Project Title: Archival Tags for Tracking King Salmon at Sea Reveal Migrations, Biology, and Oceanographic Preferences in Prince William Sound

Project Number:	01404
Restoration Category:	Research
Principal Investigator:	Dr. Jennifer L. Nielsen Alaska Biological Science Center USGS-Biological Resources Division 1011 E. Tudor Rd. Anchorage, Alaska 99503
Lead Trustee Agency:	DOI--USGS
Cooperating Agencies:	na
Alaska Sea Life Center:	Yes
Project Duration:	3 yrs
Cost FY 01:	$100.00
Geographic Area:	Prince William Sound, Gulf of Alaska
Injured Resource/Service:	King salmon

ABSTRACT

Archive tags with temperature and light-geolocation sensors will be monitored for post-smolt king salmon (*Oncorhynchus tshawytscha*) in Prince William Sound (PWS). Light/location relationships specific to the Gulf of Alaska developed under EVOS study #00478 (FY00) will be applied in this study of movement and migration paths for king salmon during maturation in ocean environments in Prince William Sound. Contemporary physical oceanographic, climatic, and bathometric data available for Prince William Sound will be incorporated into our interpretation of geolocation results and analyses of critical marine habitat derived from pressure, temperature, and light sensors deployed in king salmon. Salmon for this study will be reared in captivity (ADFG hatchery and the Alaska SeaLife Center) to 1+ year of age, acclimated and released in Prince William Sound at ADFG's new chinook sport-fishing hatchery on Esther Island, and utilize marine habitats in Prince William Sound and beyond for up to two years prior to their return to the hatchery at maturation or until recovery of the tags in the fishery.

Archival tags can provide estimates of geolocation, vertical movements, and ambient and internal temperatures for individual fish for long periods of time (up to three years). Recent tag developments allow the application of internal archive tags in smaller fish (150 mm smolt; Keith Stoodley, LOTEK Marine Technologies, Inc, personal communications), making this technology appropriate for the study of salmonids in marine environments where tag recoveries can be obtained from sport fishery, commercial harvest, and/or captures of tagged fish in spawning migrations. The opportunity to test the development and application of this tag technology for the first time in king salmon is available in collaboration with a new Alaska Department of Fish and Game chinook hatchery on Ester Island, Prince William Sound developed to address the expected increase in spot fishing with the new road to Whittier.

Tagging chinook reared in the hatchery environment to the required size (150 - 300 mm) will allow us to test efficiency and accuracy of this technology in the study of ocean use and

movement patterns for king salmon throughout the Gulf of Alaska. Live releases will not take place without preliminary tests of initial and delayed mortality, tag retention, physiological stress, growth, and fish behavior in the hatchery environment. These tests will be undertaken at two independent locations for the same year-class of chinook, ADFG's chinook hatchery outside of Anchorage (Elmendorf) and at the Alaska SeaLife Center. The first year of work will include pilot studies of tag retention, behavior, and growth for chinook in captivity (e.g. hatchery). A release experiment in the next year will be contingent on the success of the retention study and incorporate timed releases of chinook smolts, 1+, and surviving two year (retention study) fish.

Archive tagged fish will be used to document king salmon use of marine habitats, migration routes, contribution to the sport fishery, and hatchery/wild interactions for chinook. No natural production of chinook in the streams and tributaries exists in PWS (ADFG, pers. comm.), however, ocean migrations for hatchery fish may overlap with natural runs of chinook from the Copper River or other natural populations further south. Information on temperature, depth (pressure), and light from archive tags can be integrated with tidal stream data, climatic data, oceanographic bathometry, glacier discharge, hydrographic records, and sea surface satellite imagery to help track salmon distribution and migration routes throughout Prince William Sound. Our understanding of marine habitat use, feeding patterns, coastal and deepwater migrations, and maturation rates will greatly enhance EVOS recovery efforts and planning in future conservation efforts. Recovery of tags in a growing sport fishery out of Wittier and at the hatchery release site will facilitate collecting tags from different life history stages of chinook salmon within Prince William Sound.

INTRODUCTION

Our previous EVOS study (#00478) tested light-based geoposition estimates for archive tags in the Gulf of Alaska. Light sensors attached to the smaller archive tags used in this study will be designed to collect identical data for geoposition estimates. Part of this study will continue these efforts to gain accuracy of geoposition estimates on the local scale within the Gulf of Alaska and to monitor local geography, climatic, and water quality conditions leading to errors in these estimates. To that end we will complete one year's collection of *in situ* data from tag arrays mounted on a stationary buoy at the entrance of Resurrection Bay (2001) and develop a new stationary array under this study at a different latitude in Prince William Sound (2002). Analytical analyses of light-based data for geoposition estimates will be honed and adjusted based on comparisons made between the two latitudes and between years. Tags recovered from salmonids with different ocean movement patterns will allow us to develop accurate correction factors to adjust for light attenuation at depth and special conditions for Prince William Sound.

The application of archive tag technology in ocean-going fish species has been underway for several years and is an effective tool for estimates of open-ocean migration pathways and to ascertain basin-scale movements along parts of the continental shelf (Welch and Eveson 1999; R. W. Brill, personal communications). Recent developments in the architecture and size of these tags have made them appropriate for use in maturing salmon such as steelhead, sea trout, Atlantic salmon, and Arctic charr (Welch and Eveson 1999; M.A. Svenning, and F. A. Voegeli pers. comm.) Life history investigations of oceanic behavior by salmonids will be greatly enhanced by using archive tags to trace migratory patterns of individual fish during their development at sea. Crepuscular diving behavior has been demonstrated in many pelagic marine species using archive tags, but the mechanisms driving this behavior remain unknown, i.e. reaction to light scatter at dawn and dusk and/or a search for uniquely available prey items at depth during these intervals (B. Block et al. 1998; Lutcavage et al. 1999). It is interesting that

this behavior has been documented in both the Atlantic and Pacific Oceans for multiple species, including Atlantic salmon (J. Sturlaugsson, pers. comm.) It is unknown if Pacific salmon in open seawater exhibit this behavior, and if they do how they react to long crepuscular conditions in the Gulf of Alaska.

King salmon (*Oncorhynchus tshawytscha*) from the Copper River support significant commercial, sport and subsistance fisheries in the Gulf of Alaska. The distribution of chinook post-smolts and sub-adults from the Copper River throughout saltwater habitats in the Gulf of Alaska is unknown. The development of new tagging technologies can be used to document the distribution and migration patterns of important salmonid populations in saltwater habitats. The development of effective application and protocols for these technologies under local conditions, however, require initial studies in non-critical populations. Alaska Department of Fish and Game (ADFG) assumes no natural production of chinook within Prince William Sound. A new hatchery program is being developed by ADFG for the release for king salmon into Prince William Sound where a dramatic increase in sport fishery is anticipated as a result of the new road opening auto traffic to Wittier (L. Peltz, ADFG, pers. comm.) We propose to use this chinook stock for initial tagging studies using archive tags. We will be able to raise hatchery salmon post-smolts in captivity to the threshold size (150 - 300 mm) necessary for successful surgically application of archive tag recorders. This study will test tag retention, behavior and growth in tagged salmon for on year prior to any live releases. Contingent of these tests, we will acclimate and release tagged chinook from the Esther Island facility and monitor initial movements away from the release location, migrations between near-shore and open ocean habitats, and critical marine habitats for hatchery king salmon from post-smolt to maturation (1-2 years).

Finding where and when king salmon go at sea and their temporal and spatial use of specific marine locations critical to oil spill management and recovery are important steps to identifying factors potentially contributing to survival and fitness under different environmental conditions. Data developed from archive tags on hatchery chinook will provide inference on hatchery vs. wild fish interactions, “hot-spots” of chinook production within Prince William Sound, migration paths and critical ocean habitat, and spawning fidelity of hatchery fish within the basin. All of these data will set baseline structure and sampling protocols for future implementation of archive tags on wild salmonid stocks within the Gulf of Alaska, including potential studies of endemic cutthroat trout (*O. clarki clarki*), Dolly Varden (*Salvelinus malma*), and Cooper River chinook and coho (*O. kisutch*) salmon. Our studies of these hatchery stocks will provide valuable information to ADFG on the management and stability of hatchery production in this area and its contribution to the local fishery.

The definition of “critical habitat” in the marine environment for anadromous and pelagic fishes is essential to the development of reserves or protected areas (Anonymous, NOAA, 1999). In Alaska, the relationship of aquatic protected areas to subsistence, commercial, or sport fisheries is a critical factor in considerations of design and implementation of reserves. Resource protection and strategic use are not incompatible concepts when a sound foundation of scientific knowledge on the distribution and abundance of key species is incorporated into reserve planning and resource use, and if local community-based natural resource management is included in the analyses of such data (Getz et al. 1999). This proposal continues to test the application and deployment of a new technology, archive tags, in investigations into the temporal and spatial distribution of key anadromous and marine fish species in the Gulf of Alaska. Many aquatic species that fall under the jurisdiction of the Trustee Council in their efforts to restore the resources and services injured by the spill may benefit from the development and local adaptation of this technology. Monitoring of critical habitat use by Gulf

of Alaska fish species will allow the organisms to speak directly to the managers of the resource during the development, implementation and applications of recovery or enhancement activities.

For many commercially important anadromous and marine fish species ocean-use and critical habitat remain uninvestigated with little or no scientific evidence to support distribution on temporal or spatial scales. The use of radio telemetry and satellite-linked tracking for studying fishes has experienced a recent exponential growth in the development of technologies and applications (Lucas et al. 1993; Eiler 1995; Sibert 2000). In addition to critical habitat designation, physiological telemetry can now be used to monitor energy expenditure, life history migrations, stage of life cycle, and environmental conditions critical to improving and validating habitat-use models for pelagic fishes (B. Block et al. 1998). Archival technologies offer the fisheries research community a new tool that is required to resolve movement patterns, spatial and temporal habitat use, and stock structure of many migratory marine species found in the Gulf of Alaska. The critical advantage to this new technology is that it allows documentation of habitat use that is independent of harvest or fishing effort. Conventional identification tags have been used on fish since the early 1900s. Hydroacoustic tags can provide multi-day records of location, depth, temperature and swimming speed in marine fishes, but their temporal and spatial scale is limited by the range of signal recovery and transmission duration in salt water. In the late 1980's the first generation of archive tags was developed and deployed on marine fish.

Recovery rates for archive tags in the open ocean are typically low (~30%). It is unclear, however, if these poor recoveries are due to differences in survivorship of the fish, differences in tagging technique, tags location, or tag failure. In studies with an active fishery and where fish carrying an external identification tag can be collected at terminal spawning locations, archive tag recoveries can be quite successful (60-80%, D. Welch, pers. comm.) Testing tag recovery rates and efficiencies in a hatchery stock released into Prince William Sound provides the best possible conditions for initial archive tag studies using this technology in the Gulf of Alaska.

Data archived by these tags include records of ambient and internal body temperature, pressure, and light. It is possible to estimate latitude (geoposition) for tag location at any given time from light intensity, temperature, and accurate temporal measurements of dawn and dusk (Hill 1994). The longitude determination is equally accurate throughout the year and at all locations except those where no dawn and dusk events are recorded. Latitude determinations are most accurate at the solstices and useless at the equinoxes. This is clearly a problem in Alaska waters where long crepuscular periods (winter) are followed by intense solar periods (summer). The accuracy of light-level measurements, duration of crepuscular events, atmospheric aberrations, and individual fish behavior can all impact the accuracy of geoposition estimates. A current error rate of 50-60 miles is not uncommon in the analyses of these data from temperate waters. We expect a much lower error rate in Alaskan waters based on current studies of light sensors and data analyses adapted to local light conditions (EVOS #00478).

Data from archive tags can be made available at the time of recovery to any user group after developed algorithms translate sequence data stored on tags into temperature, pressure, and light information. Successful integration of archive tag data into the EVOS Trustee Council's Gulf Ecosystem Monitoring (GEM) program will allow the development of a unique and continuous information base on natural use of critical marine habitat by king salmon caught in the Whittier sport fishery and during spawning migrations. These data will allow estimates of ocean use, migrations, development rates, and movement of hatchery fish into natural salt and freshwater habitats in Prince William Sound. This proposal suggests that data collected from archive tags deployed in the Gulf of Alaska be made available to local communities and interest groups through internet web links with a USGS/BRD web site dedicated to this study. This proposal is intended to test the accuracy and efficiency of archive tags for estimates of

geoposition and ocean use by king salmon in the Gulf of Alaska. If successful these data can provide an effective database for sampling protocols and analyses of critical habitat use by post-smolt and maturing wild king salmon in Alaska waters.

Additional research on cost-effective tagging regimes for this area need to follow our development of efficient light-based geoposition estimates using archive tags. To this end the PI (JLN) has been invited to participate in a development consortium devoted to scientific advances in the application of electronic tagging tools in marine ecosystems. This informal consortium is made up of several research scientists, resource managers, and manufacturers devoted to tagging technology in ocean environments. The rationale of the consortium is to provide open communications on the existing technology (supply and demand, recent developments, application problems and successes) and to push for the appropriate level of investment and product specifications (e.g. size, transmission potential, data storage, validated data) for ongoing needs and the manufacturability (including quality, reliability, satellite platforms, price, and development times) for future research. This consortium provides an active dialogue among key researchers and institutions that are willing and able to invest resources to aid and abet the development and application of this technology in a transparent process that will share the risks and the rewards. Our satellite pop-up tag study (EVOS project 00478) designed to test geolocation technology under local application is considered one of the few "well structured technical assessments of this technology" currently in progress (D. Welch's study of steelhead ocean migration in British Columbia is another).

Our new proposal will investigate species-specific tagging protocols, size and location of tags as they affect survival rates (for both fish and tags), effects of coastal geology on tag recovery and data collection, and the effects of fish mortality and tag mortality on the interpretation of results in king salmon. These objectives will require integration of archive tag data with other significant geological, oceanographic, and climatic databases for this area. Alaska Department of Fish and Game will benefit from this study by an analysis of hatchery fish adaptation to and use of critical marine habitats in Prince William Sound. These data will allow interpretation of hatchery fish interactions with local fish stocks (both predators and prey) and other aquatic resources such as marine mammals at different locations or habitats. These data will provide information important to the development of hatchery supplementation programs and conservation strategies in this area.

This proposal requests funding to undertake archive telemetry studies on Prince William Sound king salmon incorporating five program elements:

1) Initiate an *in situ* array of archive tags on a stationary buoy in Prince William Sound and monitor light data reflecting natural solar conditions at various depths for one year. These data will be incorporated with light sensor information developed in Resurrection Bay (EVOS#00478) to provide data from two latitudes for different years. These data will serve as the baseline data against which we will develop geoposition algorithms specific to local conditions in the Gulf of Alaska.
2) Rear chinook salmon from the Willow Creek stock maintained by ADFG for live releases into PWS at ADFG's hatchery facilities (Elmendorf) and at the SeaLife Center until they reach critical size for surgical implants of archive tags (150 - 300 mm). Implant tags in 60 salmon smolts/post-smolts and retain 60 fish of equal size as non-tagged controls (2001). Monitor tag retention, behavior, and growth for one year in captivity prior to any live releases.

3) Year 2 (2002) we plan live releases at ADFG's Ester Island facility on Prince William Sound. Tagged fish will be acclimated to PWS waters at the hatchery release location for imprinting and then released into marine waters. Size structured live releases will be made based on results from our first year's pilot study of tag retention and behavior. Since king salmon typically spend 1-2 years at sea and have a three-year life cycle, recoveries from the sport fishery and in spawning habitats will be monitored in 2002 - 2004. Yearly progress reports will be made with a final report submitted by September 15, 2004.

4) Monitor tag recoveries in the fishery, at the hatchery release site, and adjacent streams. Analyze data on individual fish behavior for two years post-release using geoposition estimates developed specifically for Gulf of Alaska.

5) Plot estimates of geoposition, movement, critical habitat use, and maturation cycles from archive tags collected from king salmon in Prince William Sound. Draw inference from these data for chinook use of ocean conditions, migration paths, stray rates, and critical habitat needs for king salmon in Prince William Sound. These data will be incorporated into the GEM database and provide information on sport fishery effects in marine systems, hatchery enhancement effects on other marine organisms, and critical marine habitat needs of chinook salmon in the Gulf of Alaska.

NEED FOR THE PROJECT

A. Statement of Problem

Knowledge of the marine distribution of individual fish over time and space within the Gulf of Alaska ecosystem is needed to make sound management decisions for recovery, management of the resource, and for the development of reserves and/or protected areas in marine ecosystems. Without sound scientific support, recovery and conservation activities in marine systems will remain controversial among diverse user groups, especially in species governed by such diverse interests as chinook salmon. Including local community based information in the deployment and recovery of these scientific data will be an effective tool in resource management. Documentation of individual fish behavior in economically and ecologically important species within the Gulf of Alaska will aid in the development of a common-ground database on fish distributions over time and space during the development and implementation of management units within the marine systems where frequent conflict-of-interest problems are expected to arise.

The marine environment imposes severe constraints on the type of tags that can be used to monitor the behavior of fish in their natural environment. Seawater is highly conductive and radio waves do not propagate well in this medium. Recently marine biologists have developed new technologies in an effort to address this problem. Archive tags are internally positioned in the fish's abdomen with light and temperature sensors extending outside the fish on a thin antenna. Sensors are programmed to collect data at set intervals for up to three years. To date this technology has been applied to many important marine species including cod and anadromous salmonids (primarily in Atlantic waters) and in Canadian steelhead populations (D. Welch, pers. comm.) The developmental approach used in the acquisition and analyses of light data generated by archive tags is the same as that used for pop-up tags (EVOS #00478) with the same need for adaptation to local climatic and solar conditions.

Additional research needs to be undertaken on cost-effective and efficient tagging regimes for this new technology, especially in salmon species. The implications of the successful application of archive tags in salmon for documentation of ocean use are enormous. Documentation of changes in salmonid ocean migrations, marine habitat use, and their reaction to critical production variables in the marine environment are necessary for our understanding of salmonid response to decadal shifts in ocean conditions and larger climatic cycles of ocean productivity. This study would facilitate investigations of species-specific tagging protocols, size and location of tags as they affect survival rates (for both fish and tags), effects of coastal geology and local climate on light data, recovery probability for different terminal captures and tag types (i.e. sport fishery and weirs with archive tags vs. satellite pop-up tags), and the effects of fish mortality and tag mortality on the interpretation of results. We will also develop a platform for data exchange, crossover studies, and data archive capacity for ecosystem scale marine habitat analyses in the Gulf of Alaska. This latter objective will require integration of archive tag data with other significant geological, oceanographic, and climatic databases for this area.

Potential future applications directed at discovery and monitoring of ocean habitat use by king salmon are broad. A clear understanding of marine life history and ocean forage migrations in salmonids will only become available with the development and appropriate application of this technology. Understanding temporal and spatial use of marine habitats by critical marine species will contribute significant information to fisheries resource management decisions in the Gulf of Alaska.

B. Rationale/Link to Restoration

Information collected during this study will contribute to our ability to use new technology to assess recovery and impediments to recovery (critical habitat) for an economically and ecologically important fish species found in Prince William Sound and the Gulf of Alaska, king salmon. The proposed work represents an initial scientific approach to increase our technological capacity to investigate the factors that affect population dynamics on multiple temporal and spatial scales. If successful, this technology will help in the definition of critical habitat for proposed marine reserves in the Gulf of Alaska. Without an understanding of the general underlying patterns of habitat use that dictate population change and species interaction within marine units or areas, we can not prescribe or limit specific activities within the reserve based on species distribution. Analysis of critical habitat use, hatchery/wild interactions, and interspecific competition for different life history stages of key species will allow integration of sustainable use or limited harvest in the conservation and management of these species within critical marine areas sensitive to anthropomorphic changes over time. The development of archive tag technology offers a promising window on this type of information.

Archival tag technologies offer the fisheries research community a new tool that is required to resolve movement patterns, spatial and temporal habitat use, and stock structure of many migratory marine species found in the Gulf of Alaska. The critical advantage to this new technology is that it allows documentation of habitat use based on actual fish movement and behavior in areas and at times where human observations are impossible. Conventional identification tags have been used since the early 1900s, but individuals must be recaptured before information is obtained. Hydroacoustic tags can provide multi-day records of location, depth, temperature and swimming speed in marine fishes, but their temporal and spatial scale is limited by the range of signal recovery and transmission duration. In 1996 the first generation of archive satellite “pop-up” tags were developed and deployed on pelagic fish, but these tags are

currently limited to very large fish (~70 lbs). Implant archive tags allow recovery of data from much smaller individuals including salmon post-smolts. The data archived by these tags can include records of ambient and internal body temperature, pressure, and light. It is possible to estimate latitude and longitude for tag location at any given time from changes in light intensity (see proposal #00478). Approaches developed from studies of satellite pop-up tags in the previous proposal are transferable to analyses of data collected from implant archive tags in salmon post-smolts and young adults from the Gulf of Alaska.

C. Location

Data to be compiled will come from tags deployed in Prince William Sound. Initial physiological data concerning tagging effects and efficiencies of light intensity data will be assessed using a limited number of fish in captivity at ADFG hatchery facilities. Tagging of 40 post-smolts with archive tags will take place in collaboration with ADFG and the local sport fishing community. Tag array disposition on a stationary buoy in the Prince William Sound will parallel our previous efforts in Resurrection Bay (proposal #00478). Tag recoveries will employ local sport fishers (yr 1 & 2), collection of spawning adults at the release site (yr 1 & 2), and incidental recoveries in other sport, commercial and research fisheries in and around Prince William Sound.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

All efforts will be made throughout the project to incorporate participation in and provide local involvement in the implementation and development of this project in relation to target populations and tagging localities. Project staff will be available to present information to local communities, internet access to real-time data from satellite tags will be made available at the local level as it becomes available to the PI. All articles, video, or photographs of the tagging study will be made available to the Trustee Council. The nature of the tagging study and the charismatic character of the fish subject make this a potentially high profile public relations project for the recovery and Trustee Council.

PROJECT DESIGN

A. Objectives

1) Initiate an *in situ* array of archive tags on a stationary buoy in Prince William Sound and monitor light-data reflecting natural solar conditions at various depths in this area.
    A. These data will be incorporated with light sensor information developed in Resurrection Bay (EVOS#00478) to provide data from two latitudes over two years. These data will serve as the baseline data against which we will develop geoposition algorithms specific to local conditions in the Gulf of Alaska.

2) Rear chinook salmon from the Willow Creek stock maintained by ADFG for live releases into PWS at two independent facilities: ADFG's hatchery facilities (Elmendorf) and the SeaLife Center. Fish will be reared until they reach critical size for surgical implants of archive tags (150 - 300 mm). Implant tags in 60 salmon smolts/post-smolts and retain 60

fish of equal size as non-tagged controls under the same reading conditions. Monitor tag retention, behavior, and growth for one year in captivity prior to any live releases.

A. Cooperation and contribution of resources by ADFG has been promised by Larry Peltz, Hatchery Manager ADFG. The hatchery stock used in this program is the same Willow Creek stock used for release by ADFG in Resurrection Bay.

3) Second year (2002) we plan 60 live releases at ADFG's Ester Island facility on Prince William Sound (an additional 60 tagged chinook will be released if external funds become available for the implementation of the tag study from sources outside of EVOS). Tagged fish will be acclimated to PWS waters in holding pens at the hatchery release location for imprinting and then released into marine waters. Size structured live releases will be made based on results from our first year's pilot study of tag retention and behavior.

4) Monitor tag recoveries in the sport fishery, at the hatchery release site, and at adjacent spawning locations (strays) and analyze data on individual fish behavior for time post-release using geoposition estimates developed specifically for Gulf of Alaska and Prince William Sound. Since king salmon typically spend 1-2 years at sea and have a three-year life cycle, recoveries from the sport fishery and in spawning habitats will be monitored in 2002 - 2004. Yearly progress reports will be made to EVOS.

5) Plot estimates of geoposition, movement, critical habitat use, and maturation cycles from archive tags collected from Prince William Sound king salmon.

A. Draw inference from these data for chinook use of ocean conditions, migration paths, stray rates, and critical habitat needs for king salmon in Prince William Sound. These data will be incorporated into the GEM database and provide information on sport fishery effects in marine systems, hatchery enhancement effects on other marine organisms, and critical marine habitat needs of chinook salmon in the Gulf of Alaska.

B. Methods

A total of 120 archive tags will be deployed under various conditions to gather and analyze data on estimates of geolocation for free ranging king salmon in the Gulf of Alaska. The PI will monitor surgical tag implantation effects on a test population (N=60) with at least two veterinary scientists at two independent rearing location to avoid potentially complicating environmental effects. Tests will include anesthetic effects, physiological stress during and after tagging, stability of implantation over time, fish mortality, fish growth and fish behavior. Live releases of 60 – 120 tagged chinook will be made in year 2002 from ADFG's chinook hatchery facility of Esther Island. Recovery of tags from the fishery and from natural returns to the hatchery and in geographically proximate spawning locations will be monitored for two years post release.

Several features of the archive tags will be tested from an array of tags deployed from a stationary buoy located in Prince William Sound. This tag array will be used to test efficiency of light sensors at different latitudes within the Gulf of Alaska, temperature cycles at depth,

stability of pressure sensors at depth, and effective recovery of data over time. Estimates of actual fish location will be obtained from data collected from fish captured in the fishery and recovered at the site of release. These data will then be compared and analyzed for rigor of geoposition estimates based of our findings from previous captivity light studies and the stationary tag array in the Gulf of Alaska.

Conversion of archive data to position and movement cycles for individual fish will be made using adaptations of existing conversion algorithms available from the vendor and our initial field trials of tags in the Gulf of Alaska. New approaches to estimating geoposition from light data using time series analyses will be used in this study (R. Hill, Wildlife Computers, pers. comm.) Data for location and position for individual tags collected in the wild will be plotted on digitized maps of the Gulf of Alaska (two dimensional) incorporating any bathymetric data (three dimensional) available for this area using standard telemetry and GIS mapping methods (Baltz 1990; Cressie 1991; Thompson et al. 1992).

This study will continue the development and implementation of the internet link to Gulf of Alaska tagging studies and results will run parallel to the ongoing field studies and tagging data development. The web site will be posted on the USGS/BRD Alaska Biological Science Center's home page.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

This proposal relies on a number of significant research collaborators including ADFG's Larry Peltz and Bob Clark. Many unnamed collaborations will develop during the implementation of this project (i.e. commercial or sport boat captains, fishing volunteers, and community internet links). Known collaborators include: Dan Mulcahy, DVM, USGS/BRD fish and wildlife veterinarian; Riley Wilson, DVM Anchorage Zoo; Roger Hill, Wildlife Computers; Dr. Paul Howey, Microwave Telemetry, Inc., Jim Lotimer and Keith Stoodley, LOTEC Marine Technologies, Inc. Lee Hulbert of the National Marine Fisheries has volunteered collaboration on the analysis of light data collected from their shark pop-up tag study. All technical and clerical staff will be employees of USDGS/BRD Alaska Biological Science Center or qualified individuals contracted directly for this project.

SCHEDULE

A. Measurable Project Tasks for 2001 - 2004

Funding 2001 (EVOS)

Oct. 00 – Mar. 01:	Purchase of archive tags, dummy tags and tags for buoy array. Establish holding facilities for king salmon from FY00 broodstock from Willow Creek for use in implant studies (site determined by ADFG) and at the Alaska Sea Life Center.
April 2001	Control tests for surgical implants of tags for estimates of survival, handling stress and delayed mortality in king salmon.
May – June:	Surgical implants of archive tags in size-structured study groups (N = 60) and establishment of monitoring protocols for tag retention, growth, behavior and survival.

June - July:	Deploy light sensor tag array on stationary buoy in Prince William Sound.
May 01–Apr 02:	Monitor and evaluate fish performance, survival, behavior and tag retention at two rearing locations.
April 15, 02	Annual report due EVOS.

Funding 2002 - 2003 (EVOS/BRD)

May – June:	Surgical implants of archive tags in size-structured release groups (N = 60). Acclimation to PWS waters at hatchery site on Esther Island. Tag releases into marine waters.
June - Sept	Monitor fish recoveries from sport fishery out of Wittier (implement reward program) and from streams near release site for possible early returns of spawning fish (jacks) with tags in natural stream environments.
July 2003:	Recover light sensor tag array on stationary buoy
Sept – Dec:	Collect and analyze first data sets from sport fishery. Develop Web Page for study results and plot initial data. Consult on tagging applications and data interpretation. Develop oceanic temperature and bathymetry database for Prince William Sound.
Aug. - Nov.:	Collect tags from king salmon spawning recoveries in streams in vicinity of release site using nets, hook-and-line, and carcass recoveries.
Nov. – Dec.	Analyze yearly data sets from sport fishery, spawning recoveries, and buoy array.
Dec. – Jan.:	Integrate light data sets from all recoveries and plot fish movements over time using geolocation estimates.

Funding 2004 (BRD)

Jan. 2003:	Prepare final data presentation and attend restoration meeting.
Feb – Apr. 2003:	Integrate analyses from parallel studies of pop-up tags in Gulf of Alaska.
April 15:	Submit final report to EVOS on study results.

B. Project Milestones and Endpoints

All EVOS costs for this project will be billed in 2001-02, with primary tagging costs in 2001.

Due to timing of salmonid life cycle (up to two years at sea) data analyses will continue into FY2004.

Project will be completed upon submission of the final report prior to Sept. 15, 2004.

C. Completion Date

All project objectives billed to EVOS will be met before the end of Sept. 2003.

PUBLICATIONS AND REPORTS

Preliminary report submitted to EVOS April 15, 2002. A final report of activities will be submitted to the Restoration Office on or before 15 Sept. 2004.

Manuscript containing final results and recommendations will be submitted to a peer-reviewed scientific journal for publication in FY03-4.

Website development and maintenance of our tagging database will be available FY01-03. At the end of the project we will transfer the internet site to a webmaster designated by the Trustee Council.

PROFESSIONAL CONFERENCES

International workshop on tracking salmon at sea FY01 (British Columbia, CA)
Fourth Conference on Fish Telemetry - June 2001 (Trondheim, Norway)
American Fisheries Society - Aug 2001 (Phoenix, AZ)

NORMAL AGENCY MANAGEMENT

The work proposed here is not part of normal agency management and is related specifically to research addressing oil spill restoration concerns. No similar work has been conducted, is currently being conducted, or is planned using agency funds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This research provides fundamental information needed for the implementation and development a new technology dedicated to the identification of critical marine reserve areas in Prince William Sound and the Gulf of Alaska. The definition of critical marine habitat for economically and ecologically important fish species will serve as a cornerstone for future Trustee sponsored conservation and use management proposals under the GEM program. The

major objectives of this work require interaction with several other investigators and integration of all available data that are relevant to the question of critical marine habitat in the Gulf of Alaska.

PROPOSED PRINCIPAL INVESTIGATOR

Dr. Jennifer L. Nielsen
Alaska Biological Science Center
USGS-Biological Resources Division
1011 E. Tudor Rd.
Anchorage, AK 99503
(907) 786-3670
FAX: (907) 786-3636
jennifer_nielsen@usgs.gov

PERSONNEL QUALIFICATIONS

Jennifer Nielsen is Fisheries Supervisor and Research Biologist (GS14) with the Alaska Biological Science Center, USGS Biological Resources Division. She has conducted salmonid and fisheries research throughout the western Pacific for the past 22 years. Dr. Nielsen is an Associate Professor at the University of Alaska, Fairbanks in the School of Fisheries and Ocean Sciences. From 1995 - 1999 she was a visiting scientist at Hopkins Marine Station, Stanford University, where the first experiments on satellite pop-up tags were conducted on blue fin tuna. From 1995 - 1999, she was an Adjunct Professor in Ichthyology and Fisheries at the University of California, Berkeley and Moss Landing Marine Laboratory, and served on the Scientific Review Board for the Monterey Bay Aquarium. Dr. Nielsen has published over 30 peer-reviewed journal publications and book chapters, numerous technical reports, and gives frequent national and international presentations at scientific meetings addressing research issues in fish conservation, behavior, evolution, and genetics. Her work on salmonid fishes is recognized internationally for its contribution and focus in fisheries conservation and management.

KEY COOPERATORS

Larry Peltz
Alaska Department of Fish and Game
333 Raspberry Road
Anchorage, AK 99518
267-2157

Dr. Dan Mulcahy, DVM
Alaska Biological Science Center
1011 East Tudor Road
Anchorage, AK 99503
(907) 786-3451
dan_mulcahy@usgs.gov

Dr. Dave Douglas
Alaska Biological Science Center
1011 East Tudor Road
Anchorage, AK 99503
(907) 786-3473
dave_douglas@usgs.gov

Dr. Roger D. Hill
Wildlife Computers
16150 NE 85th St. #226
Redmond, WA 98052
(425) 881-3048
tags@wildlifecomputers.com

Dr. Keith Stoodley
LOTEK Marine Technologies Inc.
114 Cabot St.
St. John's NF
Canada A1C 1Z8
kstoodley@lotek.com

Leland B. Hulbert
NMFS, Auke Bay Laboratory
Juneau, AK
(907) 786-6056

LITERATURE CITED

Anonymous, NOAA NMFS. 1999. Ecosystems Observations: Annual report for the Monterey Bay National Marine Sanctuary 1998. J. Carless, Editor. Monterey Bat National Marine Sanctuary.

Baltz, D. M. 1990. Autecology, movements and microhabitat descriptions. Chapter 18 *in* C. B. Schreck and P. B, Moyle (eds.) *Methods for Fish Ecology*. American Fisheries Society, Bethesda, MD. pp 593-599.

Block, B.A., H. Dewar, C. Farwell, and E.D. Prince. 1998. A new satellite technology for tracking the movement of Atlantic bluefin tuna. Proc. Natl. Acad. Sci. USA 95: 9384-9389.

Block, B.A., H. Dewar, T. Williams, E.D. Prince, C. Farwell, and D. Fudge. 1998. Archival tagging of Atlantic bluefin tuna (*Thunnus thynnus thynnus*). MTS Journal 32: 37-45.

Cressie, N. A. C. 1991. *Statistics for Spatial Data*. John Wheiley & Sons, N. Y.

Eiler, J. H. 1995. A remote satellite-linked tracking system for studying pacific salmon with radio telemetry. Transactions of the American Fisheries Society 124:184-193.

Getz, W. M., Fortmann, L., Cumming, D., du Tolt, J., and six co-authors. 1999. Sustaining natural and human capital: villagers and scientists. Science 283: 1855-1856.

Hill, R.D. 1994. Theory of geolocation by light levels. In B.J. LaBoeuf and R.M. Laws (eds.) *Elephant seals: Population Ecology, Behavior and Physiology*. University of California Berkeley Press, pp. 227-236.

Lucas, M. C., A. D. Johnstone, and I. G. Priede. 1993. Use of physiological telemetry as a method of estimating metabolism of fish in the natural environment. Transactions of the American Fisheries Society 122:822-833.

Lutcavage, M. E., R.W. Brill, G.B. Skomal, B.C. Chase, and P. W. Howey. 1999. Results of pop-up satellite tagging of spawning size class fish in the Gulf of Maine: do North Atlantic bluefin tune spawn in the mid-Atlantic? Can. J. Fish. Aquat. Sci. 56:173-177.

Sibert, J. 2000. Symposium on tagging and tracking marine fish with electronic tags. Draft report to PFRP Newsletter, Pelagic Fisheries Research Program, University of Hawaii, Manoa. 4pp.

Thompson, S. K., F. L. Ramsey, and G. A. F. Seber. 1992. An adaptive procedure for sampling animal populations. Biometrics 48:1195-1199.

Welch, D.W. and J.P. Eveson. 1999. An assessment of light-based geoposition estimates from archival tags. Can. J. Fish. Aquat. Sci. 56: 1317-1327.

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Actual FY 2000	Proposed FY 2001
Personnel		$15.4
Travel		$0.6
Contractual		$1.3
Commodities		$0.9
Equipment		$54.4
Subtotal		$72.6
General Administration		$2.4
Project Total		$75.0
Full-time Equivalents (FTE)		0.4

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2002	Estimated FY 2003
$106.5	$0.0

Dollar amounts are shown in thousands of dollars.

Other Resources

USGS/BRD will provide salary for PI, staff veterinarian, and systems scientist throughout the study and support all activities including mos costs. BRD will purchase buoy array tags estimated at $7,800 needed for completion of project in FY03.
Data analysis and reporting writing will be done with BRD funds.

Revision December 2000: The budget originally proposed for this project ($100K) is being revised downward to $75K as requested by the Trustee Council. The $25K reduction being taken from salary will now be funded by the USGS instead.

FY01

Revised 12/20/00

Project Number: 01404
Project Title: Archive tags for tracking king salmon at sea
Agency: DOI-USGS--BRD

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs*:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	P
Name	Position Description					
J. Nielsen*	Fisheries Supervisor	GS14/01	3.0	7.2		
TBA**	Fisheries Project Leader	GS9/01	5.0	3.1		
D. Mulcahy*	Fish/Wild. Veterinarian	GS13/05	0.5	6.8		
D.Douglas*	Fish/Wild Scientists	GS12/05	0.5	6.0		
*all personnel costs will be covered by USGS/BRD						
**7 months salary will be funded by USGS/BRD						
	Subtotal		9.0	23.1	0.0	
					Personnel Total	

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	P
Description					
Anchorage to hatchery, Anchorage to Whittier, etc. to check potential release sites					
PI & veterinarian travel at USGS/BRD costs					
				Travel Total	

FY01

Revised 12/20/00

Project Number: 01404
Project Title: Archive tags for tracking king salmon at sea
Agency: DOI-USGS-BRD

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	P
Description	
Tag data consultation and data recovery fees Research vessel lease (private) - 1 day	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	
Commodities Costs:	F
Description	
Materials and supplies - misc.	
Commodities Total	

FY01

Revised 12/20/00

Project Number: 01404
Project Title: Archive tags for tracking king salmon at sea
Agency: DOI-USGS--BRD

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	P
Description	of Units	Price	
Archive tags (light/temp) (40 @ 1300 ea.)	40	1.3	
Dummy tags (20 @ 120 ea.)	20	0.1	
Archive tags (light/temp) for buoy array (6@ 1300 ea.)			
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	

Existing Equipment Usage:	Number	I
Description	of Units	

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001