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GEM PROPOSAL SUMMARY PAGE

(To be filled in by proposer)

Project Title: Reconstructing Sockeye Populations in the Gulf of Alaska over the Last Several Thousand Years: The Natural Background to Future Changes

Project Period: FY 04-FY 05

Proposer(s): Daniel Mann, Institute of Arctic Biology, University of Alaska
Bruce Finney, Institute of Marine Sciences, University of Alaska

Study Location: Prince William Sound, Kodiak, Kenai Peninsula

Abstract: We are reconstructing changes in sockeye salmon abundance over the last 10,000 years using the ^{15}N record left by salmon carcasses in the sediments of spawning lakes. Our research question is: ***What is the normal variability in sockeye salmon populations in the Gulf of Alaska and how does it relate to climatic changes in the Gulf of Alaska region?*** Our results provide a much-needed background to monitoring studies within the GEM program and to fisheries managers who are working to preserve and restore natural salmon runs. Results from 2002 and 2003 include two, new and unexpectedly complete records of salmon abundance in lakes on the Kenai Peninsula. Both records extend back to the time of regional deglaciation around 10,000 years ago. These new cores provide records of changing ^{15}N that are five times longer than any previous record of salmon-run history. The unexpected length and richness of these new lake-core records have motivated us to request additional funds from EVOS to cover an additional year of full funding followed by a final year of analysis and synthesis

Funding:	EVOS Funding Requested:	FY 04	$ 92.5	
		FY 05	$ 26	
	TOTAL:		$ 118.5	
	Non-EVOS Funds to be Used:	FY 04	$	
		FY 05	$	
		FY 06	$	TOTAL: $118.5

Date: June 2003

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Reconstructing Sockeye Populations in the Gulf of Alaska over the Last Several Thousand Years: The Natural Background to Future Changes

Project Number:	030649
Restoration Category:	Research and monitoring
Proposers:	Mann and Finney, University of Alaska
Lead Trustee Agency:	ADFG
Cooperating Agencies:	none
Alaska Sea Life Center:	No
Cost FY 04:	$92.5
Cost FY 05:	$26.0
Geographic areas:	Prince William Sound, Kodiak, Kenai Peninsula
Injured Resource/Service:	Sockeye salmon, GEM Transition, retrospective study

ABSTRACT

We are reconstructing changes in sockeye salmon abundance over the last 10,000 years using the ^{15}N record left by salmon carcasses in the sediments of spawning lakes in Prince William Sound, the Kenai Fjords, the Kenai River watershed, and on Kodiak Island. Our research question is: *What is the normal variability in sockeye salmon populations in the Gulf of Alaska and how does it relate to climatic changes in the Gulf of Alaska region?* Our results provide a much-needed background to monitoring studies within the GEM program and to fisheries managers who are working to preserve and restore natural salmon runs. Results from 2002 and 2003 include two, new and unexpectedly complete records of salmon abundance in lakes on the Kenai Peninsula. Both records extend back to the time of regional deglaciation around 10,000 years ago. These new cores provide records of changing ^{15}N that are five times longer than any previous record of salmon-run history. The unexpected length and richness of these new lake-core records have motivated us to request additional funds from EVOS to cover an additional year of analysis and synthesis

INTRODUCTION

A. Laying a foundation for GEM

A priority for proposals solicited by EVOS for FY 03 is to establish a foundation for the GEM program. The primary mission of the Gulf Environmental Monitoring Program is to understand how natural and human-caused changes affect marine ecosystems in the northern Gulf of Alaska (GOA). We can learn a lot about present ecosystems by documenting their past responses to global changes and human activities. Information on ecosystem history can help us predict future changes. Here we propose the final two years of a retrospective study of sockeye abundance in Prince William Sound and in the Kenai River watershed using the stable isotope tracers present in the sediments of spawning lakes. Our goal is to describe changes in sockeye salmon abundance over the last several millennia and to relate these changes to shifts in the climate/ocean system of the GOA and to human activities.

B. Sockeye salmon

Sockeye are an important resource for Native subsistence and for commercial and recreational fishing. The Trustee Council has previously made large investments in sockeye salmon recovery by purchases of stream bank, lakeside, and watershed habitats and by funding studies that detail the effects of over escapement caused by the spill. The over escapement impact was caused by the return of larger than normal numbers of spawning fish because of fisheries closures resulting from concern over oil contamination. Increased juvenile sockeye populations caused overgrazing of zooplankton stocks in spawning lakes, with consequent effects throughout the food chain. Growth rates were reduced during the freshwater part of the sockeyes' life history, and declines occurred in the health of adult fish. We have little idea about the relative severity of these over escapement effects relative to natural, prehistoric variations in sockeye populations.

C. The importance of retrospective studies

Retrospective studies like the one we propose here directly address the GEM program's goals of detecting and understanding of changes in the GOA ecosystem. To detect trends of change, we need historical data. To disentangle human-caused from nature-caused changes, we need historical data that extend back before the arrival of Europeans in the region (e.g., Finney et al., 2000; 2002). To understand the marine ecosystem, we need to describe the natural changes upon which human influences are superimposed. By understanding what happened in the past, we gain valuable perspectives on the present. In this time of global changes, learning how species and ecosystems responded to previous shifts in the environment can inform us about their future responses.

D. Previous retrospective studies of salmon populations

Finney et al. (2000) describe a 300-year record of sockeye population changes in seven lakes on Kodiak Island and the Alaska Peninsula using measurements of marine-derived nitrogen preserved in the bottom sediments of spawning lakes (Fig. 1). Marked changes in population size were found both before and after the start of intensive fisheries around AD 1900. The prehistoric changes are related to climate change (see next section), and the post-1900 changes to a combination of both climate change and fishery activity. The ^{15}N method provides a powerful tool for reconstructing changes in salmon populations in the GOA region. More recent work (Finney et al. 2002) extended records back more than 2000 years, and found evidence for regimes of both higher and lower productivity that lasted for several hundred years, superimposed on the decadal-scale variability such as observed historically. The changes in salmon returns were accompanied by large changes in lake plankton productivity, most likely due to changes in marine-nutrient input. The timing of changes in Alaska sockeye populations was similar to sardines and other fish in the California current system, demonstrating the basin-wide effects of climatic change on North Pacific fish stocks.

E. Progress to Date on EVOS Project 649

So far our project has produced some exciting and unexpected results. We are in the middle of analysis right now, so the description provided here is preliminary. Three results stand out. First, we were able to recover long sediment cores that span the last 10,000 years from both Eshamy and Upper Russian Lake. ^{15}N records covering the entire period from the last ice age to the present day provide the type of long time series that are necessary to understand how salmon respond to climatic changes. These new ^{15}N records are five times longer than anything previously known.

Our second interesting result is that the ^{15}N record from Eshamy Lake shows a slow "ramping-up" in salmon abundance between 10,000 years ago and ca. 4000 years ago. This gradual increase in run size over a 6000-year period may reflect the long-term, cumulative fertilization of the limnic ecosystem by the input of pelagic nutrients by spawning salmon. A similar "ramping-up" of salmon run sizes is suggested from the preliminary ^{15}N data in a new core we collected from Karluk Lake last summer.

The third result that most intrigues us now is that salmon populations in Eshamy, Karluk, and Iliamna Lakes seem to have fluctuated synchronously at some times in the past but not at all times. Synchronous fluctuations of salmon populations throughout the Gulf of Alaska region would be strong evidence of the action of a shared climatic and/or oceanographic driver. In contrast, asynchronous fluctuations of salmon populations in different lakes suggest an individualized response of different spawning systems and some sort of internal control. Obviously, detailed depth-age curves are required from each lake record to make judgments about synchronicity. This is currently the focus of our laboratory work.

We have obtained more data than we anticipated in the original proposal. This happened because the sedimentary records recovered from Eshamy and Upper Russian Lakes were unexpectedly long. Moreover, these records are unexpected rich in terms of the detail they contain. ^{15}N content does not vary up core in a simple and uniform way. Instead there is high variability in the ^{15}N

records, which is exciting because it implies that these lakes were experiencing radical shifts in salmon run size throughout their histories.

BACKGROUND

A. Recent changes in the GOA atmosphere/ocean system

The northern Gulf of Alaska has seen dramatic environmental changes over the last several millennia, many of which resulted from shifts in the position and intensity of the Aleutian Low (Cayan and Peterson, 1989; Lackmann and Gyakum, 1996; Mock et al., 1998). The intensity of the Aleutian Low varies at all time scales, though only those within the span of the instrumental record (ca. 100 years) are known with any certainty (Francis et al., 1997). The best studied of these variations is the Pacific Interdecadal Oscillation (PDO), which is the coupled variation in sea surface temperature (SST) and sea level pressure (SLP) resulting from the alternation between two, self-reinforcing, and quasi-stable circulation regimes in the North Pacific climate system (Latif and Barnett, 1996; Minobe, 1997; Overland et al., 1999). The PDO has undergone two complete oscillations since AD 1900 (Mantua et al., 1997). During positive phases of the PDO, the Aleutian Low moves eastward and intensifies, resulting in increased precipitation along the coast of the Gulf of Alaska. SSTs are cooler in the Alaska Gyre but warmer in nearshore waters. During negative phases of the PDO, the central northeastern Pacific warms, the Aleutian Low weakens, coastal precipitation lessens, and nearshore temperatures warm. Longer time-scale fluctuations (centuries to millennia) have occurred repeatedly in the North Pacific climate system (Mann et al., 1999). Studies of coastal tree rings extend the PDO record back to AD 1760 (Wiles et al., 1996, 1998, 199a).

Most of our proxy data for GOA climate prior to AD 1900 come from terrestrial sources (Mann and Hamilton, 1995). Both the Medieval Warm Period (ca. AD 900-1250) and the Little Ice Age (ca. AD 1250-1900) occurred in the GOA region, where they are evidenced by glacier fluctuations and by climatic changes recorded in tree rings (Wiles and Calkin, 1994; Wiles et al., 1998; Wiles et al., 1999 b). Fluctuations in summer temperature of several degrees centigrade are suggested (Wiles et al., 1996). The Medieval Warm Period is especially interesting for us today because it was the last time when global temperatures approached their post-1900 AD levels.

Moving further back in time, the Neoglacial interval (ca. 6000 BP – AD 1900) saw alternating cold and warm intervals each lasting several hundred years to one millennium (Calkin, 1988). Precipitation fluctuated as well, and in combination with temperature changes, caused snowlines to rise and fall by several hundred meters. Transitions from milder to colder conditions during the Neoglacial occurred rapidly in the space of several years to several decades. In general terms, the magnitudes and rates of natural climate changes occurring in the GOA over the last several millennia are similar to those predicted to occur over the next several centuries (Mann et al., 1999). In effect, nature has done a series of experiments in the past about how the GOA ecosystem may respond to future changes in the atmosphere-ocean system.

B. Salmon responses to changes in the atmosphere/ocean system

Climatic shifts have dramatic effects on the biota of the North Pacific, including salmon, at a variety of time scales (Finney et al., 2002). Climate variability is linked to ecosystem change in the North Pacific primarily through its forcing effects on lower trophic levels (Francis et al., 1997). These effects work their way through the food web and are modified as they proceed by species' life histories, subsistence strategies, and by top-down effects like predation. Intensification of the Aleutian Low during phases of positive PDO triggers increased zooplankton biomass in the Alaskan Gyre, probably in response to increased wind-induced upwelling and vertical mixing (Brodeur and Ware, 1992; Brodeur et al., 1996; Sugimoto and Tadokoro, 1997). Phytoplankton and zooplankton populations seem to have increased during the reorganization of upper ocean circulation in response to the 1976/1977 regime shift (Francis et al., 1998).

Some of the most dramatic effects of climatic shifts on the marine biota are evident in the histories of salmon catches (Downton and Miller, 1998). Salmon catches in Gulf of Alaska waters closely track the PDO oscillation, with stock size positively correlated with the average winter/spring strength of the Aleutian Low (Beamish and Bouillon, 1993; Mantua et al., 1997). Northern (Alaskan) and southern (Oregon, California) salmon stocks vary roughly 180^o out of phase (Francis and Sibley, 1991; Gargett, 1997).

There is no generally accepted explanation for how the Aleutian Low controls salmon populations in the North Pacific (Francis et al., 1998). One possible explanation is that increased wind mixing stimulates primary productivity in the Alaska Gyre, which provides more food for young salmon during the early marine stages of their lives. Gargett (1997) suggests that the critical link between physical forcing and salmon survival is the enhanced water-column stability in coastal areas during positive PDO phases, which increases primary productivity and subsequently food supply for salmon juvenile stages. Increased stream flow caused by increased rainfall in coastal areas during positive PDO phases may increase spawning success and hatchling survival. Probably all these factors interact to increase salmon stocks during positive phases of the PDO. Historical records are too short to tell us how climate/oceanographic parameters affect salmon populations.

C. Stable Isotopes in lake sediments as records of salmon abundance

Measurements of the natural abundance of stable isotopes make it possible to trace the flow of selected elements in ecosystems (Fry and Sherr, 1984; Owens, 1987; Peterson and Howarth, 1987; Wada et al., 1987). This has application in anadromous Pacific salmon systems because of the dichotomous nature of the two important nitrogen (N) sources, which are marine N from the decay of carcasses of returning adult salmon, and atmospheric N_2 (Kline, 1991). The two sources of N can be distinguished by del^{15}N, which is defined as the per mil difference in $^{15}N/^{14}N$ compared to an air N_2 isotope standard. The premise underlying the use of stable isotope abundance is the relative enrichment of ^{15}N in Pacific salmon (~ +12) in comparison with atmospheric N_2 (0). Food webs based on N_2 fixation tend to be low in ^{15}N (Minagawa and Wada, 1984; Owens, 1987; Wada and Hattori, 1991).

When Pacific salmon return to freshwater to spawn and die, they import significant quantities of marine-derived nutrients. Because these nutrients carry a distinctive signature of heavy nitrogen (^{15}N), the amount of ^{15}N present in the accumulating in the sediments of the spawning lake can be used as a proxy for escapement (Kline, 1991). Studies have quantified the proportion of marine-derived nitrogen (MDN) released by adult salmon as a result of spawning migration (Kline et al., 1993). Measurable shifts in the MDN content of juvenile sockeye have been observed between years of strong and weak escapement. The N-isotope composition of lake biota reflects the recent history of MDN import into the lake ecosystem (Kline et al., 1993; 1994). In some lakes, this signal is transferred to the underlying sediments. Downcore changes in the abundance of MDN can reflect changes in the number of returning adult salmon (Finney et al., 2000).

Data from Karluk and Frazer Lakes on Kodiak Island indicate that sedimentary del^{15}N closely tracks sockeye escapement (Fig. 1, Finney et al., 2000). We chose Frazer Lake as a test case for this method, as the lake was a "barren system" isolated by a waterfall from salmon prior to stocking in the late 1950s. Subsequently, a fish bypass was constructed and run size significantly increased, with an average escapement of about 200,000 since 1980 (Blackett, 1979; ADF&G, written comm., 1994). Such a large increase in escapement is clearly recorded by sedimentary del^{15}N (Fig. 1). The enrichment in del^{15}N is significant and strongly supports the hypothesis that sediment del^{15}N is influenced by salmon input of MDN. Similarly, data from Karluk Lake indicate a strong relationship between sediment del^{15}N and salmon escapement (Finney et al., 2000). Karluk Lake, one of the greatest sockeye systems in the world, had historical returns >5 million fish. Escapements averaged more than 1 million fish from the turn of the century until about 1935 but then fell to an average of less than 300,000 in the 1960s and 70s (Fig. 1; Koenings and Burkett, 1987a, ADF&G, written comm., 1994). The sedimentary del^{15}N in Karluk is significantly higher than Frazer, and it is consistent with greater salmon escapement. The large decline in sedimentary del^{15}N of about 3 parts per mil towards the top of the core reflects the decline in escapement in this system since the 1930s. These results indicate that sedimentary del^{15}N provides a valuable tool for reconstructing long-term changes in sockeye abundance.

NEED FOR THIS PROJECT

A. The Problem: What is "normal" for sockeye populations?

The recovery objective set by the EVOS Trustee Council for sockeye salmon is that adult returns-per-spawner should regain normal levels. But what is normal? If both the global environment fisheries management were stable then we might be able to define "normal". But change reigns in both nature and society, and what is normal for the last several decades may be unusual over longer time spans.

The retrospective studies we propose here can establish long-term, baseline records of changes in salmon populations in the GOA. We can use these records to define normalcy by estimating the frequency with which the observed population size occurred in the past. By knowing the extremes of natural population fluctuations in the past, we can identify abnormal population excursions as they occur in the future.

Understanding how environmental factors affect salmon populations is crucial for fisheries management in a time of global change. Also, sockeye may prove to be a useful indicator species for events within the larger GOA ecosystem. Before we can use sockeye as an indicator species, we need to understand how nonhuman factors control their numbers. From retrospective studies, we can generate testable hypotheses about how changes in the atmosphere/ocean system of the GOA will affect salmon populations in the near future. Nature has performed a series of experiments in past millennia, and we can gain access to the results of these experiments through analyses of del^{15}N in lake sediments.

B. Links: Giving GEM a time perspective

The goals of GEM are to detect, understand, and predict ecosystem changes in the GOA with the purpose of informing and assisting resource managers. Besides providing a more rigorous means of defining what is normal, our study will help lay the foundations for GEM by generating hypotheses that relate changes in the atmosphere/ocean system of the GOA to fluctuations in salmon numbers. The past is the key to the present, and climate has varied repeatedly over the last 2000 years. How did sockeye population respond to changes of several C^{o} in the past? The last time temperatures were as warm as today was during the Medieval Warm Period (AD 900-1250). How did sockeye populations respond to this previous warm period? Now that we have ^{15}N records spanning the last 10,000 years, we can also ask how salmon responded to the Hypsithermal Interval, a period of warmer-than-modern temperatures that lasted roughly three thousand years between 9000 and 6000 yr B.P. And how did salmon respond to the general intensification of global atmospheric circulation that occurred around 3000 yr B.P. at the start of the Neoglacial interval? These are all questions we can address with these new data series, once we have sufficient age control over the sedimentary record of ^{15}N.

In addition, we propose to add analyses to our existing cores to explore links between marine-derived nutrients and lake productivity, a topic of interest for the GEM watersheds research theme. We propose to add analyses of lake productivity indicators (diatom abundance/opal, organic C, and del^{13}C) to our existing analytical sequence. These additional data can be produced at relatively low cost. The new data will allow us to make direct comparisons between the marine-nutrient loading of lake systems and variability in the primary productivity of these same lakes.

C. Study Sites

To decipher the natural causes of changes in salmon abundance, it is necessary to study multiple lakes located in different parts of the Gulf of Alaska region. Lakes differ in their location relative to oceanic and atmospheric circulation patterns, in the degree to which they are influenced by glacial activity, and in the extent of human impact on their salmon runs. Our EVOS-funded study involves sockeye lakes in the northern GOA region that were affected by over escapement after the 1989 oil spill. They include Eshamy Lake in Prince Wiulliam Sound, Delight and Desire Lakes in Kenai Fjords, and Upper Russian, Skilak, and Hidden Lakes in the Kenai River watershed. To give us regional coverage, we are drawing on previous and ongoing studies by Finney of lake systems on Kodiak Island and on the Alaska Peninsula. The primary Kodiak lakes on interest are Karluk and Red Lakes with their enormous sockeye runs and Frazer Lake, a “barren” lake that provides a control for ^{15}N that was not derived from salmon.

COMMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Archaeological records contain unsynthesized data concerning the interactions between humans and salmon populations during prehistoric times (see review in Mann et al., 1999). We suspect there is also a rich oral tradition in Native communities about the history and causes of changes in salmon abundance. Within the time constraints of this one-year project, our goals are to get data on sockeye population history and then to develop hypotheses about salmon-climate interconnections. Once we have the science figured out, we want to turn to the local people, the people actually living on the land, to share our ideas and get their ideas back. We anticipate asking EVOS for additional funds in FY 2004 to pay for several trips to Kodiak Island and to villages in PWS and on the Kenai Peninsula, where we will give brief presentations showing our results and initiate conversations about what factors control salmon populations in the GOA region.

PROJECT DESIGN

A. Objectives

We intend to reconstruct sockeye abundance in Eshamy, Upper Russian, Delight, Desire, and Karluk/Red Lakes using established methods of isotope analysis of lake-bottom sediments that are retrieved by coring. The specific objectives of this study have been to:

1) Develop sediment-core chronologies and measure downcore changes in lake-productivity indicators (diatom abundance (opal), organic C and C/N ratios) as well sedimentary del^{15}N.

2) Compare sediment data corresponding to the past few decades (e.g., the period of intensive investigations by ADF&G) to salmon population statistics. We then will develop calibration relationships between del^{15}N and salmon numbers.

3) Reconstruct paleolimnologic changes in each lake over the past 10,000 years, using the results of Specific Objectives 1 and 2. Specifically, we will reconstruct time-series of lake productivity, input of marine-derived nutrients, and salmon escapement.

4) Compare del^{15}N records from PWS and the Kenai Peninsula to Finney's published and ongoing work on Kodiak Island and the Alaska Peninsula. This synthesis will result in a valuable new perspective on changes in sockeye abundance in the GOA at decadal time scales over the last 14,000 years.

5) Compare reconstructed sockeye population fluctuations with published data sets on paleoclimatic changes in the GOA region. These data sets include tree rings, glacial records, and pollen records of vegetation change. From these comparisons, we will develop a series of hypotheses about how changes in the atmosphere/ocean system affect salmon populations.

B. Methods

<u>1) Sediment cores</u>
We already have cores from Eshamy, Solf, Karluk, Frazer, and Upper Russian, Skilak Lake, and Hidden Lakes. We will core Delight Lake and Desire Lakes next month. We plan on retrieving a long core covering the entire post-glacial period from Karluk or Red Lake.

Coring sites are identified from bathymetric maps, and sites are selected to avoid gravity-flow deposition and complicated bottom topography. A piston-equipped, percussion corer is being used. Undisturbed surface cores are obtained with a device (Glew corer) designed for sampling unconsolidated sediments and obtaining an undisturbed sediment-water interface. The cores are stored in a cold room and excess material is archived for future studies.

Cores are described for lithology, texture, color, and other properties, and photographed. Each core is continuously scanned for magnetic susceptibility. Magnetic susceptibility, a measure of the abundance of magnetic minerals, provides important stratigraphic and sedimentologic information (e.g., King et al., 1983). For example, magnetic susceptibility is sensitive to volcanic ash abundance; visually undetected ashes often are easily detected in susceptibility profiles. Ash layers are common in many of the lakes, given the close proximity to active volcanoes, and they are useful for correlating between cores and between different lakes. Sediment chronologies are determined by a combination of ^{210}Pb-dating (Bruland et al., 1974) in the upper several tens of centimeters and by AMS-^{14}C dating of terrestrial plant macrofossils in sediments older than several centuries.

<u>2) Reconstructing changes in sockeye salmon abundance and productivity</u>
Changes in input of marine-derived nutrients (MDN) are determined by analysis of del^{15}N. As discussed earlier, downcore changes in the abundance of MDN (from del^{15}N) reflect changes in the number of returning adult salmon, and thus is a proxy for escapement. Organic carbon content, C/N ratio, and del^{13}C also indicate changes in organic matter source (Hedges and Parker, 1976; Meyers, 1990) and lake productivity. Time-series of organic C content, C/N ratios, and stable C and N isotopes shed light on changes in the source and supply rate of aquatic and terrestrial organic matter. In 2004 and 2005, we plan on analyzing for total diatom abundance (opal) using standard techniques. The three tracers of lake productivity (C%, del^{13}C, and opal) will allow for a robust reconstruction. We will calibrate our MDN-based reconstructions in sockeye salmon escapement with recorded escapement records. The lakes we are studying have experienced significant changes in escapement over the past few decades. These variations allow us to determine how well sedimentary del^{15}N reflects escapement. Using recent calibrations, we will estimate prehistoric escapements from downcore changes in del^{15}N.

C. Cooperating agencies, contracts, and other agency assistance

Though no formal collaborations are planned with federal agencies within this brief project, in fact we are collaborating closely with ADF&G and USFWS in ongoing, similar studies of salmon paleoecology (e.g., Schmidt et al., 1997).

SCHEDULE

A. Project Tasks and Endpoints

July 1, 2003:	Complete analyses for organic carbon and magnetic susceptibility on Upper Russian core. Submit further samples for AMS radiocarbon dating.
August 1, 2003:	Complete del^{15}N analyses on cores from Upper Russian Lake. Core Delight and Desire Lakes in Kenai Fjords.
November 1, 2003	Complete laboratory analyses of Delight and Desire Lakes. Complete opal analyses on all cores.
February 1, 2004:	Submit manuscript for publication in peer-reviewed journal concerning the Eshamy and Upper Russian Lake ^{15}N records.
April 15, 2004:	Annual report on results from FY2003
June 15, 2004:	Core either Karluk or Red Lake (Kodiak Island) to recover entire postglacial record. If necessary for additional ^{14}C dating, collect additional cores from Upper Russian and Skilak Lakes.
December 1, 2004:	Complete laboratory analyses on Karluk long core.
January 2004:	Present results and discuss implications for GEM projects at Restoration Workshop.
April 15, 2005:	Submit synthesis paper concerning climate-oceanographic drivers of salmon populations in the GOA region. Submit final report to EVOS.

PUBLICATIONS AND REPORTS

We plan to submit a manuscript describing our results from Eshamy Lake to either *Fisheries Oceanography* or *Canadian Journal of Fisheries and Aquatic Science* in the autumn of 2003. A second publication concerning the Kenai Peninsula lakes will be submitted in November 2004 to a similar journal. Our final synthesis about the connections between salmon populations and climatic change in the Gulf of Alaska region will be submitted to a journal like the *Journal of Geophysical Research.*

PROFESSIONAL CONFERENCES

We will present our results at two scientific meetings.

December 2003: Present an oral or poster presentation describing our major findings related to salmon-climate interactions over the last 10,000 years at the American Geophysical Union Fall meeting.

August 2004: Present oral or poster presentation at the Ecological Society of America meetings (meeting location is uncertain at this time).

EXPLANATION OF CHANGES IN THE CONTINUING PROJECT

We seek supplemental funding for support in FY 2004 and 2005. In FY 2004, we will complete laboratory analyses that are critical for completion of this project as it was originally proposed. The cores we recovered from Eshamy and Upper Russian lakes were unexpectedly long and contained unusually detailed records of sedimentary ^{15}N. These unexpected data necessitates increased laboratory efforts. In addition, we propose to add a component to reconstruct lake productivity for these cores.

Also in 2004, we want to retrieve a long core from one of Kodiak Island's great red salmon lakes, either Karluk or Red Lake. The core we recovered in July 2003 from Karluk Lake only extends back to 6500 yr B.P. Equipment failure during a wind storm prevented deeper coring. From the glacial geologists, we know that Red and Karluk Lakes were deglaciated around 14,000 yr B.P., so there are another 7000 years of record in the bottom of these lakes that we are now missing. The responses of salmon to the Pleistocene/Holocene transition, when the global climate/ocean system made several radical shifts, will provide valuable information on how salmon respond, recover, and are impacted by rapid climatic changes. We now have new coring equipment and are confident that we can get to the bottom of the Karluk record. Laboratory analyses and writing up the results of our project will extend into FY 2005.

PRINCIPAL INVESTIGATORS (see curricula vitae below)

Daniel H. Mann
Institute of Arctic Biology
Irving 1 Building
University of Alaska
Fairbanks, AK 99775
(907) 474-2419 or 455-6249
dmann@mosquitonet.com
fax: (907) 474-6979

Bruce P. Finney
Institute of Marine Sciences
University of Alaska
Fairbanks, AK 99775
(907) 474-7124
finney@ims.uaf.edu

DIVISION OF LABOR BETWEEN PRINCIPAL INVESTIGATORS

Dr. Mann will supervise most of the fieldwork and oversee core sampling and sedimentological descriptions in the laboratory. He will also take the lead in synthesizing Holocene climatic records for detailed comparisons with the salmon proxy records obtained in our project.

Dr. Finney will direct laboratory analyses at UAF, supervise the chronometric analyses done at other laboratories, and provide the fisheries and oceanographic expertise in the manuscripts summarizing the results of our project.

LITERATURE CITED

Beamish, R.J. and Bouillon, D.R., 1995. Marine fish production trends off the Pacific coast of Canada and the United States. Canadian Special Publication in Fishery and Aquatic Science 121, 585-591.

Blackett, R.F.,1979. Establishment of sockeye (Oncorhynchus nerka) and chinook (O. tshawytscha) salmon runs at Frazer Lake, Kodiak Island, Alaska. J. Fisheries Res. Board Can. 36, 1265-1277.

Brodeur, R.D. and Ware, D.M., 1992. Long-term variability in zooplankton biomass in the subarctic Pacific Ocean. Fisheries Oceanography 1, 32-38.

Brodeur, R.D., Frost, B.W., Hare, S.R., Francis, R.C., and Ingraham, W.J., 1996. Interannual variations in zooplankton biomass in the Gulf of Alaska, and covariation with California Current Zooplankton biomass. CalCOFI 37, 80-99.

Bruland, K.W., Bertine, K., Koide, M., and Goldberg, E.D., 1974. History of pollution in the southern California coastal zone. Environ. Sci. Tech. 8: 425-432.

Calkin, P.E., 1988. Holocene glaciation of Alaska (and adjoining Yukon Territory, Canada). Quaternary Science Reviews 7, 159-184.

Cayan, D.R., 1992. Latent and sensible heat flux anomalies over the northern oceans: the connection to monthly atmospheric circulation. Journal of Climatology 5, 354-369.

Cayan, D.R. and Peterson, D.H., 1989. The influence of north Pacific atmospheric circulation on streamflow in the West. Gephysical

Monographs 55, 375-397.
Downton, M.W. and Miller, K.A., 1998. Relationships between Alaskan salmon catch and North Pacific climate on interannual and interdecadal time scales. Journal of Fisheries and Aquatic Science 55, 2255-2265.
Finney, B.P., Gregory-Eaves, I., Sweetman, J., Douglas, S.V., and Smol, J.P., 2000. Impacts of climatic change and fishing on Pacific salmon abundance over the past 300 years. Science 290, 795-799.
Finney, B.P., Gregory-Eaves, I., Douglas, M.S.V.m and Smol, J.P., 2002. Fisheries productivity in the northeastern Pacific Ocean over the past 2,200 years. Nature (*in press*).
Francis, R.C. and Sibley, T.H., 1991. Climate change and fisheries: What are the real issues? *The Northwest Environmental Journal* 7: 295-307.
Francis, R.C., Hare, S.R., Hollowed, A.B., and Wooster, W.S., 1998. Effects of interdecadal climate variability on the oceanic ecosystems of the NE Pacific. Fisheries Oceanography 7, 1-21.
Fry, B. and Sherr, E.B.,1984. del^{13}C measurements as indicators of carbon flow in marine and freshwater ecosystems. Contr. Mar. Sci. 27:13-47.
Gargett, A.E., 1997. The optimal stability 'window': a mechanism underlying decadal fluctuations in North Pacific salmon stocks? Fisheries Oceanography 6, 109-117.
Hedges, J. I. and Parker, P. L. 1976. Land-derived organic matter in surface sediments from the Gulf of Mexico. Geochim. Cosmochim. Acta, 40: 1019-1029.
King, J.W., Banerjee, S.K., Marvin, J. and Lund, S.P. 1983. Use of small-amplitude paleomagnetic fluctuations for correlation and dating of continental climate change. Palaeogeography, Palaeoclimatology, Palaeoecology, 42: 167-183.
Kline , T. C. Jr., J. J. Goering, O. A. Mathisen, P. H. Poe and P. L. Parker. 1990. Recycling of elements transported upstream by runs of Pacific salmon: I. del^{15}N and del^{13}C evidence in Sashin Creek, southeastern Alaska. Can. J. Fish. Aquat. Sci. 47:136-144.
Kline, T. C., Jr., 1991. The significance of marine-derived biogenic nitrogen in anadromous Pacific salmon freshwater food webs. Ph.D. Thesis, University of Alaska Fairbanks, Fairbanks, Alaska, 114p.
Kline , T. C. Jr., Goering, J.J., Mathisen, O.A., Poe, P.H., Parker, P.L., and Scalan, R.S., 1993. Recycling of elements transported upstream by runs of Pacific salmon: II. del^{15}N and del^{13}C evidence in the Kvichak River watershed, southwestern Alaska. Can. J. Fish. Aquat. Sci. 50: 2350-2365.
Kline, T.C., Goering, J.J., and Piorkowski, R.J., 1994. The effect of salmon carcasses on freshwater systems. *In:* A. Milner and M. W. Oswood (Eds.) Alaskan Freshwaters. Springer-Verlag, New York.
Koenings, J. P. and Burkett, R.D., 1987a. Population characteristics of sockeye salmon (*Oncorhynchus nerka*) smolts relative to temperature regimes, euphotic volume, fry density, and forage base within Alaskan lakes. *In* H. D. Smith, L. Margolis and C. C. Wood (Eds.) Sockeye salmon (*Oncorhynchus nerka*) population and future management. Can. Spec.

Publ. Fish. Aquat. Sci. 96, p.216-234.
Lackmann, G.M. and Gyakum, J.R., 1996. The synoptic- and planetary-scale signatures of precipitating systems over the Mackenzie River basin. Atmosphere-Ocean 34, 647-674.
Lagerloef, G.S.E., 1995. Interdecadal variations in the Alaska Gyre. Journal of Physical Oceanography 25, 2242-2256.
Latif, M. and Barnett, T.P., 1996. Descadal climate variability over the North Pacific and North America: dynamics and probability. Journal of Climate 9, 2407-2423.
Mann, D.H. and Hamilton, T.D., 1995. Late Pleistocene and Holocene Paleoenvironments of the North Pacific Coast. Quaternary Science Reviews 14, 449-471.
Mann, D.H., Crowell, A.L., Hamilton, T.D., and Finney, B.P.,1999. Holocene geologic and climatic history around the Gulf of Alaska. Arctic Anthropology 35, 112-131.
Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., and Francis, R.C., 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the Meteorological Society 78, 1069-1079.
Meyers, P.A. 1990. Impacts of late Quaternary fluctuations in water-level on the accumulation of sedimentary organic matter in Walker Lake, Nevada. Palaeogeogr. Palaeoecol. Palaeoclimatol. 78: 229-240.
Minagawa, M., and Wada, E., 1984. Stepwise enrichment of ^{15}N along food chains: Further evidence and the relation between del^{15}N and animal age. Geochim. Cosmochim. Acta 48:1135-1140.
Minobe, S., 1997. A 50-70 year oscillation over the North Pacific and North America. Geophysical Research Letters 24, 683-686.
Mock, C.J., Bartlein, P.J., and Anderson, P.M., 1998. Atmospheric circulation patterns and spatial climatic variability in Beringia. International Journal of Climatology 18, 1085-1104.
Namias, J., 1969. Seasonal interactions between the North Pacific Ocean and the atmosphere during the 1960s. Monthly Weather Review 97, 173-192.
Niebauer, H.J., 1998. Variability in Bering Sea ice cover as affected by a regime shift in the North Pacific in the period 1947-1996. Journal of Geophysical Research 103, 27,717-27,737.
Overland, J.E., Adams, J.M., and Bond, N.A., 1999. Decadal variability of the Aleutian Low and its relation to high-latitude circulation. Journal of Climate 12, 1542-1548.
Owens, N. J. P. 1987. Natural variations in ^{15}N in the marine environment. Advances in Marine Biology 24:389-451.
Peterson, B. J. and Howarth, R.W., 1987. Sulfur, carbon and nitrogen isotopes used to trace organic matter flow in the salt-marsh estuaries of Sapelo Island, Georgia. Limnol. Oceanogr. 32:1195-1213.
Schmidt, D.C., Kyle, G.B., Carlson, S.R., Geiger, H.J., and Finney, B.P. Alaska's Sockeye salmon management: can we learn from success? In: "Developing and Sustaining World Fisheries Resources: The State of Science and Management, 2nd World Fisheries Congress Proceedings".

(D.A. Hancock, D.C. Sminth, A. Grant and J.P. Beumer, eds.), CSIRO, Collingwood, VIC, Australia, pp. 687-695.

Sugimoto, T. and Tadokoro, K., 1997. Interannual-interdecadal variations in zooplankton biomass, chlorophyll concentration and physical environment in the subarctic Pacific and Bering Sea. Fisheries Oceanography 6, 74-93.

Trenberth, K.E. and Hurrell, J.W., 1994. Decadal atmosphere-ocean variations in the Pacific. Climate Dynamics 9, 303-319.

Wada, E. and Hattori, A., 1991. *Nitrogen in the Sea: Forms, Abundances, and Rate Processes*. CRC Press, Boca Raton, 208pp.

Wada, E., Terazaki, M., Kabaya, Y., and Nemoto, T., 1987. ^{15}N and ^{13}C abundances in the Antarctic Ocean with emphasis on the biogeochemical structure of the food web. Deep-Sea Res. 34:829-841.

Wiles, G.C. and Calkin, P.E., 1994. Late Holocene, high resolution glacial chronologies and climate, Kenai Mountains, Alaskka. Geological Society of America Bulletin 106, 281-303.

Wiles, G.C., D'Arrigo, R.D., and Jacoby, G.C., 1996. Temperature changes along the Gulf of Alaska and the Pacific Northwest coast modeled from coastal tree rings. Canadian Journal of Forest Research 26: 474-481.

Wiles, G.C., D'Arrigo, R.D., and Jacoby, G.C., 1998. Gulf of Alaska atmosphere-ocean variability over recent centuries inferred from coastal tree-ring records. Climatic Change 38, 289-306.

Wiles, G.C., Barclay, D.J., and Calkin, P.E., 1999. Tree-ring dated 'Little Ice Age' histories of maritime glaciers from western Prince William Sound, Alaska. The Holocene 9, 163-173.

Wiles, G.C., Post, A., Muller, E.H., and Molnia, B.F., 1999. Dendrochronology and late Holocene history of Bering Piedmont Glacier, Alaska. Quaternary Research 52, 185-195.

Daniel H. Mann

EDUCATION:
1976: **B.A.** Anthropology (University of Washington)
1978: **M.S.** Forest Entomology (College of Forest Resources, University of Washington)
1983: **Ph.D.** Soil Science and Quaternary Studies (College of Forest Resources, University of Washington)

THESIS AND DISSERTATION:
M.S.: Ecology of Snowfield-foraging Arthropods on Mount Rainier (advisors: R.I. Gara and J.S. Edwards)

Ph.D.: The Quaternary History of the Lituya Glacial Refugium, Alaska (advisor: F.C. Ugolini)

POSITIONS HELD
1983-85: **Postdoctoral Research Associate**, University of Washington.

1985-88: **Director**, **Field Naturalist Program,** Botany Department, University of Vermont.

1988-90: **Research Associate**, Quaternary Research Center, University of Washington.

1989-91: **Geological Consultant,** Woodward-Clyde Environmental Consultants.

1990-91: **Research Associate**, Alaska Quaternary Center, University of Alaska.

1992: **Visiting Professor**, University of Alaska.

1993-present: Research Associate, University of Alaska

PUBLICATIONS
Refereed Journals

Ugolini, F.C. and Mann, D.H. (1979). Biopedological origin of peatlands in southeast Alaska. *Nature* 281,366-368.

Mann, D.H., Edwards, J.S., and Gara, R.I. (1980). Diel activity patterns in snowfield-foraging invertebrates on Mount Rainier, Washington. *Arctic and Alpine Research* 12, 359-368.

Edwards, J.S. and Mann, D.H. (1981). The structure of the cercal sensory system and ventral nerve cord of Grylloblatta, a comparative study. *Cell and Tissue Research* 217, 177-188.

Wright, H.E., Mann, D.H., and Glaser, P.H. (1984). Piston corers for peat and lake sediments. *Ecology* 65, 657-659.

Mann, D.H. and Ugolini, F.C. (1985). Holocene glacial history in the Lituya District, southeast Alaska. *Canadian Journal of Earth Sciences* 22, 913-928.

Mann, D.H. (1986). Reliability of a fjord glacier's fluctuations for paleoclimatic reconstructions. *Quaternary Research* 25, 10-24.

Mann, D.H., Sletten, R.S., and Ugolini, F.C. (1986). Soil development at Kongsfjord, Spitsbergen. *Polar Research* 4, 1-16.

Hequette, A. and Mann, D.H. (1987). Des figrations immergees, preuve d'une transgression marine ayant succede a l'emersion postglaciaire au Spitsbergen nord-occidental (Svalbard). *Comptes Rendus de L'Academie Des Sciences*, Serie II, 303, 1237-1240.

Forman, S.L., Mann, D.H., and Miller, G.H. (1987). Late Weichselian and Holocene relative sea-level history of Broggerhalvoya, Spitsbergen. *Quaternary Research* 27, 41-50.

Engstrom, F.B. and Mann, D.H. (1991). Fire ecology of red pine in northern Vermont, U.S.A. *Canadian Journal of Forest Research 21, 882-889.*

Riehle, J.R., Mann, D.H., Peteet, D.M., Engstrom, D.R., Brew, D.A., and Meyer, C.E. (1992). The Mount Edgecumbe tephra deposits, a marker horizon in southeastern Alaska near the Pleistocene-Holocene boundary. *Quaternary Research* 37, 183-202.

Mann, D.H. and Peteet, D.M. (1994). Extent and timing of the last glacial maximum in southwest Alaska. *Quaternary Research* 42, 136-148.

Mann, D.H., Engstrom, F.B., and Bubier, J. (1994). Fire history in the Batelle Research Forest, Vermont. *Quaternary Research* 42, 206-215.

Peteet, D.M. and Mann, D.H. (1994). Late-glacial vegetation change on Kodiak Island, Alaska. *Ecoscience* 1, 255-267.

Mann, D.H. and Hamilton, T.D. (1995). Late Pleistocene and Holocene Paleoenvironments of the North Pacific Coast. *Quaternary Science Reviews* 14, 449-471.

Mann, D.H., Fastie, C.L., Rowland, E.L., and Bigelow, N.H. (1995). Spruce succession, disturbance, and geomorphology on the Tanana River floodplain, Alaska. *Ecoscience* 2, 184-199.

Mann, D.H. and Crowell, A.L. (1996). A large earthquake occurring 700 to 800 years ago in Aialik Bay, southern coastal Alaska. *Canadian Journal of Earth Sciences* 33, 117-126.

Mann, D.H., Sletten, R.S., and Reanier, R.E. (1996). Quaternary glaciations of the Rongbuk Valley, Tibet. *Journal of Quaternary Science* 11, 267-280.

Crowell, A.L. and Mann, D.H. (1996). Human populations, sea level change, and the archaeological record of the Northern Gulf of Alaska coastline. *Arctic Anthropology* 33, 16-37.

Irvine, G.V., Mann, D.H., and Short, J.W. (1999). Multi-year persistence of oil mousse on high energy beaches distant from the Exxon Valdez spill. *Marine Pollution Bulletin* 38, 572-584.

Mann, D.H., Crowell, A.L., Hamilton, T.D., and Finney, B.P. (1999). Holocene Geologic and climatic history around the Gulf of Alaska. *Arctic Anthropology* 35, 112-131.

Mann, D.H. and Plug, L.J. (1999). Vegetation and soil development at an upland taiga site, Alaska. *Ecoscience* 6, 272-285.

Höfle, C., Edwards, M.E., Hopkins, D.M., and Mann, D.H. (2000). The full-glacial environment of the northern Seward Peninsula, Alaska, reconstructed from the 21,500-year-old Kitluk paleosol. *Quaternary Research* 53, 143-153.

Mann, D.H., Heiser, P.A., and Finney, B.P. (2002). Holocene history of the Great Kobuk Sand Dunes, Northwestern Alaska. *Quaternary Science Reviews* 21, 709-731

Mann, D.H., Peteet, D.M., Reanier, R.E., and Kunz, M.L. (2002). Responses of an arctic landscape to Lateglacial and early Holocene climatic changes: the importance of moisture. *Quaternary Science Reviews* 21, 997-1021

Mann, D.H., Reanier, R.E., Peteet, D.M., and Kunz, M.L. (2002). Environmental Change and Arctic Paleoindians. *Arctic Anthropology* 38, 119-138.

Book Chapters

Mann, D.H. (1986). Wisconsin and Holocene glaciation of southeast Alaska. pages 237-265 In: "Glaciation in Alaska", T.D. Hamilton, K.M. Reed, and R.M. Thorson (Eds.), Alaska Geological Society, Anchorage, 265 pp.

Mann, D.H., Edwards, J., Reanier, R., Chase, J. (2003). Impacts of early Polynesian settlement on the soils and vegetation of Rapa Nui (Easter Island). In: J. Loret and J. Tanacredi (Eds.), “Scientific Investigations on Easter Island,” Academic Press (in press).

VITA

BRUCE PRESTON FINNEY
Birthdate: 30 April 1957
Birthplace: Chillicothe, OH USA
Social Security Number: 473-72-3045

Institute of Marine Science
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
Fairbanks, Alaska 99775
(907) 474-7724, finney@ims.alaska.edu

EDUCATION

Ph.D. Geological Oceanography, Oregon State University, Corvallis	1986
B.S. Geology (with honors), University of Minnesota, Minneapolis	1979

PROFESSIONAL EXPERIENCE

Professor, Institute of Marine Science, University of Alaska Fairbanks	2002–
Associate Professor, Institute of Marine Science, University of Alaska Fairbanks	1998–2002
Assistant Professor, Institute of Marine Science, University of Alaska Fairbanks	1991–1998
Research Associate, Duke University, Marine Laboratory	1989–1991
Research Associate, Marine Chemistry, Oregon State University	1987–1988
Research Assistant, Geological Oceanography, Oregon State University	1980–1986

RESEARCH

Research Experience

Stable isotope and chemical analysis of sediments. Quaternary dating techniques including radiocarbon, ^{210}Pb, ^{137}Cs, tephrochronology and uranium-series. Determination of organic carbon, calcium carbonate, and biogenic silica abundances. Mineralogical studies.

Field experience in box, gravity and piston coring, water quality surveys, and hydrologic monitoring. Description and curation of geological samples. Computer-based statistical applications to geological data sets. Partitioning models of chemical composition using statistical approaches and chemical leaching studies. Time-series analysis and statistical testing.

Research Interests

- Paleoceanography, Paleolimnology, Paleoclimatology, Biogeochemical cycles
- Paleoclimatology, geochronology, paleoenvironmental reconstruction
- Late Quaternary climatic history of the North Pacific and adjacent land areas
- Comparison of climatic reconstructions with climate model simulations
- Long-term variability in North Pacific ecosystems (including Pacific salmon abundance) and relation to oceanographic and climatic changes
- Influence of climate change on aquatic and terrestrial carbon cycling
- Paleohydrology and impacts of changes in the hydrologic cycle on terrestrial vegetation
- Factors controlling the isotopic, chemical and mineralogical composition of sediments
- Sedimentary geochemistry, diagenesis of sediments, formation of authigenic phases in sediments

Five Publications Relevant to this Research

Finney, B.P., Gregory-Eaves, I., Douglas, M.S.V., and Smol, J.P. 2002. Fisheries productivity in the northeastern Pacific Ocean over the past 2,200 years. *Nature*. **416**: 729–733.

Finney, B.P., Gregory-Eaves, I., Sweetman, J., Douglas, M.S.V. and Smol, J. (2000). Impacts of Climatic Change and Fishing on Pacific Salmon Abundance Over the Past 300 Years. Finney, B.P., Gregory-Eaves, I., Sweetman, J., Douglas, M.S.V. and Smol, J. *Science* **290**: 795-799.

Satterfield, F.R. IV and Finney, B.P. (2002). Stable isotope analysis of Pacific salmon: Insights into trophic status and oceanographic conditions over the last 30 years. *Progress in Oceanography* **53**: 231-246.

Hirons, A.C., Schell, D.M. and Finney, B.P. (2001). Temporal records of $\delta^{13}C$ and $\delta^{15}N$ in North Pacific pinnipeds: Inferences regarding environmental change and diet. *Oecologia* **129**: 591-601.

Anderson, L., Abbott, M.B. and Finney, B.P. (2001). Holocene paleoclimate from oxygen isotope ratios in lake sediments, central Brooks Range, Alaska. *Quaternary Research* **55**: 313-321.

Five Other Publications

Finney, B.P. and Johnson, T.C. (1991). Sedimentation in Lake Malawi (East Africa) during the past 10,000 years: A continuous paleoclimatic record from the southern tropics. *Palaeogeography, Palaeoclimatology, Palaeoecology,* **85**: 351-366.

Barber, V.A., Juday, G.P. and Finney, B.P. (2000). Reduced growth in Alaskan white spruce from 20th century temperature-induced drought stress. *Nature* **405**: 668-673.

Naidu, A.S., Cooper, L.W., Finney, B.P., Macdonald, R.W., Alexander, C., and Semitelov, I.P. (2000). Organic carbon isotope ratios ($\delta^{13}C$) of Arctic Amerasian continental shelf sediments. *Intern. Journ. Earth Sci.* **89**: 522-532.

Abbott, M.B., Finney, B.P., Edwards, M.E., and Kelts, K.R. (2000). Lake-level reconstructions and paleohydrology of Birch Lake, central Alaska, based on seismic reflection profiles and core transects. *Quaternary Research* **53**: 154-166.

Overpeck, J., Hughen, K., Hardy, D., Bradley, R., Case, R., Douglas, M., Finney, B., Gajewski, K., Jacoby, G., Jennings, A., Lamoureux, S., MacDonald, G., Moore, J., Retelle, M., Smith, S., Wolfe, A., and Zielinski, G. (1997). Arctic Environmental Change of the Last Four Centuries. *Science* **278**: 1251–1256.

Current Graduate Students

Steve Ignell (Ph.D.), David Barto (M.S.), Anne Beesley (M.S.), Eloise Brown (M.S.)

Current and Recent Collaborators

Drs. Mary Edwards, Mark Abbott, John Smol, Dan Mann and Sathy Naidu

Ph.D. Thesis Advisor (Oregon State University): Dr. G. Ross Heath
Postdoctoral Advisor (Oregon State University): Dr. Chih-An Huh
Postdoctoral Advisor (Duke University): Dr. Thomas C. Johnson

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 04	Proposed FY 05						
Personnel	$0.0							
Travel	$0.0							
Contractual	$82.3	$84.9						
Commodities	$0.0							
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$82.3	$84.9	Estimated FY 05					
General Administration	$5.8	$7.6						
Project Total	$88.1	$92.5	$24.9					
Full-time Equivalents (FTE)	3.0	3.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY04

Project Number: 030649
Project Title: Reconstructing Sockeye Salmon Populations
Name: D.H. Mann and B.P. Finney

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Budget Category:	Authorized FY 04	Proposed FY 05						
Personnel	$29.1	$31.0						
Travel	$4.5	$5.8						
Contractual	$26.2	$28.0						
Commodities	$6.0	$3.1						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$65.8	$67.9	Estimated FY 05					
Indirect	$16.5	$17.0						
Project Total	$82.3	$84.9	$24.9					
Full-time Equivalents (FTE)	0.3	0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
1) The indirect rate is 25% as negotiated between the EVOS Trustee Council and the University of Alaska

2) Travel includes airfare from Fairbanks to study lakes and to scientific meetings in Anchorage and in Lower 48 States. We are uncertain what cities in the Lower 48 because the locations of some national meetings changes year-to-year.

3) The increased amount of our 2003 budget reflects the expansion of our project to include three new lake systems in the Kenai River watershed. These additions are detailed in the proposal's text. If the Trustees do not approve the expansion of this project, the original 2003 budget for this project was $18.8.

4) Our estimated costs in FY 04 cover personnel, communications, travel to a scientific meeting for one investigator (1.6) and two trips from Fairbanks to Anchorage for the Annual EVOS Workshop (1.4).
Personnel: 1.5 months of both Finney's and Mann's time for manuscript preparation ($16.4)
Communications and copy ($0.5)
Indirect costs: $19.9 x 0.25 = $5.0

FY04

Prepared:6-11-03

Project Number: 03649
Project Title: Reconstructing Sockeye Salmon Populations
Name: D.H. Mann and B.P. Finney

FORM 4A
Non-Trustee
SUMMARY

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

Personnel Costs:				Months	Monthly		Proposed
	Name	Position Description		Budgeted	Costs	Overtime	FY 05
	Mann	PI		2.0	9.1		18.2
	Finney	co-PI		1.0	7.3		7.3
	Krumhardt	Technician		1.0	5.5		5.5
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
							0.0
		Subtotal		4.0	21.9	0.0	
						Personnel Total	$31.0

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 03
	Fairbanks to Anchorage	0.3	4	5	0.1	1.7
	Fairbanks to Hidden, Skilak Lakes, and control lake	0.5	3	2	0.5	2.5
	Fairbanks to Lower 48 city for nat'l meeting re. climate change & fish	0.8	1	4	0.2	1.6
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$5.8

FY04

Project Number: 03649
Project Title: Reconstructing Sockeye Salmon Populations
Name: D.H. Mann and B.P. Finney

FORM 4B
Personnel
& Travel
DETAIL

Prepared: 6-11-03

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2002 - September 30, 2003

Contractual Costs:	Proposed
Description	FY 05
Laboratory analyses of N and C isotopes	6.0
AMS-radiocarbon dating, 20 samples (10 per lake) @ $500/each	15.0
210Pb analyses, three profiles @ $2000/each	6.0
boat charter fees from UAF	0.7
pickup truck and trailer mileage charges from UAF @ $0.40/mile x 800 miles	0.3
Contractual Total	$28.0

Commodities Costs:	Proposed
Description	FY 05
Materials for maintaining lake corer	1.0
Laboratory glassware, plastic vials, microscope slides, etc.	0.6
Publications (maximum allowable contribution towards page costs per project)	1.0
Communications and copy center	0.5
Commodities Total	$3.1

FY04

Prepared:6-11-03

Project Number: 03649
Project Title: Reconstructing Sockeye Salmon Populations
Name: D.H. Mann and B.P. Finney

FORM 4B
Contractual
&
Commoditie

FY 03 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2002 - September 30, 2003

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 05
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	
Description	of Units	

FY04

Prepared:6-11-02

Project Number: Project Number: 03649
Project Title: Reconstructing Sockeye Salmon Populations
Name: D.H. Mann and B.P. Finney

FORM 4B
Equipment
DETAIL