – *PRIORITY #2;*

SYNTHESIS & PREDICTION – *PRIORITY #8*

SNAPSHOT

This project examines the ecological factors that affect juvenile Chinook salmon in the Chena River, including causes of juvenile mortality in freshwater.

This work will lead to improved stock-recruitment analyses that incorporate environmental processes to better predict optimal escapements and forecast future returns.

(Laura Gutierrez)

(Mark Wipfli)

HOW WE WILL DO IT

We plan to collect data on the abundance of post-emergent fry and fingerlings at four sites along the Chena River, upstream of the flood control dam, where rearing juveniles are most abundant. We will measure the growth and condition of juvenile fish to look for competitive bottlenecks, and record fish foraging behavior in response to food and competitive interactions. We will add food to four sites within the study areas to determine whether competition for food is a factor in growth and abundance. Data loggers will allow us to measure stream depth, temperature, dissolved oxygen, photosynthetically active radiation, and stream metabolism. We will also sample regularly for nutrients (nitrogen and phosphorus), algal and invertebrate biomass on the streambed, drifting invertebrates in the water column, and terrestrial invertebrate infall into the river.

REPORT COMPLETION

May 2011

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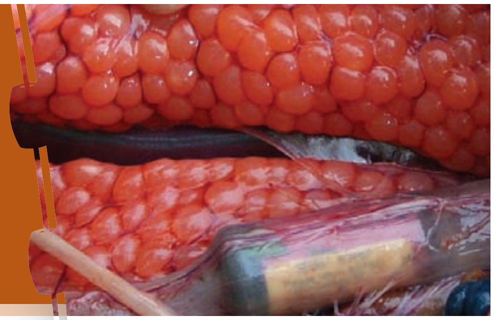


(ADF&G Staff)

FALL CHUM SALMON DISTRIBUTION IN THE UPPER TANANA RIVER

PROJECT
724

PRINCIPAL INVESTIGATOR

Bonnie Borba
Alaska Department of Fish and Game

CONTRIBUTING ORGANIZATIONS

Tanana Chiefs Conference

United States Geological Survey

RESEARCH PERIOD

May 2007 - June 2009

BUDGET

$624,491.00

SPAWNING MAINLY ON THE MAINSTEM

Fall chum salmon originating in the Tanana River represent, on average, thirty percent of the total run within the Yukon River drainage. However, the river is heavily silted and extremely braided, making monitoring spawners and spawning areas difficult. In salmon management, mainstem river habitats are primarily viewed as adult migration corridors with little attention given to their possible role as spawning habitat. On the Tanana River, no other major spawning tributaries have been found, which suggests significant mainstem spawning by fall chum salmon. Thus far, little consideration has been given to recognition and protection of fall chum salmon spawners in the upper mainstem, while potential impacts on these spawners have been increasing.

OUR OBJECTIVES

Confirm that fall chum salmon were using the mainstem Tanana River for spawning, collect information to identify and characterize these mainstem spawning habitats, and determine relative contributions of mainstem spawners to overall upper Tanana fall chum salmon populations.

Collect information used to develop a model for predicting the location of mainstem spawning habitats and collect genetic material to assist in determining where further research should focus efforts on baseline sampling.

Provide estimates of stock-specific run timing, migration rates, and movement patterns.

RESEARCH FRAMEWORK:

SALMON LIFE CYCLE – *PRIORITY #2*

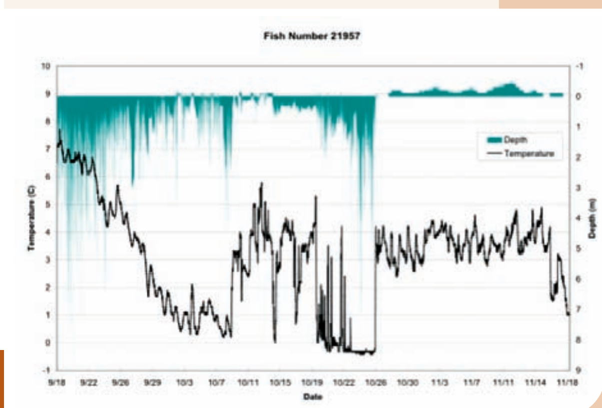
SNAPSHOT

This project investigated fall chum salmon that spawn in the mainstem of the Tanana River.

Radio telemetry was used to track fish during the run, and aerial and ground surveys were used to identify and characterize mainstem spawning habitat.

(ADF&G Staff)

(ADF&G Staff)



Temperature and depth profile of an archival radio tagged chum salmon that spawned in the Delta River, 2008. (Borba, ADF&G)

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HOW WE DID IT

We captured and radio tagged chum salmon at a site located between Manley and Old Minto on the mainstem Tanana River. Tagged fish were tracked by at least 12 remote tracking stations and numerous aerial surveys. During the first year of the study, we tested different types of radio transmitters. During year two the selected tag type was applied throughout the run. We measured coloration, scars, sex, and length of each tagged fish and collected tissue samples for genetic analysis. We conducted ground surveys of spawning areas and deployed inter-gravel monitors. We conducted aerial surveys during freeze-up to map open water which indicate areas of substantial upwelling that were compared with actual spawning sites to develop the habitat model.

PRODUCTS AND OUTREACH

Several manuscripts from this project are in development.

WHAT'S NEXT?

An increase in winter research is particularly important in high latitude regions like Alaska. Transferring the methods used in this study across high latitude river systems has the potential to reduce costs associated with remote field work that identifies unfrozen habitats, and eliminate logistical challenges associated with working outdoors in the arctic environment.

Baseline information identified for arctic river systems is critical for monitoring changes in habitat. With a warming climate, this information could detect changes in riverine ecosystems, aid in better research and management decisions, and assist in the conservation of salmon in freshwater ecosystems.

(Jeffrey F. Bromaghin)

FECUNDITY OF YUKON RIVER CHINOOK SALMON

PROJECT
806

PRINCIPAL INVESTIGATOR

Jeffrey F. Bromaghin
United States Fish and Wildlife Service

CONTRIBUTING ORGANIZATION

Alaska Department of Fish and Game

RESEARCH PERIOD

May 2008 - March 2009

BUDGET

$56,653.00

FEWER EGGS FOR YUKON CHINOOK SALMON?

Strategies for investing energy in the development of reproductive tissue, and optimizing the trade-off between total ovarian mass, egg size, and egg number (fecundity) are important determinants of salmon population productivity and individual fitness. A 2005 study found that the fecundity of Tanana River fish declined about 20% since 1989. Whether this reduction reflects a downward trend or a natural level of variability is unknown, though such a large and rapid decline raises concerns.

OUR OBJECTIVES

Initiate the first comprehensive investigation of the fecundity of Yukon River Chinook salmon populations. Specifically, to determine the degree to which fecundity differs among populations within the drainage and verify whether fecundity has decreased from historic levels.

HOW WE DID IT

We sampled 403 fish from the Alaska Department of Fish and Game Test Fishery catches in the lower Yukon River to avoid sacrificing additional fish, and to ensure that all populations would be represented. From each individual, we collected physical measurements, egg skeins, and tissue samples. We used genotype data to obtain separate estimates for different populations. We compared our estimates of egg numbers to those from previous Yukon River watershed studies.

RESEARCH FRAMEWORKS:

SALMON LIFE CYCLE – *PRIORITY #3;*

SYNTHESIS & PREDICTION – *PRIORITY #9*

SNAPSHOT

This project looked at numbers of eggs per spawning female (fecundity) for Chinook salmon in the Yukon River.

Estimates were obtained for genetically distinct populations and compared with past studies. No evidence of declining fecundity was found, but researchers did find differences between lower and upper river populations with implications for fishery management.

(Jeffrey F. Bromaghin)

(Jeffrey F. Bromaghin)

WHAT WE DISCOVERED

We found that small fish from the middle and upper portions of the drainage have markedly fewer eggs than small fish from the lower portions, suggesting that fecundity decreases with length of migration. We also found that the productivity of middle- and upper-river populations may be more dependent on the size of reproducing individuals than lower-river populations. Our estimates were considerably greater than those in the 2005 study and consistent with a 1987 study. We were unable to collect meaningful data on egg size and total ovarian mass since such measurements must be taken just prior to spawning. Our collection site on the lower river was too far from spawning areas to obtain this data.

PRODUCTS AND OUTREACH

Presentations were given at several meetings: the American Fisheries Society Alaska Chapter, Alaska Board of Fisheries, and for the AYK SSI. A draft manuscript is currently under review.

WHAT'S NEXT?

Our results suggest that a fish reproducing in the middle and upper reaches of the drainage may contribute less to subsequent generations than a similarly sized fish reproducing in the lower drainage. Fishery managers should be aware of these differences in reproductive potential.

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(Stan Zuray)

WORK-IN-PROGRESS
RAPIDS STUDENT DATA COLLECTION

PROJECT 808

PRINCIPAL INVESTIGATOR

Stan Zuray
Rapids Research Center

RESEARCH PERIOD

June 2008 - March 2011

BUDGET

$33,470.00

INVOLVING STUDENTS IN SALMON SCIENCE

Presently, there is a lack of consistent information on sex, length, weight, girth, and visible disease for Yukon River Chinook salmon bound for upper river areas and Canada. These types of data are essential for the effective management of the many salmon species that migrate upstream each year. Information on Chinook salmon, in particular, is a high priority because of recent issues of declining size and possible loss of the older age classes. There is a need to have continuing baseline studies in place to monitor changes in this fishery.

OUR OBJECTIVES

Collect full season sex, length, girth, weight, and *Ichthyophonus* disease prevalence data on Chinook salmon, and be able to determine the arrival of the fall chum salmon run.

Collect information using local students trained in data collection techniques.

Provide in-season updates on Yukon River runs.

HOW WE WILL DO IT

Tanana high school students with previous experience will collect random samples of Chinook and chum salmon at several fish camps at the Rampart Rapids. We plan to collect sex, length, girth, and weight data on 1,000

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE – *PRIORITY #3*

SNAPSHOT

This project will use trained, local high school student technicians to collect Yukon River Chinook salmon sex, length, weight, and girth data. Students will also determine the rate of *Ichthyophonus* disease in Chinook salmon, and the date of the start of the fall chum salmon run.

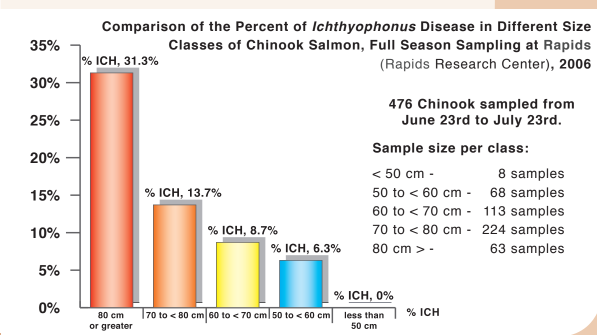
Chinook salmon, and dissect 500 Chinook salmon to detect *Ichthyophonus* disease rates. Beginning on July 20, well before the fall chum salmon run, we will examine chum salmon for flesh color. The fall run fish have flesh which is darker red with a higher fat content. For the purposes of this study, we will note the date in which 50% of fish collected belong to the fall run as the "official" beginning date of this run.

REPORT COMPLETION

May 2011

(Stan Zuray)

(Stan Zuray)



While other studies have shown that Ichthyophonus *infection is spread somewhat evenly among the different size classes of Chinook salmon, Rapids Data Collection Project has shown that the actual disease is clearly more pronounced among the larger size classes. Graph showing similar results to 2006 exist for 2007 to 2009. (Zuray, RCC)*

AYK SSI Mission: *To collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.*

ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE

BERING SEA FISHERMEN'S ASSOCIATION
110 W. 15TH AVENUE
ANCHORAGE, AK 99501
(907) 279-6519

(Paige Drobny)

WORK-IN-PROGRESS
BIOLOGICAL SAMPLING OF YUKON RIVER SALMON

PROJECT
811

PRINCIPAL INVESTIGATOR

Mike Smith
Tanana Chiefs Conference

CONTRIBUTING ORGANIZATION

Bering Sea Fishermen's Association

RESEARCH PERIOD

August 2008 - March 2011

BUDGET

$552,471.00

A CLEARER PICTURE OF YUKON SALMON

For the past decade, the largest and most consistent component of the Yukon River Chinook salmon harvest has been the subsistence harvest. Subsistence and commercial chum salmon harvests have fluctuated greatly due to changes in commercial markets, subsistence needs (generally related to dog team use), and dramatic swings in abundance for both summer and fall chum salmon stocks. Subsistence has legal priority over other harvests. However, Yukon River subsistence salmon catch information has been limited or non-existent and several escapement monitoring projects have been recently discontinued.

OUR OBJECTIVES

Conduct escapement surveys and collect age, sex, and length data on the Toklat River fall chum salmon and Nenana River coho salmon.

Collect age, sex, and length data and tissue for genetic analysis from the subsistence Chinook salmon harvests in the Yukon River drainage, and Chinook, chum, and coho salmon tissue samples from the Koyukuk and Tanana river drainages.

HOW WE WILL DO IT

We will conduct aerial and foot surveys to collect fall chum data from carcasses on the Toklat River. We will also conduct aerial counts on the Nenana River and collect data from live caught coho salmon. We will

RESEARCH FRAMEWORK:
SALMON LIFE CYCLE –
PRIORITY #3

SNAPSHOT

This project will collect subsistence salmon harvest information in the Yukon River drainage, and continue several recently vacated escapement monitoring projects, primarily in the Tanana drainage.

Age, sex, and length data and tissue for genetic analysis will be collected during the subsistence fishery and on spawned-out salmon.

(Paige Drobny)

(Paige Drobny)

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contract with participants in the Yukon River Chinook salmon subsistence fishery to collect data on sex, length, and capture method; scales for aging; and fins for genetic analysis. We will collect tissue samples from live Koyukuk and Tanana River salmon and, where practical, use locally hired technicians, as well as project staff, to collect tissue samples and age, sex, and length data from spawned-out Chinook, coho, and chum salmon in these drainages.

REPORT COMPLETION

May 2011

EXPANDING THE BIOLOGY COMMUNITY

AYK SSI is a proud partner of the Alaska Native Science & Engineering Program (ANSEP). Funding for the program was provided to address the need for effective recruitment and training programs for Alaska Native and other rural students in fisheries science and related biology-based careers.

ANSEP's new fisheries science and related biology-based program, targeting students within the AYK region, benefits the region and resources, and serves as a means of achieving the capacity building goal of the AYK SSI.

Alaska Natives and other rural students are significantly under-represented in professional positions related to fisheries science and fisheries management. As a result, non-local biologists hold virtually all professional fisheries positions in this region, including those biologists working for tribal organizations. AYK SSI, through ANSEP, is working toward providing effective recruitment and training programs for Alaska Native and other rural students.

Participating students will complete biology-based projects with practicing professionals and University of Alaska faculty and staff. This will provide those students with a first glimpse into a career in biology. The ANSEP Pre-College component is the spark that illuminates a vision of a professional science career. When students complete the high school coursework necessary for success in a fisheries and related biological science degree program, they can hit the ground running when they arrive at the University.

High school graduates will transition to fisheries and biological science degree programs via the ANSEP Summer Bridge component. The Summer Bridge will solidify the students' career vision and will build a strong foundation for academic and professional success.

ANSEP BIOLOGY SUPPORTED BY:

- ARCTIC-YUKON-KUSKOKWIM SUSTAINABLE SALMON INITIATIVE
- ALASKA DEPARTMENT OF FISH AND GAME
- UNITED STATES FISH AND WILDLIFE SERVICE
- NATIONAL FISH AND WILDLIFE FOUNDATION
- RASMUSON FOUNDATION

Dr. Herb (Ilisaurri) Schroeder
Associate Dean & Professor of Engineering (Room 204)

ANSEP™ Founder and Executive Director

Phone: **(907) 786-1860**
Email: **herb@uaa.alaska.edu**

Beth Spangler
ANSEP™ Biological Sciences (Room 203)

Phone: **(907) 786-1074**
Email: **beth_spangler@fws.gov**

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Alaska Native Science & Engineering Program
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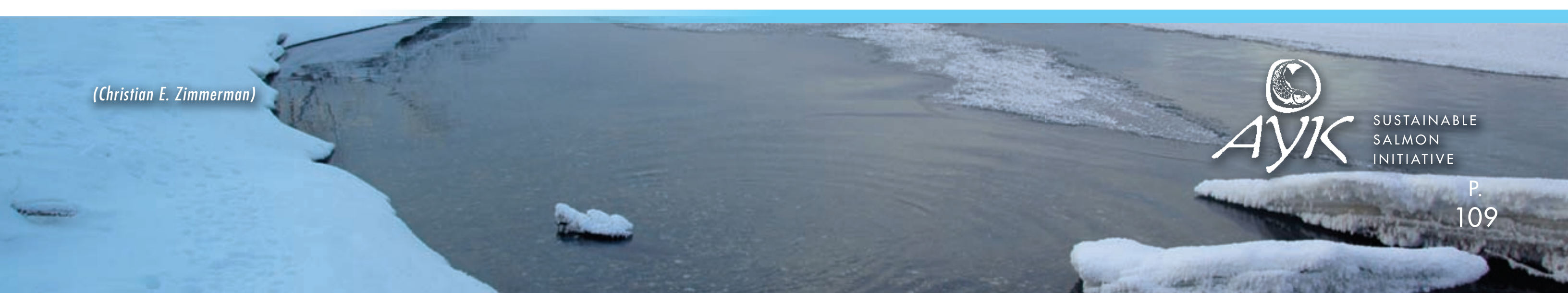
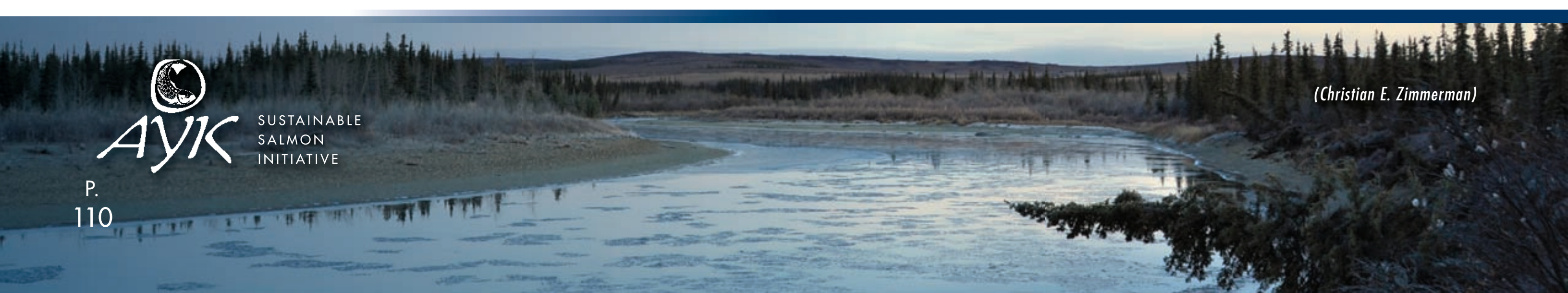
Learn more at ansep.uaa.alaska.edu



(Christian E. Zimmerman)

HIGH PRIORITY HYPOTHESIS	EXAMPLE QUESTIONS
research framework: SALMON LIFE CYCLE	
1. Marine survival of salmon is more affected by variability in ocean temperature and other 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?
2. 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?
3. 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 Local and Traditional Knowledge (LTK) recorded long-term changes in the maximum size and sex ratios of salmon?
4. 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: HUMAN SYSTEMS	
5. 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?
6. 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?
research framework: SYNTHESIS & PREDICTION	
7. 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?
8. 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?
9. 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?
10. 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?
11. 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?

Note: *Hypotheses presented above reflect statements about how processes may cause salmon abundance to vary. Hypotheses should not be interpreted as statements of fact nor statements of belief of the AYK SSI, but are propositions about how the salmon system may work—they may be true or they may be false. The hypotheses are posed as positive statements designed for studies to either prove or disprove. It may be helpful for the reader to insert before each hypothesis, "To determine whether…". Please also note that the example questions presented are not intended to be the only questions of importance. The questions may serve to stimulate researchers to craft their own hypotheses and questions as they develop research proposals.*



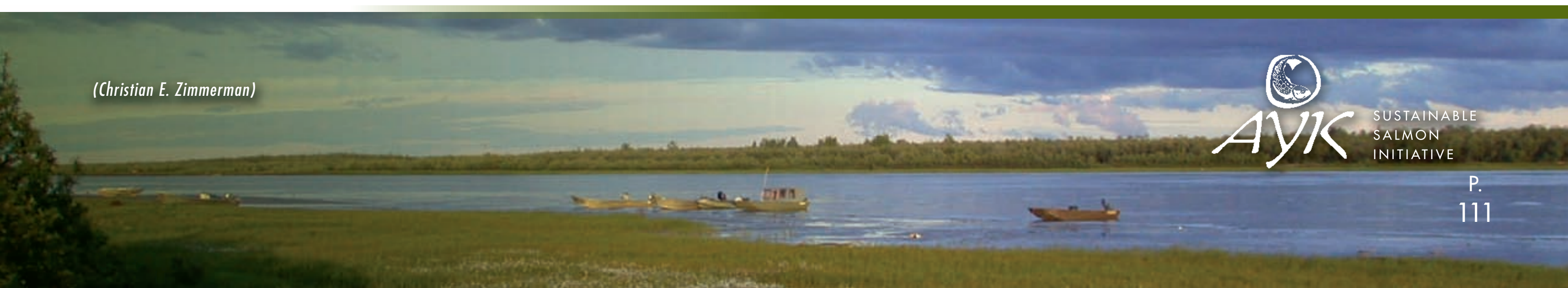
(Christian E. Zimmerman)

This figure shows the total number of funded projects addressing each priority. Note that more than one priority is assigned to many of the projects, thus the number of total projects listed exceeds the total number funded. Projects are assigned only to the priority or priorities which are directly addressed by the project objectives.

HIGH PRIORITY FRAMEWORKS

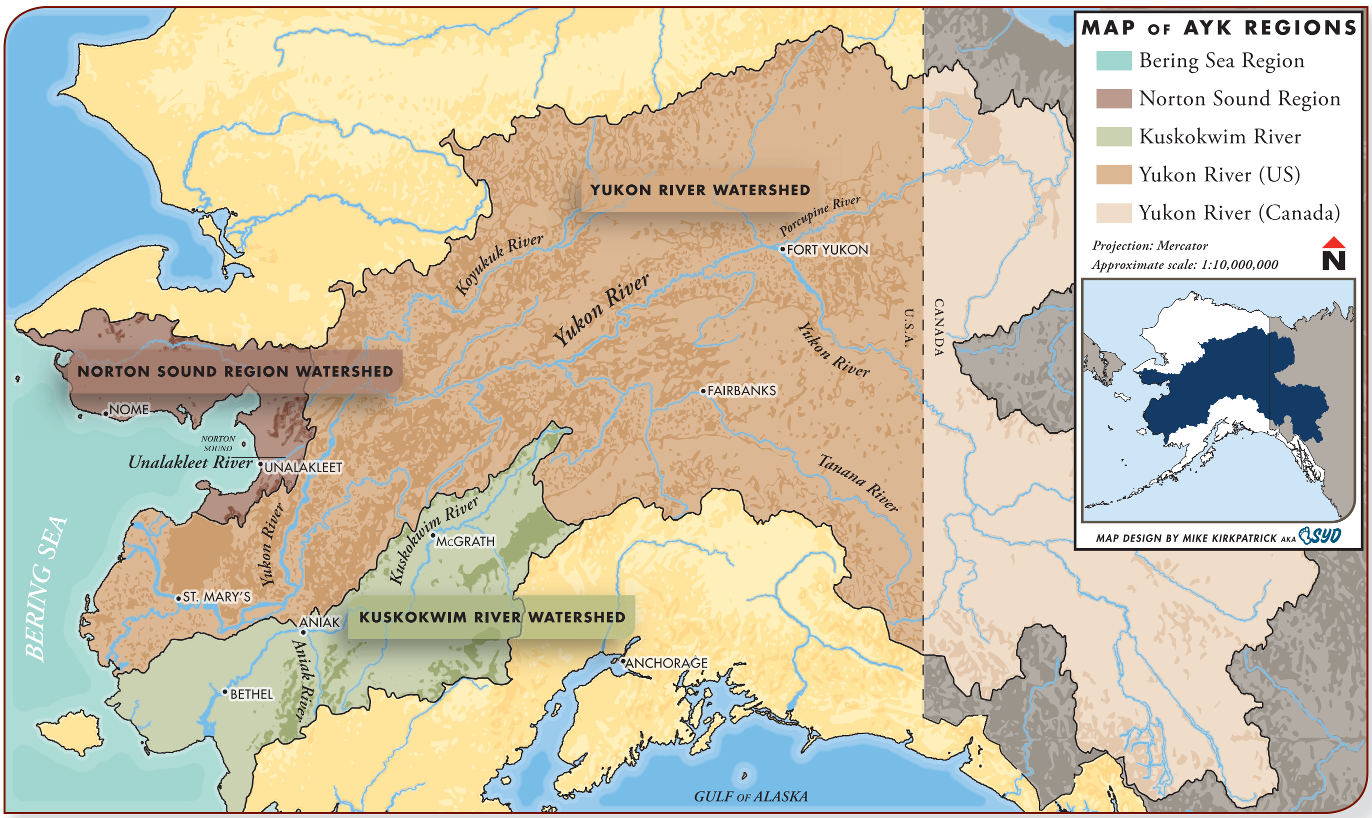
11 HIGH PRIORITY HYPOTHESES

High Priority Framework	Hypothesis	# of Projects Funded Under Each Hypothesis
SALMON LIFE CYCLE	1. Marine survival of salmon is more affected by variability in ocean temperature and environmental variables than by variability in marine fishing mortality.	7
	2. Spawning escapement and subsequent egg deposition are important determinants of the abundance of the next generation of salmon.	22
	3. Selective fishing over time has altered the size, sex ratio, and life-history type composition of salmon populations.	5
	4. Adult salmon abundance in streams shows regular periodic changes and has varied widely over the past two centuries.	3
HUMAN SYSTEMS	5. 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.	2
	6. 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.	0
SYNTHESIS & PREDICTION	7. Models that predict historic variability will forecast future salmon abundance.	6
	8. 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.	7
	9. Stock diversity and salmon stock abundance can be sustained by regulation of fishing gear and fishing times using an escapement goal management approach.	5
	10. A combination of demographic and ecosystem variables affects the variability of salmon returns in the AYK region.	13
	11. Future salmon abundance will support expected harvest demand and provide sufficient spawning salmon to maintain self-sustaining salmon returns in the AYK region.	0


(Christian E. Zimmerman)

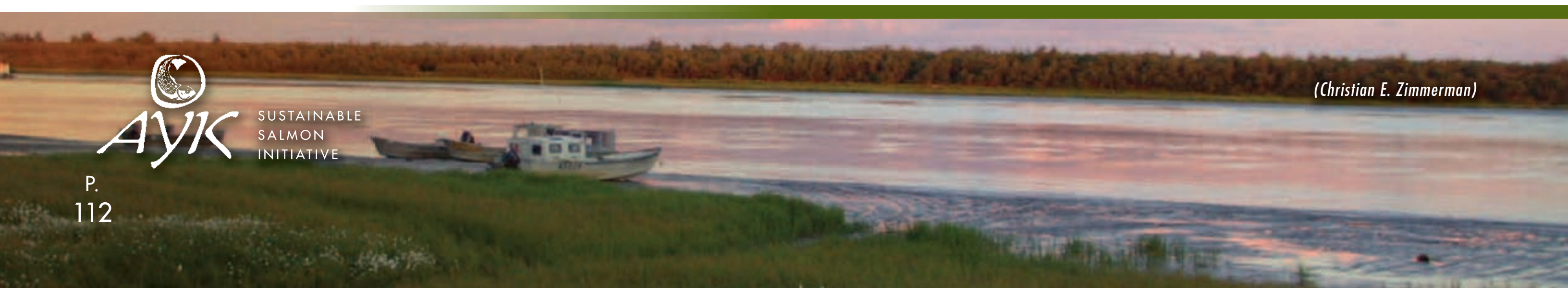
The AYK SSI has funded 55 salmon research projects addressing salmon research needs across the region. Beginning in 2006, research priorities were drawn from the AYK SSI Salmon Research & Restoration Plan, which serves as the science-based roadmap which guides the AYK SSI's "Invitations to Submit Research Proposals" and ensures that available funds target the highest priority research questions and issues.

Our fifty-five projects are broken down into the areas addressed among the four sub-regions: Norton Sound area, Yukon River watershed, Kuskokwim River watershed, the Bering Sea, plus a set of AYK SSI region-wide projects. Projects were assigned to sub-regions based on the principle focus of the project objectives and methods. Tangential references to other watersheds were not sufficient reason to add a project to a second sub-region.



In light of the broad range of priorities addressed since 2002, it is significant that the figure at right shows a fairly even distribution of projects among the four sub-regions. Thirteen projects are focused in the Norton Sound area, twelve in the Yukon River watershed and twelve in the Kuskokwim River watershed.

The Bering Sea ecosystem is the focus of eight projects and another ten projects address topics of region-wide AYK significance.



AYK REGION–WIDE

PROJECT #	PRINCIPAL INVESTIGATOR	PROJECT TITLE
303	Goodman	Uncertainty analysis for selected western Alaska chum salmon stocks
405	Peterman	Experimental design principles for salmon populations in the Arctic-Yukon-Kuskokwim
425	Olsen	Effective population size of Chinook salmon in Yukon and Kuskokwim river tributaries
606	Hilborn	Alternative methods for setting escapement goals in the Arctic-Yukon-Kuskokwim
617	Olsen	Landscape genetics of Arctic-Yukon-Kuskokwim salmon populations
708	Collie	A risk assessment framework for Arctic-Yukon-Kuskokwim chum salmon
714	Bond	Future climate/habitat of Arctic-Yukon-Kuskokwim ecosystems
735	Schroeder	Alaska Native Science and Engineering Program
902	Jones	Escapement goal setting to ensure sustainable fisheries
903	Wolfe	Human systems and sustainable salmon

BERING SEA–MARINE

PROJECT #	PRINCIPAL INVESTIGATOR	PROJECT TITLE
306	Svejkovsky	Arctic-Yukon-Kuskokwim satellite-derived environmental database
410	Ruggerone	Retrospective analysis of Arctic-Yukon-Kuskokwim Chinook salmon growth
610	Farley	Factors affecting chum salmon growth and condition
632	Templin	Stock-specific forecast of Arctic-Yukon-Kuskokwim Chinook salmon
711	Weingartner	Juvenile salmon dispersal: drifter based view
712	Myers	Climate-ocean effects on Chinook salmon
719	Kondzela	Genetic analysis of immature Bering Sea chum salmon
809	Agler	Historical analyses of Arctic-Yukon-Kuskokwim and Asian chum salmon

KUSKOKWIM RIVER WATERSHED

PROJECT #	PRINCIPAL INVESTIGATOR	PROJECT TITLE
309	Krauthoefer	Kuskokwim area subsistence salmon harvest surveys
310	Kerkvliet	Kuskokwim River salmon population estimates
409	Gilk	Characteristics of Kuskokwim River fall chum salmon
424	Meka	Body condition and feeding ecology of Kuskokwim River chum salmon
612	Molyneaux	Kuskokwim River Chinook salmon run reconstruction
618	Gilk	Kuskokwim River sockeye salmon investigations
619	Finn	Abundance, migration and survival of juvenile chum salmon, Kwethluk River
725	Olsen	Heritability of traits in wild Chinook salmon
801	Molyneaux	Kuskokwim River coho salmon investigation
802	McPhee	Ecotypic variations in Kuskokwim River sockeye salmon stocks
805	Ruggerone	Productivity of Kuskokwim River juvenile coho salmon
810	Crane	Kuskokwim River coho salmon genetics

NORTON SOUND AREA

PROJECT #	PRINCIPAL INVESTIGATOR	PROJECT TITLE
401	Magdanz	Patterns and trends in subsistence salmon harvests, Norton Sound and Port Clarence
416	Joy	Estimation of coho salmon abundance and distribution in the Unalakleet River
430	Estensen	Estimation of abundance and distribution of chum salmon in the Unalakleet River drainage
439	Gaboury	Nome River watershed habitat restoration framework
501	Zimmerman	Use of otolith microchemistry in Norton Sound salmon populations
502	Olsen	Genetic variation in Norton Sound chum salmon populations
601	Raymond-Yakoubian	Using local traditional knowledge in Norton Sound salmon populations
614	Ruggerone	Retrospective analysis of Arctic-Yukon-Kuskokwim chum and coho salmon
721	Lean	Nome River coho salmon abundance and survival
731	Smoker	Seward Peninsula smolt studies
803	Burnett	Landscape predictors of coho salmon
804	Lean	Testing habitat-based production models for coho salmon in the Fish River
807	Ruggerone	Norton Sound Chinook salmon growth and production

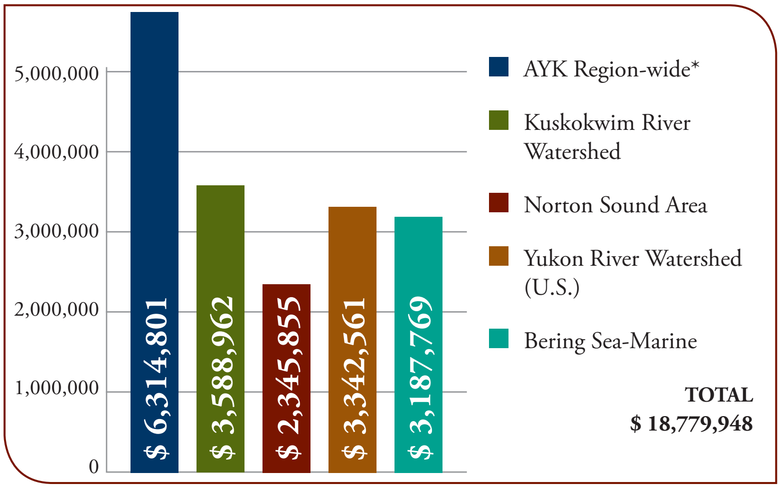
YUKON RIVER WATERSHED

PROJECT #	PRINCIPAL INVESTIGATOR	PROJECT TITLE
314	Spencer	Yukon River Chinook salmon telemetry and mark-recapture
406	Margraf	Non-lethal estimation of energy content of Yukon River Chinook salmon
414	Elkin	Capacity development and community involvement
426	Spencer	Distribution of summer chum salmon in the Yukon River drainage
436	Zimmerman	Clear Creek chum salmon ecology studies
607	Bromaghin	Selective fishery impacts: Yukon River Chinook salmon
622	Moncrieff	Natural indicators of salmon run abundance and timing, Yukon River
702	Wipfli	Ecology and demographics of Chinook salmon
724	Borba	Fall chum salmon distribution in the Upper Tanana River
806	Bromaghin	Fecundity of Yukon River Chinook salmon
808	Zuray	Rapids student data collection
811	Smith	Biological sampling of Yukon River salmon

The AYK SSI was appropriated $20,500,000 to assemble existing information, gain new information, and improve techniques for understanding the trends and causes of variation in salmon abundance and human use of salmon.

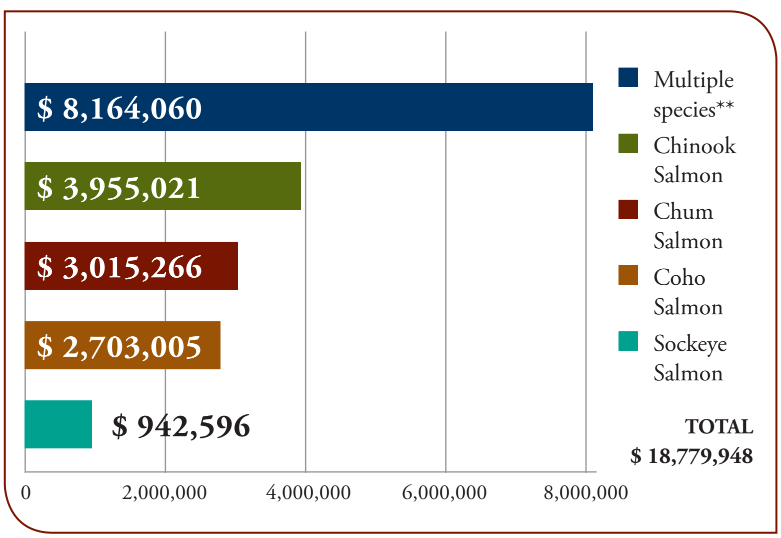
The Steering Committee has obligated 100% of the funds (this includes projections through 2011) passed through to the AYK SSI; just over $19,300,000 (this number does not include the ADF&G indirect or the NOAA reductions, which are both used for administration). Funds were directed to the Salmon Research & Restoration Plan Frameworks (Salmon Life Cycle, Human Systems, Synthesis and Prediction), broad capacity building efforts, and the administration of the AYK SSI. We provide the following charts to show how funds have been distributed.

AYK SSI PROJECT EXPENDITURES DISTRIBUTED BY REGION



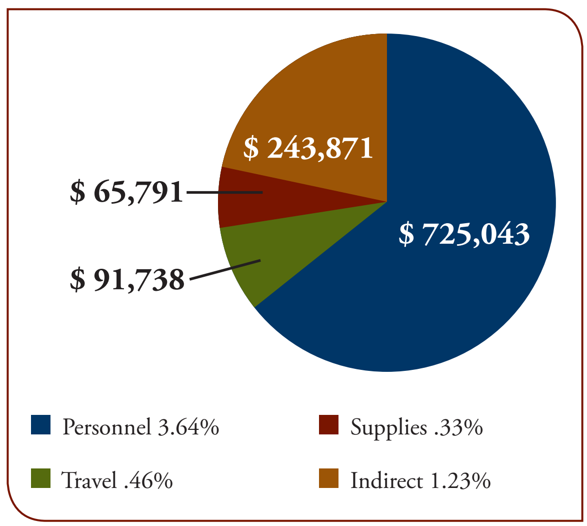
** AYK Region-wide designation includes projects directed at all regions.*

AYK SSI PROJECT EXPENDITURES DISTRIBUTED ACROSS SPECIES



*** Multiple-species includes projects which are designed to study at least two different salmon stocks.*

AYK SSI ADMINISTRATION



FINALIZED SALMON RESEARCH & RESTORATION PLAN

A joint effort between the AYK SSI Scientific Technical Committee and the National Research Council

The aim of this long-range, strategic science plan is to identify the conceptual frameworks, research themes and research priorities needed to guide research funded through the AYK Sustainable Salmon Initiative. Development of the Arctic-Yukon-Kuskokwim Salmon Research & Restoration Plan (AYK SSI RRP) helps to ensure that available funds are spent wisely.

The AYK SSI, targeting salmon stocks in the Arctic-Yukon-Kuskokwim region, benefits salmon, fishers and sustainable salmon management by:

- Drawing on the best available science to identify effective ways to investigate and understand the complexity of marine and freshwater ecosystems which support these salmon stocks;
- Providing scientific analysis and review to support the development of a high-quality, long-range restoration and research plan for the AYK region;
- Helping to ensure that the appropriated funds target high-priority research projects by identifying knowledge gaps, and prioritizing future salmon research themes and questions.

The AYK SSI RRP is available for download on our website: www.aykssi.org

THE 2007 AYK SSI SYMPOSIUM

What do we know about salmon ecology, management and fisheries?

A symposium of invited and contributed papers was held during the week of February 5, 2007. The symposium addressed a variety of topics related to biology, human dimensions, and management issues and considered their implications to the AYK SSI Salmon Research & Restoration Plan and the AYK SSI. The symposium assessed the history and current status of fish stocks, and helped direct future research.

The success of the symposium rested solely with the participants. We had over 300 registered guests. They included a blend of rural and Native leaders, state and federal agency representatives, and some of the world's leading social and biological scientists.

One of the goals of the 2007 symposium was to gather a broad spectrum of information to communicate what is known, and needs to be known, about salmon and fisheries in the Arctic-Yukon-Kuskokwim region of Alaska, including:

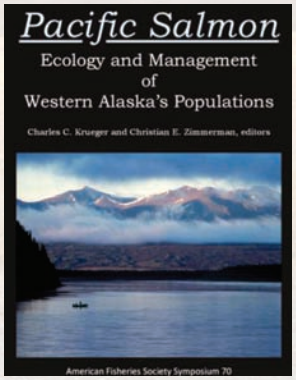
- Ecological processes that cause change in salmon populations,
- The effects of varying salmon runs on rural communities, and
- Management of salmon fisheries in the region.

This information is presented in...

PACIFIC SALMON: ECOLOGY AND MANAGEMENT OF WESTERN ALASKA'S POPULATIONS

Pacific Salmon: Ecology and Management of Western Alaska's Populations, a state-of-the-art assessment of salmon stocks and management practices in the AYK region.

This timely book, sponsored by the AYK SSI and published by the American Fisheries Society, covers the freshwater, estuarine, and marine ecology and management of salmon and is the first-ever comprehensive appraisal of the region's salmon resources.



Containing 61 chapters, the book assesses the ecological processes that cause change in salmon populations; describes the effects of varying salmon runs on rural communities; reviews state, federal, and international management of salmon fisheries in the region; and examines emerging themes at the nexus of salmon ecology and management in the AYK region.

The book includes special sections on the economic, social, and cultural significance of salmon, and on governance associated with salmon management. Reviews of several other fisheries, such as those in Washington and Oregon, provide lessons learned elsewhere that can be applied to Alaska's salmon fisheries. Several chapters conclude with recommendations for future research to promote a better understanding of the region's fisheries. This book was edited by Charles C. Krueger and Christian E. Zimmerman, both members of the AYK SSI Scientific Technical Committee.

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