Gap Analysis for the Kuskokwim Area Salmon Research Plan

Developed by

The Kuskokwim Fisheries Resources Coalition

January 2006

Executive Summary

A gap analysis was conducted to assess the state of knowledge for salmon-related information for the Kuskokwim Area that the Kuskokwim Fisheries Resources Coalition (KFRC) deemed important in 2004. The KFRC first identified 52 important Information Needs at a planning session in Bethel, Alaska in 2004. A database of salmon-related projects was then compiled to help assess progress made towards each Information Need. Projects were included in this database if they operated in the Kuskokwim Area in the 1980s or later, regardless of whether they resulted in a final report or publication. Each project was then paired with one or more of the 52 Information Need(s) identified as important by the KFRC. Based on the number of projects, the species addressed, and the geographic area covered, an assessment was made of the relative state of knowledge for each Information Need. Most (32) of the 52 had few or no projects addressing them; for these Information Needs, the state of knowledge was considered *largely unknown.* Twenty Information Needs had a substantial amount of project effort devoted to them; for these Information Needs, the state of knowledge was considered *partially known.* There were no Information Needs for which the state of knowledge was considered *adequate*.

The gap analysis also includes a summary discussion of the current situation for Information Needs within the Kuskokwim Area. Based on this summary and the list of corresponding projects, a short list of *major (remaining) information gaps* was developed. A final section, *what needs to be done*, was developed to identify specific actions to address these major information gaps. The discussion sections, project lists, and information status were all reviewed by KFRC members, individually or in small groups, beginning with a draft circulated in August of 2004. Additional experts in social science, genetics, and biology were consulted for individual sections.

The gap analysis will help investigators and funding sources identify how new projects match up with previously identified Information Needs, and to determine whether these projects address areas that are partially known or largely unknown. The gap analysis will influence the priority assigned to different Information Needs in a final research plan developed by the KFRC. In the plan, the relative state of knowledge (from the gap analysis) will be combined with an importance rating (assigned separately) to place Information Needs into priority categories for future work.

The gap analysis should be considered a living document, and should be updated in January of 2007. Results will change as new projects begin, existing projects are completed, and as Kuskokwim Area stakeholders use the gap analysis and identify improvements.

Citation: KFRC (Kuskokwim Fisheries Resources Coalition). 2006. Gap analysis for the Kuskokwim Area salmon research plan. M. Nemeth, editor. LGL Alaska Research Associates, Inc., Anchorage, Alaska.

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Gap Analysis

Overview

The purpose of the Gap Analysis is to identify where progress has been made – and not made - towards addressing the Information Needs identified by the Kuskokwim Fisheries Resources Coalition (KFRC). The results can then be compared with the relative importance assigned to each Information Need (Figures 1-4) by the KFRC at a meeting held in Bethel in 2004 (KFRC 2004). This comparison then provides the basis for the prioritization of future research (KFRC 2006). This is different from many plans in that the priority list has considered both importance and the degree to which the information is already known.

The Gap Analysis was developed in multiple steps, using an iterative process for feedback from KFRC members and outside experts. First, a search was conducted for current and recent (since 1980) projects in the Kuskokwim Area (Figure 5) that addressed any of the Information Needs. These projects were placed into a database, given standardized code numbers, and the major goal and Information Need addressed by each project was identified. These entries were then reviewed for design, errors, and omissions by numerous KFRC members. Second, this project database formed the basis for two discussion subsections of each Information Need: (a) a *summary of the current situation* of the Information Need, and (b) a summary of the *recent or current projects* to support the Information Need. These two subsections were the logical basis for a third subsection, the identification of *major information gaps*. Finally, the discussion for each Information Need ended with a fourth subsection, *what needs to be done.*

Each of the four subsections within each Information Need was reviewed by different KFRC members via an iterative process. Four people from the KFRC subcommittee reviewed the first draft of the subsections. The Gap Analysis was then divided into four parts (one for each Goal), and different KFRC members were asked to provide detailed reviews of each one. These reviews were coordinated by Matt Nemeth, an independent fishery biologist with LGL Alaska Research Associates, Inc., who served as the lead planner for the project. KFRC members provided reviews to the lead planner in writing, in person, and by teleconference, both individually and in small groups. This document includes comments submitted through December 2005; however, feedback from Kuskokwim stakeholders should continue to be cataloged, and incorporated into an update recommended for January 2007.

In their reviews, KFRC members helped incorporate species, geographic coverage, and time frames into the different subsections of the Gap Analysis. Data quality and reliability were not formally assessed, but some KFRC members factored this into their suggestions.

The remainder of the Gap Analysis is split into separate, repeated assessments of each of the four Goals identified by the KFRC. Each goal begins with an overview that provides an introduction to the aspects of the Kuskokwim Area relevant to each Goal, a summary of major work currently underway, and a recap of the Information Needs identified by the KFRC in 2004. Within each Goal, each Information Need is identified and the four subsections described above are discussed. For Goals 1 and 4, the Information Needs are discussed in groups; for Goals 2 and 3, all Information Needs are discussed independently. The final draft of the entire Gap Analysis will be included as a chapter in the main Kuskokwim Area Salmon Research Plan document.

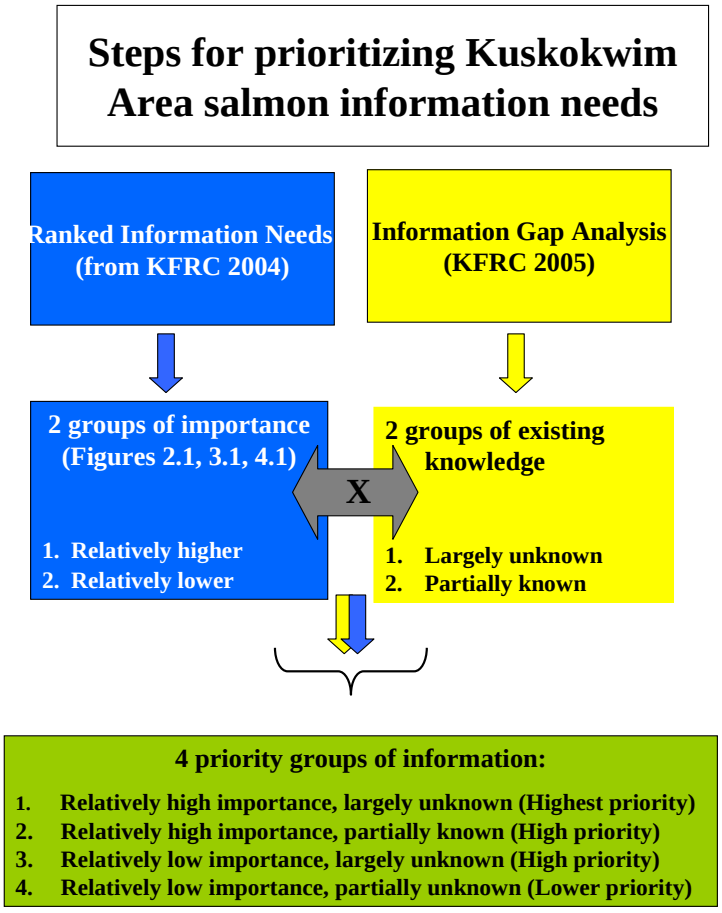

Figure 3.5. Conceptual diagram showing how assessment of information importance and existing knowledge gaps were combined to classify information into different priority groups. Figure taken from Chapter 3 of full research plan (KFRC 2006).

Table 3.1. Recommended approach for Information Needs that fall into each of four categories based on combination of importance (assigned by KFRC) and amount of existing information (identified in Gap Analysis). Table taken from Chapter 3 of full research plan (KFRC 2006).

Information Need/Gap Analysis category	Recommended approach
Group 1 Relatively higher importance; Information largely unknown	• Prioritize support for any existing projects. • Develop proposals for new projects, using sources and partners identified in Appendix C. • Identify ways to obtain information using other (existing) research platforms.
Group 2 Relatively higher importance; Information partially known	▪ Continue existing projects that provide foundational or core data. ▪ Evaluate ways to improve timing/location/methods of existing projects to maximize value of project and improve chances for future funding. ▪ Identify ways to use existing research platforms to address other Information Needs.
Group 3 Relatively lower importance; Information largely unknown	• Prioritize support for any existing projects. ▪ Identify ways to obtain information using other (existing) research platforms. • Develop proposals for new studies that do not conflict or compete with Group 1 projects or foundation/core projects in Group 2.
Group 4 Relatively lower importance; Information partially known	▪ Evaluate ways to improve timing/location/methods of existing projects to maximize value of project and improve chances for future funding. ▪ "Retrofit" projects to use as research platforms to obtain high-priority, scarce Information. ▪ Discontinue projects that conflict with higher-priority needs and cannot be adapted. ▪ Do not begin new projects unless they are needed to support projects for Groups 1 through 3.

Goal 1 - Determine the ecosystem structure and function needed to maintain evolutionary and ecosystem processes (such as by implementing an LTER).

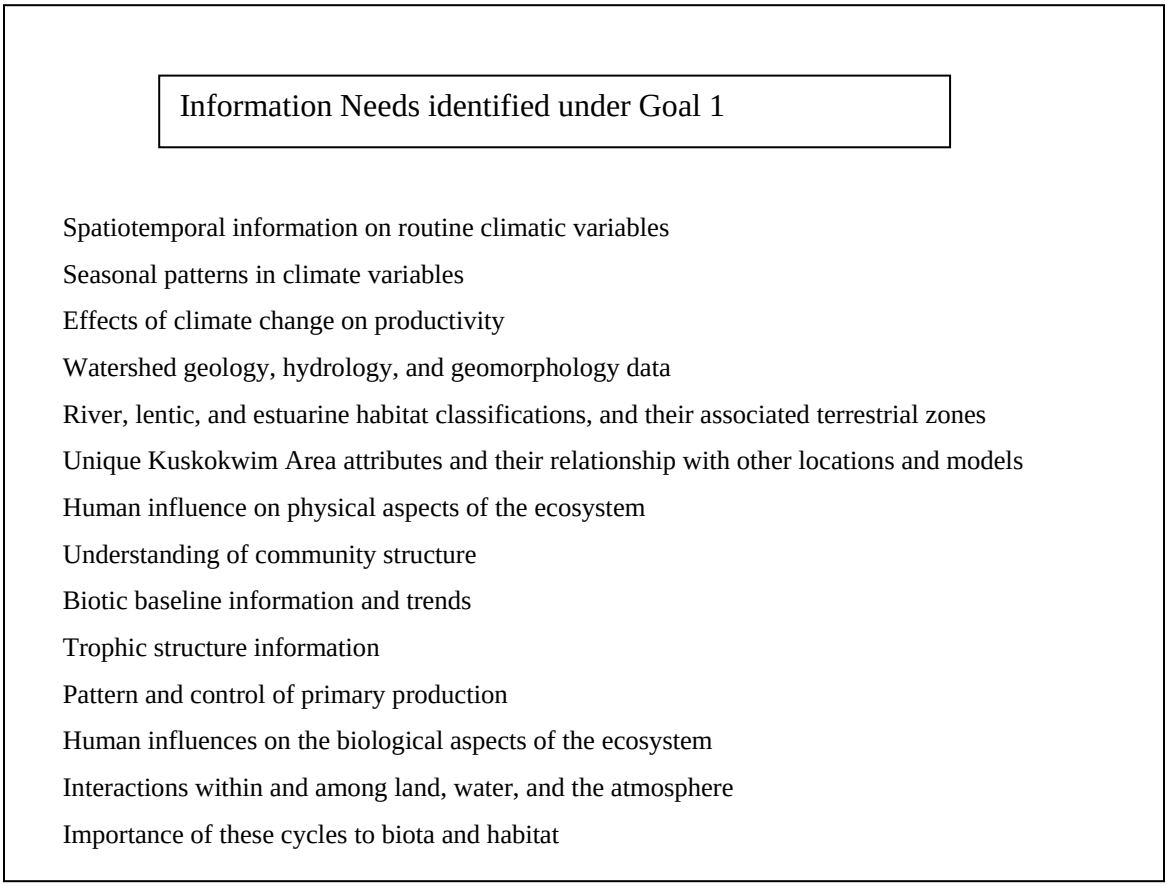

Figure 1. Information needs identified by the KFRC as important to address Goal 1: *Determine the ecosystem structure and function needed to maintain evolutionary and ecosystem processes*. Note: Goal 1 Information Needs were not ranked relative to one another.

Overview

The purpose of this goal is to acquire information on the patterns and processes that influence ecosystem structure and function and, by extension, salmon populations (KFRC 2004). Such patterns and processes would likely be described using holistic, ecosystem approaches. This Goal thus also includes information on physical and hydrological habitats needed for salmon conservation and management. Progress in the Kuskokwim Area towards Goal 1 has come both from projects that are dedicated towards specific Information Needs, and from secondary data collected by projects that target salmon population studies. More work needs to be done to collect information identified within

this goal, and to connect it in ways to improve understanding of the salmon's ecosystem. Because non-biological data are important to many aspects of this Goal, analysis of geological and climate records may be especially useful. This value is underscored by the frequent use of retrospective analysis as a research method.

One general source of information to date comes from retrospective analysis of paleolimnology conducted within the Togiak National Wildlife Refuge, whose northern portion lies within the Kuskokwim Area (Figure 5). These studies have provided a variety of basic information on glaciation, climate change, vegetation processes, and variation in production during various intervals in the last 33,000 years (Hu et al. 2001; Hu et al. 2002; Kaufman et al. 2003). Current work in the Togiak Refuge includes ongoing estimates of the nutrient budget in Arolik Lake, which lies within the Arolik River watershed that drains into Kuskokwim Bay (Project #ON-45; Table 1).

Other information comes from projects specifically intended to monitor environmental variables, such as weather stations and watershed monitoring. These projects are scattered among different areas, places, and organizations; data collected usually includes basic climate measurements at airports (NOAA 2005), water discharge (NWISWeb 2004; USFWS (Pat Walsh reference), and water quality (Wang 1999).

Environmental information is also generated by projects designed to assess salmon returns. Environmental data is a secondary concern for these projects, and is usually provided opportunistically. Variables measured typically include water temperature, water level, precipitation, and ice condition. The data provide useful basic information across a wide geographic range, but are relatively uncoordinated because site selection and sampling times are dictated by the needs of the salmon assessment projects.

A new project begun on the Kwethluk River in 2004 may also yield a variety of information identified under Goal 1. Known as the Biostation, the project will research ecosystem processes relating to alluvial floodplains and salmon (Stanford and Chaffin 2004). This approach essentially uses the Kwethluk River as a "keystream" model system to inform scientists about processes in other parts of the Kuskokwim Area.

One of the topic areas that needs more work is the assessment of current quantity, quality, and location of habitat available to salmon. More work needs to be done to determine how the existing information (described above) can be applied to this problem; where the information is insufficient to address habitat Information Needs, new projects should be developed.

In its planning approach document, the KFRC (2004) identified 14 Information Needs under Goal 1 (Figure 1). One result of the KFRC's emphasis on the holistic aspect of this entire Goal is that Information Needs are difficult to consider separately. The KFRC did not rank these Information Needs relative to one another, believing that (1) many of the Information Needs were highly interconnected, and (2) the group lacked the technical expertise to meaningfully rank the different ecosystem needs relative to one another.

This was the only Goal for which the component Information Needs were not ranked relative to one another.

Information Needs were grouped into 3 categories, termed Objectives. Because of the inter-relatedness described above, Information Needs are described in groups, based on the Objective they fall within. A description of progress within each Objective is described below. The summary of progress to date on each Information Need is in Table 1.

Goal 1 Objectives and Information Needs

Objective 1A: Describe climate, spatiotemporal climatic conditions, and the effects on the ecosystem.

Includes the following Information Needs (KFRC 2004):

Information Need #1.1: Spatiotemporal information on routine climatic variables,

Information Need #1.2: Seasonal patterns in climate variables, and

Information Need #1.3: Effects of climate change on productivity.

Summary of current situation

Most of the Kuskokwim Area projects that address Goal 1 apply to this group of three Information Needs. On the Togiak NWR, multiple water bodies are currently being monitored in a way that is designed to be coordinated with one another. This coordination is also being attempted on the Kwethluk River, where the Biostation project is attempting to gather data to increase knowledge of ecosystem processes elsewhere in the Kuskokwim Area. There have also been a number of recent studies on the Togiak NWR to describe past climate change and environmental variability (using sediment cores from water bodies; e.g., Hu et al. 2001). The USGS has conducted baseline monitoring of hydrology at various sites since 1950 (Table 6).

Few projects have been conducted to look at specific non-routine variables (e.g., erosion), and even fewer have examined ecosystem processes and pathways. One current project (FIS 04-351: Elders' TEK of 20th century ecosystems) may address some of these processes.

A final source of useful information is the opportunistic monitoring conducted in the course of salmon stock assessment projects (operated by various agencies and organizations).

Recent or current projects to support Objective

The most complete baseline environmental data are hydrological monitoring on rivers such as Brown's Creek, Crooked Creek, the Holitna River, the Kisaralik River, the Stony

River, the Tatalina River, Red Devil Creek, and on several parts of the mainstem Kuskokwim River. Current projects include:

- Real-time surface water data on Kuskokwim River at Crooked Creek (Project #ON-15) and at Lisky's Crossing (#ON-30) by the USGS,
- Environmental monitoring at salmon weirs on the Takotna (#ON-9), George (#ON-14), and Middle Fork Goodnews rivers (#ON-23) by the ADF&G/CF and USFWS (Kenai Fisheries Assistance Office),
- Elders' TEK of 20th century ecosystems in Kuskokwim Bay (#ON-24) by the Togiak NWR and the Bristol Bay Native Association,
- Weather data recorded by the Kwethluk Biostation (#ON-37) operated by the University of Montana,
- Stream gauging (measuring discharge and various quality parameters) of 20 sites on 18 rivers throughout Togiak Refuge (#ON-41),
- Water temperature monitoring of 21 rivers throughout Togiak Refuge (#ON-42),
- Monitoring of climatic variables at airports such as Bethel (#ON-43) by NOAA, and
- Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period (#ON-44), conducted by a partnership of Togiak NWR and several universities.

Major Information Gaps

- Status of water quality parameters in different stream types within the watershed – differences, similarities, and variability.
- Indices of production (primary or secondary) within the watershed.
- Climatic variables that exert strong influences on this production.
- Relationship between indices of ecosystem production (e.g., salmon abundance) to climatic conditions over the past 500 years.

What needs to be done

- Design and fund a study to evaluate and improve the connectivity and spatiotemporal coverage (and thus the value) of monitoring data being collected by existing projects. Several projects currently collect useful information, but their value would be improved by targeting specific information gaps (identified by the KASRP) while coordinating collections in time and space. Other projects underway in the region (including ones that do not target salmon) may be able to add an environmental monitoring component. Such coordination over time and place may help improve understanding of the effects of climate change in the Kuskokwim in a way that uncoordinated sampling may not.
- Identify the variables most useful for evaluating climate change and its effects on Kuskokwim Area watersheds (e.g., temperature, precipitation, water discharge, water quality, permafrost status).
- Conduct retrospective analysis in representative Kuskokwim Area systems to relate historic variation in production (e.g., salmon abundance) to climatic change.

Objective 1B: Describe the physical settings of watersheds.

Includes the following Information Needs (KFRC 2004):

Information Need 1.4: Watershed geology, hydrology, and geomorphology data,

Information Need 1.5: River, lentic, and estuarine habitat classifications, and their associated terrestrial zones,

Information Need 1.6: Unique Kuskokwim Area attributes and their relationship with other locations and models, and

Information Need 1.7: Human influence on physical aspects of the ecosystem.

Summary of current situation

The hydrological setting of the Kuskokwim Area rivers has been described somewhat by past studies of river discharge (NWISWeb 2004), water chemistry (Wang 1999), and groundwater (NWISWeb 2004). Habitat classifications have been conducted for wetlands on the Yukon Delta NWR and the Togiak NWR (project #ON-46). More information is needed on riparian and terrestrial habitat classifications, the effects of humans on water quality or physical aspects of the ecosystem (USFWS 1992), and which environmental attributes in the Kuskokwim Area can be modeled based on results from other regions.

There are several projects within this Goal that use specific sites as surrogates or models for other systems throughout the Kuskokwim Area. These include the Kwethluk River Biostation and retrospective analysis of lake cores in the Togiak National Wildlife Refuge. When providing data, these projects should also address the transferability of their results to other systems in the region.

Recent or current projects to support Objective

Projects that provide watershed, geology, hydrology, and geomorphology data:

- Real-time surface water data on Kuskokwim River at Crooked Creek (Project #ON-15) and at Lisky's Crossing (#ON-30) by the USGS,
- Environmental monitoring at salmon weirs on the Takotna (#ON-9), George (#ON-14), and Middle Fork Goodnews rivers (#ON-23) by the ADF&G/CF and USFWS (Kenai Fisheries Assistance Office),
- Elders' TEK of 20th century ecosystems in Kuskokwim Bay (#ON-24) by Togiak NWR and the Bristol Bay Native Association,
- Weather data recorded by the Kwethluk Biostation (#ON-37) operated by the University of Montana,
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- Water temperature monitoring of 21 rivers throughout Togiak Refuge (#ON-42);
- Monitoring of climatic variables at airports such as Bethel (#ON-43) by NOAA,
- Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period (#ON-44), conducted by a partnership of Togiak NWR and several universities, and

- Chemical constituents of Kuskokwim River (#97-05).

Habitat classifications:
- National Wetlands Inventory on the Yukon Delta NWR.
- Land cover map of the Togiak NWR (#ON-46).

Human influence on physical aspects of the ecosystem:
- Study of placer mining effects on the Togiak NWR (#90-03).

Major Information Gaps
- Water discharge data.
- Ice coverage in watershed – presence, extent, and timing.
- Non-wetland habitat classifications and the relative amount of habitat within each.
- Which aspects of the Kuskokwim watershed (e.g., permafrost, extended darkness in winter or daylight in summer) complicate assumptions derived from models developed more fully on other watersheds.
- Effects of human activity and resource development on water quality or processes such as erosion and sedimentation.

What needs to be done
- Develop classification systems that can be used as tools for helping to describe Kuskokwim watersheds. This would include exploring the transferability of classification systems developed in other places or ecosystems. Examples include:
    - Where are the high, medium, and low-quality stream habitats for chum, sockeye, coho, and Chinook salmon at critical life stages,
    - What are the terrestrial settings that are associated with these stream habitats,
    - What habitat classes are susceptible to degradation, and what are the primary sources of such degradation, and
    - How do unique attributes of the Kuskokwim River (e.g., presence of permafrost) affect the transfer of classification schemes that have been useful in other places?
- Use retrospective analysis (e.g., remote sensing conducted for project not related to fisheries) to help collect the data needed for classifications and physical descriptions.
- Determine the optimal scales (time and space) for monitoring stream discharges throughout the Kuskokwim Area.

Objective 1C: Describe biota and understand relationship between species and their habitat.

Includes the following Information Needs (KFRC 2004):

Information Need 1.8: Understanding of community structure,

Information Need 1.9: Biotic baseline information and trends,

Information Need 1.10: Trophic structure information,

Information Need 1.11: Pattern and control of primary production, and

Information Need 1.12: Human influences on the biological aspects of the ecosystem.

Summary of current situation

Most biotic baseline information is data on the return of spawning salmon, collected by salmon stock assessment projects (see Information Need 2.1 for a full description). Additional information is provided by several monitoring projects conducted by the Togiak National Wildlife Refuge, either alone or in partnership with other organizations (e.g., Projects # ON-41, ON-42).

Recent or current projects to support Objective

Projects that provide some data applicable to this Objective include:

- Weir projects that collect data allowing environmental conditions to be paired with salmon biological data (described in section 2.1 of Gap Analysis),
- Juvenile salmon recorded by Kwethluk River Biostation project (#ON-37), and
- Presence/absence of juvenile coho salmon conducted as an add-on project to the Takotna River weir (D. Molyneaux, ADF&G, personal communication).

Major Information Gaps

- Primary production – source, control, and amount.
- Community structure at any of several levels (e.g., plants, invertebrates, fish).
- Effects of human actions and resource development on aquatic fauna, either via acute exposure, displacement, or chronic sublethal effects.
- Baseline information on the characteristics and variability of habitat used by salmon and organisms important to salmon (e.g., predators, prey, competitors).

What needs to be done

- Conduct basic biotic research on primary productivity and community structure.
- Conduct research on how primary productivity has varied over time scales on the order of centuries.
- Extend this research to describe species distribution and communities for aquatic taxa, such as primary producers, invertebrates, and fish.
- Conduct retrospective analysis in representative Kuskokwim Area systems to relate historic variation in production (e.g., salmon abundance) to climatic change.
- Describe associations between habitats and species distributions and/or abundances.
- Identify the extent and pathways by which habitat and/or the environment affects species distributions.
- Determine the effect of water quantity and quality on fish during different life stages.

- Describe habitat characteristics and the variability of those characteristics for adult and juvenile salmon.
- Describe habitat characteristics and the variability of those characteristics for organisms important to salmon.

Objective 1D: Identify and describe biochemical, geochemical, and nutrient cycles within the ecosystem.

Includes the following Information Needs (KFRC 2004):

Information Need # 1.13: Interactions within and among land, water, and the atmosphere, and

Information Need # 1.14: Importance of these cycles to biota and habitat.

Summary of current situation

There are few current projects designed specifically to address any of the Information Needs within this Objective. Such information would include the study of interactions among the land, water, and atmosphere (e.g., nutrient flux, gas exchange), and the importance of these cycles to the biota. These topics can probably be addressed only through directed projects, not by indirect data collected in the course of other projects (i.e., salmon weirs).

Recent or current projects to support Objective

- Sampling of precipitation, surface water, and sediment to understand the isotopic and nutrient budgets of Arolik Lake (Project # ON-45), conducted by the Togiak NWR and several university research partners.

Major Information Gaps

- Biogeochemical cycling in watershed.

What needs to be done

- Describe biogeochemical pathways and cycles in the Kuskokwim watershed.
- Identify the effects and importance of biogeochemical cycles on the aquatic habitat and biota.

Goal 2 - Determine salmon life history, genetics, and productivity in relation to their place in the ecosystem.

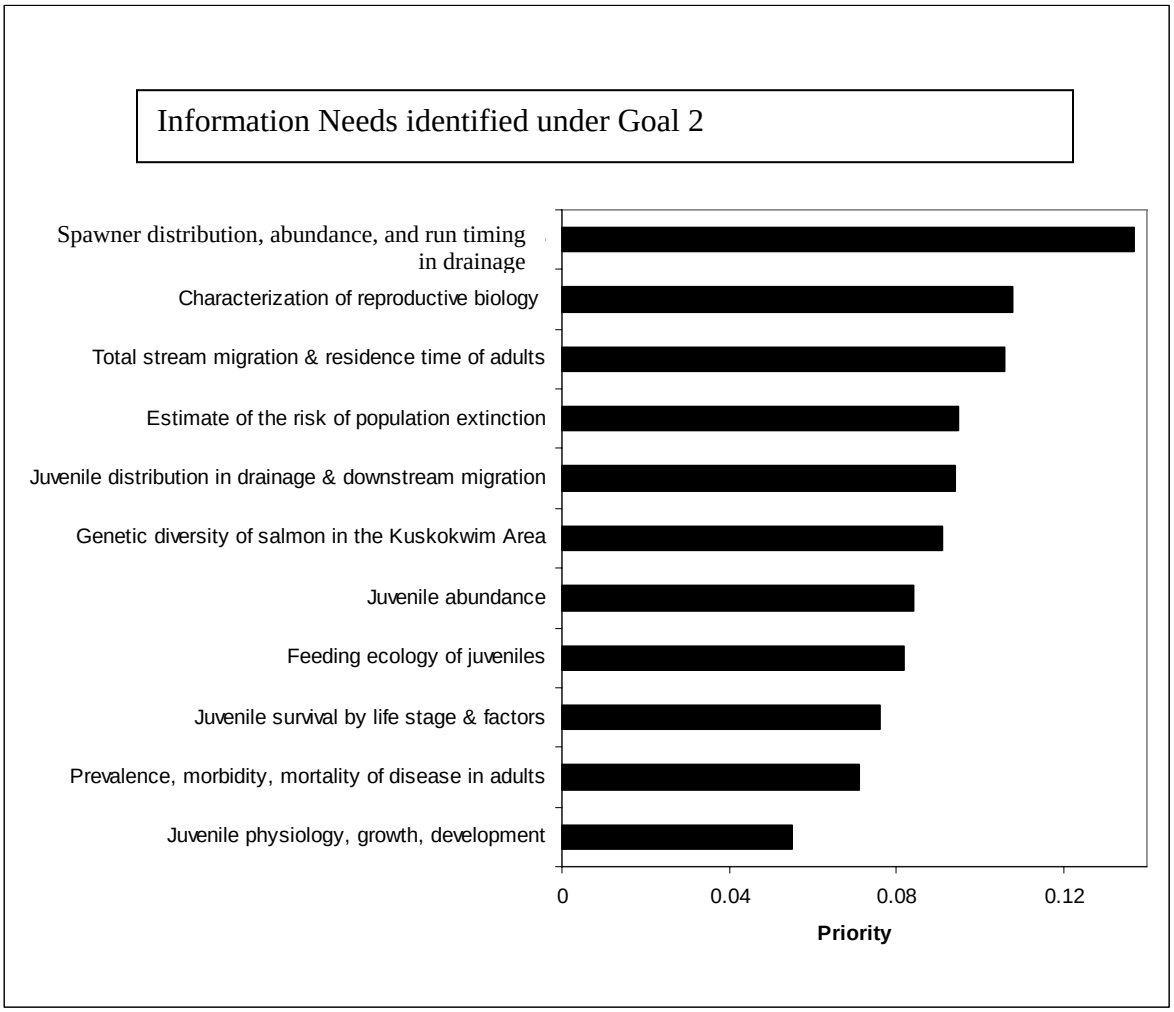

Figure 2. Information needs identified by the KFRC as important to address Goal 2: *Determine salmon life history, genetics and productivity in relation to their place in the ecosystem.* Note: The KFRC assigned a relative importance to each Information Need (x-axis), without considering the degree to which the information is already known.

Overview

This purpose of this goal was to develop a better understanding both of the basic biology/ecology of salmon and of the interaction between salmon and the larger ecosystem. Most knowledge to date of Kuskokwim salmon has come from adult assessment projects designed to manage harvests and escapements. Many basic aspects

of salmon biology are known for populations outside the region, but the degree to which these apply to Kuskokwim Area salmon has not typically been investigated. As a result, many aspects of the basic ecology of Kuskokwim salmon (e.g., feeding ecology, thermal tolerances, early life history) are unknown.

Of the projects currently underway in the Kuskokwim Area (Table 6), at least 24 appear to address Goal 2 in some way (Table 7). Fifteen of these target adult salmon enumeration (abundance or indexing), four target salmon genetics, and three investigate juvenile salmon (chum, coho, and/or Chinook). The remaining projects are assessment of contaminants and disease in salmon and an assessment of traditional ecological knowledge (TEK) of salmon population changes.

Overall, the most abundant data are those that are conducted in the course of enumeration projects, especially adult salmon distribution, run timing, and age-sex-length (ASL). Other topics that have been addressed recently are salmon disease and contaminants and salmon genetic diversity, but this information must be expanded to other species and/or in additional detail. Many highly-rated Information Needs in Goal 2, however, have barely been addressed: these include the characterization of salmon reproductive biology, the estimation of the risk of population extinction, and the distribution, survival, and abundance of juvenile salmon. Project currently underway for other reasons could serve as research platforms for pilot studies that address many of these Information Needs, but would require increased funding to enable data collection.

In their planning approach document (KFRC 2004), the KFRC ranked the eleven Information Needs identified under Goal 2 (Figure 2). Progress to date is described below, and summarized in Table 2.

Goal 2 Objectives and Information Needs

Objective 2A: Characterize adult salmon ecology and biology by stock

Information Need # 2.1: Distribution, abundance, and run timing of spawning adults in the drainage.

Summary of current situation

As noted above, many current and past projects were designed to address this Information Need (Table 2 and 7). This abundance of projects is due in part to the high importance of this information to salmon management, and to the ability to have the information generated via many different kinds of projects. If designed effectively (location, species, coordination), these projects can address multiple Information Needs or provide foundational data for future comparisons and retrospective analysis.

Current projects that address this need are comprised mainly of escapement projects on tributaries (e.g. weirs or towers) and tagging studies of salmon in the mainstem river.

These projects are often coordinated, and either benefit from one another or are entirely reliant on data from each other. Salmon marking studies to estimate population abundance in the mainstem Kuskokwim River, for example, rely on recaptures at the tributary weirs to generate abundance estimates. As in most of the Kuskokwim Area, these projects usually do not have stable long-term funding.

Recent or current projects to support Information Need

Most information comes from stock assessment projects designed to estimate or index salmon abundance, as listed below. More detailed descriptions are found in (Ward et al. 2003).

- Projects in the Kuskokwim River:
    - Chinook salmon population estimates and run timing in the mainstem Kuskokwim River (#ON-29),
    - Chum, coho, and sockeye salmon populations estimates and run timing in the mainstem Kuskokwim River (#ON-20),
    - Chinook, chum, and coho salmon population estimates in the Holitna River drainage (#ON-19), and
    - Indexing of Chinook, chum, coho, and sockeye salmon run strength in the mainstem Kuskokwim River near Bethel (#ON-28).
- Aniak River sonar:
    - Indices of chum salmon abundance (#ON-05).
- Tributary-specific run timing and abundance of adult salmon spawners:
    - George River (#ON-14),
    - Kanektok River (#ON-06),
    - Kogruluk River (#ON-07),
    - Kwethluk River (#ON-16),
    - Middle Fork Goodnews River (#ON-08),
    - Takotna River (#ON-09),
    - Tatlawiksuk River (#ON-21), and
    - Tuluksak River (#ON-17).

Major information gaps (no prioritization implied – species listed in alphabetical order)

- Distribution.
    - Chinook salmon distribution:
        - Throughout drainage (especially upstream of McGrath),
        - Mainstem river vs. tributaries, and
        - Location of spawning grounds.
    - Fall chum salmon distribution:
        - Throughout drainage (especially upstream of McGrath), and
        - Location of spawning grounds.
    - Summer chum salmon distribution:
        - Throughout drainage (especially upstream of McGrath), and
        - Location of spawning grounds.
    - Coho salmon distribution
        - Throughout drainage (especially upstream of McGrath), and
        - Of late-returning run components.

    - Pink salmon:
        - In lower reaches of tributaries downstream of weir sites, and
        - Location of spawning grounds.
    - Sockeye salmon:
        - Location of spawning grounds.
- Abundance.
    - Total abundance of each species.
    - Indices of abundance for fall chum and sockeye salmon.
    - Proportional abundance of each species among different tributaries and/or mainstem reaches.
    - Abundance of Chinook, chum, and coho salmon upstream of McGrath
    - Relative abundance in tributaries not currently monitored (i.e., what proportion of the total Kuskokwim salmon run returns to these tributaries?).
    - Amount of bias in pink salmon abundance estimates due to gear selectivity at counting weirs.
- Run timing.
    - Run timing of Chinook, chum, and coho salmon in drainage upstream of McGrath.
    - Fall chum salmon.
    - Late-returning coho salmon.
    - Stock-specific run timing through primary harvest area for all salmon species.

What needs to be done

- Determine total salmon abundance of each species over last several decades (Requires scalar data set and time series that indexes annual abundance).
- Examine feasibility of using expansion factors to estimate salmon abundance.
- Conduct a rigorous review of the best suite of methods and locations needed to address Information Needs throughout the Kuskokwim Area. Are current approaches capable of addressing the remaining information gaps?
- Estimate the extent of salmon distribution (juvenile and adult) in Kuskokwim Area tributaries, and identify high-productivity habitats (such as by using habitat classifications, modeling, or radio telemetry).

Information Need # 2.2: Stream migration and total residence time of adults.

Summary of current situation

There is enough existing information to make limited estimates of residence time and stream migration rates of Kuskokwim River salmon. These estimates can be made by comparing passage through downriver (e.g., Bethel Test Fishery) and upriver sites (e.g., weirs), or by using radio telemetry (e.g., projects ON-19 and ON-20). However, there is not yet enough information to definitively estimate total residence time or migration rate for any species for the entirety of their Kuskokwim River spawning return. There is also no information available for rivers that empty directly into Kuskokwim Bay.

Recent or current projects to support Information Need
Projects that provide relevant information (Tables 2 and 7) are:

- Adult monitoring projects (multiple species).
    - Weir projects (e.g., #ON-6).
    - Aerial surveys (#ON-3, ON-4).
    - Aniak Sonar (#ON-5).
    - Bethel test fishery (#ON-28).
- Mark-recapture or radio telemetry projects.
    - Holitna River (Chinook and chum: #ON-19).
    - Kuskokwim River mainstem (chum, sockeye, coho: #ON-20).

Major information gaps

- Residence time and migration rates of all salmon from entry into the Kuskokwim River to the Bethel test fishery or the Kalskag fishwheel (project #ON-20) site.
- Residence time and migration rates of Chinook and pink salmon upstream of Kalskag fishwheel site.
- Residence time and migration rates of all salmon in other Area rivers besides the Kuskokwim.

What needs to be done

- Maximize the species and sample size covered by radio telemetry in the mainstem Kuskokwim River (#ON-20).
- Maximize temporal and spatial coverage within the Kuskokwim. For example, current estimates from project #ON-20 only estimate migration rate and residence time upstream of Kalskag, while existing weir projects only provide estimates up to the weir, and not necessarily until death.
- Improve estimates on the other rivers draining into Kuskokwim Bay by pairing existing upriver enumeration projects (e.g., weirs) with new downriver projects to mark salmon.
- Pursue methods that would pair genetic identification of salmon in Kuskokwim Bay with upstream enumeration projects.

Information Need # 2.3: Characterization of reproductive biology.

Summary of current situation
There are no projects underway that are designed to directly address some portion of salmon reproductive biology, nor do there appear to have been any in the past.

Recent or current projects to support Information Need
Some attempt has been made to estimate Chinook salmon potential egg deposition on the Kwethluk and Tuluksak rivers. Using associations between fecundity and egg deposition on the Salcha River (in the Yukon River drainage), Harper and Watry (unpublished data) estimated potential egg deposition on the Kwethluk rivers in 1992 and 2003 (Harper and Watry 2001). There are no other projects relevant to this Information Need.

Major information gaps

- All salmon.
    - Fecundity.
    - Potential egg deposition.
    - Embryo development.
    - Contributions of age and size subgroups to reproductive success of the run.

What needs to be done

- Evaluate fecundity and potential egg production of Kuskokwim Area salmon runs.
- Use retrospective analysis to determine whether potential egg production has changed over time.

Information Need # 2.4: Prevalence, morbidity, and mortality of disease in adults

Summary of current situation

The disease *Icthyophonous* has been detected in Kuskokwim Area Chinook salmon, but samples are limited (on 20 samples evaluated, and only in 2001). *Icthyophonous* has not been identified as a major problem in the Kuskokwim River yet, but its presence is troubling given the extent of the disease in Yukon River Chinook, its association with rising water temperatures, and the potential for water temperature increases in the Kuskokwim Area.

Heavy metals and persistent organic pollutants (DDT and PCBs) in Kuskokwim Area chum have been evaluated to assess the threat to human consumers and to the salmon themselves (Matz and Mueller 2004; ADEC 2004). Preliminary findings are that contaminant levels are relatively low and thus do not pose a consumption risk to humans (Matz and Mueller 2004; ADEC 2004), and that indicators of fish health (reproductive hormones, enzyme levels, vitamins, tissue lesions, and sex chromosomes) are not abnormal (Matz and Mueller 2004).

Recent or current projects to support Information Need

- 18 chum from Kuskokwim Bay, the Yukon River, and Bristol Bay were evaluated for metal and POPs contaminants in 2002. More samples were collected in 2003 and 2004, but have not yet been analyzed (B. Gerlach, ADEC, personal communication).
- Chum salmon were collected from the Kuskokwim River near Bethel in 2001 and evaluated for heavy metals and POP contaminants (Matz and Mueller 2004; ON-36).
- 20 Chinook salmon were sampled from the Kuskokwim River in 2001 to assess presence of *Icthyophonous.*

Major information gaps

- *Icthyophonous* presence and extent.
    - Extent in Chinook salmon.
    - Presence in any other salmon.

    - Associations between prevalence and location/timing of salmon.
- Contaminants.
    - Presence, type, and extent in species besides chum.

What needs to be done

- Test for *Icthyophonous* again in the near future to begin establishing a baseline that would detect future changes in infection rates.
    - Include species that are known to be infected with *Icthyophonous* on other rivers, such as the Taku and Yukon Rivers.
    - Test in a way that assess potential correlation between the disease and either extent of fish movement upriver or with increased water temperature.
- Repeat the contaminants study on a species of salmon with an extended freshwater residence time (sockeye, coho, or Chinook salmon); if possible, pair these with samples of cohort year pink or chum sample to 1) help determine whether Kuskokwim Area salmon are picking up contaminants in either fresh or marine waters, and 2) replicate the previous chum studies in time.

Objective 2B: Characterize juvenile salmon ecology and biology

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Information Need # 2.5: Juvenile distribution in drainage and downstream migration.

Summary of current situation

The only information on juvenile distribution and migration in the Kuskokwim Area comes from peripheral data gathered from juvenile projects conducted for other reasons, or that which can be inferred from studies of adult spawner distribution.

Recent or current projects to support Information Need

Juvenile distribution data comes from four current studies designed primarily to address other topics or life stages. These projects are:

- Project # ON-01, which examines juvenile chum biology in the Kuskokwim River and provides some information on chum presence/absence and downstream timing.
- Project # ON-02, which evaluates run timing and habitat use of juvenile chum in Kuskokwim Bay.
- Minnow trapping of juvenile Chinook and coho salmon as an addition to adult assessments at the Takotna River weir (# ON-09).
- Presence/absence information from juvenile salmon sampling conducted as part of a Chinook salmon sex ratio study (# ON-35).

Major information gaps

- Chinook, coho, and sockeye salmon distribution.
    - Total potential rearing habitat.
    - Seasonal habitat use, including overwintering.
    - Habitat use by age class.

- Chum and pink salmon distribution.
    - Are juveniles distributed beyond the range of parent spawners?
- Downstream migration of all salmon.
    - Timing and behavior.
    - Importance of environmental and genetic influences.

What needs to be done

- Conduct dedicated projects to estimate distribution of each salmon species in Kuskokwim Area watersheds.
    - Use indirect information from existing projects to assist with the design and setup.
    - Use habitat modeling and classification systems (including from outside the Kuskokwim Area) to minimize the amount of time and expense spent on field sampling.
- Conduct field sampling to build run time curves for downstream migration of juvenile salmon. Choose systems with multiple species for maximum benefit, and extend sampling over time to capture discrete run time groups (populations).

Information Need # 2.6: Feeding ecology of juveniles.

Summary of current situation

There is preliminary information on the feeding ecology of juvenile chum salmon in Kuskokwim Bay, but not for any other species or locations.

Recent or current projects to support Information Need

- Project #ON-02 evaluates the feeding ecology of juvenile chum salmon in Kuskokwim Bay.

Major information gaps

- Feeding ecology in freshwater (all salmon species).
- Feeding ecology in nearshore / estuarine habitats (all species except chum).

What needs to be done

- Describe diet of juvenile salmon in the Kuskokwim Area in a way that will provide information to managers regarding the times, habitats, and diet components that are critical to juvenile survival. These include:
    - Chum and pink salmon.
        - Onset of feeding, diet component in freshwater.
        - Diet components in estuary or marine water.
    - Coho, Chinook, and sockeye salmon.
        - Chief dietary component by life stage (age-0, -1, -2, etc).
        - Habitats that are important sources of these dietary components.
- Evaluate degree of dietary specialization in salmon by species and life stage – are these salmon generalist feeders, or do they rely on certain prey at specific times in their lives?

- Identify existing projects that can be used as platforms for generating initial diet descriptions.

Information Need #2.7: Juvenile survival by life stage and factors that influence it.

Summary of current situation
There is no existing information on the survival rates or influences of juvenile salmon in the Kuskokwim Area.

Recent or current projects to support Information Need
None.

Major information gaps
- Mortality rates and sources.
    - Freshwater, inseason - all salmon.
    - Freshwater, overwinter - coho, sockeye, Chinook salmon.
    - Marine, interannual – all salmon.

What needs to be done
- Generate preliminary models of juvenile survival in freshwater by combining information from other projects, such as:
    - Combining juvenile abundance data (new project – see Information Need # 2.8, below) with parental abundance data.
- Initiate survival studies in a way that will allow estimates of both marine and freshwater mortality.

Information Need # 2.8: Juvenile abundance.

Summary of current situation
Abundance of juvenile salmon in the Kuskokwim Area is unknown.

Recent or current projects to support Information Need
There are no projects that estimate or index juvenile salmon abundance.

Major information gaps
- Abundance of any/all juvenile salmon populations or species.

What needs to be done
- Develop a field project that can estimate or index juvenile salmon abundance.
    - Design the project to include information of distribution and run timing (as described above).
- Evaluate the potential for using models of juvenile abundance based on habitat classifications, adult returns, and salmon life history models. Develop these abundance models in places that allow future ground-truthing via field projects.

Information Need # 2.9: Juvenile salmon physiology, growth, and development.

Summary of current situation
Data have been collected for chum, but not for any other salmon in the Kuskokwim Area.

Recent or current projects to support Information Need
- Project ON-01 is evaluating juvenile chum physiology and development in the lower Kuskokwim River.
- Project ON-02 is studying juvenile chum energetics in Kuskokwim Bay.

Major information gaps
- Growth, development, and physiology of all species besides chum.

What needs to be done
- Include assessments of physiology and growth in any new projects that entail capture of juvenile salmon.

Objective 2C: Characterize biology through population genetics

Information Need # 2.10: Genetic diversity of salmon in the Kuskokwim Area.

Summary of current situation
There is some existing information (based on allozymes) of genetic diversity of Kuskokwim Area chum, Chinook, and coho salmon (Projects 95-06, 96-01, ON-22). More work will be needed before diversity data are sufficient for many inseason management needs, to determine population structure, or to model population viability. Baseline information on pink and sockeye salmon diversity still needs to be collected.

Recent or current projects to support Information Need
Current studies that provide information on the genetic diversity of Kuskokwim Area salmon include:
- Estimates of genetic variation of coho salmon in the Kuskokwim River (ON-22),
- A comparison of fall and summer chum genetics (ON-34), and
- Estimates of effective population size of Chinook salmon on the Kwethluk and Tuluksak rivers (ON-31).

In addition, genetic information is also being collected via samples collected using non-genetic projects as research platforms. These include:
- Kwethluk River weir (#ON-16),
- Bethel test fishery (#ON-28), and
- Chum/sockeye/coho mark-recapture project near Kalskag (#ON-20).

Important past projects include:
- Baseline studies of Chinook and chum genetics, using allozymes (Project #95-06; #96-01), and

- Estimates of sex ratios of immature Kuskokwim Area chum in the False Pass marine fishery.

Major information gaps

- Genetic diversity of pink, sockeye, coho, and fall chum salmon.

What needs to be done

- Support and maintain existing projects that develop genetic baselines.
- Identify existing projects that can be used as research platforms to expand genetic diversity databases.

Information Need # 2.11: Estimate of the risk of population extinction.

Summary of current situation

Little or no progress has been made towards addressing this Information Need.

Recent or current projects to support Information Need

- In 2004, project #ON-31 was begun to estimate effective population size of Chinook salmon on the Kwethluk and Tuluksak rivers (Chinook: KFRC ON-31). The project will attempt to generate retrospective estimates back to the 1990s by using archived scales (K. Harper, USFWS, personal communication).

Major information gaps

- Estimates of extinction risk for any salmon population in the Kuskokwim Area.

What needs to be done

- Support project #ON-31 until completion and evaluate the transferability of results to other tributaries.
- Use existing genetic or stock assessment projects as research platforms to expand estimates to other species and populations.

Goal 3 - Management of salmon stocks for long-term sustained yield with an emphasis on subsistence priority

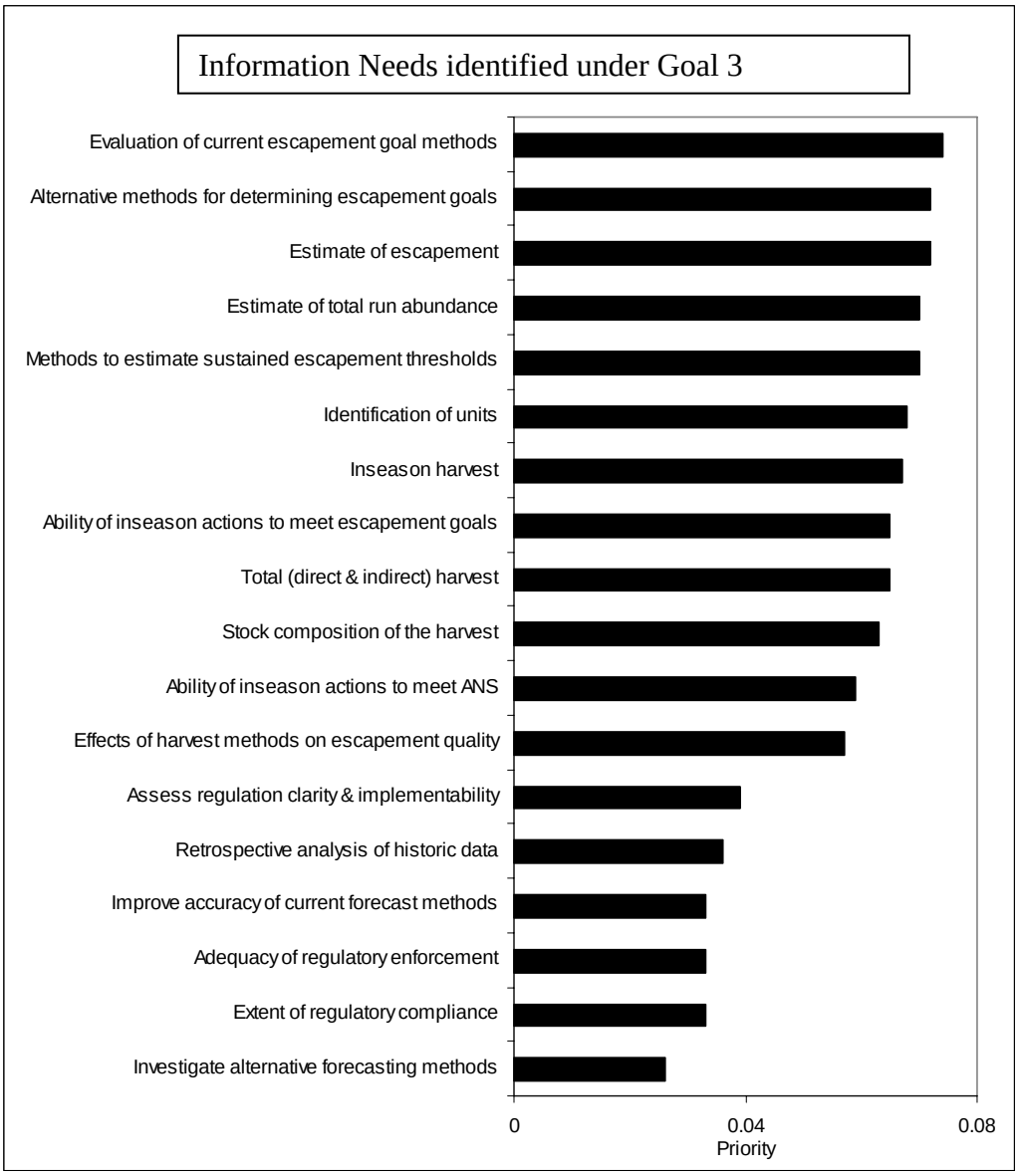

Figure 3. Information needs identified by the KFRC as important to address Goal 3: *Manage salmon stocks for long term sustained yield with emphasis on subsistence priority*. Note: The KFRC assigned a relative importance to each Information Need (x-axis), without considering the degree to which the information was already known.

Overview

Kuskokwim Region salmon stocks have been difficult to manage because numerous mixed stock assemblages among different salmon species overlap in run timing. This is further complicated by the large size, remoteness, and geographic diversity of the region. The region's salmon fisheries are distinguished geographically as those associated with smaller coastal rivers entering Kuskokwim Bay and fisheries occurring in the Kuskokwim River.

Although the Kuskokwim River is the second largest in Alaska and supports one of the largest subsistence fisheries in the state, research and management tools have been limited to commercial catch data, inseason test fisheries and aerial survey monitoring of escapement. Ideally, fishery managers have preseason knowledge of salmon run abundance and can accurately assess stock specific run strength. From that knowledge, they identify whether there is a harvestable surplus (after meeting spawning abundance requirements), then provide for the priority use of subsistence fishers throughout the drainage, and then allow any remaining surplus to be allocated to other fishers (sport, commercial, and personal use). The gauntlet nature of this fishery, the need to spread harvest opportunity over much of the river, and the potential for differential exploitation (especially between upper and lower river stocks) increase the challenge of managing the fisheries for all users.

Currently, fishery managers do not forecast run abundance, monitor actual abundance in season, or have sufficient knowledge of run timing differences among stocks to evaluate the need to selectively target or protect individual stocks. Decisions to open and close fisheries are based on catch per unit effort (CPUE) trends from a gillnet test fishery operated near Bethel, CPUE and catch monitoring from commercial and subsistence fisheries, and select tributary escapement counts. Escapement requirements are set according to the state's Policy for Statewide Salmon Escapement Goals (5 AAC 39.223). In 2001, the Alaska Board of Fisheries (Board) set escapement goals for 22 stocks of salmon in the Kuskokwim Area: twelve for Chinook salmon, four for (fall) chum salmon, and three for both coho and sockeye salmon (ADF&G 2004). All of these escapement goals are spawning escapement goals (SEGs), and are generally the average escapement observed for each system in the past. Traditional spawner-recruit analyses are not possible for individual tributaries because harvest by stock is unknown.

Drainage-wide abundance and stock specific migratory timing would help to meet the challenge of sustainable management of salmon fisheries in the Kuskokwim Area. Abundance estimates are needed pre-season, in-season, and as representative of actual spawning abundance (i.e. total abundance minus total harvest equals spawning escapement). Drainage-wide abundance, when coupled with a drainage wide escapement goal, would allow managers to identify a harvestable surplus. Stock-specific migratory timing information would help managers evaluate stock timing differences and determine if stocks may be differentially harvested through time. Harvest strategies must be

evaluated and exploitation rates calculated. A goal of sustainable management must also include escapement counts with adequate distribution throughout the drainage.

Much of the current salmon research and monitoring effort is devoted to projects that address salmon abundance and run timing on tributaries that are thought to represent important contributions to the total abundance of salmon returning to the Kuskokwim Area (Table 6). In many respects, these projects provide the foundational data needed for both current management, and for future improvements that could someday yield estimates of total run abundance in the Kuskokwim Area. These projects can also be considered "core" projects, in that they form an aggregate that yields more information than could be obtained from one project alone. The placement of weirs in multiple parts of the drainage, for example, allows them to serve as tag recovery stations that permits estimates of migration rates and tributary-specific indices of abundance in the drainage. Some projects also increasingly serve as research platforms for other information.

Weirs are currently operated on six major tributaries of the Kuskokwim River and a sonar-counting project is operated on a seventh. Weirs have also been installed to monitor escapements into the major salmon producing systems of Kuskokwim Bay, the Goodnews River and Kanektok River (Figure 5) The majority of these projects were initiated in the 1990's or early 2000's with special appropriations intended to address stock declines. A weir on the Kogrukluk River indexes the Holitna River stock, and has annual escapement data dating back to 1976. The Goodnews River weir has monitored escapements into the Middle Fork, a major tributary of this river, since 1986. Locations for weirs were established based on consideration of known spawning patterns derived from past aerial surveys and local knowledge of fish movements. An attempt was made to place weirs strategically throughout the watershed so that major hydrographic areas were represented. However, independent evaluations of the reliability of weirs in their current locations for providing an accurate index of the timing and magnitude of escapement have only been undertaken for Holitna River Chinook, chum and coho stocks (Project #ON-19.) Weirs operated to monitor salmon escapement have also provided valuable research platforms for recovery of tags, collecting biological samples for genetic stock assessment and population structure as well as monitoring environmental parameters in the watershed.

Monitoring salmon in large, complex systems includes obtaining reliable timing and distribution of spawning stocks. In highly turbid river systems like the Kuskokwim River, this is often best accomplished with remote sensing techniques such as sonar or tagging. Radio telemetry studies have been conducted for Chinook salmon since 2000 (Projects #ON-19, #ON-29) and have provided detailed timing and distribution data for parts of the Kuskokwim River drainage. This information has been used to address some of the information requested in both Goal 2 and 3, including the evaluation of the adequacy of escapement monitoring, measurement of run timing and migration rates, and development of abundance estimates of stocks and stock groups. In addition, a radio telemetry pilot study was initiated in 2005 to document the distribution and timing of Kuskokwim River sockeye salmon stocks. Similar information has been collected for chum, sockeye and coho salmon stocks from a mark-recapture study conducted since

2003 (#ON-20). Finally, progress has been made towards the development of genetic baselines and stock markers for chum, Chinook and coho via projects ongoing since the mid 1990's. These projects have collectively advanced the knowledge of the abundance, timing, and distribution of salmon stocks returning to their spawning areas.

This information helps Kuskokwim Area salmon managers to implement and make adjustments to the harvest management plans developed based on post-season assessment of the data. The development of these management plans is an incremental process. Time series data (escapements, harvests, stock composition, age and sex structure) are needed to assess the productivity and carrying capacity of salmon populations and are foundational to meaningful assessment of environmental factors that may influence and account for variability of salmon production. Shotwell (2004) provided an analysis and useful solution to the problem facing Kuskokwim fisheries managers in her run reconstruction analysis and development of a basic spawner recruit model for Kuskokwim and Yukon River chum stocks based on limited data. This model provided reasonable forecasts of returns, and accounted for major component of the residual variation based on Principle Component Analysis of thirty environmental factors. Further development and application of this work is planned for other salmon species.

The Kuskokwim Area management process includes weekly meetings during the fishing season of the Kuskokwim Fisheries Management Working Group, which meets to discuss and recommend fisheries openings and conservation actions. Inseason monitoring projects provide important information for this meeting, and are another part of the management process. Outside of the season, the management process includes the meetings and evaluations conducted by the Alaska Board of Fisheries, which meets every three years to set escapement goals and evaluate regulations and management. During the group discussion by the KFRC (2004), an assessment of current management methods themselves was also identified as a desirable component of several Information Needs within this goal.

The current structure of the management system provides several opportunities for assessments of the management system recommended by the KFRC in their planning approach document (KFRC 2004). The Working Group, for example, is an inseason management process in which people from throughout the area meet regularly throughout the season to assess the effects of management actions on the fishery, issue recommendations, and then regroup later to re-evaluate these recommendations. The Board of Fish cycle and the Federal Subsistence Board incorporate numerous reviews of data, escapement goals, and the processes used to collect the data and issue the recommendations (Molyneaux 2004). Although all of these are actions designed to manage the fishery, they also end up providing assessments of the management system in the process.

In their planning approach document, the KFRC (2004) ranked 18 Information Needs under Goal 3 (Figure 3). Many of these are addressed to at least some degree by current projects related to escapement enumeration, harvest assessment and monitoring, or ASL data collection. Still other Information Needs are addressed to some degree by the

reviews and evaluations that occur in the course of the management processes described above. The KFRC also, however, identified a need for fishery management evaluations conducted outside of the normal management process (KFRC 2004). Such evaluations would include studies or white papers commissioned to review alternatives to or effects of current management practices; to date, these evaluations are rare.

When the KFRC rated the relative importance of the different Information Needs within Goal 3, the most apparent break came between the top 12 and the bottom 6 (Figure 3). These top 12 are all addressed to at least some degree by the current management process or by specific projects. Progress to date is described below, and summarized in Table 3.

Goal 3 Objectives and Information Needs

Objective 3A**:** Review escapement goals and the methods used to determine those goals

Information Need # 3.1: Evaluation of current escapement goal methods.

Summary of current situation

Escapement goals are ranges that have historically been developed within the ADFG, then reviewed by the Alaska Board of Fisheries (Board). Escapement goal ranges and methods were reviewed by the Board during its last cycle (2001), after being proposed by inter-organizational review teams. ADF&G must review escapement goals with the Board, but does not have to take action unless it affects allocation. The Board's review process is open to public comment.

The Sustainable Salmon Policy (5 AAC 39.222) defines three types of escapement goals, each of which entail different levels of information. In descending order of required information (ADF&G 2004), these are:

- Biological escapement goals (BEGs). BEGs are expressed as a range, are scientifically defensible, and are intended to provide the greatest potential for maximum sustained yield.
- Sustained Escapement Goals (SEGs). SEGs are a level of escapement known to provide for a sustained yield over 5 or 10 years, as indicated by estimates or indices of abundance. SEGs are used in situations in which BEGs cannot be estimated due to data limitations.
- Sustained Escapement Thresholds (SETs). SETs are those levels of escapement below which the sustainability of the salmon run is in jeopardy. An SET is based on the lower ranges of historic escapements from which the salmon run has historically rebounded.

Information essential for escapement goals comes from harvest data, age data, and salmon assessment projects (i.e., weirs, count towers, and other adult salmon enumeration projects).

In 2001, the Board approved 22 SEGs, no BEGs, and no SETs for the Kuskokwim Area (ADF&G 2004).

Recent or current projects to support Information Need

Two recent initiatives have been conducted that were designed specifically to evaluate escapement goal methodologies outside of the Board of Fish process:

- The "Inter-Divisional Escapement Goal Review Team", comprised of ADF&G regional research biologists, biometricians, and fishery scientists (ADF&G 2004; this Team completed its final meeting in April 2005, with final results pending), and
- "AYK Escapement Working Group" Regional Tribal Organizations meeting with ADFG to discuss data sharing, alternative approaches to setting escapement models, and alternative management systems (e.g. OSY verses MSY, or harvest rate versus escapement-based management strategies).

Major information gaps

- Reviews of current escapement goals.
- Data needed to establish BEGs.

What needs to be done

- Continue foundational projects that provide feedback and evaluation to the escapement goals.
- Support directed efforts, such as those described above, to evaluate escapement goal calculation or methods. Conduct such efforts in a way that will maximize regional support.
- Fund review and synthesis of escapement goal setting methods, data requirements, limitations and applications for salmon stocks in northern regions.
- Develop Continuing Education Course on selection and application of production and carrying capacity models for sustaining and managing salmon stocks in Alaska.

Information Need # 3.2: Investigation of alternative methods for determining escapement goals

Summary of current situation

Escapement goals for Kuskokwim Area salmon are all SEGs, which are based on long-term averages of salmon return to tributaries. One goal of the ADF&G is to begin replacing SEGs with BEGs, which require more rigorous data, including information on spawner-recruit relationships.

Prior to the last Board meeting, there were few investigations into alternative methods for estimating escapement goals (alternative as to those defined by the Sustainable Salmon Policy and listed in 3.1, above). Since 2001, however, there has been some interest in alternatives in different parts of the AYK region, such as using a habitat-based approach to estimating adult salmon carrying capacity. In the Kuskokwim Area, the only such

project conducted so far has been by O'Brien and Margraff (2005), who estimated chum salmon spawning potential to derive a chum spawning abundance estimates.

Recent or current projects to support Information Need

- A joint USFWS/UAF project (Project #ON-33) was recently conducted to develop a habitat-based escapement goal for chum salmon on the Tuluksak River. The project quantified useable spawning area to estimate the number of spawners needed to fully seed the spawning habitat (O'Brien and Margraff, 2005). This work may provide useful estimates of the unexploited production potential of a spawning stock. This type of information can also be incorporated in conventional spawner recruit production and carrying capacity models, especially for stocks where intensive management limits contrast in the data.
- Dissertation by Shotwell (2004), which shows how models can be used to evaluate escapement goals.
- ADFG workshops proposed to provide information and training on implementing the State's Escapement Goal and Sustainable Salmon Policies (R. Cannon, USFWS, personal communication).
- Assessment of habitat-based production models for Kuskokwim Area stocks (AYK Escapement Goal Review Team).

Major information gaps

- Assessment of the applicability of different methods being used outside of the western Alaska.
- Assessment of the suitability of different escapement goal methods for different species of salmon.
- Data needs for different escapement goal methods – are there methods for which we already have foundational data?

What needs to be done

- Review alternative models being used to generate escapement goal methods in other regions and evaluate their applicability to the Kuskokwim Area.
- Determine the value of different escapement goal methods to different salmon species in the Kuskokwim – are methods best suited to chum inadequate for freshwater-rearing species?
- Monitor habitat/environmental data in a way that will allow it to become accessible to future models seeking to incorporate the environment into escapement goals.

Objective 3B: Determine sustained escapement thresholds

Information Need # 3.3: Identify population units (at any of several scales).

Summary of current situation

Some genetics work underway may help address this topic. Recent and current projects provide foundational data needed for broad retrospective analysis. The identification of population units will likely change as genetic techniques evolve over time.

Recent or current projects to support Information Need
Some genetics projects will provide information useful for addressing this need. Goal 2 provides a detailed listing of these projects. Those that may apply to this section include:

- Estimates of genetic variation of coho salmon in the Kuskokwim River (#ON-22),
- A comparison of fall and summer chum genetics (#ON-34),
- Estimates of effective population size of Chinook salmon on the Kwethluk and Tuluksak rivers (#ON-31),
- Baseline studies of Chinook and chum genetics, using allozymes (#95-06; #96-01), and
- Estimates of sex ratios of immature Kuskokwim Area chum in the False Pass marine fishery.

Major information gaps
- Genetic markers for identification of population units at a scale practical for salmon management.
- Precision of genetic markers.
- Consistency of methods among laboratories.

What needs to be done
- Identify and continue foundational projects.
- Develop and standardize markers.
- Use existing stock assessment projects as platforms to expand baseline collections.

Information Need # 3.4: Determine methods and protocols for determining sustained escapement thresholds (SETs).

Summary of current situation
As described in 3.1, SETs are generated using the lower ranges of known escapements from which a salmon stock has historically rebounded (ADF&G 2004). SETs levels are set to provide for a target point of recovery, and are implemented in response to an Action Plan that is in turn initiated in response to several years of failure to reach an escapement goal. All SETs undergo ADF&G review as part of the Alaska Board of Fish cycle (D. Bernard, ADF&G, personal communication).

Information used to develop the SETs come from existing adult salmon assessment projects, including those that estimate or index escapement, and those that provide information on stock-specific run timing. There have been no projects conducted specifically to evaluate alternative ways to determine an SET (or, more properly, a replacement for an SET that is thought to provide a more accurate target for a point of stock recovery).

Recent or current projects to support Information Need

- No projects conducted specifically evaluate SET methodology.
- Projects contributing data used in current SETs.
    - Escapement estimates or indices (various).
    - Stock specific run timing (various adult tagging studies, genetic studies, tributary escapement projects).

Major information gaps

- The effectiveness of SETs in providing recoveries for stocks.

What needs to be done

- Evaluate SET methods and protocols to identify improvements or alternative methods.
- Evaluate quality of data from individual projects used to generate SETs.
- Evaluate State's SET policies in light of Federal ESA's for salmon.

Objective 3C: Develop preseason forecasting

Information Need # 3.5: Investigate alternative forecasting methods.

Summary of current situation

Salmon returns to the Kuskokwim Area are not forecast; instead the ADF&G generates broad outlooks based on prior data. Age-3 Chinook salmon in one year, for example, can be used as an indicator of age-4 Chinook return strength in the next year. The relationship between current and subsequent runs varies among species, and is undoubtedly affected by environmental factors. The sources and effects of such environmental factors, however, are unknown and are thus not factored into salmon run forecasts. Shotwell (2004) generated a model to predict chum salmon returns to western Alaska that included environmental variables. This model has generated some discussion among western Alaska salmon managers, but has not been used to formally forecast returns. There are no other current or recent projects devoted to researching ways to improve forecasting methods.

Recent or current projects to support Information Need

- Model developed and presented by Shotwell (2004) for western Alaska chum.

Major information gaps

- Evaluations of forecasting models used for salmon populations outside of western Alaska.
- Long-term data series that allow estimates of total run abundance;
- Variables known to correlate with return of each salmon species to the Kuskokwim Area.
- Adequate time series of foundation data needed to develop forecasting models (e.g., estimates of total abundance with associated brood tables).

What needs to be done

- Produce a discussion paper that evaluates alternative models, including a thorough presentation of models used elsewhere. Such a paper should include a strategy for testing models any models that appear adaptable to the Kuskokwim Area.

Information Need # 3.6: Improved accuracy of forecasting methods.

Summary of current situation

This Information Need is directly tied to #3.5, summarized above. There was general sentiment at the KFRC meeting (KFRC 2004) that current salmon forecasts in the Kuskokwim Area are unreliable, and that improving this accuracy is not a high priority until alternative methods have been developed.

Recent or current projects to support Information Need

There are no current evaluations of run forecasting, either by improving existing models or by developing alternative ones.

Major information gaps

- Accuracy of models used to forecast return of salmon species outside of the Kuskokwim Area.
- Transferability of these models, if any, to the Kuskokwim Area.

What needs to be done

- Produce a discussion paper that evaluates potential ways to improve current forecasting models. Such a paper should include discussions of the adequacy of current data, which potential variables could be considered to improve accuracy, a framework by which to test such potential improvements, and a discussion of alternative models used elsewhere.
- Current management does not depend on forecasting, but rather on inseason monitoring and assessment of key indicators of run abundance to implement an inseason management plan designed to meet set escapement goals. The inseason management plan or strategy is developed by post season assessments of historic catch and escapement data. This approach to management needs to documented and published to allow peer review. Also, retrospective analysis should be undertaken based on modeling for risk assessment of under harvest or over harvest of stocks when applying this method.

Objective 3D: Develop methods for determining inseason run estimates and run timing

Information Need # 3.7: Inseason harvest data.

Summary of current situation

ADF&G operates a catch monitoring program for the commercial fishery in the lower Kuskokwim Area. Processors are required to report harvests within specific time periods.

These inseason estimates of harvest are checked postseason against harvest ticket data maintained in a statewide database. Also, managers often survey fishing effort, via aerial surveys, to assess the number of fishermen participating in openings and communicate daily with processors and fishermen about the harvest and fishing conditions. Some managers on the Kuskokwim will spend much of the fishing period in a skiff making numerous boat-to-boat spot checks in the fishery.

Inseason catch monitoring data have been collected from subsistence fisheries in the lower and middle Kuskokwim River for several years. These data are considered qualitative, and are used to help guide inseason management actions.

Recent or current projects to support Information Need
Inseason subsistence harvest data is provided by:

- Project ON-25, which covers the lower Kuskokwim River, near Bethel, and
- Project ON-26, which covers the middle Kuskokwim River.

Major information gaps

- Subsistence harvest data from Bethel.

What needs to be done

- Continue supporting existing projects that collect inseason harvest data.
- Evaluate how effectively these data are used for inseason management.

Information Need # 3.8: Escapement estimates

Summary of current situation
Escapement data have historically been viewed as one of the highest priorities for salmon studies in the Kuskokwim Area, and have thus been a large portion of research and monitoring efforts. There are escapement estimates for multiple years on several Kuskokwim River tributaries, the Middle Fork Goodnews River, and the Kanektok River. Escapement to the entire Kuskokwim River has not been estimated, however.
Data are currently being collected on seven tributaries with weirs, one tributary with sonar, and on the mainstem Kuskokwim with mark-recapture. Aerial surveys are also conducted on as many as several dozen tributaries (depending on year).

Recent or current projects to support Information Need
In 2005, escapement will be estimated on several rivers and tributaries (Tables 3 and 6) to help estimate abundance and provide information for harvest management, including:

- Kuskokwim River drainage,
    - George, Tatlawiksuk, Kogrukluk, Takotna, Kwethluk, Aniak, Takotna, and Holitna rivers.
- Middle Fork Goodnews River,
- Kanektok River, and
- Aerial surveys of multiple rivers, reaches.

Major information gaps

    - Chinook salmon.
    - Mainstem spawners.
- Chum salmon.
    - Fall chum, throughout drainage.
    - Summer chum.
- Coho salmon.
    - In drainage upstream of McGrath.
    - Of late-returning component.
- Sockeye salmon.
    - Of late-returning component.

What needs to be done

- Operate existing projects with periodic evaluations to increase information quality and connectivity.
- Conduct retrospective analysis of correlations of trends within and between escapement projects as well as other monitoring data e.g. test fisheries.
    - Can the projects be operated in a way that yields data useful beyond those specific rivers/reaches?
- Evaluate the potential for new technologies or methods to:
    - Operate existing projects in more desirable locations or times,
    - Begin new projects that can replace or improve existing ones,
    - Expand or redirect coverage based on telemetry data and modeling applications (i.e. need for Aniak River Chinook escapement recapture data), and
    - Develop MR estimate for Chinook above the Holitna River (requires additional recapture projects in the upper drainage).

Objective 3E: Conduct run reconstructions

Information Need # 3.9: Stock composition of the harvest.

Summary of current situation

Salmon returning to the Kuskokwim Area are managed for mixed stocks, with SEGs set for 22 stocks (as described in Information Need 3.1). There is not currently enough knowledge, however, to differentiate among these stocks in the lower river or the harvest. Currently, genetic markers are being developed to increase the ability to identify chum and Chinook salmon in the Kuskokwim Area. These include single nucleotide polymorphisms (SNPs) for chum salmon and both SNPs and microsatellite markers for Chinook salmon. For chum salmon, current technology allows discrimination between fall- and summer-run salmon in the inriver fishery mixtures. One goal of current salmon genetic research is to acquire enough baseline data to analyze the stock composition of salmon captured in the Bethel test fishery (W. Templin, ADF&G Gene Conservation Lab, personal communication).

Recent or current projects to support Information Need

- Estimates of genetic variation of coho salmon in the Kuskokwim River (ON-22).
- A comparison of fall and summer chum genetics (ON-34).
- Baseline studies of Chinook and chum genetics, using allozymes (Project #95-06; #96-01).

Major information gaps

- Precision of markers.
- Genetic markers able to identify stock origin of salmon at a scale useful for harvest management.

What needs to be done

- Develop and standardize markers.
- Develop necessary baselines, using existing stock assessment projects as platforms where possible.

Information Need # 3.10: Total (direct and indirect) harvest.

Summary of current situation

The ADF&G has estimated direct harvest from commercial, subsistence, and recreational harvests for many years as a fundamental part of managing fisheries in the Kuskokwim Area (Table 6). Indirect harvest, such as from bycatch or interception fisheries, is not estimated. In the 1980's, a project was conducted to estimate the bycatch of chum salmon caught in the sockeye salmon fishery conducted in the Area M fishery, near False Pass on the Alaska Peninsula (project #87-01).

Recent or current projects to support Information Need

- Inseason monitoring of the subsistence fishery (projects #ON-25 and ON-26).
- Postseason harvest estimates of the recreational (#ON-10), commercial (#ON-11), and subsistence (#ON-12) fisheries.

Major Information gaps

- The size of the subsistence harvest in Bethel.
- Estimates of interception of Kuskokwim Area salmon in marine fisheries.

What needs to be done

- Continue to estimate direct harvest by commercial, recreational, and subsistence fisheries.
- Conduct a small project to identify potential sources and likely intensity of indirect harvests.
- Use this identification to develop or guide appropriate projects to quantify indirect harvest.

Information Need # 3.11: Estimate total run abundance.

Summary of current situation

The large size of the Kuskokwim River and the extended migration time of returning salmon have thus far prevented any direct estimate of the total abundance of salmon returning to the Kuskokwim Area or the Kuskokwim River. This estimate is currently being attempted by piecing together, or "reconstructing", the runs of coho, sockeye, and chum salmon based on data collected by multiple projects. These projects include combining population estimates from the middle mainstem Kuskokwim River, escapements to weirs on tributaries, and harvests of salmon from throughout the drainage. The ADF&G has also attempted to directly estimate the run abundance by using sonar to count fish in the mainstem river, but this approach was discontinued in the mid-1990's.

Recent or current projects to support Information Need

Recent or current projects that are integral to the run reconstruction approach include:

- Chum, sockeye, and coho abundance estimates in the mainstem Kuskokwim River at river km 309, near Kalskag. These abundance estimates require:
    - Marking of fish at Kalskag, using the fishwheel projects (#ON-20), and
    - Recovering marked fish upstream of Kalskag, using weirs on the George, Tatlawiksuk, Kogrukluk, and Takotna rivers (Tables 3 and 7).
- Estimates of escapement to tributaries downstream of Kalskag (e.g., Kwethluk, Tuluksak, Aniak rivers) to add to estimates from Kalskag,
- Salmon harvest estimates to add to inriver abundance and escapement estimates (projects #ON-10, ON-11, and ON-12).

In addition, Project 95-03 attempted to use sonar on the mainstem Kuskokwim River to estimate salmon abundance, but was discontinued after 1995.

Major Information gaps

- Abundance of all salmon species in the mainstem Kuskokwim River.

What needs to be done

- Continue to support projects needed to estimate abundance estimates via run reconstruction approach.
- Evaluate potential error in the estimates from run reconstruction, especially with respect to cumulative error resulting from combining results from multiple projects.
- Identify how the usefulness and quality of the data will be evaluated, either for individual projects or the entire approach; i.e., *are individual projects making the expected contribution to the run reconstruction? Is the entire approach generating realistic and reliable estimates of total abundance?*

Information Need # 3.12: Retrospective analysis of historic data.

Summary of current situation

Although retrospective analysis of historic data was identified as an Information Need by the KFRC, it should really be considered an approach instead of an information type. Retrospective analysis is a research approach that can be used to address Information Needs, just as field studies, data synthesis, and traditional ecological knowledge are also

approaches. Retrospective analysis has been used in the Kuskokwim Area, and there is growing awareness of its value throughout the AYK region (R. Cannon, USFWS, personal communication). The larger planning document contains more discussion of this approach as a research method.

Recent or current projects to support Information Need

Kuskokwim Area projects that have recently used retrospective analysis as a research approach include:

- A retrospective analysis of tributary escapements was recently conducted as part of the most recent escapement goal reviews (D. Molyneaux, ADF&G, personal communication),
- Shotwell (2004) used historic data to develop run reconstructions back to the 1970s,
- Harper and Watry (2001) combined historic escapement and ASL data with literature values of fecundity to estimate historic Chinook salmon egg deposition in the Kwethluk and Tuluksak rivers, and
- Retrospective analysis of harvest data, conducted by the Board of Fisheries (BOF RC 411).

Major Information Gaps

- Not applicable because this is really a method, not an information need (as described in the Summary section, above).

What needs to be done

- Identify Information Needs that can be best addressed using retrospective methods, especially where the approach may be more cost-effective than collecting new field data.

Objective 3F: Evaluate management system

Information Need # 3.13: Ability of inseason actions to accurately guide harvest to meet escapement goals.

Summary of current situation

This Information Need is primarily addressed through the interactive management process, including both inseason evaluations and postseason reporting. Inseason, projects such as the Bethel test fishery and the inseason harvest monitoring are combined with initiatives such as ADF&G's summaries and the Kuskokwim Working Group meetings to provide feedback regarding how management actions appear to affect harvest and escapement. Post-season, the ADF&G publishes an Annual Management Report for the entire Kuskokwim Area (e.g., Ward et al. 2003) that includes lengthy evaluation and discussion of management actions, the fishery harvest, and progress towards meeting escapement goals.

Recent or current projects to support Information Need

- Bethel test fishery,
- Inseason harvest monitoring,
- Kuskokwim Working group inseason meetings,
- Postseason harvest estimates, and
- Postseason reporting of stock assessment projects.

Major Information Gaps

- Improved escapement data described under Information Need #2.1.
- The current suite of actions appears well-designed to address major Information Needs, but an assessment of their success over time is still needed.

What needs to be done

- Continue projects that provide essential inseason data (e.g., harvest estimates, Bethel test fishery).
- Evaluate what other projects, if any, may be needed to improve the quality of data supplied.
- Continue Working Group meetings that provide discussion and feedback.
- Conduct a project that specifically evaluates how well inseason actions contribute to reaching escapement goals.

Information Need # 3.14: Effects of harvest methods on population structure and escapement quality.

Summary of current situation

The ADF&G has collected age, sex, and length data (ASL data) of Kuskokwim Area salmon for many years (Folletti 2004). These data allow the ADF&G to evaluate biological trends in the salmon catch over time, space, and in different types of fisheries (subsistence, commercial, recreational), thereby helping address this Information Need.

ASL baseline data have been used to evaluate effects of the subsistence fishing schedule on the ASL structure of Chinook salmon returning to the Kuskokwim River (Molyneaux et al. 2005). Gill nets with relatively large mesh (>= 8 inches) appear to harvest a larger proportion of older, female Chinook than do other fisheries using smaller mesh gill nets. Such selectivity by harvest gear has been shown to affect the phenotype of other fish populations over time (Law 2002). There have been no similar evaluations of other salmon species in the Kuskokwim Area.

Recent or current projects to support Information Need

- ASL data reporting (Folletti 2004).
- Evaluation of ASL composition of Chinook salmon from 2004 Kuskokwim River subsistence fishery (Molyneaux et al. 2005).
- Salmon assessment projects that provide ASL data, including commercial catch sampling, Bethel test fishery, and salmon escapement projects (Table 7).
- Salmon assessment projects that provide run timing data, especially those that can provide a historical comparison.

Major information gaps

- Long-term effect of the demonstrated size selectivity of different gear types on the Kuskokwim River Chinook salmon run.
- Assessment of effects, if any, of gear type on runs of other Kuskokwim Area salmon.

What needs to be done

- Continue periodic reporting and summarizing of ASL data.
- Determine which existing projects are especially important for providing ASL and run timing data and solidify support for these projects.
- Expand assessment of Molyneaux et al. (2005) to other relevant salmon species and Chinook salmon populations.

Information Need # 3.15: Extent of regulatory compliance.

Summary of current situation

Regulatory violation are recorded, but there has been no study of the extent of compliance and what trends, if any, there are over time or among fisheries.

Recent or current projects to support Information Need

- None.

Major information gaps

- Compliance rates in the commercial, recreational, and subsistence fisheries for all Kuskokwim Area salmon species.

What needs to be done

- Overview assessment of the presence and effects regulatory violations, and what the trends and causes of these violations are.

Information Need # 3.16: Adequacy of regulatory enforcement.

Summary of current situation

Regulatory enforcement is conducted by the Alaska State Troopers on State waters, and by the USFWS on Federal waters. There has been no recent study to identify which aspects of the fishery have adequate and inadequate enforcement.

Recent or current projects to support Information Need

- None.

Major information gaps

- Adequacy of enforcement efforts for any salmon fishery in the Kuskokwim Area.

What needs to be done

- Local communities and enforcement agencies should be surveyed to determine when and where there may be inadequate enforcement.

Information Need # 3.17: Ability of inseason actions to meet ANS.

Summary of current situation
The amount of salmon necessary for subsistence (ANS) is a range established by the Alaska Board of Fish (Bergstrom and Whitmore 2004). The Board uses harvest information that accurately reflects usage patterns in the subsistence fishery. The Board revised the ANS range for the Kuskokwim Area in 2001, and based this range on the low and mean subsistence harvests for the most recent ten years (see Bergstrom and Whitmore 2004 for methodology details). These ranges were identified in RC 411, and are listed in Table 5.

The degree to which Kuskokwim Area management actions achieve satisfactory subsistence harvest levels is addressed primarily by two inseason harvest monitoring projects, by the regular inseason meetings of the Kuskokwim Working Group, and by the Annual Reports published by the Commercial and Subsistence fisheries divisions of the ADF&G.

Recent or current projects to support Information Need
- Inseason harvest monitoring (projects #ON-25 and ON-26).
- Kuskokwim Working Group inseason meetings.
- Postseason reporting by ADF&G.

Major information gaps
- Whether inseason actions are sufficient to allow the range of harvests identified as ANS.

What needs to be done
- Identify and evaluate whether the current method for setting ANS levels needs improvement.

Information Need # 3.18: Assess regulation clarity and implementability.

Summary of current situation
There are no current or recent efforts to address this Information Need.

Recent or current projects to support Information Need
- None.

Major information gaps
- Degree to which fishery participants understand fishery regulations.

What needs to be done
- Identify an effective method (e.g., surveys of permitholders?) to evaluate regulation clarity and the effects of participation in the fisheries.

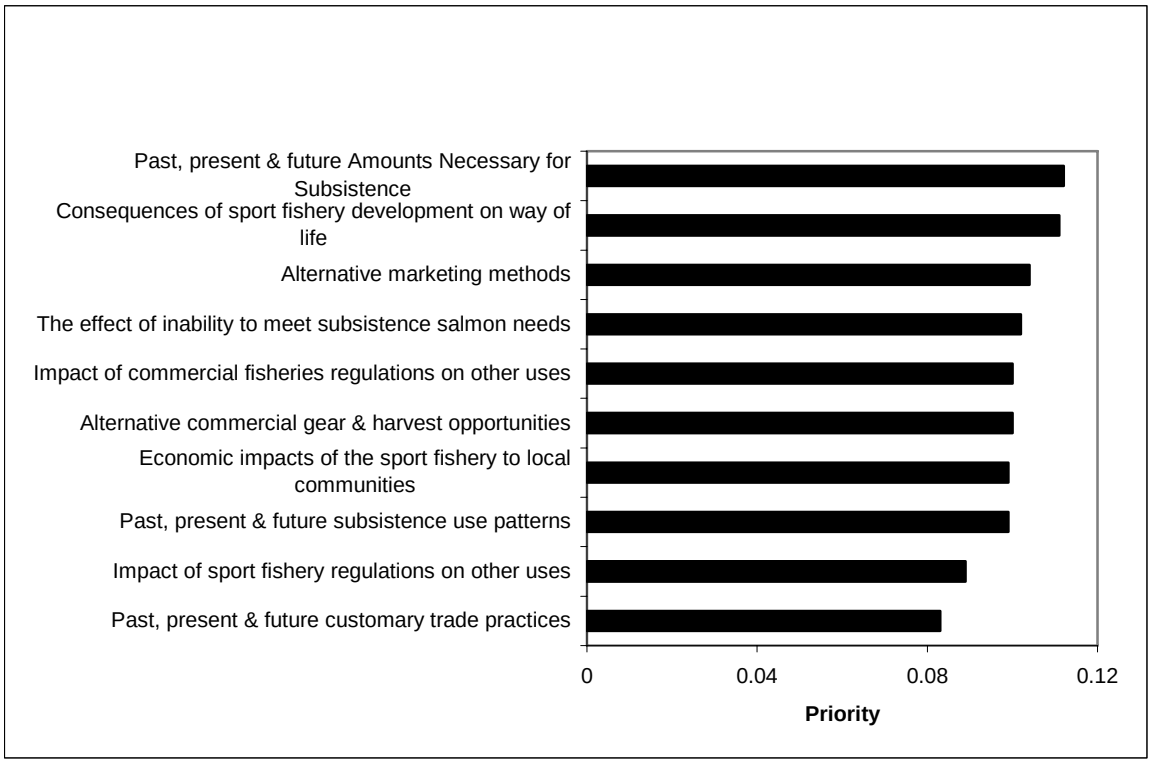

Figure 4. Priority ranking of Information Needs for Goal 4 developed by the KFRC (2004): *Determine the relationship between socioeconomic and demographic trends and subsistence, commercial, and sport fisheries.* Note: The KFRC assigned a relative importance to each Information Need (x-axis), without considering the degree to which the information was already known.

Overview

This goal is intended to improve the understanding of the relationship among the multiple salmon fisheries and Kuskokwim Area communities. The prevailing theme was the need to understand how local socioeconomic systems are affected by the fisheries. In their discussions, KFRC members stressed that this effect is a two-way equation: communities can cause changes to the salmon, which can then cause changes to the communities. As a result, one recurring theme was the need to estimate future demographic changes in the Kuskokwim Area so that future pressure on the fishery can be predicted. Inherent in this theme is the need to analyze current systems and historic trends to understand the relationship between human populations and salmon harvests. These topics require investment in economic and social science research, and entities that have not historically

been involved in salmon research may be especially well-equipped to make important contributions towards this goal.

Resources currently available to help address this goal include databases and reports produced by the ADF&G Division of Subsistence (ADFG/DS; 2005), the Alaska Department of Labor (2005), and the federal Office of Subsistence Management (2005). The Community Profile Database assembled by the ADF&G/DS provides a searchable summary of some demographic data relevant to this Goal, such as harvest information, demographics, human population trends, economics, and labor statistics. The database is available on the Internet at http://www.subsistence.adfg.state.ak.us/geninfo/publctns/cpdb.cfm). The ADF&G/DS is currently updating the database (and may rename it in 2006). Technical reports have also been produced on specific topics and communities relevant to this goal; many of these reports can be found in the "publications" section of the ADF&G/DS web site (http://www.subsistence.adfg.state.ak.us/geninfo/publctns/techpap.cfm). Andersen and Overturf (1986) provide an annotated bibliography of subsistence reports produced before 1986 (http://www.subsistence.adfg.state.ak.us/techpap/tp111.pdf).

Subsistence salmon harvests are estimated at the end of each fishing season, and have provided the greatest amount of fisheries information relevant to this Goal. These estimates are based on household surveys (project #ON-27) and have been conducted since approximately 1960, but the project title, lead organization, survey methods, and funding source have varied over that time. ADF&G/DS assumed the lead investigation role in 1988 and now conducts the project in collaboration with other organizations. The federal Office of Subsistence Management often helps fund such projects. Information from the surveys includes household fishing participation, fishing methods, and harvest quantities of chum, coho, sockeye, Chinook, and pink salmon (Ward et al. 2003; OSM 2005); results from surveys through the year 2002 are available on the ADF&G/DS web site (http://www.subsistence.adfg.state.ak.us).

In their planning approach document, the KFRC (2004) ranked 10 Information Needs under Goal 4 (Figure 4). Determining the past, present, and future amounts necessary for subsistence (ANS) was ranked as the most important Information Need. Most of the remaining Information Needs were more process-oriented, such as documenting the effect of various demographic or socioeconomic changes on the subsistence way of life in the Kuskokwim Area. ANS was estimated by the Alaska Board of Fish in 2001 (Table 5); most of the remaining topics are not being addressed by salmon researchers in the Kuskokwim Area at this time. There were three recurring themes among these Information Needs:

1. Estimating change in the 3 main fisheries (subsistence, commercial, and recreational) over the next 30 years;
2. Modeling socioeconomic and demographic change over the next 30 years, and estimating how these changes will affect use of the fishery resource; and,
3. Investigating the effect of potential shortages of salmon on the subsistence way of life in the Kuskokwim Area.

Each of these themes require quality harvest and demographic data, both now and in the future, as a foundation for models of the effects of change.

Goal 4 Objectives and Information Needs

Objective 4A: Determine the relationship between socioeconomic trends and subsistence opportunity and harvest.

Includes the following Information Needs (KFRC 2004):

Information Need 4.1: Past, present, and future customary trade practices,

Information Need 4.2: Past, present, and future subsistence use patterns,

Information Need 4.3: Effect of inability to meet subsistence salmon needs, and

Information Need 4.4: Past, present, and future Amounts Necessary for Subsistence.

Summary of current situation

The greatest amount of existing information under this Objective falls under Information Need 4.2. Subsistence harvest data have been collected since before statehood, but methods and specific data have changed over the years. As noted above, the ADF&G/DS has led the collection of these data since 1988. Subsistence harvest information has been described for specific communities and resources, including the lower Kuskokwim (Coffing 1991), the middle Kuskokwim (Brelsford et al. 1986; Coffing and Utermohle 1990), the upper Kuskokwim (Stokes 1985), and Kuskokwim Bay communities (Wolfe et al. 1983). One notable gap is harvest information for Bethel, which is a relatively large community compared to others in the Kuskokwim Area. Expansion factors used to estimate harvest in many small rural communities may not be appropriate for estimating harvest in Bethel, thus leading to uncertainty about the number of salmon harvested by Bethel residents.

The amount of salmon necessary for subsistence (ANS) was established by the Alaska Board of Fish in 2001, using the low and mean subsistence harvests for the prior ten years (as described in Information Need 3.17, and in Bergstrom and Whitmore 2004). Information needed for ANS is thus directly linked to harvest information; in general, this means that past and present ANS is relatively well-known (because we have the harvest information used to set this range; Table 5). Quality harvest information and demographic data are needed for any future models of ANS.

There has been little or no progress towards modeling the potential effects of an inability to meet subsistence needs within the communities.

Recent or current projects to support Information Need

- Kuskokwim Area postseason salmon harvest assessments (#ON-27).

Major information gaps

- Historic methods and/or levels of Information Needs 4.1 and 4.2.
- Subsistence harvest by Bethel residents.
- Projections of population demographics and how changing populations will alter demand for salmon.
- Projections of future subsistence use patterns, customary trade practices, and ANS.

What needs to be done

- Estimate human population growth and demographic trends through the year 2030.
- Estimate subsistence harvest by residents of Bethel.
- Evaluate different scenarios for how these demographic estimates may affect demand for salmon.
- Evaluate the ability to current salmon populations to meet this project salmon demand.
- Discuss the consequences of a projected shortage of salmon (if any) on Kuskokwim Area communities.
- Describe historic and current levels for 4.1 and 4.2.

Objective 4B: Determine the relationship between socioeconomic and demographic trends and commercial opportunity and harvest.

Includes the following Information Needs (KFRC 2004):

Information Need 4.5: Impact of commercial fishery on other uses,

Information Need 4.6: Alternative commercial gear and harvest opportunities, and

Information Need 4.7: Potential for alternative marketing methods.

Summary of current situation

Commercial fishing effort, harvest, and value in the Kuskokwim Area peaked in 1988 and remained strong through the mid-1990's. The commercial fishery has generally declined since then, primarily due to decreased salmon numbers, processing capacity, and prices (Ward et al. 2003). Commercial fishing periods are currently set based on a number of factors, one of which is the harvestable surplus of salmon as escapement goals and subsistence needs are met. Once open, the fishing periods for both commercial and subsistence fisheries are adjusted in tandem based on apparent harvestable surplus. When subsistence periods are short or scarce, for example, commercial periods are closed; when commercial periods are opened, subsistence periods are usually extended (e.g., Ward et al. 2003). An argument can thus be made that, as presently operated, the commercial fishery exerts less effect on other factors than these factors exert on the commercial fishery.

An alternative structure to the commercial fishery was discussed in 2002, when a proposal was temporarily submitted to the Board of Fisheries to form a cooperative

salmon fishery on the Kuskokwim River (Ward et al. 2003). This proposal marks the most substantial, recent discussion of alternative harvesting and marketing methods for the commercial salmon fishery.

There have been no projects recently conducted to specifically evaluate Information Needs 4.5 – 4.7. Such projects could come initially in the form of white papers, theses, or policy evaluations.

Recent or current projects to support Information Need

- No direct projects or reports.
- Indirectly, reports that address subsistence use patterns in lower Kuskokwim Area fisheries and that discuss the commercial fishery as part of this.

Major information gaps

- How commercial salmon fisheries affect subsistence fisheries and the mixed-subsistence system in the Kuskokwim Area.
- Alternative methods for commercial gear.
- Whether alternative markets exist for Kuskokwim Area salmon.
- Whether alternative products can be taken from Kuskokwim Area salmon.

What needs to be done

- Produce review/white papers that directly address Information Needs 4.5 – 4.7. Examples of topics within these would presumably include:
    - Effects of the current structure of the commercial fishery on other uses,
    - Effects of variation and instability in the commercial fishery on other uses,
    - Ways to add value from the commercial fishery, such as by producing additional products like fish oil,
    - The potential for niche markets for Kuskokwim Area salmon, and
    - Describe relationship between commercial and subsistence fishery.

Objective 4C: Determine the relationship between socioeconomic and demographic trends and sport fish opportunity and harvest.

Includes the following Information Needs (KFRC 2004):

Information Need 4.8: Impact of sport fish regulations on other uses,

Information Need 4.9: Positive and negatives impacts to local communities (multiplier effect), and

Information Need 4.10: Positive and negative consequences of sport fishery development on the way-of-life in the Kuskokwim Area (tourism, sociological changes).

Summary of current situation

Recreational fishing in the Kuskokwim Area is managed by the ADF&G Sport Fish Division (ADF&G / SF). The lower Kuskokwim River and Kuskokwim Bay, are

identified as distinct management sections. Subsistence users have expressed discontent with recreational fishers in the past, primarily because of concerns about harvest pressure or because a belief that catch and release fishing is disrespectful to the fish. Local residents and communities thus continue to request that fishery managers eliminate or restrict recreational fishing (Lafferty 2004). At the same time, many parts of the Kuskokwim Area have become well-known for sport fishing, and a number of fishing guide services now operate throughout the watershed.

A concern repeatedly raised at the KFRC meetings was that recreational fisheries, if not developed carefully, could have negative effects on the economy, the subsistence fisheries, or the cultural values of Kuskokwim Area residents. Although the Kuskokwim Area is now a destination for recreational fishers from outside the region, KFRC members noted that much of the revenue generated by the sport fishing services may not stay in the community. Guiding services may provide all lodging, food, and transportation for clients, for example, and then purchase all necessary supplies from less expensive sources outside the region. Local residents may thus realize little value from the revenue brought in from recreational fishing. KFRC members also noted that money that does remain in the community can affect tone, values, and, ultimately, the way of life of subsistence-based communities. Many of these concerns could be summed up by the question *How much benefit is derived from recreational fishing in the Area, and is it worth the actual and potential drawbacks?*

Recent or current projects to support Information Need

Wolfe (1989) reported that recreational fisheries on the Togiak, Kanektok, and Goodnews rivers affected subsistence users in 1987. Recreational fishers displaced subsistence fishers from traditional (i.e., preferred) subsistence fishing sites simply by occupying the site before subsistence fishers arrived. Subsistence fishers also disliked the catch and release fishing practiced by recreational fishers, believing that catch and release represented an improper disposal of fish that would eventually lead to shortages of returning fish. Importantly, recreational fishers were relatively unaware of their effects on subsistence users, or of the negative perceptions that subsistence fishers held of them (Wolfe 1989).

There have been no recent studies of the effects of the recreational fishing on subsistence fishing in the Kuskokwim Area since Wolfe (1989), nor have there been detailed studies of the economic effects of recreational fishing in the region.

Major information gaps

- Economic benefit of recreational fishing in the Kuskokwim Area – value, recipients, and mechanisms.
- Predicted growth of recreational fishery in the next 30 years.
- Ways in which sport fish regulations affect other resource users.
- Impacts of sport fishery on local communities – economic, social, etc.
- Impacts of sport fishery on cultural values and social systems in the Area.

What needs to be done

- Estimate the size and growth of the sport fishery over the next 30 years.
- Determine how the recreational fishery provides benefit to the local community, and quantify the monetary value of this benefit.
- Identify ways to increase the benefit from the sport fishery to the local community.
- Identify non-financial impacts (cultural, social, etc.) of sport fisheries on the local community.
- Describe relationship between sport and fishery and other fisheries and resource uses.

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Figure 5. Map of Kuskokwim Area showing major drainages, salmon stock assessment projects, and commercial salmon fishing districts.

Table 1. Summary of state of knowledge and recommendations for Goal 1:*Determine the ecosystem structure and function needed to maintain evolutionary and ecosystem processes (such as by implementing an LTER).*

Information Need	Projects / Initiatives (see Table 6 for list of projects by #)	State of knowledge		
		Adequate	Partially known	Largely unknown
1.1. Spatiotemporal information on routine climatic variables	Project # ON-09 Takotna River weir Project # ON-14 George River weir Project # ON-15 Real time surface water data Project # ON-21 Tatlawiksuk River salmon weir Project # ON-23 Middle Fork Goodnews River coho salmon escapement enumeration Project # ON-24 Elders' TEK of 20th century ecosystems and fish pop changes Project # ON-30 Real time surface water data Project # ON-41 Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR Project # ON-42 Water temperature monitoring of 21 rivers throughout Togiak Refuge Project # ON-43 Routine monitoring of climatic variables by NOAA (e.g., at Bethel airport) Project # ON-44 Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period Project # ON-45 Hydrological and sedimentological monitoring to calibrate paleoclimate proxies,Arolik Lake, Togiak NWR		**X**	
1.2. Seasonal patterns in climate variables	Project # ON-41 Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR Project # ON-42 Water temperature monitoring of 21 rivers throughout Togiak Refuge Project # ON-43 Routine monitoring of climatic variables by NOAA (e.g., at Bethel airport) Project # ON-44 Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period Project # ON-45 Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak NWR		**X**	

Table 1. Summary of state of knowledge and recommendations for Goal 1:*Determine the ecosystem structure and function needed to maintain evolutionary and ecosystem processes (such as by implementing an LTER).*

Information Need	Projects / Initiatives (see Table 6 for list of projects by #)	State of knowledge		
		Adequate	Partially known	Largely unknown
1.3. Effects of climate change on productivity				**X**
1.4. Watershed geology, hydrology, and geomorphology data	Project # ON-15 Real time surface water data Project # ON-41 Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR Project # ON-42 Water temperature monitoring of 21 rivers throughout Togiak Refuge Project # ON-37 Kwethluk River biostation		**X**	
1.5. River, lentic, and estuarine habitat classifications, and their associated terrestrial zones.	Project # ON-46 Land cover map of the Togiak NWR			**X**
1.6. Unique Kuskokwim Area attributes and their relationship with other locations and models				**X**
1.7. Human influence on physical aspects of the ecosystem				**X**
1.8. Understanding of community structure				**X**
1.9. Biotic baseline information and trends				**X**
1.10. Trophic structure information				**X**
1.11. Pattern and control of primary production				**X**
1.12. Human influences on the biological aspects of the ecosystem				**X**
1.13. Interactions within and among land, water, and the atmosphere	Project # ON-45 Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak NWR			**X**
1.14. Importance of these cycles to biota and habitat				**X**

Table 2. Summary of state of knowledge and recommendations for Goal 2:*Determine salmon life history, genetics, and productivity in relation to their place in the ecosystem.*

Information Need	Projects / Initiatives (see Table 6 for list of projects by #)	State of knowledge		
		Adequate	Partially known	Largely unknown
2.1. Current distribution, abundance, and run timing of spawning adults in the drainage	Project # ON-24 Elders' TEK of 20th century ecosystems and fish pop changes Project # ON-05 Aniak River sonar Project # ON-06 Kanektok River weir Project # ON-07 Kogrukluk River weir Project # ON-08 Middle Fork Goodnews weir Project # ON-09 Takotna River weir Project # ON-14 George River weir Project # ON-16 Abundance and run timing of adult salmon in the Kwethluk River Project # ON-17 Abundance and run timing of adult salmon in the Tuluksak River Project # ON-18 Kanektok River weir salmon escapement enumeration Project # ON-19 Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radiotelemetry Project # ON-20 Kuskokwim River chum, sockeye, and coho salmon stock assessment Project # ON-21 Tatlawiksuk River salmon weir Project # ON-23 Middle Fork Goodnews River coho salmon escapement enumeration Project # ON-28 Bethel drift gillnet Project # ON-29 In-river abundance of chinook salmon in the Kuskowkim River Project # ON-34 Characteristics of fall chum salmon in the Kuskokwim River drainage		**X**	
2.2. Total stream migration and residence time of adults	Project # ON-23 Middle Fork Goodnews River coho salmon escapement enumeration Project # ON-16 Abundance and run timing of adult salmon in the Kwethluk River Project # ON-17 Abundance and run timing of adult salmon in the Tuluksak River Project # ON-16 Abundance and run timing of adult salmon in the Kwethluk River Project # ON-17 Abundance and run timing of adult salmon in the Tuluksak River Project # ON-20 Kuskokwim River chum, sockeye, and coho salmon stock assessment		**X**	
2.3. Characterization of reproductive biology	Project # ON-16 Abundance and run timing of adult salmon in the Kwethluk River Project # ON-17 Abundance and run timing of adult salmon in the Tuluksak River			**X**

Table 2. Summary of state of knowledge and recommendations for Goal 2:*Determine salmon life history, genetics, and productivity in relation to their place in the ecosystem.*

Information Need	Projects / Initiatives (see Table 6 for list of projects by #)	State of knowledge		
		Adequate	Partially known	Largely unknown
2.4. Prevalence, morbidity, and mortality of disease in adults	Project # ON-36 Environmental contaminants in Kuskokwim and Yukon River chinook and chum salmon			**X**
2.5. Distribution of juveniles in the drainage and their downstream migration timing.	Project # ON-09 Takotna River weir Project # ON-01 Lower Kuskokwim River juvenile chum salmon studies Project # ON-02 Kuskokwim Bay juvenile chum salmon studies Project # ON-32 Goodnews/Carter Bay fish distribution Project # ON-35 Description of chinook salmon sex ratios			**X**
2.6. Feeding ecology (diet) of juveniles	Project # ON-02 Kuskokwim Bay juvenile chum salmon studies			**X**
2.7. Juvenile survival by life stage and factors (e.g., habitat types, other environmental characteristics, genetics) that influence it.				**X**
2.8. Juvenile salmon abundance.				**X**
2.9. Juvenile physiology, growth, and development	Project # ON-01 Lower Kuskokwim River juvenile chum salmon studies Project # ON-02 Kuskokwim Bay juvenile chum salmon studies Project # ON-40 Retrospective analysis of AYK Chinook growth in freshwater and marine habitats, 1964-2004			**X**
2.10. Genetic diversity of salmon residing in and returning to the Kuskokwim Area.	Project # ON-28 Bethel drift gillnet Project # ON-31 Effective population size of chinook salmon in the Kwethluk and Tuluksak rivers Project # ON-22 Genetic variation among coho salmon populations from the Kuskokwim River region Project # ON-34 Characteristics of fall chum salmon in the Kuskokwim River drainage Project # ON-35 Description of chinook salmon sex ratios Project # ON-38 Genetic stock ID of Kuskokwim River chinook salmon		**X**	
2.11. The risk of population extinction.	Project # ON-31 Effective population size of chinook salmon in the Kwethluk and Tuluksak rivers			**X**

Table 3. Summary of state of knowledge and recommendations for Goal 3 Management of salmon stocks for long-term sustained yield with emphasis on subsistence priority.

Information Need	Projects / Initiatives (see Table 6 for list of projects by #)	State of knowledge		
		Adequate	Partially known	Largely unknown
3.1. Need to evaluate current escapement goal methods.	AYK Escapement Goal Review Team; ADF&G inter-divisional escapement goal review team		**X**	
3.2. Need to investigate alternative methods for determining escapement goals (e.g., habitat-based, ecological, other spawner-recruit)	Project # ON-33 Development of habitat-based escapement goals for chinook salmon (Kwethluk, Tuluksak rivers)			**X**
3.3. Identify units (drainage-wide, tributary, other aggregates)	Project # ON-34 Characteristics of fall chum salmon in the Kuskokwim River drainage Project # ON-38 Genetic stock ID of Kuskokwim River chinook salmon		**X**	
3.4. Need to determine methods and protocols for estimating sustained escapement thresholds (e.g., using effective population size information).			**X**	
3.5. Need to investigate alternative forecasting methods (e.g., modeling).	Shotwell (2004) work on chum salmon run reconstruction and return forecasts			**X**
3.6. Improved accuracy of current forecast methods (e.g., egg deposition, climatic influences on survivability).				**X**
3.7. Inseason harvest.	Project # ON-25 Bethel area in-season subsistence salmon data collection Project # ON-26 Middle Kuskokwim River inseason subsistence salmon harvest data collection		**X**	
3.8. Escapement estimates	Project # ON-03 Aerial surveys Kanektok, Goodnews rivers Project # ON-04 Aerial surveys Kuskokwim Area Project # ON-05 Aniak River sonar Aniak Project # ON-06 Kanektok River weir Kanektok Project # ON-07 Kogrukluk River weir Kogrukluk Project # ON-08 Middle Fork Goodnews weir Middle Fork Goodnews Project # ON-09 Takotna River weir Takotna Project # ON-14 George River weir George Project # ON-16 Abundance and run timing of adult salmon in the Kwethluk River Kwethluk Project # ON-17 Abundance and run timing of adult salmon in the Tuluksak River Tuluksak Project # ON-18 Kanektok River weir salmon escapement enumeration Kanektok Project # ON-19 Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radiotelemetry Holitna Project # ON-21 Tatlawiksuk River salmon weir Tatlawiksuk Project # ON-23 Middle Fork Goodnews River coho salmon escapement enumeration Middle Fork Goodnews		**X**	

Table 3. Summary of state of knowledge and recommendations for Goal 3 Management of salmon stocks for long-term sustained yield with emphasis on subsistence priority.

Information Need	Projects / Initiatives (see Table 6 for list of projects by #)	State of knowledge		
		Adequate	Partially known	Largely unknown
3.9. Stock composition of harvest	Project # ON-13 ASL sampling Project # ON-38 Genetic stock ID of Kuskokwim River chinook salmon			**X**
3.10. Total harvest (e.g., direct and indirect sources of mortality).	Project # ON-10 Catch and effort assessment - sport fish Project # ON-11 Catch and effort assessment - commercial fish Project # ON-12 Kuskokwim Area post-season subsistence salmon surveys Project # ON-39 Kuskokwim River in-season subsistence salmon harvest data collection		**X**	
3.11. Total run abundance.	Project # ON-20 Kuskokwim River chum, sockeye, and coho salmon stock assessment		**X**	
3.12. Retrospective analysis of historic data.	Incorrectly identified as an Information Need by Project # 2004 (now treated as a research method in the plan / gap analysis)	**NA**	**NA**	**NA**
3.13. Effectiveness of inseason actions in accurately guiding harvest to meet escapement goals.	# ON-21:Tatlawiksuk River salmon weir		**X**	
3.14. Effects of various harvest methods on population structure and escapement quality.	Project # ON-13 ASL sampling Molyneaux et al. 2005 - effects of gill net mesh on Chinook ASL		**X**	
3.15. Extent of regulatory compliance.				**X**
3.16. Adequacy of regulatory enforcement.				**X**
3.17. Effectiveness of inseason actions on accurately guiding harvest to meet amount necessary for subsistence.	Targeted using management process: combining fishing openings with harvest assessments		**X**	
3.18. Clarity of regulation and their implementability.				**X**

Table 4. Summary of state of knowledge and recommendations for Goal 4:*Determine the relationship between socioeconomic and demographic trends and subsistence, commercial, and sport fisheries.*

Information need	Projects / Initiatives (see Table 6 for list of projects by #)	State of knowledge		
		Adequate	Partially known	Largely unknown
4.1. Past, present, and future customary trade practices.				**X**
4.2. Past, present, and future subsistence use patterns.	Project # ON-27:Bethel, Aniak, Kuskokwim Area post-season subsistence harvest household surveys.		**X**	
4.3. Effect of inability to meet subsistence salmon needs.				**X**
4.4. Past, present, and future Amounts Necessary for Subsistence.	Project # ON-27: Bethel, Aniak, Kuskokwim Area post-season subsistence harvest household surveys; *also,* Alaska Board of Fish determination for Kuskokwim Area, 2001.		**X**	
4.5. Impact of commercial fishery on other uses.				**X**
4.6. Alternative commercial gear and harvest opportunities.				**X**
4.7. Potential for alternative marketing methods				**X**
4.8. Impact of sport fish regulations on other uses.				**X**
4.9. Economic impacts (of recreational fishing) to local communities (multiplier effect).				**X**
4.10. Positive and negative consequences of sport fishery development on the way-of-life in the Kuskokwim Area (tourism, sociological changes).	Wolfe 1989			**X**

Table 5. Amount Necessary for Subsistence in the Kuskokwim Area, as determined by the Alaska Board of Fish in 2001 (Bergstrom and Whitmore 2004).

Area	Species	Amount of fish necessary
Kuskokwim River drainage portion of the Kuskokwim Area	King salmon	64,500-83,000
	Chum salmon	39,500-75,500
	Sockeye salmon	27,500-39,500
	Coho salmon	24,500-35,000
Remainder of Kuskokwim Area	All salmon	7,500-13,500

Table 6. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by project code number. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
2	Distribution of juveniles in the drainage and their downstream migration timing	KFRC ON-01	Lower Kuskokwim River juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Zimmerman and Meka 2004
2	Juvenile physiology, growth, and development	KFRC ON-01	Lower Kuskokwim River juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Zimmerman and Meka 2004
2	Distribution of juveniles in the drainage and their downstream migration timing	KFRC ON-02	Kuskokwim Bay juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Hillgruber et al. 2004
2	Feeding ecology (diet) of juveniles	KFRC ON-02	Kuskokwim Bay juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Hillgruber et al. 2004
2	Juvenile physiology, growth, and development	KFRC ON-02	Kuskokwim Bay juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Hillgruber et al. 2004
3	Escapement data	KFRC ON-03	Aerial surveys	Kanektok, Goodnews rivers	SK	ADFG/CF		?	Burkey et al 2000
3	Escapement data	KFRC ON-04	Aerial surveys	Kuskokwim Area	CK	ADFG/CF		1976-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-05	Aniak River sonar	Aniak	CH	ADFG/CF		1980-current	Burkey et al 2000
3	Escapement data	KFRC ON-05	Aniak River sonar	Aniak	CH	ADFG/CF		1980-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-06	Kanektok River weir	Kanektok	CK, CH, CO, SK	NVK		1999-current	Burkey et al 2000
3	Escapement data	KFRC ON-06	Kanektok River weir	Kanektok	CK, CH, CO, SK	NVK		1999-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-07	Kogrukluk River weir	Kogrukluk	CK, SK, CH, CO	ADFG/CF		1976-current	Burkey et al 2000
3	Escapement data	KFRC ON-07	Kogrukluk River weir	Kogrukluk	CK, SK, CH, CO	ADFG/CF		1976-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-08	Middle Fork Goodnews weir	Middle Fork Goodnews	CK, SK, CH, PK, CO	ADFG/CF		1991-current	Burkey et al 2000
3	Escapement data	KFRC ON-08	Middle Fork Goodnews weir	Middle Fork Goodnews	CK, SK, CH, PK, CO	ADFG/CF		1991-current	Burkey et al 2000
1	Spatiotemporal information on routine climatic variables	KFRC ON-09	Takotna River weir	Takotna	CK, CO, CH	ADFG/CF	Molyneaux	2000 -	OSM 2005
2	Distribution of juvenile salmon in the drainage	KFRC ON-09	Takotna River weir	Takotna	CK, CO	ADFG/CF	Molyneaux	2000 -	OSM 2005
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-09	Takotna River weir	Takotna	CK, CO, CH	ADFG/CF	Molyneaux	2000 -	OSM 2005
3	Escapement data	KFRC ON-09	Takotna River weir	Takotna	CK, CO, CH	ADFG/CF	Molyneaux	2000 -	OSM 2005
3	Harvest (direct and indirect sources of mortality)	KFRC ON-10	Catch and effort assessment - sport fish	Kuskokwim Area	Salmon	ADF&G/SF		? - current	Burkey et al 2000
3	Harvest (direct and indirect sources of mortality)	KFRC ON-11	Catch and effort assessment - commercial fish	Kuskokwim Area	Salmon	ADF&G/CF		1960-current	Burkey et al 2000
3	Harvest (direct and indirect sources of mortality)	KFRC ON-12	Kuskokwim Area post-season subsistence salmon surveys	Kuskokwim Area	CK, SK, CH, CO	ADF&G/DS	Krauthoefer	1960-current	OSM 2005
3	Stock composition of harvest	KFRC ON-13	ASL sampling	Kuskokwim Area	CK, SK, CH, CO	ADF&G/CF		1961-current	Burkey et al 2000
1	Spatiotemporal information on routine climatic variables	KFRC ON-14	George River weir	George	CK, CH, CO	ADF&G/CF	Molyneaux	1996-current	OSM 2005

Table 6. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by project code number. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-14	George River weir	George	CK, CH, CO	ADFG/CF	Molyneaux	1996-current	OSM 2005
3	Escapement data	KFRC ON-14	George River weir	George	CK, CH, CO	ADFG/CF	Molyneaux	1996-current	OSM 2005
1	Spatiotemporal information on routine climatic variables	KFRC ON-15	Real time surface water data	Kuskokwim R at Crooked Creek		USGS		1952-current	NWISWeb 2004
1	Watershed geology, hydrology, and geomorphology data	KFRC ON-15	Real time surface water data	Kuskokwim R at Crooked Creek		USGS		1952-current	NWISWeb 2004
2	Characterization of reproductive biology	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Stream migration and total residence time of adults	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Total stream migration and residence time of adult salmon	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
3	Escapement data	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Characterization of reproductive biology	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004
2	Stream migration and total residence time of adults	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Total stream migration and residence time of adult salmon	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004
3	Escapement data	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-18	Kanektok River weir salmon escapement enumeration	Kanektok	CK, CH, PK, SK, CO	ADFG/CF		2004-2006	OSM 2004
3	Escapement data	KFRC ON-18	Kanektok River weir salmon escapement enumeration	Kanektok	CK, CH, PK, SK, CO	ADFG/CF		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-19	Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radio telemetry	Holitna	CK, CO, CH	ADFG/SF	Evenson	2000-2005	OSM 2004
3	Escapement data	KFRC ON-19	Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radio telemetry	Holitna	CK, CH, CO	ADFG/SF	Evenson	2000-2005	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-20	Kuskokwim River chum, sockeye, and coho salmon stock assessment	Kuskokwim	CH, SK, CO	ADFG/CF	Kerkvliet/Pawelek	2004-2006	OSM 2004
2	Total stream migration and residence time of adults	KFRC ON-20	Kuskokwim River chum, sockeye, and coho salmon stock assessment	Kuskokwim	CH, SK, CO	ADFG/CF	Kerkvliet/Pawelek	2004-2006	OSM 2004
3	Estimate of total run abundance spawning adults in the drainage	KFRC ON-20	Kuskokwim River chum, sockeye, and coho salmon stock assessment	Kuskokwim	CH, SK, CO	ADFG/CF	Kerkvliet/Pawelek	2004-2006	OSM 2004
1	Spatiotemporal information on routine climatic variables	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2002
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2004

Table 6. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by project code number. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
3	Escapement data	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2002
3	Effectiveness of inseason actions in accurately guiding harvest to meet escapement goals	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2004
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-22	Genetic variation among coho salmon populations from the Kuskokwim River region	Kuskokwim region	CO	USFWS	Crane	2004-2006	OSM 2004
1	Spatiotemporal information on routine climatic variables	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
2	Stream migration and residence time of adults	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
3	Escapement data	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
1	Spatiotemporal information on routine climatic variables	KFRC ON-24	Elders' TEK of 20th century ecosystems and fish pop changes	Kuskokwim Bay region	Salmon	Togiak NWR		2004	OSM 2004
2	Distribution, abundance, and run timing	KFRC ON-24	Elders' TEK of 20th century ecosystems and fish pop changes	Kuskokwim Bay region	Salmon	Togiak NWR		2004	OSM 2004
3	Inseason harvest	KFRC ON-25	Bethel area in-season subsistence salmon data collection	Kuskokwim region	CK	ONC		2004	OSM 2004
3	Inseason harvest	KFRC ON-26	Middle Kuskokwim River inseason subsistence salmon harvest data collection	Kuskokwim region	CK, SK, CH	KNA		2004	OSM 2004
4	Past, Present, and Future ANS	KFRC ON-27	Bethel, Aniak, Kuskokwim Area post-season subsistence harvest household surveys	Kuskokwim region	CK, SK, CH, CO	ADFG/DS		2004	OSM 2004
4	Past, Present, and Future subsistence use patterns	KFRC ON-27	Bethel, Aniak, Kuskokwim Area post-season subsistence harvest household surveys	Kuskokwim region	CK, SK, CH, CO	ADFG/DS		2004	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-28	Bethel drift gillnet	Kuskokwim	CK, SK, CH, CO	ADFG/CF		1983-current	Burkey et al 2000
2	Genetic diversity of salmon in the Kuskokwim Area	KFRC ON-28	Bethel drift gillnet	Kuskokwim	CK, SK, CH, CO	ADFG/CF		1983-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-29	In-river abundance of chinook salmon in the Kuskokwim River	Kuskokwim	CK	ADFG/SF	Stuby	2002-2006	OSM 2005
1	Spatiotemporal information on routine climatic variables	KFRC ON-30	Real time surface water data	Kuskokwim R at Lisky's Crossing		USGS		1952-current	NWISWeb 2004
2	Estimate of the risk of population extinction	KFRC ON-31	Effective population size of chinook salmon in the Kwethluk and Tuluksak rivers	Kwethluk, Tuluksak rivers	CK	USFWS	Olsen	2004-	AYK SSI 2005
2	Genetic diversity of salmon in the Kuskokwim Area	KFRC ON-31	Effective population size of chinook salmon in the Kwethluk and Tuluksak rivers	Kwethluk, Tuluksak rivers	CK	USFWS	Olsen	2004-	AYK SSI 2005
2	Juvenile distribution in drainage and downstream migration	KFRC ON-32	Goodnews/Carter Bay fish distribution	7 Goodnews/Carter tributaries	CO	BLM		2004	Scott 2003
3	Investigation of alternative methods for determining escapement goals	KFRC ON-33	Development of habitat-based escapement goals for chinook salmon	Kwethluk, Tuluksak rivers	CK, CH	USFWS/UAF	O'Brien	2004-	K. Harper
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-34	Characteristics of fall chum salmon in the Kuskokwim River drainage	Kuskokwim	CH	ADFG/CF	Gilk	2005	AYK SSI 2005

Table 6. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by project code number. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-34	Characteristics of fall chum salmon in the Kuskokwim River drainage	Kuskokwim	CH	ADFG/CF	Gilk	2005	AYK SSI 2005
3	Identify population units	KFRC ON-34	Characteristics of fall chum salmon in the Kuskokwim River drainage	Kuskokwim	CH	ADFG/CF	Gilk	2005	AYK SSI 2005
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-35	Description of chinook salmon sex ratios	Tuluksak, Kwethluk rivers	CK	USFWS	Crane	2002	P. Crane, Pers. Comm.
2	Juvenile distribution in drainage and downstream migration	KFRC ON-35	Description of chinook salmon sex ratios	Tuluksak, Kwethluk rivers	CK	USFWS	Crane	2002	P. Crane, Pers. Comm.
2	Prevalence, morbidity, and mort laity of disease in adults	KFRC ON-36	Environmental contaminants in Kuskokwim and Yukon River chinook and chum salmon	Kuskokwim at Bethel	CK, CH	USFWS	Matz	2001	A. Matz, Pers. Comm
1	Multiple	KFRC ON-37	Kwethluk biostation	Kwethluk	General	??	Stanford	2004-	M. Rearden, Pers. Comm.
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-38	Genetic stock ID of Kuskokwim River chinook salmon	Various	CK	ADFG/CF	Templin	2005-2007	OSM 2005
3	Identify population units	KFRC ON-38	Genetic stock ID of Kuskokwim River chinook salmon	Various	CK	ADFG/CF	Templin	2005-2007	OSM 2005
3	Stock composition of harvest	KFRC ON-38	Genetic stock ID of Kuskokwim River chinook salmon	Various	CK	ADFG/CF	Templin	2005-2007	OSM 2005
3	Harvest (direct and indirect sources of mortality)	KFRC ON-39	Kuskokwim River in-season subsistence salmon harvest data collection	Various	CK	ADFG/CF	Molyneaux	2005-2007	OSM 2005

Table 6. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by project code number. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
2	Juvenile salmon physiology, growth, and development	KFRC ON-40	Retrospective analysis of AYK Chinook growth in freshwater and marine habitats, 1964-2004	Kuskokwim	CH	USGS	Nielsen	2005	AYK SSI 2005
1	Seasonal patterns in climate variables	KFRC ON-41	Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Alan Peck, Water Resources Branch, USFWS	1998-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-41	Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Alan Peck, Water Resources Branch, USFWS	1998-2005	Pat Walsh, Togiak NWR
1	Watershed geology, hydrology, and geomorphology data	KFRC ON-41	Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Alan Peck, Water Resources Branch, USFWS	1998-2005	Pat Walsh, Togiak NWR
1	Seasonal patterns in climate variables	KFRC ON-42	Water temperature monitoring of 21 rivers throughout Togiak Refuge	Togiak NWR	Salmon	Togiak NWR	Pat Walsh, Togiak NWR	2001-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-42	Water temperature monitoring of 21 rivers throughout Togiak Refuge	Togiak NWR	Salmon	Togiak NWR	Pat Walsh, Togiak NWR	2001-2005	Pat Walsh, Togiak NWR
1	Watershed geology, hydrology, and geomorphology data	KFRC ON-42	Water temperature monitoring of 21 rivers throughout Togiak Refuge	Togiak NWR	Salmon	Togiak NWR	Pat Walsh, Togiak NWR	2001-2005	Pat Walsh, Togiak NWR
1	Seasonal patterns in climate variables	KFRC ON-43	Routine monitoring of climatic variables by NOAA (e.g., at Bethel airport)	Various	Salmon	NOAA		?	http://www.ncdc.noaa.gov/oa/ncdc.html
1	Spatiotemporal information on routine climatic variables	KFRC ON-43	Routine monitoring of climatic variables by NOAA (e.g., at Bethel airport)	Various	Salmon	NOAA		?	http://www.ncdc.noaa.gov/oa/ncdc.html
1	Seasonal patterns in climate variables	KFRC ON-44	Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period	Togiak NWR	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-44	Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period	Togiak NWR	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Interactions within and among land, water, and the atmosphere	KFRC ON-45	Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak National Wildlife Refuge	Arolik Lake	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Seasonal patterns in climate variables	KFRC ON-45	Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak National Wildlife Refuge	Arolik Lake	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-45	Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak National Wildlife Refuge	Arolik Lake	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	River, lentic, and estuarine habitat classifications, and their associated terrestrial zones	KFRC ON-46	Land cover map of the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Pat Walsh	2002-2005	Pat Walsh

	Species codes	CO= coho	Organization codes	ADFG = Alaska Department of Fish and Game	NVK = Native Village of Kwinhagak
		CH = chum		CF = Commercial Fisheries	OSM = Office of Subsistence
		CK = chinook		BLM = Bureau of Land Management	ONC = Oritsararmuit Native Council
		SK = sockeye		DS = Division of Subsistence	Togiak NWR = Togiak National Wildlife
		PK = pink		KNA = Kuskokwim Native Association	TTC = Takotna Tribal Council
				NPS = National Park Service	UAF = University of Alaska Fairbanks
					USFWS = US Fish and Wildlife Service

Table 7. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by Goal and Information Need. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
1	Interactions within and among land, water, and the atmosphere	KFRC ON-45	Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak National Wildlife Refuge	Arolik Lake	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Multiple	KFRC ON-37	Kwethluk biostation	Kwethluk	General	??	Stanford	2004-	M. Rearden, Pers. Comm.
1	River, lentic, and estuarine habitat classifications, and their associated terrestrial zones	KFRC ON-46	Land cover map of the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Pat Walsh	2002-2005	Pat Walsh
1	Seasonal patterns in climate variables	KFRC ON-41	Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Alan Peck, Water Resources Branch, USFWS	1998-2005	Pat Walsh, Togiak NWR
1	Seasonal patterns in climate variables	KFRC ON-42	Water temperature monitoring of 21 rivers throughout Togiak Refuge	Various	Salmon	Togiak NWR	Pat Walsh, Togiak NWR	2001-2005	Pat Walsh, Togiak NWR
1	Seasonal patterns in climate variables	KFRC ON-43	Routine monitoring of climatic variables by NOAA (e.g., at Bethel airport)	Various	Salmon	NOAA		?	http://www.ncdc.noaa.gov/oa/ncdc.html
1	Seasonal patterns in climate variables	KFRC ON-44	Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period	Togiak NWR	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Seasonal patterns in climate variables	KFRC ON-45	Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak National Wildlife Refuge	Arolik Lake	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-09	Takotna River weir	Takotna	CK, CO, CH	ADFG/CF	Molyneaux	2000 -	OSM 2005
1	Spatiotemporal information on routine climatic variables	KFRC ON-14	George River weir	George	CK, CH, CO	ADFG/CF	Molyneaux	1996-current	OSM 2005
1	Spatiotemporal information on routine climatic variables	KFRC ON-15	Real time surface water data	Kuskokwim R at Crooked Creek		USGS		1952-current	NWISWeb 2004
1	Spatiotemporal information on routine climatic variables	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2002
1	Spatiotemporal information on routine climatic variables	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
1	Spatiotemporal information on routine climatic variables	KFRC ON-24	Elders' TEK of 20th century ecosystems and fish pop changes	Kuskokwim Bay region	Salmon	Togiak NWR		2004	OSM 2004
1	Spatiotemporal information on routine climatic variables	KFRC ON-30	Real time surface water data	Kuskokwim R at Lisky's Crossing		USGS		1952-current	NWISWeb 2004
1	Spatiotemporal information on routine climatic variables	KFRC ON-41	Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Alan Peck, Water Resources Branch, USFWS	1998-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-42	Water temperature monitoring of 21 rivers throughout Togiak Refuge	Various	Salmon	Togiak NWR	Pat Walsh, Togiak NWR	2001-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-43	Routine monitoring of climatic variables by NOAA (e.g., at Bethel airport)	Various	Salmon	NOAA		?	http://www.ncdc.noaa.gov/oa/ncdc.html
1	Spatiotemporal information on routine climatic variables	KFRC ON-44	Estimating climatic variation (cycling of temperature and precipitation) in southwestern Alaska in the Holocene period	Togiak NWR	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR
1	Spatiotemporal information on routine climatic variables	KFRC ON-45	Hydrological and sedimentological monitoring to calibrate paleoclimate proxies, Arolik Lake, Togiak National Wildlife Refuge	Arolik Lake	Salmon	Northern Arizona University	Darrell Kaufman	2003-2005	Pat Walsh, Togiak NWR

Table 7. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by Goal and Information Need. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
1	Watershed geology, hydrology, and geomorphology data	KFRC ON-15	Real time surface water data	Kuskokwim R at Crooked Creek		USGS		1952-current	NWISWeb 2004
1	Watershed geology, hydrology, and geomorphology data	KFRC ON-41	Baseline monitoring - discharge and water quality on 18 rivers in the Togiak NWR	Togiak NWR	Salmon	Togiak NWR	Alan Peck, Water Resources Branch, USFWS	1998-2005	Pat Walsh, Togiak NWR
1	Watershed geology, hydrology, and geomorphology data	KFRC ON-42	Water temperature monitoring of 21 rivers throughout Togiak Refuge	Togiak NWR	Salmon	Togiak NWR	Pat Walsh, Togiak NWR	2001-2005	Pat Walsh, Togiak NWR
2	Characterization of reproductive biology	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Characterization of reproductive biology	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004
2	Distribution of juvenile salmon in the drainage	KFRC ON-09	Takotna River weir	Takotna	CK, CO	ADFG/CF	Molyneaux	2000 -	OSM 2005
2	Distribution of juveniles in the drainage and their downstream migration timing	KFRC ON-01	Lower Kuskokwim River juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Zimmerman and Meka 2004
2	Distribution of juveniles in the drainage and their downstream migration timing	KFRC ON-02	Kuskokwim Bay juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Hillgruber et al. 2004
2	Distribution, abundance, and run timing	KFRC ON-24	Elders' TEK of 20th century ecosystems and fish pop changes	Kuskokwim Bay region	Salmon	Togiak NWR		2004	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-05	Aniak River sonar	Aniak	CH	ADFG/CF		1980-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-06	Kanektok River weir	Kanektok	CK, CH, CO, SK	NVK		1999-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-07	Kogrukluk River weir	Kogrukluk	CK, SK, CH, CO	ADFG/CF		1976-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-08	Middle Fork Goodnews weir	Middle Fork Goodnews	CK, SK, CH, PK, CO	ADFG/CF		1991-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-09	Takotna River weir	Takotna	CK, CO, CH	ADFG/CF	Molyneaux	2000 -	OSM 2005
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-14	George River weir	George	CK, CH, CO	ADFG/CF	Molyneaux	1996-current	OSM 2005
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-18	Kanektok River weir salmon escapement enumeration	Kanektok	CK, CH, PK, SK, CO	ADFG/CF		2004-2006	OSM 2004

Table 7. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by Goal and Information Need. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-19	Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radio telemetry	Holitna	CK, CO, CH	ADFG/SF	Evenson	2000-2005	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-20	Kuskokwim River chum, sockeye, and coho salmon stock assessment	Kuskokwim	CH, SK, CO	ADFG/CF	Kerkvliet/Pawelek	2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-28	Bethel drift gillnet	Kuskokwim	CK, SK, CH, CO	ADFG/CF		1983-current	Burkey et al 2000
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-29	In-river abundance of chinook salmon in the Kuskokwim River	Kuskokwim	CK	ADFG/SF	Stuby	2002-2006	OSM 2005
2	Distribution, abundance, and run timing of spawning adults in the drainage	KFRC ON-34	Characteristics of fall chum salmon in the Kuskokwim River drainage	Kuskokwim	CH	ADFG/CF	Gilk	2005	AYK SSI 2005
2	Estimate of the risk of population extinction	KFRC ON-31	Effective population size of chinook salmon in the Kwethluk and Tuluksak rivers	Kwethluk, Tuluksak rivers	CK	USFWS	Olsen	2004-	AYK SSI 2005
2	Feeding ecology (diet) of juveniles	KFRC ON-02	Kuskokwim Bay juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Hillgruber et al. 2004
2	Genetic diversity of salmon in the Kuskokwim Area	KFRC ON-28	Bethel drift gillnet	Kuskokwim	CK, SK, CH, CO	ADFG/CF		1983-current	Burkey et al 2000
2	Genetic diversity of salmon in the Kuskokwim Area	KFRC ON-31	Effective population size of chinook salmon in the Kwethluk and Tuluksak rivers	Kwethluk, Tuluksak rivers	CK	USFWS	Olsen	2004-	AYK SSI 2005
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-22	Genetic variation among coho salmon populations from the Kuskokwim River region	Kuskokwim region	CO	USFWS	Crane	2004-2006	OSM 2004
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-34	Characteristics of fall chum salmon in the Kuskokwim River drainage	Kuskokwim	CH	ADFG/CF	Gilk	2005	AYK SSI 2005
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-35	Description of chinook salmon sex ratios	Tuluksak, Kwethluk rivers	CK	USFWS	Crane	2002	P. Crane, Pers. Comm.
2	Genetic diversity of salmon residing in and returning to the Kuskokwim Area	KFRC ON-38	Genetic stock ID of Kuskokwim River chinook salmon	Various	CK	ADFG/CF	Templin	2005-2007	OSM 2005
2	Juvenile distribution in drainage and downstream migration	KFRC ON-32	Goodnews/Carter Bay fish distribution	7 Goodnews/Carter tributaries	CO	BLM		2004	Scott 2003
2	Juvenile distribution in drainage and downstream migration	KFRC ON-35	Description of chinook salmon sex ratios	Tuluksak, Kwethluk rivers	CK	USFWS	Crane	2002	P. Crane, Pers. Comm.
2	Juvenile physiology, growth, and development	KFRC ON-01	Lower Kuskokwim River juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Zimmerman and Meka 2004
2	Juvenile physiology, growth, and development	KFRC ON-02	Kuskokwim Bay juvenile chum salmon studies	Kuskokwim	CH	USGS		2003 -	Hillgruber et al. 2004

Table 7. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by Goal and Information Need. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
2	Juvenile salmon physiology, growth, and development	KFRC ON-40	Retrospective analysis of AYK Chinook growth in freshwater and marine habitats, 1964-2004	Kuskokwim	CH	USGS	Nielsen	2005	AYK SSI 2005
2	Prevalence, morbidity, and mort laity of disease in adults	KFRC ON-36	Environmental contaminants in Kuskokwim and Yukon River chinook and chum salmon	Kuskokwim at Bethel	CK, CH	USFWS	Matz	2001	A. Matz, Pers. Comm
2	Stream migration and residence time of adults	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
2	Stream migration and total residence time of adults	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Stream migration and total residence time of adults	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Total stream migration and residence time of adult salmon	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
2	Total stream migration and residence time of adult salmon	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004
2	Total stream migration and residence time of adults	KFRC ON-20	Kuskokwim River chum, sockeye, and coho salmon stock assessment	Kuskokwim	CH, SK, CO	ADFG/CF	Kerkvliet/Pawelek	2004-2006	OSM 2004
3	Effectiveness of inseason actions in accurately guiding harvest to meet escapement goals	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2004
3	Escapement data	KFRC ON-03	Aerial surveys	Kanektok, Goodnews rivers	SK	ADFG/CF		?	Burkey et al 2000
3	Escapement data	KFRC ON-04	Aerial surveys	Kuskokwim Area	CK	ADFG/CF		1976-current	Burkey et al 2000
3	Escapement data	KFRC ON-05	Aniak River sonar	Aniak	CH	ADFG/CF		1980-current	Burkey et al 2000
3	Escapement data	KFRC ON-06	Kanektok River weir	Kanektok	CK, CH, CO, SK	NVK		1999-current	Burkey et al 2000
3	Escapement data	KFRC ON-07	Kogrukluk River weir	Kogrukluk	CK, SK, CH, CO	ADFG/CF		1976-current	Burkey et al 2000
3	Escapement data	KFRC ON-08	Middle Fork Goodnews weir	Middle Fork Goodnews	CK, SK, CH, PK, CO	ADFG/CF		1991-current	Burkey et al 2000
3	Escapement data	KFRC ON-09	Takotna River weir	Takotna	CK, CO, CH	ADFG/CF	Molyneaux	2000 -	OSM 2005
3	Escapement data	KFRC ON-14	George River weir	George	CK, CH, CO	ADFG/CF	Molyneaux	1996-current	OSM 2005
3	Escapement data	KFRC ON-16	Abundance and run timing of adult salmon in the Kwethluk River	Kwethluk	CK, CH, SK, CO, PK	USFWS		2004-2006	OSM 2004
3	Escapement data	KFRC ON-17	Abundance and run timing of adult salmon in the Tuluksak River	Tuluksak	CK, CH, PK, SK, CO	USFWS		2004-2006	OSM 2004

Table 7. Salmon-related projects underway in the Kuskokwim Area, 2004, sorted by Goal and Information Need. Projects listed duplicate times if they strongly address multiple Information Needs.

Updated 10/18/05 Goal addressed	Information Need addressed	KFRC Project code	Project title	Location	Species	Lead organization	Lead contact	Years operated	Reference
3	Escapement data	KFRC ON-18	Kanektok River weir salmon escapement enumeration	Kanektok	CK, CH, PK, SK, CO	ADFG/CF		2004-2006	OSM 2004
3	Escapement data	KFRC ON-19	Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radio telemetry	Holitna	CK, CH, CO	ADFG/SF	Evenson	2000-2005	OSM 2004
3	Escapement data	KFRC ON-21	Tatlawiksuk River salmon weir	Tatlawiksuk	CK, CO, CH	ADFG/CF		1998-2006	OSM 2002
3	Escapement data	KFRC ON-23	Middle Fork Goodnews River coho salmon escapement enumeration	Middle Fork Goodnews	CO	ADFG/CF		2004-2006	OSM 2004
3	Estimate of total run abundance spawning adults in the drainage	KFRC ON-20	Kuskokwim River chum, sockeye, and coho salmon stock assessment	Kuskokwim	CH, SK, CO	ADFG/CF	Kerkvliet/Pawelek	2004-2006	OSM 2004
3	Harvest (direct and indirect sources of mortality)	KFRC ON-10	Catch and effort assessment - sport fish	Kuskokwim Area	Salmon	ADFG/SF		? - current	Burkey et al 2000
3	Harvest (direct and indirect sources of mortality)	KFRC ON-11	Catch and effort assessment - commercial fish	Kuskokwim Area	Salmon	ADFG/CF		1960-current	Burkey et al 2000
3	Harvest (direct and indirect sources of mortality)	KFRC ON-12	Kuskokwim Area post-season subsistence salmon surveys	Kuskokwim Area	CK, SK, CH, CO	ADFG/DS	Krauthoefer	1960-current	OSM 2005
3	Harvest (direct and indirect sources of mortality)	KFRC ON-39	Kuskokwim River in-season subsistence salmon harvest data collection	Various	CK	ADFG/CF	Molyneaux	2005-2007	OSM 2005
3	Identify population units	KFRC ON-34	Characteristics of fall chum salmon in the Kuskokwim River drainage	Kuskokwim	CH	ADFG/CF	Gilk	2005	AYK SSI 2005
3	Identify population units	KFRC ON-38	Genetic stock ID of Kuskokwim River chinook salmon	Various	CK	ADFG/CF	Templin	2005-2007	OSM 2005
3	Inseason harvest	KFRC ON-25	Bethel area in-season subsistence salmon data collection	Kuskokwim region	CK	ONC		2004	OSM 2004
3	Inseason harvest	KFRC ON-26	Middle Kuskokwim River inseason subsistence salmon harvest data collection	Kuskokwim region	CK, SK, CH	KNA		2004	OSM 2004
3	Investigation of alternative methods for determining escapement goals	KFRC ON-33	Development of habitat-based escapement goals for chinook salmon	Kwethluk, Tuluksak rivers	CK, CH	USFWS/UAF	O'Brien	2004-	K. Harper
3	Stock composition of harvest	KFRC ON-13	ASL sampling	Kuskokwim Area	CK, SK, CH, CO	ADFG/CF		1961-current	Burkey et al 2000
3	Stock composition of harvest	KFRC ON-38	Genetic stock ID of Kuskokwim River chinook salmon	Various	CK	ADFG/CF	Templin	2005-2007	OSM 2005
4	Past, Present, and Future ANS	KFRC ON-27	Bethel, Aniak, Kuskokwim Area post-season subsistence harvest household surveys	Kuskokwim region	CK, SK, CH, CO	ADFG/DS		1960-current	OSM 2004
4	Past, Present, and Future subsistence use patterns	KFRC ON-27	Bethel, Aniak, Kuskokwim Area post-season subsistence harvest household surveys	Kuskokwim region	CK, SK, CH, CO	ADFG/DS		1960-current	OSM 2004

	Species codes	CO= coho	Organization codes	ADFG = Alaska Department of Fish and Game	NVK = Native Village of Kwinhagak
		CH = chum		CF = Commercial Fisheries	OSM = Office of Subsistence
		CK = chinook		BLM = Bureau of Land Management	ONC = Oritsararmuit Native Council
		SK = sockeye		DS = Division of Subsistence	Togiak NWR = Togiak National Wildlife
		PK = pink		KNA = Kuskokwim Native Association	TTC = Takotna Tribal Council
				NPS = National Park Service	UAF = University of Alaska Fairbanks
					USFWS = US Fish and Wildlife Service