

## ***Project Title: Testing Archival Tag Technology in Alaska Salmon***

Project Number:	02404
Restoration Category:	Research
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Lead Trustee Agency:	DOI--USGS
Cooperating Agencies:	ADFG
Alaska Sea Life Center:	No
Project Duration:	2 <sup>nd</sup> of 3 yrs
Cost FY 02:	\$104.6
Geographic Area:	Cook Inlet
Injured Resource/Service:	Coho salmon

### ***ABSTRACT***

Archive tags with temperature, pressure, and light-geolocation sensors will be monitored for hatchery released coho salmon (*Oncorhynchus kisutch*) in Cook Inlet. 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 coho salmon during maturation in salt-water environments in Cook Inlet. Contemporary physical oceanographic, climatic, and bathometric data available for Cook Inlet will be incorporated into our interpretation of geolocation results and analyses of critical marine habitat and migratory pathways derived from pressure, temperature, and light sensors deployed and recovered in coho salmon. Salmon for this study will be reared in captivity (ADFG hatchery at Fort Richardson) to 1+ year of age (200-250 mm), acclimated and released in Cook Inlet as part of ADFG's Ship Creek sport-fishing hatchery release. Return and recovery of the tagged coho will be monitored as jacks at the Ship Creek weir, and in the sports fishery including a reward system for tag recoveries in the Ship Creek silver salmon derby.

Archival tags can provide estimates of geolocation, vertical movements, and ambient and internal temperatures for individual fish for long periods of time (up to 18 months for these coho). 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 coho salmon is available in collaboration with the Alaska Department of Fish and Game's Fort Richardson hatchery production of coho salmon for release into Ship Creek.

Tagging coho reared in the hatchery environment to the required size (200 - 250 mm) will allow us to test efficiency and accuracy of this technology in the study of ocean use and movement patterns for coho salmon throughout Cook Inlet. Live releases will follow preliminary tests of initial and delayed mortality, tag retention, physiological stress, growth, and fish behavior in the hatchery environment. The first year of work has included pilot studies of tag retention, behavior, and growth for coho in captivity (e.g. hatchery). We have 277 hatchery coho on an accelerated growth regime (current mean size = 157 mm FL) at Fort Richardson

hatchery. Coho over 150 mm have been tagged with visible implant tags (VIT) to identify them as individuals. We have contracted with LOTEK for the purchase of 125 “beta” archival tags for coho smolts and 60 dummy tags of the same size. Surgical implant protocols were developed in collaboration with the University of Waterloo (Dr. Scott McKinley) in Canada. Ship Creek coho will be tagged following tag delivery expected in mid-May. A spring release experiment in the first year will be contingent on the successful implementation and retention of these tags. All surviving tagged coho will be released with the rest of the Ship Creek hatchery coho the first week in June. We will survey for early jack recoveries at the Ship Creek weir and among sport fishers from mid-July through November 2001. Monitoring the recovery of tags in the coho commercial fishery in Cook Inlet and the derby sport fishery on Ship Creek facilitates a higher probability of adult recoveries in the first 18 months of this project.

Archive tagged fish will be used to document coho salmon use of marine habitats, migration routes, contribution to the sport fishery, and hatchery/wild interactions for salmon in Cook Inlet. Information on temperature, depth (pressure), and light from archive tags can be integrated with tidal stream data, climatic data, oceanographic bathymetry, stream discharge, hydrographic records, and sea surface satellite imagery to help track salmon distribution and migration routes throughout Cook Inlet. We have researched electronic records for ocean bathymetry in Cook Inlet and are developing a base map in ARC-View to use in plotting coho movements throughout Cook Inlet based on tag recoveries and archival environmental data. Our understanding of marine habitat use, forage patterns, coastal and deepwater migrations, and maturation rates will greatly enhance EVOS recovery efforts and planning in future GEM conservation efforts.

## **INTRODUCTION**

Our previous EVOS study (#00478) is testing light-based geolocation estimates for satellite pop-up and archive tags in the Gulf of Alaska. Light sensors attached to the smaller archive tags used in this study are being designed to collect identical data for geolocation estimates. Part of this study will continue these efforts to gain accuracy of geolocation estimates on the local scale within the Gulf of Alaska and Cook Inlet and to monitor local geography, climatic, and water quality conditions leading to errors in these estimates. To that end we will complete nine months collection of *in situ* data from two tags retained on halibut in captivity at the Alaska SeaLife Center (June 2001) and from tag arrays mounted on a stationary buoy at the entrance of Resurrection Bay (November 2001). Analytical analyses of light-based data for geolocation estimates made in this study will serve as a baseline for data collected from archival tags on coho in Cook Inlet. Archival 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 tidal and oceanographic conditions found in Cook Inlet.

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.) J. L. Nielsen (PI) recently received a Census of Marine Life grant from the Sloan Foundation’s Pacific Ocean Salmon Tracking Project (CoML POST - 2002-2004) for a field test of archival and acoustic tagging of steelhead kelts on the Kenai Peninsula. 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. Both offshore and

coastal elements will provide critically needed insight on how salmon use the ocean during their extensive migrations. Implementation of this cutting edge tagging technology will provide improved understanding into how current and anticipated climate changes may affect salmonid population dynamics. 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 Alaska. Use of this technology has the potential to capture the imagination of the public through an education and outreach component.

Coho salmon (*Oncorhynchus kisutch*) from the Fort Richardson fish hatchery are thought to support significant commercial, sport and subsistence fisheries. The distribution of coho post-smolts and sub-adults throughout saltwater habitats in Cook Inlet is unknown. Recent documentation of Beluga whale distributions in Cook Inlet throughout the winter suggests that coho yearlings may provide an important part of the marine food web for this region. The effect of hatchery releases of coho on natural salmonid production in Cook Inlet is also unstudied. The implementation 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) production of coho at the Fort Richardson fish hatchery provides an excellent opportunity to grow fish to required size for tagging and subsequent release into natural marine habitats (L. Peltz, ADFG, pers. comm.) We have used the Ship Creek coho stock for our initial tagging studies using salmon archive tags.

We have been able to raise 277 hatchery salmon pre-smolts in captivity to the threshold size (150 mm) necessary for successful application of archive tag. Current coho sizes 95% CI range from 153-161mm fork length and 95% CI weights range from 48-55 grams. Larger coho have been tagged with visible implant tags (VIT) to identify them as individuals (N = 46). We have contracted with LOTEK for the purchase of 125 "beta" archival tags for coho smolts and 60 dummy tags of the same size (\$61,843.20). Surgical implant protocols were developed in collaboration with the University of Waterloo (Dr. Scott McKinley). In these tests dummy tags were implanted in trout of various sizes and we monitored post surgical recovery (100%) and placed tagged fish in swimming stress tests post recovery. Two light-stalk positions (anterior center and from the lower side of the abdomen) were tested with our first experimental surgeries. We found no difference in swimming ability post recovery for tagged or untagged fish in these experiments. When the first beta-test salmon archive tags are available from LOTEK in mid-May we will test surgical implant protocols, fish recovery, and behavior in tagged coho salmon for one to two weeks prior to live releases in Ship Creek. All surviving tagged coho will be released with the Ship Creek hatchery coho the first week in June. We will survey for early jack recoveries at the Ship Creek weir and among sport fishers from mid-July through November 2001.

Finding where and when coho 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 coho will provide inference on hatchery vs. wild fish interactions, “hot-spots” of coho production within Cook Inlet, 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 throughout Alaska, including potential studies of endemic cutthroat trout (*O. clarki clarki*), Kenai feeder chinook salmon (*O. tshawytscha*), coastal steelhead (*O. mykiss*), Dolly Varden (*Salvelinus malma*), and Cooper River chinook and coho salmon. Our studies of 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, electronic archive tags, in investigations into the temporal and spatial distribution of key anadromous and marine fish species. 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 near-shore and marine fish species will allow these 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 throughout 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 to estimate catch effects. 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 Cook Inlet provides the best possible conditions for initial archive tag studies using this technology in 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 or oceanic 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 coho salmon caught in the Ship Creek sport fishery and during spawning migrations. These data will allow estimates of the duration of ocean use, migrations, development rates, and movement of hatchery fish into natural salt and freshwater habitats in Cook Inlet. This proposal suggests that data collected from archive tags deployed in Cook Inlet 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 coho salmon in Cook Inlet. If successful these data can provide an effective database for sampling protocols and analyses of critical habitat use by post-smolt and maturing wild salmon populations throughout 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) was 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. J. L. Nielsen (PI), David Welch (Pacific Biological Station DFO, Nanaimo, B.C.), and George Boehlert (NMFS, Pacific Grove, CA) recently received a Census of Marine Life grant from the Sloan Foundation's Pacific Ocean Salmon Tracking Project (CoML POST - 2002-2004) for a field test of steelhead kelt migrations

on the Kenai Peninsula (Ninilchik River, Anchor, and Deep creeks), Smith River, California, and on the Keogh River, B.C., using archival and acoustic tags. 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. Both offshore and coastal elements will provide critically needed insight on how salmon use the ocean during their extensive migrations as pre-adult and adult fish.

Our current proposal (EVOS #01404) is investigating 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 coho salmon in Ship Creek. 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 Cook Inlet. 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. Significant data already exist for beluga whale distribution within Cook Inlet that can be compared to coho salmon migrations. These data will provide information important to the development of hatchery supplementation programs and conservation strategies for the marine food web in this area.

This proposal requests continued funding to undertake archive telemetry studies on Cook Inlet coho salmon incorporating five program elements. We address our progress made on all of these aspects of the study below:

- 1) Rear coho salmon from the Ship Creek stock maintained by ADFG for live releases into Cook Inlet at ADFG's hatchery facilities (Fort Richardson and Elmendorf) until they reach critical size for surgical implants of archive tags (~200 mm).
  - a. This part of the project is underway and protocols for accelerated growth in coho salmon are in place at the hatchery. We initiated the study with 292 coho on 12/12/01 and currently are holding 277 live fish (5% mortality, primarily due to protocol implementation studies and initial tagging experiments).
  - b. We initiated accelerated growth protocols for coho at Fort Richardson Hatchery. Water temperature was slowly increased to 14° C over two days. Diet rations were increased to 0.5g/fish/day. In three months the average coho fork length has increased from 109.63 mm to 157.02 mm and average weight from 15.85 to 51.46 grams. Average fish condition factor (K) has increased from 1.17 to 1.30 and instantaneous growth factor (IGR) ranged from 0.01 to 0.04 over the same period.
- 2) Implant beta-test archival tags in salmon pre-smolts. Monitor tag retention, behavior, and growth in captivity prior to any live releases.
  - a. We have placed "visible implant tags" (VI tags) in 46 coho to date. These colorful individually numbered tags are placed in the ocular orbit above the eye and mark fish as individuals. VI tags should remain clearly visible in the coho through their adult stage and will allow identification of archive-tagged

coho in the study area if other external indicators fail. Beta production salmon archival tags (N = 125) and dummy tags (N = 60) of the same specifications have been ordered from LOTEK for \$61,843.20.

- b. We went to the University of Waterloo (UW), Toronto, Canada to experiment on implementation protocols for the first production of dummy archive tags. Dr. Scott McKinley, faculty at UW, is the only person in the world who has had experimental experience in the implementation of these tags in Atlantic salmon under contract with LOTEK. Dr. McKinley assisted Derek Wilson (USGS) in the development and experimental tests of protocols for coho salmon in our study. Fifteen hatchery rainbow trout were used as surrogates for coho pre-smolts and implanted with dummy archival tags in the laboratory at Waterloo. Fish size ranged from 180 - 335 mm in length. Tag size was 35 mm long by 1mm circumference with a 155 mm light stalk (average weight = 6.9 g). Two protocols for the extension of the external light stalk were tested, extension from the anterior side and extension from the central lower abdomen. All rainbow trout survived the surgical implants.
  - c. Swimming performance and stamina tests were made on tagged and untagged rainbow trout at UW. Control fish were of the same size as the tagged fish in this experiment. Fish were placed in velocity chambers and tested at water velocities ranging from 0.4 - 1.4 m/sec (0.1 m/sec intervals, RPM 240 – 840). Each fish was tested at each velocity interval for 10 minutes. U-crit speed was calculated by increasing the RPM/water velocity every ten minutes by 1/10 of a meter per second. There was no statistical difference between U-crit values for tagged trout (average = 1.047 m/sec) and control (untagged) fish (average = 1.054 m/sec).
  - d. The dummy tags received from LOTEK were slightly larger than the original specifications projected by LOTEK. After the UW experiments we feel that a critical size threshold will be 200 mm for these tags in coho or about 2.5% weight of the whole fish. We are currently modeling our experimental coho population at the hatchery to predict how many of the prototype tags we will be able to implement with these new criteria prior to the release of hatchery fish into Ship Creek. We are in communications with LOTEK on the standardization of these tags and how we might implement even smaller tags. Future design modification on the tags will be implemented in the 2002 release. An earlier start on accelerated growth at the hatchery in 2002 will also allow us to product more fish at the required size.
- 3) 2001 and 2002 live releases of archived tagged fish with VI and/or archival tags will be made in association with the standard hatchery releases made by ADGF into Ship Creek. Expected release dates are May 25-June 5 each year.
- a. This release includes an imprinting period for coho in Ship Creek water at the Elmendorf Fish Hatchery outside of Anchorage. After an initial recovery period, tagged coho will be integrated into the general hatchery population for transport and eventual release into Ship Creek.

- b. Observations will be made during integration and upon release for factors contributing to injury or incidental mortality of tagged fish under these protocols.
  - c. We will modify the 2002 releases based on data assembled from the first year's experiments.
- 4) Monitor tag recoveries in the fishery, at the hatchery release site, and in adjacent streams.
- a. We have contracted with the Ship Creek silver salmon derby organizers to include information about our tagging program in their literature for 2001. We will be offering a tag recovery fee and a lottery for a reward drawn from all recovered tags in 2001.
  - b. We expect tag recovery to begin with the movement of coho jacks (immature males) into Ship Creek starting in mid-July 2001. We will work with ADFG in checking the Ship Creek weir everyday to monitor jack movements and look for tagged fish. USGS employees will walk the creek during peak angling hours, before, during, and after the derby. We will informally interview anglers to discuss the tagging study, our recovery efforts, and the lottery opportunity. We anticipate the first year's recover will consist primarily of jack recoveries in Ship Creek at the weir.
  - c. In 2002 and subsequent return years we will monitor the adult population for tagged fish migrating up Ship Creek both from the sport fishery and at the weir.
  - d. Information dissemination and outreach will be made to the Cook Inlet commercial coho fishery fleet in an effort to recover any tagged fish from their harvest. To this end all tagged fish will also have their adipose fin removed prior to release.
- 5) Plot estimates of geolocation, movement, critical habitat use, and maturation cycles from archive tags collected from coho salmon in Cook Inlet. Draw inference from these data for coho use of ocean conditions, migration paths, stray rates, and critical marine habitat needs. These data will be incorporated into the GEM database and provide information on:
- a. Identification of the distribution and habitat utilization by key life stages of coho salmon in Cook Inlet.
  - b. Identify critical marine features:
    - i. Do coho respond to sharp thermal boundaries?
    - ii. Do coho depend on specific marine structural features?
    - iii. Do coho use specific migration pathways?
  - c. Gain inference on the ecosystem dynamics of Cook Inlet;
    - i. How do other species respond to coho movement within Cook Inlet?
    - ii. What is the interaction between hatchery and wild coho in Cook Inlet?
  - d. Predict how long-term trends in coho distribution, fish condition, growth, and survival may be impacted by changes in marine habitats due to natural or anthropomorphic shifts in ocean conditions.



## ***NEED FOR THE PROJECT***

### ***A. Statement of Problem***

Knowledge of the marine distribution of fish over time and space within Alaska's near-shore and oceanic ecosystems 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 coho 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 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 Cook Inlet. 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 coho 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 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 marine waters throughout Alaska, coho 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 throughout 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 throughout 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 pre-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 project #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 pre-smolts and young adults throughout Alaska.

## ***C. Location***

Data to be compiled will come from tags deployed in Cook Inlet. 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 at Fort Richardson and Elmendorf Air Base. Tagging and recovery of coho with archive tags will take place in collaboration with ADFG and the local sport and commercial fishing communities. Tag array disposition on a stationary buoy in Resurrection Bay (project #00478) will provide general background information for the interpretation of light data in geolocation estimates for Alaska waters. Tag recoveries will employ local sport fishers through links with the Ship Creek silver salmon derby, survey for early returning males (jacks) in Ship Creek, collection of tagged adults at the release site (Ship Creek weir), and incidental recoveries in other sport, commercial and research fisheries in and around Cook Inlet.

## ***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 the local community. An active web site at <www.absc.usgs.gov> will include internet access to real-time data from tags 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) Rear coho salmon from the Ship Creek stock for live releases into Cook Inlet at ADFG's hatchery facilities (Fort Richardson and Elmendorf) until they reach critical size for surgical implants of archival tags (~200 mm).
- 2) Implant beta-test archival tags in salmon pre-smolts. Monitor tag retention, behavior, and growth in captivity prior to any live releases.
- 3) 2001 and 2002 live releases of all tagged fish with VI and/or archival tags will be made in association with the standard hatchery releases made by ADGF into Ship Creek. Expected release dates are May 25-June 5 each year.
- 4) Monitor tag recoveries in the fishery, at the hatchery release site, and adjacent streams.
- 5) Plot estimates of geolocation, movement, and marine habitat use from archival tags collected from coho salmon in Cook Inlet. Draw inference from these data for coho use of ocean conditions, migration paths, stray rates, and critical marine habitat needs. These data will be incorporated into the GEM database and provide information on:
  - (a) Identification of the distribution and habitat utilization by key life stages of coho salmon in Cook Inlet.
  - (b) Identify critical marine features:
    - (i) Do coho respond to sharp thermal boundaries?
    - (ii) Do coho depend on specific marine structural features?
    - (iii) Do coho use specific migration pathways?
  - (c) Gain inference on the ecosystem dynamics of Cook Inlet;
    - (i) How do other species respond to coho movement within Cook Inlet?
    - (ii) What is the interaction between hatchery and wild coho in Cook Inlet?

## ***B. Methods***

Active archive tags and dummy tags will be deployed in each of two years and under various conditions to gather and analyze data tag recovery and marine habitat use by coho salmon in Cook Inlet. Prior to the initial release, we will monitor surgical tag implantation effects on a test population (University of Waterloo). Tests will include anesthetic effects, physiological stress during and after tagging, swimming ability post tagging, stability of implantation over time, fish mortality, fish growth and fish behavior post tagging. Live releases of 60 – 185 tagged coho will be made in years 2001 and 2002 from ADFG's coho hatchery facility at Fort Richardson into Ship Creek. Recovery of tags from the fishery and from natural returns to the Ship Creek weir and in geographically proximate spawning locations will be monitored for 18 months post release. Estimates of actual fish location will be obtained from data collected from tagged fish captured in the fishery or recovered at the weir. These data will then be compared and analyzed for rigor of geolocation estimates based on 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 light sensor tags in the Gulf of Alaska. New approaches to estimating geolocation 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 Cook Inlet (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 of Alaska tagging studies in marine fishes 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 at <[www.absc.usgs.gov](http://www.absc.usgs.gov)>.

## ***C. Cooperating Agencies, Contracts, and Other Agency Assistance***

This proposal relies on a number of significant research collaborators including ADFG's Bill Hauser, Larry Peltz, Jeff Milton, and Bob Clark. Many unnamed collaborations will develop during the implementation of this project (i.e. commercial or sport fishers, fishing volunteers, and community participants). Known collaborators include: Dan Mulcahy, DVM, USGS/BRD fish and wildlife veterinarian; Scott McKinley, University of Waterloo; Roger Hill, Wildlife Computers; Dr. Paul Howey, Microwave Telemetry, Inc., Jim Lotimer and Keith Stoodley, LOTEK Marine Technologies, Inc.; David Welch, DFO Nanaimo, Canada; George Boehlert, NMFS, Pacific Grove, CA. All technical and clerical staff will be employees of USGS/BRD Alaska Biological Science Center or qualified individuals contracted directly for this project.

## ***SCHEDULE***

### ***A. Measurable Project Tasks for 2001 - 2004***

***Funding 2001 (EVOS/USGS BRD)***

- January: Initiate accelerated growth protocols for coho at Fort Richardson hatchery (292 fish). Implement population monitoring for growth and survival in coho salmon.
- February: Develop web page for project.
- March: Purchase of archival and dummy tags for coho study. Initiate VI tagging in fish at critical size.
- April: Control tests for surgical implants of tags for estimates of survival, handling stress, swimming ability and delayed mortality in tagged fish (University of Waterloo).
- May – June: Surgical implants of archive tags in size-structured study groups and implement monitoring protocols for tag retention, growth, behavior and survival. Release tagged coho with general hatchery release into Ship Creek.
- July: Update web page for study results and plots of initial data.
- July – Nov.: Monitor and evaluate tagged fish recovery, survival, behavior and tag retention from fish recovered in the sport fishery on Ship Creek, the Ship Creek weir, and the commercial fishery in Cook Inlet.

***Funding 2002- 2003 (EVOS/USGS BRD)***

- Dec. 01-January 02: Initiate accelerated growth protocols for 300 coho at Fort Richardson Hatchery. Implement population monitoring for growth and survival in coho salmon.
- March 02: Purchase of additional archive tags (second generation) for coho study. Initiate VI tagging in fish at critical size.
- April 02: Second year surgical implants of tags in captivity for estimates of survival, stress, swimming ability and delayed mortality in tagged fish at Fort Richardson Hatchery.
- April 15, 02: Annual report due EVOS on preliminary results.
- May – June 02: Surgical implants of archive tags in size-structured coho study groups. Release tagged coho with general hatchery release into Ship Creek.

- July –Nov. 02: Monitor and evaluate tagged fish recovery, survival, behavior and tag retention from fish recovered in the sport fishery on Ship Creek, the Ship Creek weir, and the commercial fishery in Cook Inlet.
- Aug. 02: Presentation will be given on preliminary results of study at AFS meeting, Baltimore, MD.
- Nov. – Dec. 02: Data integration for tag recoveries, plot coho distribution and movement patterns in Cook Inlet.
- Jan. 2003: Prepare data presentation and attend restoration meeting.
- April 15, 03: Annual report due EVOS.
- July –Nov. 03: Monitor and evaluate tagged fish recovery, survival, behavior and tag retention from fish recovered in the sport fishery on Ship Creek, the Ship Creek weir, and the commercial fishery in Cook Inlet.
- Nov. – Dec. 03: Data integration for tag recoveries, plot coho distribution and movement patterns in Cook Inlet.

***Funding 2004 (USGS BRD)***

- April 15 2004: Submit final report to EVOS on study results.
- June – Sept. 04: Preparation of manuscript for publication of results of coho tagging study.

***B. Project Milestones and Endpoints***

All EVOS costs for this project will be incurred in 2001 or 2002, with primary tagging costs in 2001 and secondary costs in 2002. Survey and monitoring costs increase in FY2002 due to increased probability of adult tag recoveries at the Ship Creek weir and a second tagging and release of coho from the hatchery. Similar costs of recovery in 2003 will be covered by USGS/BRD.

Due to timing of coho salmonid life cycle in Cook Inlet (one year 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 in first year's recovery of tags. 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 FY04.

Website development and maintenance of our tagging database will be available FY01-04. At the end of the project we will transfer the internet site to a webmaster designated by the Trustee Council.

## ***PROFESSIONAL CONFERENCES***

International workshop was held on tracking salmon at sea FY01 (British Columbia, CA). Preliminary report of findings will be given at AFS meeting in Baltimore MD, August 2002. Final results will be presented at professional scientific meeting yet to be identified.

## ***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 habitat for coho in Cook Inlet. 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 Alaska.

## ***PROPOSED PRINCIPAL INVESTIGATOR***

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## ***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.

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### ***LITERATURE CITED***

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**2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>Budget Category:</b>	Actual FY 2001	Proposed FY 2002				
Personnel	\$15.40	\$44.1				
Travel	\$0.60	\$0.8				
Contractual	\$1.30	\$2.0				
Commodities	\$0.90	\$0.9				
Equipment	\$54.40	\$50.0	LONG RANGE FUNDING REQUIREMENTS			
Subtotal	\$72.60	\$97.8			Estimated	
General Administration	\$2.40	\$6.8			FY 2003	
Project Total	\$75	\$104.6				
Full-time Equivalents (FTE)	0.4	1.4				
Other Resources			Dollar amounts are shown in thousands of dollars.			
<p>USGS/BRD will provide salary for PI, staff veterinarian, and systems scientist throughout the study and support all activities including logistical travel and training costs.                      Data analysis and reporting writing will be done with USGS/BRD funds.</p> <p><b>Revision December 2000:</b> 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.</p>						

**FY02**

Prepared 4/9/01

Project Number: 02404  
 Project Title: Testing Archival Tag Technology in Alaska Salmon  
 Agency: DOI-USGS--BRD

**2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>Personnel Costs*:</b>		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2002
Name	Position Description					
J. Nielsen*	Fisheries Supervisor	GS14/01	3.5	7.2		0.0
D. Wilson**	Fisheries Biologist	GS7/01	9.0	4.2		37.8
D. Mulcahy*	Fish/Wild. Veterinarian	GS13/05	0.5	6.8		0.0
D. Douglas*	Fish/Wild Scientists	GS12/05	0.5	6.0		0.0
Biological technician TBA	Fisheries Technician	GS05/01	3.0	2.1		6.3
						0.0
						0.0
						0.0
						0.0
*all personnel costs will be covered by USGS/BRD						
**3 months salary will be funded by USGS/BRD						
						0.0
						0.0
Subtotal			16.5	26.3	0.0	
<b>Personnel Total</b>						<b>\$44.1</b>
<b>Travel Costs:</b>		Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2002
Description						
PI travel to professional conference						0.80
Web site preparation at USGS/BRD costs						0.00
PI & veterinarian travel to tagging site at USGS/BRD costs						0.00
Technical staff travel to hatchery site and weir at USGD/BRD costs						0.00
Data analyses, ARC-View mapping at USGS/BRD costs						0.00
<b>Travel Total</b>						<b>0.80</b>

**FY02**

Prepared 4/9/01

Project Number: 02404  
 Project Title: Testing Archival Tag Technology in Alaska Salmon  
 Agency: DOI-USGS-BRD

**2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>Contractual Costs:</b>		Proposed
Description		FY 2002
Tag recovery reward reimbursements - Ship Creek Fish Derby		2.0
Additional tag recovery costs for 2003 & 2004 covered by USGS/BRD		0.0
ARC-View technical mapping training covered by USGS/BRD		0.0
<b>Contractual Total</b>		<b>\$2.0</b>
<b>Commodities Costs:</b>		Proposed
Description		FY 2002
Materials and supplies - misc.		0.9
Hatchery costs for accelerated growth in coho covered by ADFG		0.0
2002 - 2004 Publication costs will be covered by USGS/BRD		0.0
<b>Commodities Total</b>		<b>\$0.9</b>

**FY02**

Prepared 4/9/01

Project Number: 02404  
 Project Title: Testing Archival Tag Technology in Alaska Salmon  
 Agency: DOI-USGS--BRD

**2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET**

October 1, 2001 - September 30, 2002

<b>New Equipment Purchases:</b>		Number of Units	Unit Price	Proposed FY 2002
Description				
Archive tags (light/temp/pressure) (100 @ 480 ea.)		100	0.5	50.0
				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.		<b>New Equipment Total</b>		\$50.0
<b>Existing Equipment Usage:</b>		Number of Units	Inventory Agency	
Description				
Any tags remaining from FY01 will be implanted in coho in 2002.				

**FY02**

Prepared 4/9/01

Project Number: 02404  
 Project Title: Testing archival tag technology in Alaska salmon  
 Agency: USGS